

# Chaudhary Bansi Lal University

(A State University established under Haryana Act No. 25 of 2014)



## Scheme of Examination For Postgraduate Programme

### M.Sc. PHYSICS

as per NEP 2020

Curriculum and Credit Framework for Postgraduate Programmes  
(Multiple Entry-Exit, Internships and Choice Based Credit System  
LOCF)

With effect from the session 2025-26 (in phased manner)

### DEPARTMENT OF PHYSICS

Chaudhary Bansi Lal University, Prem Nagar-127031  
Bhiwani  
HARYANA, INDIA

**Programme Learning Outcomes (PLOs) for PG Programmes as per NEP-2020**

| PLOs  |                                          | Master Degree in Physics                                                                                                                                                                                                                                                                                                                          |
|-------|------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|       |                                          | <b>After the completion of Master degree in Physics the student will be able to:</b>                                                                                                                                                                                                                                                              |
| PLO-1 | Knowledge and Understanding              | Demonstrate the fundamental and advanced knowledge of the subject and understanding of recent developments and issues, including methods and techniques, related to the Physics.                                                                                                                                                                  |
| PLO-2 | General Skills                           | Acquire the general skills required for performing and accomplishing the tasks as expected to be done by a skilled professional in the fields of Physics.                                                                                                                                                                                         |
| PLO-3 | Technical/ Professional Skills           | Demonstrate the learning of advanced cognitive technical/professional skills required for completing the specialized tasks related to the profession and for conducting and analyzing the relevant research tasks indifferent domains of the Physics.                                                                                             |
| PLO-4 | Communication Skills                     | Effectively communicate the attained skills of the Physics in well-structured and productive manner to the society at large.                                                                                                                                                                                                                      |
| PLO-5 | Application of Knowledge and Skills      | Apply the acquired knowledge and skills to the problems in the subject area, and to identify and analyze the issues where the attained knowledge and skills can be applied by carrying out research investigations to formulate evidence-based solutions to complex and unpredictable problems associated with the field of Physics or otherwise. |
| PLO-6 | Critical thinking and Research Aptitude  | Attain the capability of critical thinking in intra/inter-disciplinary areas of the Physics enabling to formulate, synthesize, and articulate issues for designing of research proposals, testing hypotheses, and drawing inferences based on the analysis.                                                                                       |
| PLO-7 | Traditional knowledge, Values and Ethics | Demonstrate awareness of traditional astronomical tools and methodologies and compare them with modern instruments. Understand the historical, cultural, and philosophical foundations of Indian science and its global relevance.                                                                                                                |
| PLO-8 | Capabilities/qualities and mindset       | To exercise personal responsibility for the outputs of own work as well as of group/team and for managing complex and challenging work(s) that requires new/strategic approaches.                                                                                                                                                                 |
| PLO-9 | Employability and job-ready skills       | Attain the knowledge and skills required for increasing employment potential, adapting to the future work and responding to the rapidly changing demands of the employers/industry/society with time.                                                                                                                                             |



# Chaudhary Bansi Lal University Bhiwani

Scheme of Examination for the Post Graduate Programmes (M.Sc. Physics)  
as per NEP 2020 Curriculum and Credit Frame work for Postgraduate Programmes  
(Choice Based Credit System LOCF) with effect from the session 2025-26 (in a phased manner)

## 2-year PG Programme

### Semester I

| Course Type | Course Code   | Nomenclature of course             | Theory (T)/ Practical (P) | Credits | Contact hours per week |   |   | Internal Assessment Marks | End Term Examination Marks | Total Marks | Examination hours |
|-------------|---------------|------------------------------------|---------------------------|---------|------------------------|---|---|---------------------------|----------------------------|-------------|-------------------|
|             |               |                                    |                           |         | L                      | T | P |                           |                            |             |                   |
| CC-1        | 25PN-PHY-101  | Mathematical Physics               | T                         | 4       | 4                      | 0 | 0 | 30                        | 70                         | 100         | 3                 |
| CC-2        | 25PN-PHY-102  | Classical Mechanics                | T                         | 4       | 4                      | 0 | 0 | 30                        | 70                         | 100         | 3                 |
| CC-3        | 25PN-PHY-103  | Quantum Mechanics -I               | T                         | 4       | 4                      | 0 | 0 | 30                        | 70                         | 100         | 3                 |
| DEC-1       | 25PN-PHY-105E | Electronic Devices and Circuits- I | T                         | 4       | 4                      | 0 | 0 | 30                        | 70                         | 100         | 3                 |
|             | 25PN-PHY-105M | Material Science -I                |                           | 24      | 4                      | 0 | 0 | 30                        | 70                         | 100         | 3                 |
| CC-4        | 25PN-PHY-104  | General Electronics-I              | P                         | 4       | 0                      | 0 | 8 | 30                        | 70                         | 100         | 3                 |
| PC-1        | 25PN-PHY-106  | Physics Lab- I                     | P                         | 4       | 0                      | 0 | 8 | 30                        | 70                         | 100         | 3                 |

# Semester II

|       |                 |                                    |   |   |    |   |   |   |   |    |    |     |   |
|-------|-----------------|------------------------------------|---|---|----|---|---|---|---|----|----|-----|---|
| CC-5  | 25PN-PHY-201    | Nuclear and Particle Physics       | T | 4 | 26 | 4 | 0 | 0 | 4 | 30 | 70 | 100 | 3 |
| CC-6  | 25PN-PHY-202    | Solid State Physics                | T | 4 |    | 4 | 0 | 0 | 4 | 30 | 70 | 100 | 3 |
| CC-7  | 25PN-PHY-203    | Quantum Mechanics - II             | T | 4 |    | 4 | 0 | 0 | 4 | 30 | 70 | 100 | 3 |
| DEC-2 | 25PN-PHY-205E   | Electronic Devices and Circuits-II | T | 4 |    | 4 | 0 | 0 | 4 | 30 | 70 | 100 | 3 |
|       | 25PN-PHY-205M   | Material Science -II               |   |   |    |   |   |   |   |    |    |     |   |
| CC-8  | 25PN-PHY-204    | General Electronics-II             | P | 4 |    | 0 | 0 | 8 | 8 | 30 | 70 | 100 | 3 |
| PC-2  | 25PN-PHY-206    | Physics Lab-II                     | P | 4 |    | 0 | 0 | 8 | 8 | 30 | 70 | 100 | 3 |
| IKS   | 25PN-PHY-IKS201 | India's contribution to science    | T | 2 |    | 2 | 0 | 0 | 2 | 15 | 35 | 50  | 3 |

In order to enhance the employability and for the development of the research aptitude in students. A non-credited optional internship courses of 4-6 weeks' duration during summer vacation after II<sup>nd</sup> semester may be allowed to be completed by student.

**Note:** 25PN-PHY-IKS201 may be offered through Classroom Lectures, Online Video Lectures, and MOOCs-based Content. Nearly 2% of the syllabus is devoted to IKS-related content. Faculty members shall incorporate relevant IKS concepts and material related to the topics covered in their respective theory lectures.

**Note:** Students who opt for **DEC-1: Electronic Device and Circuits-I** in the 1<sup>st</sup> Semester shall be required to take **DEC-2: Electronic Device and Circuits-II** in the 2<sup>nd</sup> Semester. Similarly, students who opt for **DEC-1: Material Science-I** in the 1<sup>st</sup> Semester shall be required to take **DEC-2: Material Science-II** in the 2<sup>nd</sup> Semester.



Semester III (Option -I)

| Course Type | Course Code      | Nomenclature of course         | Theory (T)/ Practical (P) | Credits |    | Contact hours per week |   |   |       | Internal Assessment Marks | End Term Examination Marks | Total Marks | Examination hours |
|-------------|------------------|--------------------------------|---------------------------|---------|----|------------------------|---|---|-------|---------------------------|----------------------------|-------------|-------------------|
|             |                  |                                |                           | Total   |    | L                      | T | P | Total |                           |                            |             |                   |
| CC-9        | 25PN-PHY-301     | Electrodynamics                | T                         | 4       | 26 | 4                      | 0 | 0 | 4     | 30                        | 70                         | 100         | 3                 |
| CC-10       | 25PN-PHY-302     | Atomic & Molecular Physics-I   | T                         | 4       |    | 4                      | 0 | 0 | 4     | 30                        | 70                         | 100         | 3                 |
| CC-11       | 25PN-PHY-303     | General Physics Lab-I          | P                         | 4       |    | 0                      | 0 | 8 | 8     | 30                        | 70                         | 100         | 3                 |
| DEC-3       | 25PN-PHY-304CM   | Condensed Matter Physics-I     | T                         | 4       |    | 4                      | 0 | 0 | 4     | 30                        | 70                         | 100         | 3                 |
|             | 25PN-PHY-304EC   | Electronics-I                  | T                         | 4       |    | 4                      | 0 | 0 | 4     | 30                        | 70                         | 100         | 3                 |
| DEC-4       | 25PN-PHY-305RH   | Radiation & Health Physics     | T                         | 4       |    | 4                      | 0 | 0 | 4     | 30                        | 70                         | 100         | 3                 |
|             | 25PN-PHY-305NM   | Nanoscience and Nanotechnology | T                         | 4       |    | 4                      | 0 | 0 | 4     | 30                        | 70                         | 100         | 3                 |
| PC-3        | 25PN-PHY-306     | Physics Lab-III                | P                         | 4       |    | 0                      | 0 | 8 | 8     | 30                        | 70                         | 100         | 3                 |
| EEC         | 25PN-PHY-EEC-301 | Electronic Instrumentation     | T-P                       | 2       |    | 1                      | 0 | 2 | 3     | 15                        | 35                         | 50          | 3                 |

*[Handwritten signature]*

**Semester IV (Option -I)**

|       |                |                                                |     |   |    |   |   |   |   |    |    |     |   |
|-------|----------------|------------------------------------------------|-----|---|----|---|---|---|---|----|----|-----|---|
| CC-12 | 25PN-PHY-401   | Atomic and Molecular Physics-II                | T   | 4 | 24 | 4 | 0 | 0 | 4 | 30 | 70 | 100 | 3 |
| CC-13 | 25PN-PHY-402   | Statistical Mechanics                          | T   | 4 |    | 4 | 0 | 0 | 4 | 30 | 70 | 100 | 3 |
| DEC-5 | 25PN-PHY-403CM | Condensed Matter Physics-II                    | T+P | 4 |    | 3 | 0 | 2 | 5 | 30 | 70 | 100 | 3 |
|       | 25PN-PHY-403EC | Electronics-II                                 | T+P | 4 |    | 3 | 0 | 2 | 5 | 30 | 70 | 100 | 3 |
| DEC-6 | 25PN-PHY-404CP | Computational Physics                          | T+P | 4 |    | 3 | 0 | 2 | 5 | 30 | 70 | 100 | 3 |
|       | 25PN-PHY-404TS | Thin Films coatings and applications           | T   | 4 |    | 4 | 0 | 0 | 4 | 30 | 70 | 100 | 3 |
| DEC-7 | 25PN-PHY-405ET | Experimental Techniques in Physics             | T+P | 4 |    | 3 | 0 | 2 | 5 | 30 | 70 | 100 | 3 |
|       | 25PN-PHY-405FE | Fundamentals of Energy Systems and Clean Power | T+P | 4 |    | 3 | 0 | 2 | 5 | 30 | 70 | 100 | 3 |
| PC-4  | 25PN-PHY-406   | Physics Lab-IV                                 | P   | 4 |    | 0 | 0 | 8 | 8 | 30 | 70 | 100 | 3 |

**Note:** Students who opt for DSC-3: Electronics-I in the 3rd Semester shall be required to take DSE-5: Electronics-II in the 4th Semester. Similarly, students who opt for DSC-3: Condensed Matter Physics-I in the 3rd Semester shall be required to take DSE-5: Condensed Matter Physics-II in the 4th Semester.

Semester III (Option -II)

| Course Type | Course Code                      | Nomenclature of course                                       | Theory (T)/ Practical (P) | Credits |    | Contact hours per week |        |        |        | Internal Assessment Marks | End Term Examination Marks | Total Marks | Examination hours |
|-------------|----------------------------------|--------------------------------------------------------------|---------------------------|---------|----|------------------------|--------|--------|--------|---------------------------|----------------------------|-------------|-------------------|
|             |                                  |                                                              |                           | Total   |    | L                      | T      | P      | Total  |                           |                            |             |                   |
| CC-9        | 25PN-PHY-301                     | Electrodynamics                                              | T                         | 4       |    | 4                      | 0      | 0      | 4      | 30                        | 70                         | 100         | 3                 |
| CC-10       | 25PN-PHY-302                     | Atomic & Molecular Physics-I                                 | T                         | 4       |    | 4                      | 0      | 0      | 4      | 30                        | 70                         | 100         | 3                 |
| CC-11       | 25PN-PHY-303                     | General Physics Lab-I                                        | P                         | 4       |    | 0                      | 0      | 8      | 8      | 30                        | 70                         | 100         | 3                 |
| DEC-3       | 25PN-PHY-304CM<br>25PN-PHY-304EC | Condensed Matter Physics-I<br>Electronics-I                  | T<br>T                    | 4<br>4  | 26 | 4<br>4                 | 0<br>0 | 0<br>0 | 4<br>4 | 30<br>30                  | 70<br>70                   | 100<br>100  | 3<br>3            |
| DEC-4       | 25PN-PHY-305RH<br>25PN-PHY-305NM | Radiation & Health Physics<br>Nanoscience and Nanotechnology | T<br>T                    | 4<br>4  |    | 4<br>4                 | 0<br>0 | 0<br>0 | 4<br>4 | 30<br>30                  | 70<br>70                   | 100<br>100  | 3<br>3            |
| PC-3        | 25PN-PHY-306                     | Physics Lab-III                                              | P                         | 4       |    | 0                      | 0      | 8      | 8      | 30                        | 70                         | 100         | 3                 |
| EEC         | 25PN-PHY-EEC-301                 | Electronic Instrumentation                                   | T                         | 2       |    | 0                      | 0      | 4      | 4      | 15                        | 35                         | 50          | 3                 |

*[Handwritten signature]*

Semester IV (Option -II)

|       |                |                                      |     |    |    |   |   |   |   |    |     |     |   |
|-------|----------------|--------------------------------------|-----|----|----|---|---|---|---|----|-----|-----|---|
| DEC-5 | 25PN-PHY-403CM | Condensed Matter Physics-II          | T+P | 4  | 24 | 3 | 0 | 1 | 5 | 30 | 70  | 100 | 3 |
|       | 25PN-PHY-403EC | Electronics-II                       | T+P | 4  |    | 3 | 0 | 1 | 5 | 30 | 70  | 100 | 3 |
| DEC-6 | 25PN-PHY-404CP | Computational Physics                | T+P | 4  |    | 3 | 0 | 1 | 5 | 30 | 70  | 100 | 3 |
|       | 25PN-PHY-404TS | Thin Films coatings and applications | T   | 4  |    | 3 | 0 | 1 | 5 | 30 | 70  | 100 | 3 |
|       | 25PN-PHY-405RS | Dissertation/Project                 | P   | 12 |    |   |   |   |   | 90 | 210 | 300 |   |
| PC-4  | 25PN-PHY-406   | Physics Lab-IV                       | P   | 4  |    | 0 | 0 | 8 | 8 | 30 | 70  | 100 | 3 |

**Note:** Students who opt for DSC-3: Electronics-I in the 3rd Semester shall be required to take DSE-5: Electronics-II in the 4th Semester. Similarly, students who opt for DSC-3: Condensed Matter Physics-I in the 3rd Semester shall be required to take DSE-5: Condensed Matter Physics-II in the 4th Semester.

*[Handwritten signature]*

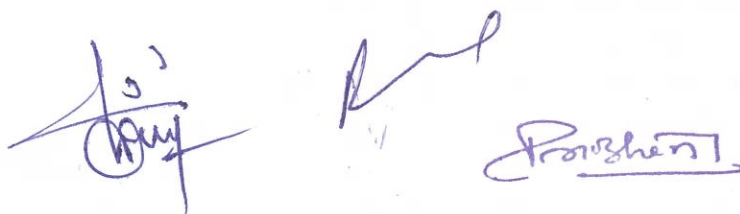


| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A - Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
| Name of Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |               |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1 <sup>st</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Mathematical Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 25PN-PHY-101 /                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |               |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | CC-1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |               |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <p><b>CLO 101.1:</b> Understand basics of group theory, preparation of group multiplication tables and construction of character table of symmetry groups.</p> <p><b>CLO 101.2:</b> Find the Fourier series expansion, Fourier integrals, Fourier and Laplace transforms of functions and derivatives.</p> <p><b>CLO 101.3:</b> Obtain explicit expressions of Hermite, Laguerre, Bessel and Legendre polynomials and to establish their recurrence relations and other properties.</p> <p><b>CLO 101.4:</b> Derive Cauchy integral theorem, Cauchy integral formula, Taylor and Laurent series expansion of functions of complex variable and to evaluate some typical definite integral using the method of contour integration.</p> |           |               |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Practical | Total         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0         | 4             |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0         | 4             |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 0         | 30            |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 0         | 70            |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0         | 100           |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |               |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
| Instructions for Paper-Setter                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
| <ol style="list-style-type: none"> <li>The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration.</li> <li>The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus.</li> <li>The question paper is expected to contain problems to the extent of 20% of total marks.</li> <li>The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.</li> </ol> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           | Contact Hours |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Matrices and Group Theory:</b><br>Matrices: Orthogonal, Unitary and Hermitian matrices, Eigenvalues and eigenvectors of matrices, Matrix diagonalization.<br>Fundamentals of Group theory: Definition of a group and illustrative examples, Group multiplication table, rearrangement theorem, cyclic groups, sub-groups and cosets, permutation groups, conjugate elements and class                                                                                                                                                                                                                                                                                                                                               |           | 15            |

|                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                 |
|---------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
|                                                                                       | structure, normal divisors and factor groups, isomorphism and homomorphism, class multiplication. Group representation: Reducible and irreducible representations, great orthogonality theorem (without proof) and its geometric interpretation.                                                                                                                                                                                                                                                                                                                                                    |                                 |
| II                                                                                    | <b>Differential Equation:</b> Solution of linear differential equation of first and second order with constant coefficients, ordinary point, singular point (Regular and Irregular), series solution around an ordinary point, series solution around a regular singular point by Frobenius method, Solution of Legendre's differential equation, Solution of Bessel's differential equation, Solution of Laguerre and Hermite's differential equations, Fourier transform, Fourier cosine and sine transform, Laplace transform, Properties of Laplace transforms, Inverse Laplace transformation. | 15                              |
| III                                                                                   | <b>Special Functions:</b> Bessel Functions: Bessel functions of the first kind $J_n(x)$ , Generating function, Recurrence relations, Expansion of $J_n(x)$ when $n$ is half an odd integer, Integral representation; Legendre Polynomials $P_n(x)$ : Generating function, Recurrence relations and special properties, Rodrigues' formula, Orthogonality of $P_n(x)$ ; Associated Legendre polynomials, Hermite and Laguerre Polynomials: generating function & recurrence relations only.                                                                                                          | 15                              |
| IV                                                                                    | <b>Functions of a complex variable and calculus of residues:</b> Complex algebra, Functions of a complex variable, Cauchy's integral theorem, Cauchy's integral formula; Taylor and Laurent expansions; Singularities; Cauchy's residue theorem, Cauchy principle value, Singular points and evaluation of residues, Jordan's Lemma; Evaluation of definite integrals of the type: $\int_0^{2\pi} f(\sin \theta, \cos \theta) d\theta$ ; $\int_{-\infty}^{\infty} f(x) dx$ ; $\int_{-\infty}^{\infty} f(x) e^{iax} dx$ using Cauchy's residue theorem.                                              | 15                              |
| <b>Total Contact Hours</b>                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 60                              |
| <b>Suggested Evaluation Methods</b>                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                 |
| <b>Internal Assessment: 30</b>                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>End Term Examination: 70</b> |
| ➤ <b>Theory</b>                                                                       | <b>30</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | ➤ <b>Theory:</b> <b>70</b>      |
| • Class Participation:                                                                | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Written Examination             |
| • Seminar/presentation/assignment/quiz/class test etc.:                               | 10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                 |
| • Mid-Term Exam:                                                                      | 15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                 |
| <b>Part C-Learning Resources</b>                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                 |
| <b>Recommended Books/e-resources/LMS:</b>                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                 |
| 1. Group Theory and Quantum Mechanics by M. Tinkam.                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                 |
| 2. Mathematical Methods for Physicists (4 <sup>th</sup> edition) by G. Arfken.        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                 |
| 3. Mathematical Methods for Physicists (6 <sup>th</sup> edition) by Arfken and Weber. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                 |
| 4. Mathematical Physics for Physicists and Engineers by L. Pipes.                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                 |
| 5. Introduction to Mathematical Physics by C. Harper.                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                 |



| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A - Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
| Name of Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 1 <sup>st</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Classical Mechanics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |               |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 25PN-PHY-102                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |               |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | CC-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |               |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |               |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |               |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <p><b>CLO 102.1:</b> Demonstrate a basic and advanced knowledge of Lagrangian and Hamiltonian Formulations and solve related problems. Identify the cyclic coordinates and understand their importance in Hamiltonian formulation.</p> <p><b>CLO102.2:</b> Acquire knowledge of canonical Transformation and various generating functions for this transformation. Develop a deep understanding to tackle the problems of classical mechanics under small oscillations.</p> <p><b>CLO 102.3:</b> Demonstrate the concept of motion of a particle under central force and apply advanced methods to deal with central force problems. Use Hamilton-Jacobi theory for finding the solutions of various Classical systems.</p> <p><b>CLO 102.4:</b> Understand the foundations of nonlinear dynamics in general and chaotic motion and fractals, in particular. Perform stability analysis of cubic an harmonic oscillator and undamped pendulum, and find chaotic trajectories.</p> |           |               |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Practical | Total         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0         | 4             |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0         | 4             |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0         | 30            |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0         | 70            |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0         | 100           |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |               |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
| <b>Instructions for Paper- Setter:</b> The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           | Contact Hours |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Lagrangian and Hamiltonian formulations: Hamilton's principle,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           | 15            |



|                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                 |
|------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
|                                                                                                            | Derivation of Lagrange's equations from Hamilton's principle, Principle of Least Action and its applications, Canonical Transformation; The Hamiltonian Formalism: Canonical formalism, Hamiltonian equations of motion, The physical significance of the Hamiltonian, Cyclic coordinates, Routhian procedure and equations, Derivation of Generating functions, examples, properties, Derivation of Hamiltonian equations from variational principle.                                                                                                                                                                                        |                                 |
| II                                                                                                         | <b>Poisson bracket and theory of small oscillations:</b> Poisson bracket, special cases of Poisson bracket, Poisson theorem, Poisson bracket and canonical transformation, Jacobi identity and its derivation, Lagrange bracket and its properties, the relationship between Poisson and Lagrange brackets and its derivation, the angular momenta and Poisson bracket, Liouville's theorem and its applications; Theory of small oscillations: Formulation of the problem, Eigenvalue equation and the principle axis transformation, frequencies of free vibrations and normal coordinates, free vibrations of a linear triatomic molecule. | 15                              |
| III                                                                                                        | <b>Two-body central force problem and H-J theory:</b> Two body central force problem: Reduction to the equivalent one body problem, the equation of motion and first integrals, classification of orbits, the Virial theorem, the differential equation for the orbit, integrable power law in time in the Kepler's problem, scattering in central force field; H-J Theory: H-J equation and their solutions, use of H-J method for the solution of harmonic oscillator problem, Hamilton's principle function, Hamilton's characteristic function and their properties.                                                                      | 15                              |
| IV                                                                                                         | <b>Introductory non-linear dynamics:</b> Classical Chaos: Linear and nonlinear systems, periodic motion, Perturbation and KAM theorem, dynamics in phase space, phase portraits for conservative systems, attractors, classification and stability of equilibrium points, stability analysis of cubic an harmonic oscillator and un damped pendulum, chaotic trajectories and Liapunov exponent, Poincare Map, Henon-Hiels Hamiltonian, bifurcation, driven-damped harmonic oscillator, the logistic equation, Fractals and dimensionality.                                                                                                   | 15                              |
| <b>Total Contact Hours</b>                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 60                              |
| <b>Suggested Evaluation Methods</b>                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                 |
| <b>Internal Assessment: 30</b>                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>End Term Examination: 70</b> |
| ➤ Theory                                                                                                   | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | ➤ Theory: 70                    |
| •Class Participation:                                                                                      | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Written Examination             |
| •Seminar/presentation/assignment/quiz/class test etc.:                                                     | 10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                 |
| •Mid-Term Exam:                                                                                            | 15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                 |
| <b>Part C-Learning Resources</b>                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                 |
| <b>Recommended Books/e-resources/LMS:</b>                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                 |
| 1. Classical Mechanics (3 <sup>rd</sup> ed., 2002) by H. Goldstein, C. Poole and J. Safko, Pearson Edition |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                 |
| 2. Classical Mechanics by John R Taylor.                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                 |
| 3. Chaos and Integrability in nonlinear dynamics: An introduction (1989) by Michael Tabor.                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                 |
| 4. Nonlinear dynamics: Integrability, Chaos and patterns (2003) by M. Lakshmanan and S. Rajasekar.         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                 |
| 5. Classical Mechanics, J.C. Upadhyaya, Himalaya Publishing House.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                 |



| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------|
| Part A-Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |         |
| Name of Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | M. Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |         |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 1 <sup>st</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |         |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Quantum Mechanics-I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |         |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 25PN-PHY-103                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |         |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | CC-3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |         |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |         |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |         |
| Course Learning Outcomes (CLOs)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <p><b>CLO 103.1:</b> Realize basic quantum-mechanical view point, learn its wave mechanical &amp; matrix formulations, and solve the Schrödinger equation for simple potentials, including harmonic and central potentials.</p> <p><b>CLO 103.2:</b> Construct matrices for observables and wave functions in different representations, apply matrix theory to linear harmonic oscillator, and describe the time-development of a quantum system in Schrödinger, Heisenberg and Interaction pictures.</p> <p><b>CLO 103.3:</b> Calculate the eigenvalues and eigen functions for the orbital and general angular momenta, learn the matrix representation of angular momentum, and perform addition of two angular momenta.</p> <p><b>CLO 103.4:</b> Grasp the concepts of identity &amp; indistinguishability, understand symmetric and anti-symmetric wave functions, construct spin and total wave functions for a system of two spin <math>\frac{1}{2}</math> particles, and comprehend connection among spin, symmetry &amp; statistics.</p> |           |         |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Practical | Total   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0         | 4       |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0         | 4       |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0         | 30      |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0         | 70      |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0         | 100     |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |         |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |         |
| <b>Instructions for Paper- Setter:</b> The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |         |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           | Contact |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Hours |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| I   | <b>Schrodinger formulation of Quantum Mechanics:</b> Recapitulation of basic concepts: Two-slit experiment with <i>em</i> radiation and matter particles, Quantum-mechanical view point, The Schrödinger wave equation, Expectation values, Ehrenfest theorem; Interpretative postulates of quantum mechanics: Dynamical variables as Hermitian operators, Eigenvalues and eigen functions, Expansion in eigen functions; Illustration of postulates for energy and momentum: Orthogonality of eigen functions, Reality of eigenvalues, Closure property, Probability function and expectation value, Co-ordinate and momentum representations of wave function, Uncertainty principle for two arbitrary observables; Problems: A charged particle in a uniform static magnetic field (eigen functions and Landau levels); The Hydrogen atom (reduced mass, radial wave functions and energy eigenvalues). | 15    |
| II  | <b>Matrix formulation of Quantum Mechanics:</b> Preliminaries: Hermitian and unitary matrices, Transformation and diagonalization of matrices, Matrices of infinite rank; Representation of observables and wave functions as matrices, Transformation theory, choice of basis, change of basis, unitary transformations, Hilbert space representation; Dirac's ket and bra notation; Time-development of quantum system: Schrödinger, Heisenberg and Interaction pictures, Link with classical equations of motion, Quantization of a classical system; Application to motion of a particle in an <i>em</i> field; Matrix theory of the harmonic oscillator: Spectrum of eigenvalues and eigen functions, Matrices for position, momentum and energy operators (energy representation).                                                                                                                   | 15    |
| III | <b>Quantum theory of Angular Momentum:</b> Orbital angular momentum operator <b>L</b> , Cartesian and spherical polar co-ordinate representation, Commutation relations, Orbital angular momentum and spatial rotations, Eigenvalues and eigen functions of $L^2$ and $L_z$ , Spherical harmonics; General angular momentum <b>J</b> : Eigenvalues and eigen functions of $J^2$ and $J_z$ , Matrix representation of angular momentum operators, Spin angular momentum, Wave function including spin (Spinor); Spin one-half: Spin eigen functions, Pauli spin matrices; Addition of two angular momenta, Clebsch-Gordan coefficients and their calculation for $j_1 = j_2 = 1/2$ , $j_1 = 1$ , $j_2 = 1/2$ and $j_1 = j_2 = 1$ ; The Wigner-Eckart theorem.                                                                                                                                               | 15    |
| IV  | <b>Many-particle systems and identical particles:</b> Many-particle Schrödinger wave equation, Stationary-state solutions; Systems of identical particles, Physical meaning of identity, Principle of indistinguishability, Exchange and transposition operators, Totally symmetric and anti-symmetric wave functions, Time-invariance of symmetry, Construction of symmetric and anti-symmetric wave functions, Connection among spin, symmetry and statistics of identical particles, Fermions and bosons; Spin and total wave functions for a system of two spin $1/2$ particles, Pauli exclusion principle and Slater determinant; Application to the electronic system of the helium atom ( <i>para</i> - and <i>ortho</i> -                                                                                                                                                                          | 15    |



|                                                                                         |                                                                                                  |                          |
|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|--------------------------|
|                                                                                         | helium); Limit of distinguishability of identical particles; Basic idea of quantum entanglement. |                          |
| Total Contact Hours                                                                     |                                                                                                  | 60                       |
| Suggested Evaluation Methods                                                            |                                                                                                  |                          |
| Internal Assessment: 30                                                                 |                                                                                                  | End Term Examination: 70 |
| ➤ Theory                                                                                | 30                                                                                               | ➤ Theory: 70             |
| • Class Participation:                                                                  | 5                                                                                                | Written Examination      |
| • Seminar/presentation/assignment/quiz/class test etc.:                                 | 10                                                                                               |                          |
| • Mid-Term Exam:                                                                        | 15                                                                                               |                          |
| Part C-Learning Resources                                                               |                                                                                                  |                          |
| Recommended Books/e-resources/LMS:                                                      |                                                                                                  |                          |
| 1. Quantum Mechanics (3 <sup>rd</sup> edition) by L. I. Schiff                          |                                                                                                  |                          |
| 2. Quantum Mechanics (2 <sup>nd</sup> edition) by B. H. Bransden and Joachain           |                                                                                                  |                          |
| 3. Quantum Mechanics (3 <sup>rd</sup> edition) by S. Gasiorowicz                        |                                                                                                  |                          |
| 4. Quantum Mechanics (3 <sup>rd</sup> edition) by E. Merzbacher                         |                                                                                                  |                          |
| 5. Quantum Mechanics by John L. Powell and B. Crasemann                                 |                                                                                                  |                          |
| 6. Quantum Mechanics by A. K. Ghatak and S. Loknathan                                   |                                                                                                  |                          |
| 7. Introductory Quantum Mechanics (4 <sup>rd</sup> edition) by Richard L. Liboff        |                                                                                                  |                          |
| 8. Quantum Mechanics: Concepts and Applications (2 <sup>nd</sup> edition) by N. Zettili |                                                                                                  |                          |
| 9. Quantum Mechanics by Y. B. Band and Y. Avishai                                       |                                                                                                  |                          |

102  
Chauhan

R

Poozhen

| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A - Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |               |
| Name of Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |               |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 1 <sup>st</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |               |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Electronic Devices and Circuits-I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 25PN-PHY-105E                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |               |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | DEC-1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |               |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |               |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |               |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <p><b>CLO 105.1:</b> Be aware of the general characteristics of important semiconductor materials. Develop a deep understanding of the basic design, operation and characteristics of a pn-junction and a BJT along with knowledge of the basic network theorems and their applications in electronic circuit analysis.</p> <p><b>CLO 105.2:</b> Learn to devise and analyze various transistor amplifier models. Understand the concept of negative feedback and its importance in amplifiers.</p> <p><b>CLO 105.3:</b> Perform a load-line analysis and design of various biasing schemes in amplifiers. Acquaint with the frequency response of variously coupled amplifiers and sources of noise in electronic devices.</p> <p><b>CLO 105.4:</b> Gain knowledge of classification, sources of distortions and their estimation, operation and determination of efficiency of power amplifiers. Clearly understand the need of regulation, operation and circuit analysis of different voltage and current regulators.</p> |           |               |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Practical | Total         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0         | 4             |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0         | 4             |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0         | 30            |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0         | 70            |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0         | 100           |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |               |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |               |
| <p><b>Instructions for Paper- Setter:</b> The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |               |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           | Contact Hours |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Basics of pn-junction, BJT and Network Theorems:</b> Semiconductors: intrinsic and extrinsic semiconductors, charge densities in p and n type semiconductors, conduction by charge drift and diffusion, the pn-junction, energy level diagrams of                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           | 15            |



|                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
|                                                                                         | pn-junction under forward and reverse bias conditions, derivation of pn-diode equation, Zener diode, Zener and avalanche breakdowns, clipping and clamping circuits; The bipolar junction transistor: basic working principle, configurations and characteristics, voltage breakdowns, Network theorems: node, mesh, superposition, Miller's, Thevenin's and Norton's theorems.                                                                                                                                                                                                                              |                                 |
| II                                                                                      | <b>Amplifier Models, Feedback and Biasing:</b> Two port network analysis: active circuit models, gain in decibels, equivalent circuit for BJT, the trans conductance model for BJT, analysis of CE, CB, and CC amplifiers; An amplifier with feedback, effect of negative feedback on gain and its stability, distortions, input and output impedances of amplifiers, Location of quiescent (Q) point, biasing circuits for amplifiers: fixed bias, emitter feedback bias & voltage feedback bias, bias compensation, bias techniques for linear integrated circuits, thermal runaway and thermal stability. | 15                              |
| III                                                                                     | <b>Frequency Response of Amplifiers:</b> The amplifier pass band, mid frequency range response of a direct coupled CE cascade, the high frequency equivalent circuit (Miller effect), the high frequency response of a direct coupled CE cascade, the frequency response of RC and transformer coupled CE amplifiers, gain-frequency plots of amplifier response (Bode plots), bandwidth of cascaded amplifiers, bandwidth criterion for the transistor, the gain-bandwidth product, composite amplifier designs, bootstrapping in amplifiers, noise in amplifiers, noise figure.                            | 15                              |
| IV                                                                                      | <b>Power Amplifiers and Regulators:</b> Power amplifiers: class A large signal amplifier, second and higher order harmonic distortions, the transformer coupled power amplifier, impedance matching, efficiency, push-pull amplifiers, class-B amplifiers, complementary stages, cross over distortions, class-AB operation, heat sinks, derating curve; Electronic voltage regulators: basic operation and analysis of Zener diode voltage regulator, single BJT shunt and series regulators, feedback series BJT regulator and current regulator, overload and short circuit protection circuits.          | 15                              |
| <b>Total Contact Hours</b>                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 60                              |
| <b>Suggested Evaluation Methods</b>                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| <b>Internal Assessment: 30</b>                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>End Term Examination: 70</b> |
| ➤ <b>Theory</b>                                                                         | <b>30</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | ➤ <b>Theory:</b> <b>70</b>      |
| • Class Participation:                                                                  | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Written Examination             |
| • Seminar/presentation/assignment/quiz/class test etc.:                                 | 10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                 |
| • Mid-Term Exam:                                                                        | 15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                 |
| <b>Part C-Learning Resources</b>                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| <b>Recommended Books/e-resources/LMS:</b>                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| 1. Electronic fundamentals and applications (5 <sup>th</sup> Ed.) by J. D. Ryder.       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| 2. Integrated Electronics by J. Millman and C. C. Halkias.                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| 3. Circuits and Networks: Analysis and Synthesis by A.Sudhakar and S.M.S. Palli         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| 4. Electronic devices and circuits by Y. N. Bapat.                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| 5. Pulse, digital and switching waveforms by J. Millman and H. Taub.                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| 6. Millman's Electronic Devices and Circuits by J. Millman, C. C. Halkias&SatyabrataJit |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| 7. Electronic Devices and Circuit Theory by Robert L Boylestadand Louis Nashelsky.      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| 8. Solid state Electronic Devices by B.G. Streetman and S.K. Banerjee.                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |



| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |               |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A-Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |               |
| Name of Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | M. Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |               |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 1 <sup>st</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |               |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Materials Science-I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |               |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 25PN-PHY-105M                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | DEC-I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
| Course Learning Outcomes (CLOs)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <p><b>CLO 105.1:</b> Understand the basic concepts and properties of Materials and describe how and why defects (point, line and planar) in materials greatly affect engineering properties and limit their use in service</p> <p><b>CLO 105.2:</b> Understand strengthening and grasp the importance of various strengthening mechanisms and describe various parameters involved in elastic deformation, plastic deformation, an elastic deformation etc.</p> <p><b>CLO 105.3:</b> Grasp the concept of phase diagrams and be able to predict microstructures and understand transformation mechanisms (nucleation and growth, martensitic) and comprehend Iron-Carbon system and ceramics.</p> <p><b>CLO 105.4:</b> Elucidate the kinematics of elastic collisions and have in depth understanding energetic ion beam based techniques (given in the syllabus) for analysis of materials and perform computations of depth profiles and concentration analysis using these techniques, Choose the most appropriate technique for characterization.</p> |           |               |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Practical | Total         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0         | 4             |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0         | 4             |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 0         | 30            |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 0         | 70            |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0         | 100           |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |               |
| <b>Instructions for Paper- Setter:</b> The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |               |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           | Contact Hours |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>Imperfections in Solids:</b> Point Defects: vacancy, substitutional, interstitial, Frenkel and Schottky defects, equilibrium concentration of Frenkel and Schottky defects; Line Defects: slip planes and slip directions, edge and screw dislocations, Burger's vector, cross-slip, glide and climb, jogs, dislocation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           | 15            |

|                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
|                                                                                                                                                      | energy, super & partial dislocations, dislocation multiplication, Frank Read sources; Planar Defects: grain boundaries and twin interfaces; Dislocation Theory – experimental observation of dislocation, dislocations in FCC, HCP and BCC lattice.                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                 |
| II                                                                                                                                                   | <b>Mechanical Properties:</b> Stress Strain Curve; Elastic Deformation: atomic mechanism of elastic deformation and anisotropy of Young's modulus, elastic deformation of an isotropic material; Anelastic and Viscous deformation; Plastic Deformation: Schmid's law, critically resolved shear stress; Strengthening Mechanisms: work hardening, recovery, recrystallization, strengthening from grain boundaries, low angle grain boundaries. Yield point. Strain aging, solid solution strengthening, two phase aggregates, strengthening from fine particles; Fracture: ideal fracture stress, brittle fracture-Griffith's theory, ductile fracture.                                                      | 15                              |
| III                                                                                                                                                  | <b>Microstructure:</b> Solid Solutions and Intermediate Phases: phase rule, unitary & binary phase diagrams, Lever rule, Hume-Rothery rule; Free Energy and Equilibrium Phase Diagrams: complete solid miscibility, partial solid miscibility-eutectic, peritectic and eutectoid reactions, eutectoid mixture; Nucleation, Growth and Overall Transformation Kinetics; Martensitic Transformation; The Iron-Carbon System: various phases, phase diagram, phase transformations, microstructure and property changes in iron-carbon system; Ceramics: glass transition temperature, glassformers, commercial ceramics, mechanical properties, high temperature properties.                                     | 15                              |
| IV                                                                                                                                                   | <b>Materials Processing and Characterization:</b> Ion Implantation: introduction, ion implantation process, depth profile, radiation damage and annealing effects of trace-impurities, implantation induced alloying and structural phase transformation; Rutherford Backscattering Spectrometry (RBS): principle, kinematics of elastic collision, shape of the backscattering spectrum, depth profiles and concentration analysis, applications; Elastic Recoil Detection Analysis (ERDA): basic principle, kinematics, concentration analysis, depth profiling, depth resolution, applications; Secondary Ion Mass Spectroscopy (SIMS): basic principle, working, yield of secondary ions and applications. | 15                              |
| <b>Total Contact Hours</b>                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 60                              |
| <b>Suggested Evaluation Methods</b>                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                 |
| <b>Internal Assessment: 30</b>                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>End Term Examination: 70</b> |
| ➤ <b>Theory</b>                                                                                                                                      | <b>30</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | ➤ <b>Theory: 70</b>             |
| • Class Participation:                                                                                                                               | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Written Examination             |
| • Seminar/presentation/assignment/quiz/class test etc.:                                                                                              | 10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                 |
| • Mid-Term Exam:                                                                                                                                     | 15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                 |
| <b>Part C-Learning Resources</b>                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                 |
| <b>Recommended Books/e-resources/LMS:</b>                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                 |
| 1. Material Science by J. C. Anderson, K. D. Leaver, J. M. Alexander and R. D. Rawlings                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                 |
| 2. Mechanical Metallurgy by G. E. Dieter                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                 |
| 3. Ion Implantation by G. Dearnally                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                 |
| 4. Fundamentals of Surface and Thin Film Analysis by L. C. Feldman and J. W. Mayer                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                 |
| 5. Surface Analysis Methods in Material Science by D. J. O'Connor, B. A. Sexton and R. St. C. Smart (Eds), Springer Series in Surface Sciences 2023. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                 |



| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A- Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |               |
| Name of the Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |               |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 1 <sup>st</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |               |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | General Electronics-I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |               |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 25PN-PHY-104                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | CC-4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |               |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |               |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <b>CLO 104.1:</b> Draw and understand the frequency response of different Filter circuits and a RC-coupled amplifier in its three configurations. Also measure important parameters of rectifier, filter, voltage regulator and pn-junction circuits.<br><b>CLO 104.2:</b> Design and draw load characteristics of a push-pull amplifier<br><b>CLO 104.3:</b> Design and understand the operations of clipping, clamping circuits, differentiating and integrating circuits.<br><b>CLO 104.4:</b> Measure the sensitivities of X and Y plates of a CRO and determine frequency and phase-difference using a CRO. |           |               |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Practical | Total         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 4         | 4             |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 8         | 8             |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 30        | 30            |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 70        | 70            |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 100       | 100           |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 4 hours   |               |
| Part B – Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |               |
| Practicals                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           | Contact Hours |
| <b>Note: Student will perform at least eight experiments. The examiner will allot one practical at the time of end term examination.</b><br>1. To determine various parameters of a pn-junction diode.<br>2. To study the frequency response of low-pass, high-pass and band-pass filters.<br>3. To study the rectifier circuits and to measure the ripple factors of C, L and $\pi$ -section filters. Also study the stabilization characteristics of a voltage regulator consisting of IC-741.<br>4. To study the load characteristics of a Class-B push-pull amplifier.<br>5. To draw frequency response characteristics of a RC-coupled single stage BJT amplifier in all the three configurations.<br>6. To measure (a) phase difference, (b) deflection sensitivities and (c) frequency of an unknown ac signal using CRO.<br>7. To study the clipping and the clamping circuits.<br>8. To study the differentiating and integrating circuits.<br>9. To simplify a complex circuit into a simpler equivalent circuit consisting of a voltage source in series with a resistance or by Thevenin's circuit.<br>10. To simplify a complex circuit into a single current source in |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           | 120           |



|                                                                                                                        |                                                                                                                                                             |                                                                |
|------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|
|                                                                                                                        | parallel with a resistance or by Norton's circuit.                                                                                                          |                                                                |
| 11.                                                                                                                    | To analyze circuits with multiple independent voltage or current sources by considering the effect of each source individually or by Superposition circuit. |                                                                |
| 12.                                                                                                                    | To study the characteristics of CB and CE Transistor configuration.                                                                                         |                                                                |
| <b>Suggested Evaluation Methods</b>                                                                                    |                                                                                                                                                             |                                                                |
| <b>Internal Assessment: 30</b>                                                                                         |                                                                                                                                                             | <b>End Term Examination: 70</b>                                |
| ➤ Practicum                                                                                                            | 30                                                                                                                                                          | ➤ Practicum 70                                                 |
| • Class Participation:                                                                                                 | 5                                                                                                                                                           | Lab record, Viva-Voce, write-up and execution of the practical |
| • Seminar/Demonstration/Viva-voce/Lab records etc.:                                                                    | 25                                                                                                                                                          |                                                                |
| <b>Part C - Learning Resources</b>                                                                                     |                                                                                                                                                             |                                                                |
| <b>Recommended Books/e-resources/LMS:</b>                                                                              |                                                                                                                                                             |                                                                |
| 1. Integrated Electronics by J. Millman and C. C. Halkias                                                              |                                                                                                                                                             |                                                                |
| 2. Pulse, digital and switching waveforms by J. Millman and H. Taub                                                    |                                                                                                                                                             |                                                                |
| 3. Electronic devices and circuits by Y. N. Bapat                                                                      |                                                                                                                                                             |                                                                |
| 4. Microwave devices and circuits by Samuel Y. Liao                                                                    |                                                                                                                                                             |                                                                |
| 5. Physics of semiconductor Devices by S. M. Sze                                                                       |                                                                                                                                                             |                                                                |
| 6. Electronic instrumentation and measurement techniques by W. D. Cooper and A. D. Helfrick                            |                                                                                                                                                             |                                                                |
| 7. OPAMPs and linear IC circuits by Ramakant A. Gayakwad                                                               |                                                                                                                                                             |                                                                |
| 8. Electronics for Scientists and Engineers: Devices, Circuits and Systems by TV Viswanathan, GK Mehta and V Rajaraman |                                                                                                                                                             |                                                                |

| Session: 2025-26                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |               |
|----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A – Introduction                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |               |
| Name of the Programme                                                                        | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |               |
| Semester                                                                                     | 1 <sup>st</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |               |
| Name of the Course                                                                           | Physics Lab-I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |               |
| Course Code                                                                                  | 25PN-PHY-106                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| Course Type                                                                                  | PC-1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Level of the course                                                                          | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |               |
| Pre-requisite for the course (if any)                                                        | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |               |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to: | <p><b>CLO 106.1:</b> Determine the ionization potential of mercury. Measure the width of a narrow slit using diffraction phenomenon. Calculate the Planck's constant using a suitable light source.</p> <p><b>CLO 106.2:</b> Set Fabry-Parot interferometers for various practical measurements. Verify the energy quantization using the Frank-Hertz Experiment.</p> <p><b>CLO 106.3:</b> Demonstrate different harmonics present in complex signals using Fourier Analysis. Verify the inverse square law of radiation flux.</p> <p><b>CLO 106.4:</b> Measure the band gap of a semiconductor material. Understand the underlying dynamics mimicked by the Chua' and Feigenbaum circuits.</p>                                                                                                                                                                                                                                                                          |           |               |
| Credits                                                                                      | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Practical | Total         |
|                                                                                              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 4         | 4             |
| Teaching Hours per week                                                                      | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 8         | 8             |
| Internal Assessment Marks                                                                    | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 30        | 30            |
| End Term Exam Marks                                                                          | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 70        | 70            |
| Max. Marks                                                                                   | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 100       | 100           |
| Examination Time                                                                             | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 4 hours   |               |
| Part B-Contents of the Course                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |               |
| Practicals                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           | Contact Hours |
|                                                                                              | <p><b>Note: Student will perform at least eight experiments. The examiner will allot one practical at the time of end term examination.</b></p> <ol style="list-style-type: none"><li>1. To determine the ionization potential of mercury.</li><li>2. To measure the width of a narrow slit using the diffraction phenomenon.</li><li>3. To determine the value of Planck's constant using photocell/LED.</li><li>4. Fabry-Parot interferometer experiment.</li><li>5. Demonstration of energy quantization using the Frank-Hertz Experiment.</li><li>6. Fourier analysis of complex signals</li><li>7. To determine band-gap of a semiconductor material.</li><li>8. To verify the inverse square law of radiation flux.</li><li>9. To study nonlinear dynamics using Chua' circuit.</li><li>10. To study nonlinear dynamics using Feigenbaum circuit.</li><li>11. To study B-H curve of a given ferrite sample and find energy loss in case of ferrite Core.</li></ol> |           | 120           |

|                                                                                                   |                                                                                                        |                                                                |
|---------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|
|                                                                                                   | 12. To determine the capacitance of a parallel plate Capacitor using Capacitance and permittivity kit. |                                                                |
|                                                                                                   | 13. To determine the value of $e/m$ i.e. specific charge for an electron by Helical Method.            |                                                                |
|                                                                                                   | 14. To determine the wavelength of an given source using the double-slit experiment                    |                                                                |
| <b>Suggested Evaluation Methods</b>                                                               |                                                                                                        |                                                                |
| <b>Internal Assessment: 30</b>                                                                    |                                                                                                        | <b>End Term Examination: 70</b>                                |
| ➤ <b>Practicum</b>                                                                                | <b>30</b>                                                                                              | ➤ <b>Practicum</b> <b>70</b>                                   |
| • Class Participation:                                                                            | 5                                                                                                      | Lab record, Viva-Voce, write-up and execution of the practical |
| • Seminar/Demonstration/Viva-voce/Lab records etc.:                                               | 25                                                                                                     |                                                                |
| <b>Part C-Learning Resources</b>                                                                  |                                                                                                        |                                                                |
| <b>Recommended Books/e-resources/LMS:</b>                                                         |                                                                                                        |                                                                |
| 1. Integrated Electronics by J. Millman and C. C. Halkias                                         |                                                                                                        |                                                                |
| 2. Nonlinear dynamics: Integrability, Chaos and patterns (2003) by M. Lakshmanan and S. Rajasekar |                                                                                                        |                                                                |
| 3. Introduction to Solid State Physics (7 <sup>th</sup> edition) by Charles Kittel                |                                                                                                        |                                                                |
| 4. Modern Physics by Arthur Beiser                                                                |                                                                                                        |                                                                |
| 5. Elements of Nuclear Physics by W. E. Meyerhof.                                                 |                                                                                                        |                                                                |
| 6. Nuclear Radiation Detectors by S. S. Kapoor and V. S. Ramamurthy.                              |                                                                                                        |                                                                |

*[Handwritten signature]*

*[Handwritten signature]*

*[Handwritten signature]*



| Session: 2025-26                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |       |
|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------|
| Part A – Introduction                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |       |
| Name of Programme                                                                             | M. Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |       |
| Semester                                                                                      | 2 <sup>nd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |       |
| Name of the Course                                                                            | Nuclear and Particle Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |       |
| Course Code                                                                                   | 25PN-PHY-201                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |       |
| Course Type                                                                                   | CC-5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |       |
| Level of the course                                                                           | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |       |
| Pre-requisite for the course (if any)                                                         | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |       |
| Course Learning Outcomes (CLOs)<br>After completing this course, the learner will be able to: | <p><b>CLO 201.1:</b> Understand the energy loss processes of different energetic particles in a medium and mechanisms of interaction of gamma photon with matter and Learn about the basic properties and characteristics of Nuclear forces, and their mediating particle.</p> <p><b>CLO 201.2:</b> Know and learn about various type of detectors used in nuclear physics experiments, unique properties of different detectors and their applications in the field of nuclear physics and Differentiate between different type of nuclear reactions, relevant aspects associated with nuclear reactions and kinematics of such reactions.</p> <p><b>CLO 201.3:</b> Describe certain properties associated with nuclei, models governing different aspects of nuclear behaviour and detailed understanding of deuteron problem and understand the phenomenon of radioactive decays of alpha and beta particles, their detailed formalism.</p> <p><b>CLO 201.4:</b> Know about different elementary particles, their quark content and quark model and Learn about decay of some elementary particles and laws governing such decays.</p> |           |       |
| Credits                                                                                       | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Practical | Total |
|                                                                                               | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0         | 4     |
| Teaching Hours per week                                                                       | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0         | 4     |
| Internal Assessment Marks                                                                     | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 0         | 30    |
| End Term Exam Marks                                                                           | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 0         | 70    |
| Max. Marks                                                                                    | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0         | 100   |
| Examination Time                                                                              | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |       |

### Part B-Contents of the Course

**Instructions for Paper- Setter:** The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

| Unit                                | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Contact Hours |
|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| I                                   | <b>Radiation Interaction and Nuclear Forces:</b> Interaction of Charged Particles with Matter: qualitative description of various energy loss mechanisms, their relative contribution in case of heavy ions and electrons, classical stopping power equation for electronic energy-loss (no derivation) with significance of various terms involved, behavior of electronic energy-loss curve as a function of ion velocity, concept of energy straggling and range straggling and their correlation; Interaction of Gamma Radiation with Matter: features of photoelectric, Compton and pair production processes, Nuclear Forces: experimental evidence of charge symmetry and charge independence of nuclear forces, concept of isospin, Meson theory of nuclear forces, relationship between the range of the force and mass of the mediating particle. | 15            |
| II                                  | <b>Radiation Detectors and Nuclear Reactions:</b> Gamma Ray Spectrometer: basic principle and working of NaI (Tl) scintillation detector, mechanism of pulse formation, basic idea of pulse processing unit, concept of energy resolution and efficiency of detector and its applications; Semiconductor Detectors: basic principle, construction and working and applications of Si surface barrier detector, high purity germanium detector. Nuclear Reactions: types of nuclear reactions, Q-value of a nuclear reaction and its determination, definition of cross section and its significance, elementary idea of compound nuclear reactions and direct reactions. Concept of neutron detection, Coulomb excitation, nuclear kinematics.                                                                                                              | 15            |
| III                                 | <b>Nuclear Properties and Radioactive Decays:</b> Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semi-empirical mass formula, liquid drop model, Deuteron problem; Ground state of deuteron, Magnetic moment and its importance in the determination of exact ground state of deuteron. Radioactive Decays: energetics of alpha decay, tunnel theory of alpha decay, energetics of beta decay, Fermi theory of allowed beta decay, importance of Fermi-Kurie plot, parity non-conserving property of neutrino;                                                                                                                                                                                                                                                                                             | 15            |
| IV                                  | <b>Particle Physics:</b> Units in high energy physics; Classification of particles-fermions and bosons, particles and antiparticles; Strange particles, Basic idea of different fundamental types of interactions with suitable examples; Quark flavors and their quantum numbers, Quarks as constituents of Hadrons, Qualitative idea of Quark confinement and asymptotic freedom, necessity of introducing the Color quantum no., Quark model, decay of pion and muon, Gell-Mann Nishijima formula, conservation laws.                                                                                                                                                                                                                                                                                                                                    | 15            |
| <b>Total Contact Hours</b>          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 60            |
| <b>Suggested Evaluation Methods</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |               |



| Internal Assessment: 30                                                 |    | End Term Examination: 70 |    |
|-------------------------------------------------------------------------|----|--------------------------|----|
| ➤ Theory                                                                | 30 | ➤ Theory:                | 70 |
| • Class Participation:                                                  | 5  | Written Examination      |    |
| • Seminar/presentation/assignment/quiz/class test etc.:                 | 10 |                          |    |
| • Mid-Term Exam:                                                        | 15 |                          |    |
| Part C-Learning Resources                                               |    |                          |    |
| <b>Recommended Books/e-resources/LMS:</b>                               |    |                          |    |
| 1. Introduction to Experimental Nuclear Physics by R. M. Singru.        |    |                          |    |
| 2. Elements of Nuclear Physics by W. E. Meyerhof.                       |    |                          |    |
| 3. Nuclear Radiation Detectors by S. S. Kapoor and V. S. Ramamurthy     |    |                          |    |
| 4. Introduction to High Energy Physics (2nd edition) by D. H. Perkins.  |    |                          |    |
| 5. Radiation Detection and Measurement by G. F. Knoll.                  |    |                          |    |
| 6. Nuclear Physics Theory and Experiment, by R. R. Roy and B. P. Nigam. |    |                          |    |

*[Signature]*

*[Signature]*

*[Signature]*



| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------|
| Part A–Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |       |
| Name of Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | M. Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |       |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 2 <sup>nd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |       |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Solid State Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |       |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 25PN-PHY-202                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |       |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | CC-6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |       |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |       |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |       |
| Course Learning Outcomes (CLOs)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <p><b>CLO 202.1:</b> Analyze the structure of a crystalline solid in terms of lattice, basis and unit cell, and of a non-crystalline solid on the basis of pair-distribution function and deduce the structure of a crystalline solid from the XRD pattern.</p> <p><b>CLO 202.2:</b> Calculate the dispersion of lattice waves for crystals with mono- and diatomic basis, and acquire an understanding of phonon and use it to determine the lattice heat capacity in the Einstein and Debye models.</p> <p><b>CLO 202.3:</b> Learn the Bloch's theorem, solve the KP model &amp; one-electron Schrödinger equation for a periodic potential, classify materials into conductors, semiconductors and insulators, and apply the tight binding &amp; Wigner-Seitz methods for calculation of energy bands.</p> <p><b>CLO 202.4:</b> Grasp main characteristics of superconductors, along with qualitative aspects of the BCS theory, explain flux quantization in a superconducting ring, and the DC&amp; AC Josephson effects.</p> |           |       |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Practical | Total |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0         | 4     |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0         | 4     |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0         | 30    |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0         | 70    |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0         | 100   |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |       |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |       |
| <p><b>Instructions for Paper- Setter:</b> The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |       |

| Unit | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Contact Hours |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| I    | <b>Crystal Structure:</b> Recapitulation of basic concepts: Bravais lattice and Primitive vectors; Primitive, Conventional and Wigner-Seitz unit cells; Crystal structures of Diamond, Cubic $ZnS$ and $NaCl$ ; Packing Fraction, Packing fraction of $sc$ , $bcc$ , $fcc$ , $hcp$ and Diamond structure; Symmetry operations and fundamental types of lattices; Index system for crystal planes. Determination of crystal structure by X-ray diffraction: Reciprocal lattice and Brillouin zones (examples of $sc$ , $bcc$ and $fcc$ lattices); Bragg and Laue formulations of X-ray diffraction by a crystal and their equivalence; Laue equations; Ewald construction; Brillouin interpretation; Crystal and atomic structure factors; Structure factor of the $bcc$ and $fcc$ lattices, Examples of $NaCl$ and diamond; Experimental methods of structure analysis: Types of probe beam.                                                                                                                                                                                           | 15            |
| II   | <b>Lattice dynamics and thermal properties:</b> Cohesive energy in solids; Qualitative idea of Ionic bonds, Covalent bonds, Hydrogen bonds, Intermolecular bonds, Dispersion bonds, dipole-dipole bonds and Metallic binding. Classical theory of lattice vibration (in harmonic approximation): Vibrations of crystals with monatomic basis- Dispersion relation, First Brillouin zone, Group velocity; Two atoms per primitive basis- dispersion of acoustical and optical modes. Quantization of lattice waves: Phonons, Phonon momentum, Inelastic scattering of neutrons by phonons. Thermal properties: Lattice (phonon) heat capacity; Normal modes; Density of states in one and three dimensions; Models of Debye and Einstein, Debye $T^3$ law; Basic idea about point imperfection in crystals.                                                                                                                                                                                                                                                                             | 15            |
| III  | <b>Electronic properties of solids:</b> Sommerfeld's free electron gas model, Density of states, Fermi sphere, Fermi and ground-state energy; Heat capacity of electronic gas, experimental heat capacity of metals, Thermal Effective Mass, Electrical Conductivity and Ohm's law, Motion in a Magnetic field and Hall effect, Difficulties with the free electron gas model; Band theory of solids; Periodic potential and Bloch's theorem; Kronig-Penney model; Wave equation of electron in a periodic potential, Effective Mass in Crystal and its Physical Significance, Central equation, Crystal momentum of electron, Solution of the central equation, Approximate solution at and near a zone boundary; Periodic, extended and reduced zone schemes of energy band representation; Number of orbital's in a band; Classification into metals, semiconductors and insulators. Calculation of energy bands: Tight binding method and its application to $sc$ , $bcc$ and $bcc$ structures; Wigner-Seitz method, Cohesive energy; Pseudo-potential methods (qualitative idea). | 15            |
| IV   | <b>Superconductivity:</b> Experimental survey: Superconductivity and its occurrence, Destruction of superconductivity by magnetic fields, Meissner effect, Type I and type II superconductors, Entropy, Free energy, Heat capacity, Energy gap, Microwave and infrared properties, Isotope effect; Theoretical survey: Thermodynamics of the superconducting transition, London equation, London penetration depth, Coherence length; Microscopic theory: Qualitative features of the BCS theory, BCS ground state wave function; Quantitative predictions of the BCS theory, critical temperature, energy gap, critical field,                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 15            |



|                                                                                                                                                                                                                                 |    |                     |                          |    |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|---------------------|--------------------------|----|
| specific heat; Flux quantization in a superconducting ring, duration of persistent currents; Dc and Ac Josephson effects; Macroscopic long-range quantum interference; High T <sub>c</sub> superconductors (introduction only). |    | Total Contact Hours |                          | 60 |
| Suggested Evaluation Methods                                                                                                                                                                                                    |    |                     |                          |    |
| Internal Assessment: 30                                                                                                                                                                                                         |    |                     | End Term Examination: 70 |    |
| ➤ Theory                                                                                                                                                                                                                        | 30 | ➤ Theory:           | 70                       |    |
| • Class Participation:                                                                                                                                                                                                          | 5  | Written Examination |                          |    |
| • Seminar/presentation/assignment/quiz/class test etc.:                                                                                                                                                                         | 10 |                     |                          |    |
| • Mid-Term Exam:                                                                                                                                                                                                                | 15 |                     |                          |    |
| Part C-Learning Resources                                                                                                                                                                                                       |    |                     |                          |    |
| Recommended Books/e-resources/LMS:                                                                                                                                                                                              |    |                     |                          |    |
| 1. Introduction to Solid State Physics (7 <sup>th</sup> edition) by Charles Kittel                                                                                                                                              |    |                     |                          |    |
| 2. Solid State Physics by Neil W. Ashcroft and N. David Mermin                                                                                                                                                                  |    |                     |                          |    |
| 3. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth                                                                                                                                        |    |                     |                          |    |
| 4. Principles of the Theory of Solids (2 <sup>nd</sup> edition) by J. M. Ziman                                                                                                                                                  |    |                     |                          |    |
| 5. Condensed Matter Physics by Michael P. Marder                                                                                                                                                                                |    |                     |                          |    |
| 6. Applied Solid State Physics by Rajnikant                                                                                                                                                                                     |    |                     |                          |    |



| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A - Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
| Name of Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | M. Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |               |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 2 <sup>nd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Quantum Mechanics-II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |               |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 25PN-PHY-203                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |               |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | CC-7                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |               |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |               |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |               |
| Course Learning Outcomes (CLOs)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <p><b>CLO 203.1:</b> Formulate perturbation, variational &amp; WKB methods for obtaining approximate solutions of the Schrödinger equation, and comprehend simple physical effects: Zeeman &amp; Stark effects &amp; alpha decay.</p> <p><b>CLO 203.2:</b> Apply the time-dependent perturbation theory to deal with atom-em radiation interaction and calculate explicitly the transition probability for induced absorption and emission.</p> <p><b>CLO 203.3:</b> Explicate electronic structure of many-electron atoms in central-field approximation, estimate the central potential using the Thomas-Fermi &amp; Hartree methods, and have an understanding of molecular energy levels.</p> <p><b>CLO 203.4:</b> Grasp the basics of quantum scattering theory, learn the partial waves and Green's function methods for deriving scattering cross-sections, and calculate these for finite square well, hard sphere &amp; screened Coulomb potentials.</p> |           |               |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Practical | Total         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0         | 4             |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0         | 4             |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0         | 30            |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 0         | 70            |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0         | 100           |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |               |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
| <b>Instructions for Paper- Setter:</b> The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           | Contact Hours |

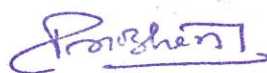
|                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |    |
|-------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| I                                   | <b>Approximate methods for bound states-I:</b> Stationary perturbation theory: Non-degenerate case- First-order and second-order corrections to energy eigenvalues and eigenfunction, Perturbation of an oscillator (harmonic and anharmonic ( $ax^3 + bx^4$ ) perturbations), Ground state of Helium atom; Degenerate case- Removal of degeneracy in first and second order, Zeeman effect without electron spin, First-order Stark effect in $n=2$ state of Hydrogen, Fine structure of hydrogen atom (Relativistic and spin-orbit coupling corrections); Rayleigh-Ritz variational method: Ground and excited states, Application to ground state of Helium, Van der Waals interaction using perturbation and variational methods.                                                                                  | 15 |
| II                                  | <b>Approximate methods for bound states-II:</b> The WKB approximation: Classical limit, Approximate solutions, Asymptotic nature of the solutions, Solution near a turning point, Linear turning point, Connection at the turning point, Asymptotic connection formulae, Application to energy levels of a quantum well, tunneling through a potential barrier and alpha decay; First-order time-dependent perturbation theory, Transition probability for constant and harmonic perturbations, Transition to a group of final states- The Fermi golden rule, Applications: Ionization of a hydrogen atom, Ionization probability, Interaction of an atom with <i>em</i> radiation (semi-classical treatment), Transition probability for induced absorption and emission, perturbation theory in scattering problems. | 15 |
| III                                 | <b>Selected applications of Quantum Mechanics:</b> Atomic structure of many-electron atoms: Central-field approximation, Periodic system of elements, Thomas-Fermi statistical model, Evaluation of the potential, Hartree's self-consistent fields and connection with the variational method, Corrections to the central-field approximation, L-S and j-j couplings; Molecular structure: Classification of energy levels, Wave equation; The Hydrogen molecule: Potential energy function, The Morse potential, Rotation and vibration of diatomic molecules, Energy levels.                                                                                                                                                                                                                                        | 15 |
| IV                                  | <b>Quantum theory of scattering:</b> Scattering experiments and cross-sections, The laboratory and center-of-mass systems, Scattering amplitude and cross-section; The method of partial waves: Phase shift, Differential and total cross-sections, Relation between phase shift and scattering potential, Convergence of the partial-wave series, Scattering by a finite square well, Resonances- Breit-Wigner formula, Scattering by a hard-sphere potential; Green's function method: Lippmann-Schwinger equation, The Born series, The first Born approximation, Scattering of an electron by a screened Coulomb potential in Born approximation and validity criterion; Scattering of two identical spinless bosons, and spin-1/2 fermions.                                                                       | 15 |
| <b>Total Contact Hours</b>          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 60 |
| <b>Suggested Evaluation Methods</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |    |



| Internal Assessment: 30                                                                 |    | End Term Examination: 70 |    |
|-----------------------------------------------------------------------------------------|----|--------------------------|----|
| ➤ Theory                                                                                | 30 | ➤ Theory:                | 70 |
| • Class Participation:                                                                  | 5  | Written Examination      |    |
| • Seminar/presentation/assignment/quiz/class test etc.:                                 | 10 |                          |    |
| • Mid-Term Exam:                                                                        | 15 |                          |    |
| Part C-Learning Resources                                                               |    |                          |    |
| <b>Recommended Books/e-resources/LMS:</b>                                               |    |                          |    |
| 1. Quantum Mechanics (3 <sup>rd</sup> edition) by L. I. Schiff                          |    |                          |    |
| 2. Quantum Mechanics (2 <sup>nd</sup> edition) by B. H. Bransden and Joachain           |    |                          |    |
| 3. Introduction to Quantum Mechanics (2 <sup>nd</sup> edition) by David J. Griffiths    |    |                          |    |
| 4. Quantum Mechanics by A. K. Ghatak and S. Loknathan                                   |    |                          |    |
| 5. A Textbook of Quantum Mechanics by P. M. Mathews and K. Venkatesan                   |    |                          |    |
| 6. Quantum Mechanics by John L. Powell and B. Crasemann                                 |    |                          |    |
| 7. Quantum Mechanics: Concepts and Applications (2 <sup>nd</sup> edition) by N. Zettili |    |                          |    |









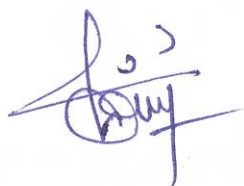
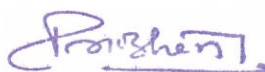
| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------|
| Part A - Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |       |
| Name of Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |       |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 2 <sup>nd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |       |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Electronic Devices and Circuits-II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |       |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 25PN-PHY-205E                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |       |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | DEC-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |       |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |       |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |       |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                    | <p><b>CLO 205E.1:</b> Well acquainted with the basic structures, operations, characteristics and biasing schemes of various field effect transistors. Understand the operations of different multivibrator circuits.</p> <p><b>CLO 205E.2:</b> Develop a clear understanding of the basics of OPAMPS, its operating modes, internal structure and its vital design parameters. Become familiar with the basic structure, operation, characteristics and important applications of negative resistance devices.</p> <p><b>CLO 205E.3:</b> Design and describe the operations of various families of logic gates. Simplify involved Boolean expressions with the help of Boolean algebra and K-map.</p> <p><b>CLO 205E.4:</b> Explain the construction, operation, characteristics and important technological applications of various photonic devices. Explain the construction, operation, characteristics and important technological applications of different temperature sensitive devices.</p> |           |       |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Practical | Total |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0         | 4     |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0         | 4     |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0         | 30    |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0         | 70    |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0         | 100   |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |       |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |       |
| <p><b>Instructions for Paper- Setter:</b> The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |       |

question. All questions will carry equal marks.

| Unit                                | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Contact Hours |
|-------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| I                                   | <b>Field Effect Transistors and Multivibrators:</b> Basic structure and operation of JFET, calculation of pinch off voltage, V-I characteristics of JFET, the FET small signal model, metal oxide semiconductor field effect transistor (MOSFET), physical structure, operation and characteristics, enhancement and depleted modes of operation, metal semiconductor field effect transistor (MESFET), low frequency common source and common drain FET amplifiers, FET biasing, FET as a voltage variable resistor (VVR); Multivibrators: a fixed biased transistor, a self-biased transistor and a direct connected bistable multivibrator circuits, Schmitt trigger circuit, triggering techniques for bistable multivibrators, collector-coupled and emitter-coupled monostable and astable multivibrators. | 15            |
| II                                  | <b>OPAMPs and Negative Resistance Devices:</b> The basic OPAMP, inverting and non-inverting mode of operation of OPAMP, effect of negative feedback on input and output resistances of OPAMPs, the differential amplifier, common mode rejection ratio (CMRR), the emitter coupled differential amplifier, the transfer characteristics of a differential amplifier, an IC OPAMP (MC-1530 Motorola) and its dc analysis, offset voltages and currents, universal balancing techniques, measurement of OPAMP parameters; basic working principles, characteristics and applications of uni-junction transistor (UJT), four layer diode (pnpn-diode), tunnel diode and silicon controlled rectifier.                                                                                                               | 15            |
| III                                 | <b>Digital Circuits:</b> Digital (binary) operation of a system, logic systems, the OR gate, the AND gate, the NOT gate, the exclusive OR gate, De Morgan's laws, Boolean algebra, the NAND and NOR diode-transistor gates, Modified DTL gates, fan-in and fan-out, wired logics, high threshold logic (HTL) gates, transistor-transistor logic (TTL) gates, output stages for TTL gates, resistance-transistor logic (RTL) gates, direct coupled transistor logic (DCTL) gates, emitter coupled logic (ECL) gates, digital MOSFET circuits, complementary MOS (CMOS) logic gates, comparison of logic families, Karnaugh-map (K-map) up to four variable and its applications.                                                                                                                                  | 15            |
| IV                                  | <b>Optoelectronic and Temperature Sensing Devices:</b> Radiative and nonradiative transitions, basic construction, operation, characteristics and applications of solar cells, light dependent resistance (LDR), photodiodes, p-i-n diodes, metal semiconductor photodiodes, avalanche photodiodes, light emitting diodes (LEDs), semiconductor diode lasers, photo transistors, resistance thermometers, thermocouples and thermistors.                                                                                                                                                                                                                                                                                                                                                                         | 15            |
| <b>Total Contact Hours</b>          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 60            |
| <b>Suggested Evaluation Methods</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |               |



| Internal Assessment: 30                                                                                                |    | End Term Examination: 70 |    |
|------------------------------------------------------------------------------------------------------------------------|----|--------------------------|----|
| ➤ Theory                                                                                                               | 30 | ➤ Theory:                | 70 |
| • Class Participation:                                                                                                 | 5  | Written Examination      |    |
| • Seminar/presentation/assignment/quiz/class test etc.:                                                                | 10 |                          |    |
| • Mid-Term Exam:                                                                                                       | 15 |                          |    |
| Part C-Learning Resources                                                                                              |    |                          |    |
| <b>Recommended Books/e-resources/LMS:</b>                                                                              |    |                          |    |
| 1. Integrated Electronics by J. Millman and C. C. Halkias                                                              |    |                          |    |
| 2. Pulse, digital and switching waveforms by J. Millman and H. Taub                                                    |    |                          |    |
| 3. Electronic devices and circuits by Y. N. Bapat                                                                      |    |                          |    |
| 4. Microwave devices and circuits by Samuel Y. Liao                                                                    |    |                          |    |
| 5. Physics of semiconductor Devices by S. M. Sze                                                                       |    |                          |    |
| 6. Electronic instrumentation and measurement techniques by W. D. Cooper and A. D. Helfrick                            |    |                          |    |
| 7. OPAMPs and linear IC circuits by Ramakant A. Gayakwad                                                               |    |                          |    |
| 8. Electronics for Scientists and Engineers: Devices, Circuits and Systems by TV Viswanathan, GK Mehta and V Rajaraman |    |                          |    |




| Session: 2025-26                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------|
| Part A–Introduction                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |       |
| Name of Programme                                                                                                                                                                                          | M. Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |       |
| Semester                                                                                                                                                                                                   | 2 <sup>nd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |       |
| Name of the Course                                                                                                                                                                                         | Materials Science-II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |       |
| Course Code                                                                                                                                                                                                | 25PPN-PHY-205M                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |       |
| Course Type                                                                                                                                                                                                | DEC-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |       |
| Level of the course                                                                                                                                                                                        | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |       |
| Pre-requisite for the course (if any)                                                                                                                                                                      | ---                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |       |
| Course Learning Outcomes (CLOs)<br>After completing this course, the learner will to:                                                                                                                      | <p><b>CLO 205M.1:</b> Comprehend various tests (Tension test, hardness tests, Impact test, fatigue test, creep test) used for measuring the mechanical properties of materials and Realize the difference between strength and hardness of materials. Compute various strength and ductility measures from engineering stress-strain curve and true stress-strain curves.</p> <p><b>CLO 205M.2:</b> Understand magnetic processes, Diamagnetism, Paramagnetism, density of states curves for a metal; and Grasp the concepts of Ferromagnetism, exchange interactions, domain structure; Antiferromagnetism, Ferrimagnetism and Ferrites</p> <p><b>CLO 205M.3:</b> Elucidate the physics describing dielectrics and ferroelectric materials, with focus on the functionality and Describe the optical properties of insulators</p> <p><b>CLO 205M.4:</b> Understanding of the surface and concepts of salvage depth and Grasp the concept, working and applications of different electron and photon based surface analysis techniques.</p> |           |       |
| Credits                                                                                                                                                                                                    | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Practical | Total |
|                                                                                                                                                                                                            | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0         | 4     |
| Teaching Hours per week                                                                                                                                                                                    | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0         | 4     |
| Internal Assessment Marks                                                                                                                                                                                  | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0         | 30    |
| End Term Exam Marks                                                                                                                                                                                        | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0         | 70    |
| Max. Marks                                                                                                                                                                                                 | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0         | 100   |
| Examination Time                                                                                                                                                                                           | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |       |
| Part B-Contents of the Course                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |       |
| <b>Instructions for Paper- Setter:</b> The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |       |

compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

| Unit                       | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Contact Hours |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| I                          | <b>Material Testing:</b> The Tension Test: engineering stress-strain curve, true stress-strain curve, instability in tension, Considere's construction, ductility measurement, effect of strain rate on flow properties, strain rate sensitivity; notch tensile test; The Hardness Test: Brinell hardness, Meyer hardness, Vicker's hardness number and test, Rockwell hardness test, Knoop hardness number and test; The Impact Test: brittle fracture problem, notched bar impact tests-Carpy and Izod Impact tests; The Fatigue Test: fatigue failures, stress cycles, the S-N curve, fatigue limit; The Creep Test: creep curve, primary, secondary and tertiary creep, effect of temperature and stress on the creep curve.                                            | 15            |
| II                         | <b>Magnetic Materials:</b> Magnetic Processes: Larmor frequency; Diamagnetism, magnetic susceptibility, Langevin's diamagnetism equation; Paramagnetism, Curie constant, density of states curves for a metal; Ferromagnetism, Curie temperature, Curie-Weiss law, exchange interactions, domain structure; Antiferromagnetism and magnetic susceptibility of an antiferromagnetic material; Ferrimagnetism and Ferrites; Paramagnetic, ferromagnetic and cyclotron-resonance.                                                                                                                                                                                                                                                                                              | 15            |
| III                        | <b>Dielectric, Optical and Ferroelectric Materials:</b> Introduction, Energy bands, dielectric constant, complex permittivity, dielectric loss factor, polarization, mechanism of polarization, classification of dielectrics-frequency dependence of dielectric constant; Optical Phenomena in Insulators Colour of crystals - Excitons - weakly bound and tightly bound excitons. Colour centers - F-centers and other electronic centers in alkali halides. Ferroelectrics: General characteristics - piezoelectric, pyroelectric and ferroelectric materials. Classification of ferroelectrics and representative materials. Ferroelectric domains. Polarization catastrophe, Landau theory of first and second-order phase transitions, anti ferroelectric materials . | 15            |
| IV                         | <b>Solid Surfaces and Analysis:</b> Surface and its importance, selvedge depths of surface; Methods of Surface Analysis: Auger Electron spectroscopy (AES)- basic principle, methodology, composition analysis and depth profiling; X-ray photoelectron spectroscopy (XPS) or ESCA: principle, methodology and quantitative analysis; Glancing angle X-ray Diffraction (GXR), basic concept, methodology and structural analysis; Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM): Principle, methodology and Applications in surface analysis; Atomic Force Microscopy (AFM): Basic principle, Methodology, applications in structural analysis.                                                                                             | 15            |
| <b>Total Contact Hours</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 60            |



| Suggested Evaluation Methods                                                                                                                  |    |                          |    |
|-----------------------------------------------------------------------------------------------------------------------------------------------|----|--------------------------|----|
| Internal Assessment: 30                                                                                                                       |    | End Term Examination: 70 |    |
| ➤ Theory                                                                                                                                      | 30 | ➤ Theory:                | 70 |
| • Class Participation:                                                                                                                        | 5  | Written Examination      |    |
| • Seminar/presentation/assignment/quiz/class test etc.:                                                                                       | 10 |                          |    |
| • Mid-Term Exam:                                                                                                                              | 15 |                          |    |
| Part C-Learning Resources                                                                                                                     |    |                          |    |
| Recommended Books/e-resources/LMS:                                                                                                            |    |                          |    |
| 1. Material Science, J.C. Anderson, K.D. Leaver, J. M. Alexander and R. D. Rawlings                                                           |    |                          |    |
| 2. Mechanical Metallurgy, G.E. Dieter.                                                                                                        |    |                          |    |
| 3. Electronic Processes in Materials, L. V. Azaroff and J. J. Brophy                                                                          |    |                          |    |
| 4. Fundamentals of Surface and Thin Film Analysis, L.C. Feldman and J. W. Mayer                                                               |    |                          |    |
| 5. Surface Analysis Methods in Material Science, D. J. O'Connor, B. A. Sexton and R. St. CSmart (Eds), Springer Series in Surface Sciences 23 |    |                          |    |
| 6. Solid State Physics – A J Dekker (McMillan, 1971)                                                                                          |    |                          |    |
| 7. Materials Science and Engineering by William D. Callister                                                                                  |    |                          |    |

*Asif*

*P*

*Parshant*



| Session: 2025-26                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A - Introduction                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| Name of the Programme                                                                        | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |               |
| Semester                                                                                     | 2 <sup>nd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| Name of the Course                                                                           | General Electronics-II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |               |
| Course Code                                                                                  | 25PN-PHY-204 /                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |               |
| Course Type                                                                                  | CC-8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
| Level of the course                                                                          | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Pre-requisite for the course (if any)                                                        | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |               |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to: | <b>CLO 204.1:</b> Draw V-I characteristics of an UJT and also able to design and able to determine the frequency of saw-tooth waves using UJT.<br><b>CLO 204.2:</b> Design and draw load characteristics of a push-pull amplifier and design and verify truth tables of the basic logic gates.<br><b>CLO 204.3:</b> Design and understand the operations of astable multivibrator. Also draw the characteristics of various opto-electronic devices.<br><b>CLO 204.4:</b> Explain the FET as VVR, the V-I characteristics of an emitter coupled differential amplifier, pn pn-diode and thermistor.                                                                                                         |           |               |
| Credits                                                                                      | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Practical | Total         |
|                                                                                              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 4         | 4             |
| Teaching Hours per week                                                                      | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 8         | 8             |
| Internal Assessment Marks                                                                    | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 30        | 30            |
| End Term Exam Marks                                                                          | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 70        | 70            |
| Max. Marks                                                                                   | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 100       | 100           |
| Examination Time                                                                             | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 4 hours   |               |
| Part B-Contents of the Course                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| Practicals                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           | Contact Hours |
|                                                                                              | <b>Note: Student will perform at least six experiments. The examiner will allot one practical at the time of end term examination.</b><br>1. To draw the V-I characteristics of a Uni-Junction Transistor.<br>2. To generate saw-tooth waves using UJT and find its frequency.<br>3. To design circuits for OR, AND, NOT, NAND and NOR logic gates and verify their truth tables.<br>4. To study the astable multivibrator.<br>5. To draw characteristics of opto-electronic devices.<br>6. To study a FET as voltage variable resistance (VVR).<br>7. To draw transfer characteristics of an emitter-coupled BJT differential amplifier.<br>8. To draw characteristics of a negative resistance thermistor |           | 120           |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |                                                                |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|----------------------------------------------------------------|
| 9. To draw the V-I characteristics of a pnpn-diode.<br>10. To generate square waves using a Schmitt's trigger circuit.<br>11. Designing of an integrator using operational amplifier for a given specification & study of its frequency response.<br>12. Designing of a differentiator using operational amplifier for a given specification & study its frequency response.<br>13. Designing a first order Low-pass filter by using operational amplifier.<br>14. Designing a first order High-pass filter using operational amplifier.                                              |           |                                                                |
| <b>Suggested Evaluation Methods</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |                                                                |
| <b>Internal Assessment: 30</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           | <b>End Term Examination: 70</b>                                |
| ➤ <b>Practicum</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>30</b> | ➤ <b>Practicum</b> <b>70</b>                                   |
| • Class Participation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 5         | Lab record, Viva-Voce, write-up and execution of the practical |
| • Seminar/Demonstration/Viva-voce/Lab records etc.:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 25        |                                                                |
| <b>Part C-Learning Resources</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |                                                                |
| <b>Recommended Books/e-resources/LMS:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |                                                                |
| 1. Integrated Electronics by J. Millman and C. C. Halkias<br>2. Pulse, digital and switching waveforms by J. Millman and H. Taub<br>3. Electronic devices and circuits by Y. N. Bapat<br>4. Microwave devices and circuits by Samuel Y. Liao<br>5. Physics of semiconductor Devices by S. M. Sze<br>6. Electronic instrumentation and measurement techniques by W. D. Cooper and A. D. Helfrick<br>7. OPAMPs and linear IC circuits by Ramakant A. Gayakwad<br>8. Electronics for Scientists and Engineers: Devices, Circuits and Systems by TV Viswanathan, GK Mehta and V Rajaraman |           |                                                                |

| Session: 2025-26                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |               |
|----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A - Introduction                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |               |
| Name of the Programme                                                                        | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| Semester                                                                                     | 2 <sup>nd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |               |
| Name of the Course                                                                           | Physics Lab-II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |               |
| Course Code                                                                                  | 25PN-PHY-206                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |               |
| Course Type                                                                                  | PC-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |               |
| Level of the course                                                                          | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
| Pre-requisite for the course (if any)                                                        | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to: | <p><b>CLO 206.1:</b> Calculate the Planck's constant using a suitable light source and half life of Indium.</p> <p><b>CLO 206.2:</b> Measure the mass absorption coefficient of <math>\beta</math>-rays in Aluminum and the band gap of a semiconductor. Set Michelson interferometer for various practical measurements</p> <p><b>CLO 206.3:</b> Determine the strength of <math>\alpha</math>-source and verify nuclear statistics using SSNTD.</p> <p><b>CLO 206.4:</b> Determine the specific heat of a given solid specimen and the thermoelectric voltage as a function of the temperature differential. Study of Dia-, para- and ferromagnetic materials in an inhomogeneous magnetic field.</p>                                                   |           |               |
| Credits                                                                                      | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Practical | Total         |
|                                                                                              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4         | 4             |
| Teaching Hours per week                                                                      | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 8         | 8             |
| Internal Assessment Marks                                                                    | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 30        | 30            |
| End Term Exam Marks                                                                          | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 70        | 70            |
| Max. Marks                                                                                   | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 100       | 100           |
| Examination Time                                                                             | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4 hours   |               |
| Part B-Contents of the Course                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |               |
| Practicals                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           | Contact Hours |
|                                                                                              | <p><b>Note: Student will perform at least six experiments. The examiner will allot one practical at the time of end term examination.</b></p> <ol style="list-style-type: none"><li>1. To study absorption of <math>\beta</math>-rays in Aluminum.</li><li>2. Michelson interferometer experiment.</li><li>3. To determine the half-life of Indium.</li><li>4. To determine the strength of an <math>\alpha</math>-source using SSNTD.</li><li>5. To study nuclear statistics using SSNTD.</li><li>6. To determine band-gap of a semiconductor material.</li><li>7. To determine the specific heat of a given solid specimen.</li><li>8. See back effect: Determining the thermoelectric voltage as a function of the temperature differential.</li></ol> |           | 120           |



|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <p>9. Study Dia-, para- and ferromagnetic materials in an inhomogeneous magnetic field.</p> <p>10. To find the velocity and compressibility of solid/ liquid sample using Ultrasonic Interferometer</p> <p>11. Lattice dynamic kit</p> <p>a) Study of the Dispersion relation for the “Monoatomic Lattice” and Comparison with theory.</p> <p>b) Determination of the Cut-off frequency of the Monoatomic Lattice.</p> <p>c) Study of the Dispersion relation for the Di-atomic Lattice, Acoustical mode and Energy gap and Comparison with theory.</p> <p>12. . To determine the Dielectric constant of polar and non-polar liquids</p> |                                                                |
| <b>Suggested Evaluation Methods</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                |
| <b>Internal Assessment: 30</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>End Term Examination: 70</b>                                |
| ➤ <b>Practicum</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>30</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | ➤ <b>Practicum</b> <b>70</b>                                   |
| • Class Participation:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Lab record, Viva-Voce, write-up and execution of the practical |
| • Seminar/Demonstration/Viva-voce/Lab records etc.:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 25                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                |
| <b>Part C-Learning Resources</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                |
| <b>Recommended Books/e-resources/LMS:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                |
| <ol style="list-style-type: none"> <li>1. Introduction to Experimental Nuclear Physics by R. M. Singru.</li> <li>2. Elements of Nuclear Physics by W. E. Meyerhof.</li> <li>3. Nuclear Radiation Detectors by S. S. Kapoor and V. S. Ramamurthy</li> <li>4. Introduction to High Energy Physics (2nd edition) by D. H. Perkins.</li> <li>5. Radiation Detection and Measurement by G. F. Knoll.</li> <li>6. Nuclear Physics Theory and Experiment, by R. R. Roy and B. P. Nigam.</li> <li>7. Introduction to Solid State Physics (7<sup>th</sup> edition) by Charles Kittel</li> <li>8. Solid State Physics by Neil W. Ashcroft and N. David Mermin.</li> </ol> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                |

| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A - Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
| Name of the Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Common to all PG Programmes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |               |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2 <sup>nd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | India's contribution to Science                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 25PN-PHY-IKS201                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | IKS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |               |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 200-299                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |               |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | ---                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |               |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                | <p><b>CLO IKS201.1:</b> Understand the development of astronomy in the Indus, Vedic, and Post-Vedic periods.</p> <p><b>CLO IKS201.2:</b> Explain the Indian Yuga system, Moon star and planet movements, and Indian systems.</p> <p><b>CLO IKS201.3:</b> Identify traditional Indian astronomical instruments and their functions.</p> <p><b>CLO IKS201.4:</b> Analyze the contribution of observatories to astronomy.</p> <p><b>CLO IKS201.5:</b> Appreciate the lives and works of Indian scientists and their scientific impact</p> <p><b>CLO IKS201.6:</b> Evaluate the role of Indian scientific ins like CSIR, ISRO, and DAE in development.</p> |           |               |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Practical | Total         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0         | 2             |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0         | 2             |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 0         | 15            |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 35                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 0         | 35            |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 50                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 0         | 50            |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |               |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
| <b>Instructions for Paper- Setter:</b> The examiner will set 5 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist 7 parts covering entire syllabus (7x1 = 07 Marks). The examinee will be required to attempt 3 questions, selecting one question from each unit and the compulsory question. All questions (except compulsory question) will carry equal marks. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           | Contact Hours |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Astronomy: Astronomy in Indus and Vedic period, Post Vedic<br>Astronomy: Planetary Kinematics, the early traditions of siddhanta,<br>Brief Idea of Yuga system of India and phases of Moon, rising and<br>setting of stars & Planets Indian Calendar : Pancanga, nakstra, festival<br>dates in the Indian calendar                                                                                                                                                                                                                                                                                                                                     |           | 15            |

|                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                 |
|---------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| II                                                                                                            | Astronomical Instruments: Samrat Yantra, Disha Yantra, Cakra Yantra, Jai Prakash Yantra, Phalaka-Yantra, Kapala-Yantra, Nalaka-Yantra, Dhanuryantra, Chatra-Yantra, Gola-Yantra, Karttari-Yantra, Pitha-Yantra And Chatra-Yantra, Development of Astronomical Laboratories: Delhi Observatory and Jaipur Observatory<br>Life and work of Indian Scientists: Sir Jagadish Chandra Bose, P.C. Ray, Srinivasa Ramanujan, Sir C.V. Raman, Meghnad Saha, Satyendra Nath Bose, S.S. Bhatnagar, Homi Jehangir Bhabha and Vikram Sarabhai Role and development of CSIR, ISRO and DAE. | 15                              |
| <b>Note: Scope of the syllabus shall be restricted to generic and introductory level of mentioned topics.</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                 |
| <b>Total Contact Hours</b>                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 30                              |
| <b>Suggested Evaluation Methods</b>                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                 |
| <b>Internal Assessment: 15</b>                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>End Term Examination: 35</b> |
| ➤ Theory                                                                                                      | 15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | ➤ Theory 35                     |
| • Class Participation:                                                                                        | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Written Examination             |
| • Seminar/presentation/assignment/quiz/class test etc.:                                                       | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                 |
| • Mid-Term Exam:                                                                                              | 7                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                 |
| <b>Part C-Learning Resources</b>                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                 |
| <b>Recommended Books/e-resources/LMS:</b>                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                 |
| 1. History Of Astronomy In India by S.N. Sen, K.S. Shukla.                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                 |
| 2. Indian Mathematics and Astronomy: Some Landmark                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                 |



| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------|
| Part A - Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |       |
| Name of the Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |       |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 3 <sup>rd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |       |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Electrodynamics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |       |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 25PN-PHY-301                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |       |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | CC-9                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |       |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |       |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |       |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <p>CLO 301.1: Analyze and Solve complex electrostatic and magnetostatic boundary-value problems using advanced analytical techniques like boundary conditions, Laplace equations, and multipole expansions.</p> <p>CLO 301.2: Apply Maxwell's equations to evaluate energy, momentum, and power conservation laws in electrodynamics using the Poynting vector and Maxwell's stress tensor. Model and Characterize the propagation of electromagnetic waves</p> <p>CLO 301.3: Predict fields and total radiated power from stationary, moving, and accelerating charges utilizing gauge transformations, retarded potentials, and Larmor's formulation.</p> <p>CLO 301.4: Formulate and Unify the laws of classical electrodynamics within the geometric framework of Special Relativity using four-vectors and the covariant electromagnetic field tensor.</p> |           |       |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Practical | Total |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0         | 4     |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0         | 4     |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 0         | 30    |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 0         | 70    |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0         | 100   |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |       |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |       |
| <p><b>Instructions for Paper- Setter:</b> The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |       |

| Unit                                                                                                                                                                                                                                                                                                                              | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Contact Hours                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| I                                                                                                                                                                                                                                                                                                                                 | <b>Review of Electrostatics and Magnetostatics</b> Poisson and Laplace equations, Solution of Laplace equation in Rectangular coordinates and spherical coordinates, electrostatic boundary conditions, energy stored in continuous charge distribution, Multipole expansion: potential at large distances, Electric field in matter: Bound current, field inside dielectrics, Electric displacement, susceptibility. Magnetic vector potential, Magnetostatic boundary conditions, multipole expansion of the vector potential, field of a magnetized object: Bound current, magnetic susceptibility and permeability.         | 15                              |
| II                                                                                                                                                                                                                                                                                                                                | <b>Electromagnetic Waves and Radiation by Moving Charges</b><br>Maxwell's equation in free space and matter, Poynting's theorem, Newton's third law in electrodynamics, Maxwell's stress tensor, conservation of momentum, Electromagnetic wave in vacuum, energy and momentum of EM wave, EM wave in matter, Reflection and Refraction of electromagnetic waves at a plane interface between dielectrics, Fresnel relations, Brewster's angle, Wave propagation in conducting media: absorption and dispersion, Wave guides: TE and TM modes in rectangular wave guides.                                                       | 15                              |
| III                                                                                                                                                                                                                                                                                                                               | <b>Potential, fields and Radiations:</b> Potential formulation: Scaler and vector potential, Gauge transformations, Coulomb and Lorentz Gauge, Retarded potentials, Lienard-Wiechart potentials and fields due to moving point charge, Dipole radiation: Electric dipole radiation and magnetic dipole radiations, Total power radiated by moving charge: Larmor's formula and its relativistic generalization, Radiation reaction.                                                                                                                                                                                             | 12                              |
| IV                                                                                                                                                                                                                                                                                                                                | <b>Electrodynamics and Relativity:</b> The Special theory of relativity, Lorentz transformation (without derivation) and results of special relativity: Time dilation and length contraction, velocity addition<br>Review of Four vectors, the concepts of Minkowski space, space-time geometry, Lorentz transformation in four dimensional space.<br>Relativistic Mechanics (Basic idea): Proper time and velocity, relativistic energy, momentum and relativistic Dynamics<br>Relativistic Electrodynamics: Field transformations, Electromagnetic field tensor. Current density 4-vector and 4-vector potential (Basic idea) | 18                              |
| <b>Suggested Evaluation Methods</b>                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                 |
| <b>Internal Assessment: 30</b>                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>End Term Examination: 70</b> |
| ➤ Theory                                                                                                                                                                                                                                                                                                                          | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | ➤ Theory: 70                    |
| • Class Participation:                                                                                                                                                                                                                                                                                                            | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Written Examination             |
| • Seminar/presentation/assignment/quiz/class test etc.:                                                                                                                                                                                                                                                                           | 10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| • Mid-Term Exam:                                                                                                                                                                                                                                                                                                                  | 15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| <b>Part C-Learning Resources</b>                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                 |
| 1.Introduction to Electrodynamics by D. J. Griffiths.<br>2.Classical Electrodynamics by J.D. Jackson<br>3.Electrodynamics by S. P. Puri.<br>4.Introduction to Electrodynamics by A. Z. Capri and P. V. Panat.<br>5.Introduction to Plasma Physics by F. F. Chen.<br>6.Classical Theory of Fields by L.D. Landau and E.M. Lifshitz |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                 |

| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------|
| Part A - Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |       |
| Name of the Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |       |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 3 <sup>rd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |       |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Atomic & Molecular Physics-I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |       |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 25PN-PHY-302                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |       |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | CC-10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |       |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |       |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |       |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <p><b>CLO 302.1:</b> Map atomic energy states, quantum numbers, and selection rules to explain the fine and hyperfine spectra of alkali and helium systems.</p> <p><b>CLO302.2:</b> Analyze atomic behavior in magnetic and electric fields, distinguishing between Zeeman, Paschen–Back, and Stark effects.</p> <p><b>CLO 302.3:</b> Classify molecular geometry and interpret the rotational spectra of rigid and non-rigid diatomic rotators, including isotope effects.</p> <p><b>CLO 302.4:</b> Apply harmonic and anharmonic (Morse) models to determine vibrational energy levels and decode the PQR branches of vibrating rotators.</p> <p><b>CLO 302.5:</b> Describe electronic band structures, calculate dissociation energies, and utilize the Franck-Condon principle and Fortrat parabolas.</p> <p><b>CLO 302.6 :</b> Construct Jablonski diagrams to evaluate radiative (fluorescence, phosphorescence) and non-radiative molecular transitions.</p> |           |       |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Practical | Total |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0         | 4     |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0         | 4     |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0         | 30    |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0         | 70    |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0         | 100   |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |       |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |       |
| <p><b>Instructions for Paper- Setter:</b> The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |       |



| Unit                                                                            | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Contact Hours                   |
|---------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| I                                                                               | <b>Atomic Physics:</b> Physical interpretation of quantum numbers, Pauli principle, Terms for equivalent & non-equivalent electron atom, Space Quantization: Stern-Gerlach experiment, Normal & anomalous Zeeman effect, Stark Effect, Paschen-Back effect, Spectrum of He-atom, spectra of alkali elements, and fine structure in alkali spectra, Intensities of spectral lines: General selection rule; Hyperfine structure of Spectra lines: Isotope effect and effect of Nuclear Spin, width of spectral lines.          | 15                              |
| II                                                                              | <b>Rotational spectra of diatomic molecules:</b> Type of molecular energy states and molecular spectra, Diatomic molecules and their rotational spectra: Types of molecules, Diatomic linear symmetric top, asymmetric top and spherical top molecules, Rotational spectra of diatomic molecules as a rigid rotator, Isotope effect in rotational spectra, energy levels and spectra of non-rigid rotor, intensity of rotational lines.                                                                                      | 15                              |
| III                                                                             | <b>Vibrational Spectra of diatomic molecules :</b> Born Oppenheimer approximation, , Progression and sequences, Vibrational energy of diatomic molecule , Diatomic molecules as a simple harmonic oscillator, Diatomic molecules as an anharmonic oscillator, Energy levels and spectrum, Morse potential energy curve, Molecules as vibrating rotator, vibration spectrum of diatomic molecules, PQR Branches, Vibrational coarse structure of electronic bands                                                             | 15                              |
| IV                                                                              | <b>Electronic Spectra of diatomic molecules and Fluorescence:</b> Silent feature of electronic spectra, formation of electronic spectra, Intensity of electronic bands in absorption and in emission-Frank Condon Principle and Condon parabola, Dissociation and pre-dissociation, Dissociation energy; Rotational fine structure of electronic bands, The Fortrat parabola, Fluorescence: Fluorescence and Phosphorescence and their mechanisms, Kasha's rule, Quantum Yield, Non-radiative transition, Jablonski Diagram. | 15                              |
| <b>Suggested Evaluation Methods</b>                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| <b>Internal Assessment: 30</b>                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>End Term Examination: 70</b> |
| ➤ <b>Theory</b>                                                                 | <b>30</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | ➤ <b>Theory:</b> <b>70</b>      |
| • Class Participation:                                                          | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Written Examination             |
| • Seminar/presentation/assignment/quiz/class test etc.:                         | 10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                 |
| • Mid-Term Exam:                                                                | 15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                 |
| <b>Part C-Learning Resources</b>                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| 1. Principles of fluorescence spectroscopy by Joseph R. Lakowicz                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| 2. Atomic spectra & atomic structure by Gerhard Herzberg                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| 3. Molecular structure & spectroscopy by G. Aruldas                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| 4. Fundamentals of molecular spectroscopy by Colin N. Banwell& Elaine M. McCash |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| 5. Introduction to Atomic spectra by Raj Kumar                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |
| 6. Atomic and Molecular Spectroscopy by V.K. Jain                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                 |

| Session: 2025-26                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |       |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------|
| Part A - Introduction                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |       |
| Name of the Programme                                                                                                                                                                                                                                                                                          | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |       |
| Semester                                                                                                                                                                                                                                                                                                       | 3 <sup>rd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |       |
| Name of the Course                                                                                                                                                                                                                                                                                             | Condensed Matter Physics-I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |       |
| Course Code                                                                                                                                                                                                                                                                                                    | 25PN-PHY-304CM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |       |
| Course Type                                                                                                                                                                                                                                                                                                    | DEC-3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |       |
| Level of the course                                                                                                                                                                                                                                                                                            | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |       |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                          | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |       |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                   | <p><b>CLO 304CM.1:</b> Explain the classical and quantum theories of electrons in solids, including the Drude and Sommerfeld models, Fermi-Dirac statistics, density of states, and the limitations of free-electron theory.</p> <p><b>CLO 304CM.2:</b> Analyze the electronic band structure of solids using Bloch theorem, Kronig-Penney model, nearly-free electron approximation, Brillouin zones, and reciprocal lattice concepts to distinguish between metals, semiconductors, and insulators.</p> <p><b>CLO 304CM.3:</b> Interpret the electronic properties of semiconductors through concepts such as band gaps, charge carriers, effective mass, carrier concentration, mobility, Hall effect, and Fermi surface topology in metals.</p> <p><b>CLO 304CM.4:</b> Evaluate the optical response of solids using dielectric function formalism, plasma oscillations, interband transitions, excitonic effects, Raman scattering, and screening phenomena in electron systems.</p> <p><b>CLO304CM.5:</b> Explain dielectric, ferroelectric, and ferroic properties of materials, including polarization mechanisms, phase transitions, domain structures, Landau theory, and multifunctional ferroic materials for technological applications.</p> <p><b>CLO 304CM.6:</b> Apply fundamental condensed matter concepts to understand the behavior of modern electronic and functional materials used in semiconductor, photonic, and energy-related technologies.</p> |           |       |
| Credits                                                                                                                                                                                                                                                                                                        | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Practical | Total |
|                                                                                                                                                                                                                                                                                                                | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0         | 4     |
| Teaching Hours per week                                                                                                                                                                                                                                                                                        | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0         | 4     |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                      | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0         | 30    |
| End Term Exam Marks                                                                                                                                                                                                                                                                                            | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0         | 70    |
| Max. Marks                                                                                                                                                                                                                                                                                                     | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0         | 100   |
| Examination Time                                                                                                                                                                                                                                                                                               | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |       |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |       |
| <b>Instructions for Paper- Setter:</b> The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |       |



paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

| Unit | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Contact Hours |
|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| I    | <b>Free Electron Theory:</b> Drude theory of electrical and thermal conductivity, Sommerfeld free-electron model, Fermi-Dirac statistics, Fermi energy, Fermi surface and density of states, Electronic heat capacity, Electrical conductivity and limitations of free-electron theory<br><b>Band Theory of Solids:</b> Periodic potential and Bloch theorem, Kronig-Penney model (qualitative and simple treatment), Nearly-free electron approximation, Origin of energy bands and band gaps, Metals, semiconductors and insulators, Brillouin zones and reciprocal space, Wigner-Seitz construction in reciprocal lattice, Cohesive energy of solids (introductory treatment)                                 | 12            |
| II   | <b>Semiconductor Crystals:</b> Direct and indirect band-gap semiconductors, Optical absorption processes, Motion of electrons in energy bands, Holes and hole dynamics, Effective mass and effective mass tensor, Physical interpretation of effective mass, Effective masses in semiconductors, Intrinsic carrier concentration, Carrier mobility and conductivity, Hall effect and Hall coefficient<br><b>Fermi Surfaces and Metals:</b> Construction of Fermi surfaces, Free-electron and nearly-free-electron Fermi surfaces, Fermi surface of square lattice, Electron, hole and open orbits, de Haas-van Alphen effect and its applications, Experimental determination of Fermi surfaces                  | 12            |
| III  | <b>Free-Electron Optics:</b> Dielectric function of free electron gas, Plasma oscillations and plasma frequency, Plasma optics, Dispersion relation for electromagnetic waves, Longitudinal and transverse plasma modes, Transparency of alkali metals in ultraviolet region, Plasmons and their experimental observation<br><b>Optical Processes:</b> Optical reflectance, Kramers-Kronig relations, Electronic inter-band transitions, Optical absorption in solids, Excitons: Frenkel and Mott-Wannier excitons, Raman scattering in crystals and applications<br><b>Screening Effects:</b> Electrostatic screening, Screened Coulomb potential, Mott metal-insulator transition, Screening effects in metals | 18            |
| IV   | <b>Dielectric Properties:</b> Polarization mechanisms, Macroscopic electric field, Local electric field, Dielectric susceptibility, Dielectric constant and polarizability, Clausius-Mossotti relation, Electronic polarizability, Classical theory of electronic polarizability<br><b>Ferroelectrics and Phase Transitions:</b> Structural phase transitions, Order parameter concept, Landau theory of phase transitions, Ferroelectric crystals and classification, Ferroelectric domains, Antiferroelectricity<br><b>Ferroic Materials:</b> Piezoelectricity, Pyroelectricity, Ferroelasticity, Introduction to multiferroics and applications                                                               | 18            |

#### Suggested Evaluation Methods

| Internal Assessment: 30                                 |    | End Term Examination: 70 |    |
|---------------------------------------------------------|----|--------------------------|----|
| ➤ Theory                                                | 30 | ➤ Theory:                | 70 |
| • Class Participation:                                  | 5  | Written Examination      |    |
| • Seminar/presentation/assignment/quiz/class test etc.: | 10 |                          |    |
| • Mid-Term Exam:                                        | 15 |                          |    |



### **Part C-Learning Resources**

1. Introduction to solid state Physics, 7<sup>th</sup> Edition by Charles Kittel
2. Solid State Physics by Neil W. Ashcroft and N. David Mermin
3. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth
4. Principles of the Theory of Solids (2nd edition) by J. M. Ziman
5. Condensed Matter Physics by Michael P. Marder
6. Advanced Solid State Physics by P. Phillips
7. Semiconductor Physics and Devices by Donald A. Neamen.
8. Optical Properties of Solids by Mark Fox.
9. Principles and Applications of Ferroelectrics and Related Materials by M. E. Lines and A. M. Glass.
10. Electronic Transport in Mesoscopic Systems by Supriyo Datta.
11. Magnetism in Condensed Matter by Stephen Blundell.
12. Nanostructures and Nanotechnology by Douglas Natelson.

| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A - Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| Name of the Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |               |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 3 <sup>rd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Electronics-I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |               |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 25PN-PHY-304EC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |               |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | DEC-3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |               |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |               |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <p><b>CLO 304EC.1:</b> Design and comprehend a host of OPAMP based linear analog electronic circuits.</p> <p><b>CLO 304EC.2:</b> Students will be able to analyze and design operational amplifier and their applications in various electronic circuits.</p> <p><b>CLO 304EC.3:</b> Gain a fair understanding of the operation and underlying circuitry of amplitude and frequency modulations.</p> <p><b>CLO 304EC.4:</b> Understand the necessary circuitry of digital modulation techniques and Radars.</p> <p><b>CLO 304EC.5:</b> Explain the principle of Oscillators and Boolean algebra types &amp; techniques.</p> <p><b>CLO 304EC.6:</b> Understand the working of low- and high-frequency oscillators and apply Boolean algebra principles for the simplification and implementation of digital logic circuits.</p> <p><b>CLO 304EC.7:</b> Become familiar with the ideal MS contacts, their classification, surface effects and Their important applications.</p> <p><b>CLO 304EC.8:</b> Describe the basics of ideal and non-ideal MOS systems, MOS capacitance, MOS memories and charged-coupled devices.</p> |           |               |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Practical | Total         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0         | 4             |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0         | 4             |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0         | 30            |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0         | 70            |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 0         | 100           |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| <p><b>Instructions for Paper- Setter:</b> The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           | Contact Hours |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |    |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| I   | <b>Applications of Operational Amplifiers:</b> Summing and scaling, Integrator, differentiator, Filters (LPF, HPF, BPF, BRF, APF), logarithmic and anti-logarithmic amplifier. Voltage follower, voltage to current and current to voltage converter. Bridge amplifier, AC coupled amplifier. DAC and ADC : parameters of DAC, binary weighted resistor DAC, R-2R ladder DAC, Types of ADC : counter type, successive approximation type, flash type, dual slope integrator type                                                                     | 15 |
| II  | <b>Modulation and Communication:</b> Basic operation and internal circuitry of PLL, active filters (Butter-Worth 1st and 2nd order), amplitude modulation, frequency spectrum and power in the AM wave, generation of AM waves, demodulation of AM waves. frequency modulation, block diagram of transmitter and super heterodyne receiver, digital communication, basic idea about delta modulation, PCM and PWM, block diagram of Radar, radar range equation and applications of Radars.                                                          | 15 |
| III | <b>Unit III: Oscillators and Boolean algebra:</b> Introduction, the oscillatory circuit, essentials of transistor circuits, Low frequency oscillators (R-C phase shift, Wien bridge oscillator), high frequency oscillators (Hartley oscillator, Colpitt's oscillator), Boolean Algebra: Boolean laws and theorems, sum of product (SOP) and product of sum (POS) expressions, minterms, maxterms, canonical SOP and POS form expressions, Implementation of SOP/POS by using minimum number of two input NAND/NOR gates only, Logical Venn Diagram. | 15 |
| IV  | <b>Unit IV: MS contacts and MOS systems:</b> Metal semiconductor contacts, ideal MS contacts, Schottky barriers and ohmic contacts, surface effects on MS contacts, applications of MS contacts, the ideal MOS structure and its analysis, capacitance of MOS system, non-ideal MOS system: oxide and interface charges, origin of oxide charges, effect of bias voltage, MOS memories, and charge-coupled devices.                                                                                                                                  | 15 |

#### Suggested Evaluation Methods

| Internal Assessment: 30                                 |    | End Term Examination: 70 |    |
|---------------------------------------------------------|----|--------------------------|----|
| ➤ Theory                                                | 30 | ➤ Theory:                | 70 |
| • Class Participation:                                  | 5  | Written Examination      |    |
| • Seminar/presentation/assignment/quiz/class test etc.: | 10 |                          |    |
| • Mid-Term Exam:                                        | 15 |                          |    |

#### Part C-Learning Resources

1. Integrated electronics by J Millman & CC Halkias.
2. Micro Electronics by J Millman & A Grabel.
3. Electronic communications by D Roddy and J Coolen.
4. Electronic Communications: Modulation and Transmission by RJ Schoenbeck
5. OPAMPs and linear IC circuits by Ramakant A. Gayakwad
6. Electronic fundamentals and applications (5th ed.) by J D Ryder
7. Electronic Devices & Circuit Theory by Robert L Boylestad & Louis Nashelsky
8. Microelectronic Circuits: Theory and Applications (6th ed.) by Adel S Sedra and Kenneth C Smith



**Session: 2025-26**

**Part A - Introduction**

|                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |       |
|----------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------|
| Name of the Programme                                                                        | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |       |
| Semester                                                                                     | 3 <sup>rd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |       |
| Name of the Course                                                                           | Radiation & Health Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |       |
| Course Code                                                                                  | 25PN-PHY-305RH                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |       |
| Course Type                                                                                  | DEC-4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |       |
| Level of the course                                                                          | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |       |
| Pre-requisite for the course (if any)                                                        | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |       |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to: | <p><b>CLO 305RH.1:</b> Quantify radioactive decay kinetics and explain the origins of cosmic, terrestrial, and advanced radiations (X-rays, Bremsstrahlung, Synchrotron, Cherenkov).</p> <p><b>CLO 305RH.2:</b> Define and apply standard radiation metrics, including Activity, KERMA, absorbed/equivalent/effective doses, and Annual Limit on Intake (ALI).</p> <p><b>CLO 305RH.3:</b> Evaluate the operation and use cases of gas-filled, scintillation, semiconductor (HPGe), track (SSNTD), and thermoluminescent (TLD) detectors.</p> <p><b>CLO 305RH.4:</b> Classify neutrons by energy level and identify appropriate sources, collimation techniques, and detection methods for slow to fast neutrons.</p> <p><b>CLO 305RH.5:</b> Analyze the biological impact of ionizing radiation on cellular structures (DNA/RNA) and differentiate between somatic (early) and stochastic (late) human health effects.</p> <p><b>CLO 305RH.6:</b> Implement ICRP protection principles (Justification, Optimization, Dose Limits), manage internal/external hazards, and classify/dispose of radioactive waste.</p> |           |       |
| Credits                                                                                      | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Practical | Total |
|                                                                                              | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0         | 4     |
| Teaching Hours per week                                                                      | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0         | 4     |
| Internal Assessment Marks                                                                    | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0         | 30    |
| End Term Exam Marks                                                                          | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0         | 70    |
| Max. Marks                                                                                   | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0         | 100   |
| Examination Time                                                                             | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |       |

**Part B-Contents of the Course**

**Instructions for Paper- Setter:** The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

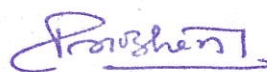
| Unit                                                    | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Contact Hours                   |
|---------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| I                                                       | <b>Radioactivity and Sources of Radiations:</b> Radioactive decay, Half life time, Radioactive growth and decay, Radioactive equilibrium, Radioactive series, Radioactive branching, Radioactive dating, Artificial radioactivity, and Uses of radio-isotopes, X-rays: Characteristic X-rays, Bremsstrahlung radiations, synchrotron radiation, Cherenkov radiation, Cosmic rays: Discovery, Nature of a cosmic rays, soft and hard component, and Geometric effects on cosmic rays; Terrestrial radiations: Radon gas and Radioactive isotopes of lighter elements, Radiation quantities and units: Activity, KERMA, Exposure, Dose, Equivalent Dose, Effective Dose, Annual Limit on Intake (ALI).                                  | 15                              |
| II                                                      | <b>Interaction of radiation (basic):</b> Active Vs Passive detector, Gas filled radiation detectors: ionization chambers, proportion counters, GM counters, and Spark counter. Scintillation (organic/inorganic) counter; Solid State Detector: Solid State Nuclear Track Detector (SSNTD), Semiconductor Detectors (Junction type detector, Lithium drift Germanium detector, and HPGe), Thermo – Luminescent Dosimeters (TLD), Chemical detectors (Photographic Emulsions Films). Neutron sources, Neutron collimators, Properties of neutrons, Classification of neutrons according to energy, Neutron detectors: Slow neutron detectors (Boron trifluoride proportional counter), Medium and fast neutron detectors (basic idea). | 15                              |
| III                                                     | <b>Biological Effects of Ionizing Radiation:</b> Introduction, Cell Biology: Structure and function of living cell, cell division-mitosis, meiosis and differentiation, central dogma of molecular biology, genetic codes-DNA, RNA and Proteins; Effect of Radiation on Cell: inhibition of cell division, chromosome aberrations, genes mutation, and cell death; Biological effects of Radiation on Human: Somatic Effects (Early effect) and Stochastic effect (Late effect)                                                                                                                                                                                                                                                       | 15                              |
| IV                                                      | <b>Principles of Radiological Protection:</b> Justification of Practice, Optimization of Practice, and Dose Limitations; Internal Exposure, Dose Limit for (i) Radiation Workers (ii) Public, Occupational Exposure of Women, Apprentices and Students; Production of Radioisotopes and Labeled Compounds: Introduction, Separation of Isotopes, Production of labeled compounds, Specific Activity of labeled compounds, Storage, Quality, and Purity of Radio-labeled compounds, Internal Hazards and External Hazards; Evaluation and Control of Radiation Hazard, Radiation Shield, Monitoring of External Radiation, Disposal of radioactive wastes, Sources of radioactive waste, Classification of radioactive wastes.         | 15                              |
| <b>Suggested Evaluation Methods</b>                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                 |
| <b>Internal Assessment: 30</b>                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <b>End Term Examination: 70</b> |
| ➤ Theory                                                | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | ➤ Theory: 70                    |
| • Class Participation:                                  | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Written Examination             |
| • Seminar/presentation/assignment/quiz/class test etc.: | 10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                 |
| • Mid-Term Exam:                                        | 15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                 |
| <b>Part C-Learning Resources</b>                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                 |



1. Radiation Detection and Measurement by Glenn F. Knoll.
2. Concepts of Modern Physics by Arthur Beiser, S Mahajan, and S Rai Choudhury.
3. Radiation Oncology Physics: a handbook for teachers and students; International Atomic Energy Agency Vienna, 2005.
4. Practical knowledge for Handling Radioactive Sources by Dr. Claus Grupen.
5. Introduction to Radiological Physics and Radiation Dosimetry by Frank Herbert Attlx
6. Radiation Biology: a handbook for teachers and students; International Atomic Energy Agency Vienna, 2010.
7. Student Solutions Manual to accompany Radiation Detection and Measurement by Glenn F. Knoll.
8. Nuclear and Particle Physics by S. L. Kakani and ShubhraKakani.









**Session: 2025-26****Part A–Introduction**

|                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |       |
|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------|
| Name of Programme                                                                             | M. Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |       |
| Semester                                                                                      | 3 <sup>rd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |       |
| Name of the Course                                                                            | Nanoscience and Nanotechnology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |       |
| Course Code                                                                                   | 25PN-PHY-305NM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |       |
| Course Type                                                                                   | DEC-4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |       |
| Level of the course                                                                           | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |       |
| Pre-requisite for the course (if any)                                                         | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |       |
| Course Learning Outcomes (CLOs)<br>After completing this course, the learner will be able to: | <p><b>CLO 306NM.1:</b> Students will be able to describe and explain the fundamental properties of nanomaterials and nanostructures.</p> <p><b>CLO 306NM.2:</b> Students will be able to analyze the density of states in various nanostructures and evaluate its influence on their optical properties.</p> <p><b>CLO 306NM.3:</b> Students will gain knowledge of the major synthesis and fabrication techniques used for the preparation of nanomaterials and nanostructures.</p> <p><b>CLO 306NM.4:</b> Students will be able to quantitatively interpret and analyze experimental results obtained from characterization techniques such as X-ray diffraction (XRD) and photoluminescence (PL).</p> |           |       |
| Credits                                                                                       | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Practical | Total |
|                                                                                               | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 0         | 4     |
| Teaching Hours per week                                                                       | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 0         | 4     |
| Internal Assessment Marks                                                                     | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0         | 30    |
| End Term Exam Marks                                                                           | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 0         | 70    |
| Max. Marks                                                                                    | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 0         | 100   |
| Examination Time                                                                              | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |       |

**Part B-Contents of the Course**

**Instructions for Paper- Setter:** The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

| Unit | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Contact Hours |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| I    | <b>Review of Density of States:</b> Free electron theory (qualitative idea) and its features, Idea of band structure: Kronig Penny model, Metals, insulators and semiconductors, Concept of effective mass, Derivation of density of states in 3D, 2D, 1D and 0D systems, Density of states in bands, Variation of density of states with energy, Variation of density of states and band gap energy with size of crystal, Electronic structure from Bulk to quantum dot, Excitons: Frenkel and Mott-Wannier excitons | 15            |
| II   | <b>Physics of reduced dimensional systems and devices:</b> Quantum confinement, Electron confinement in one, two and three dimensional infinitely deep square well                                                                                                                                                                                                                                                                                                                                                    | 15            |

|                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                 |
|----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
|                                                                                                                                  | potentials, Various low dimensional systems: Quantum well structure; Idea of quantum well structure, Electron wave function and energy in quantum well structure (infinite well approximation), Density of states and optical absorption in quantum well, Quantum wires: Electron wave function and energy, Density of states, Quantum dots: Electron wave function and energy, Density of states, idea of hetero-junction LED, Quantum well laser and quantum dot laser, Coulomb blockade and Single electron transistor                                                                                                                                                                                            |                                 |
| III                                                                                                                              | <b>Synthesis of Nanomaterials/Nanostructures:</b> Bottom up and top down approaches for synthesis of nano materials, Synthesis of zero-dimensional nanostructures (Nanoparticles): Sol-Gel Process, Epitaxial core-shell nanoparticles, Ball milling, One-dimensional nanostructures (Nanowires, Nanorods, Nanotubes): Electrochemical deposition, Lithography, Two-dimensional nanostructures (Thin Films & Quantum wells): Molecular beam epitaxy (MBE), MOCVD, Cluster beam evaporation, Ion beam deposition, Chemical bath deposition technique                                                                                                                                                                  | 15                              |
| IV                                                                                                                               | <b>Characterization of Nanomaterials/Nanostructures:</b> Effect of particle size and Strain on width of XRD peaks of nanomaterials, Determination of crystallite/particle size and strain in nanomaterials using Debye Scherer's formula and Williamson–Hall's plot, Transmission electron microscopy: Basic principle, Brief idea of set up, Sample preparation, Imaging modes (Dark & Bright Field ), Photoluminescence (PL) spectroscopy: Basic principle and idea of instrumentation, Shift in PL peaks with particle Size, Determination of alloy composition in thin films of compound semiconductors, Estimation for width of quantum wells, Raman spectroscopy: Basic principle and idea of instrumentation. | 15                              |
| <b>Total Contact Hours</b>                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 60                              |
| <b>Suggested Evaluation Methods</b>                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                 |
| <b>Internal Assessment: 30</b>                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>End Term Examination: 70</b> |
| ➤ <b>Theory</b>                                                                                                                  | <b>30</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | ➤ <b>Theory:</b> <b>70</b>      |
| • Class Participation:                                                                                                           | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Written Examination             |
| • Seminar/presentation/assignment/quiz/class test etc.:                                                                          | 10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                 |
| • Mid-Term Exam:                                                                                                                 | 15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                 |
| <b>Part C-Learning Resources</b>                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                 |
| <b>Recommended Books/e-resources/LMS:</b>                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                 |
| 1. Physics of Low Dimensional Semiconductors by John H. Davies                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                 |
| 2. Introduction to Nano-technology by Charles P. Poole & Jr. Frank J. Owens.                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                 |
| 3. Quantum Mechanics for Nanostructures by Vladimir V. Mitin, Dmitry I. Sementsov&Nizami Z. Vagidov.                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                 |
| 4. Nanostructures & Nanomaterials: Synthesis, Properties & Applications by Guozhong Cao.                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                 |
| 5. Introduction to Nano: Basics to Nanoscience and Nanotechnology by Amretashis Sengupta & Chandan Kumar Sarkar.                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                 |
| 6. Solid State Physics by A. J. Dekker .                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                 |
| 7. Essentials in Nano-science and nanotechnology by Narendra Kumar, Sunita Kumbhat.                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                 |
| 8. Encyclopedia of Materials Characterization: Surfaces, Interfaces, Thin Films by C. Richard Brundle and Charles A. Evans, Jr.. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                 |



| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A–Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Name of Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                | M. Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |               |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4 <sup>th</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                               | Electronic Instrumentation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |               |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 25PN-PHY-EEC-301                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |               |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                      | EEC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |               |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                            | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |               |
| Course Learning Outcomes (CLOs)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                    | <p><b>CLO EEC301.1:</b> Develop understanding of basic electronic components, circuit laws, semiconductor devices, and measurement instruments through hands-on experiments.</p> <p><b>CLO EEC301.2:</b> Acquire practical skills to construct, test, and analyze basic electronic circuits and sensor-based systems using standard laboratory instruments.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Practical | Total         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1         | 2             |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                          | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 2         | 3             |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                        | 10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 5         | 15            |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                              | 20                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 15        | 35            |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 20        | 50            |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| <b>Instructions for Paper- Setter:</b> The examiner will set 3 questions from a unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 10 parts covering entire syllabus (10x1 = Marks). The examinee will be required to attempt 2 questions; selecting one question from the unit and the compulsory question. All questions will carry equal marks. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           | Contact Hours |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Introduction to Electronic Components</b> Passive components: Resistor, Capacitor, Inductor, Identification, color coding, rating, and testing using DMM, Ideal vs real components. <b>Semiconductor Devices:</b> p-n junction diode, LED, Zener diode, Basic working principles, I–V characteristics, Transistor (BJT): structure and basic operation. <b>Basic Circuit Laws and Network Analysis:</b> Ohm's law, Series and parallel combinations of resistors, Kirchhoff's laws (brief introduction), Power dissipation in circuits. <b>Electrical Measurements and Instruments:</b> Digital Multimeter (DMM): voltage, current, resistance measurement, AC vs DC measurements, CRO/DSO: basic principle and applications, Measurement of amplitude, frequency, phase. <b>Rectifier Circuits and Power Supply Basics:</b> Half-wave rectifier: working and waveform, Full-wave rectifier: bridge and center-tap, Ripple concept and basic filtering idea. <b>Transistor Applications:</b> Transistor as a switch, LED indicator circuits, Basic digital switching concept, <b>Sensors and Calibration,</b> Temperature sensors: RTD and thermistor, Principle of measurement, Calibration of ammeter and basic error analysis |           | 15            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Practical</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           | 30            |



|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
|  | <ol style="list-style-type: none"> <li>1. Identification and testing of passive electronic components (Resistor, Capacitor, Inductor) using a Digital Multimeter (DMM).</li> <li>2. Identification and testing of semiconductor devices (Diode, LED, Zener diode, Transistor).</li> <li>3. Verification of Ohm's Law and determination of resistance.</li> <li>4. Study of series and parallel combinations of resistors.</li> <li>5. Measurement of AC and DC voltage and current using a multimeter.</li> <li>6. Study of V-I characteristics of a diode and determination of cut-in voltage.</li> <li>7. Study of Zener diode characteristics and voltage regulation.</li> <li>8. Construction and testing of half-wave rectifier.</li> <li>9. Construction and testing of full-wave rectifier.</li> <li>10. Study of transistor as a switch.</li> <li>11. Study of LED-based indicator circuits.</li> <li>12. Measurement of amplitude, frequency, and phase using CRO/DSO.</li> <li>13. Calibration of an ammeter using a standard meter.</li> <li>14. Measurement of temperature using RTD or thermistor sensor.</li> </ol> <p><b>Note: Student will perform at least four experiments. The examiner will allot one Practicum at the time of end term examination.</b></p> |  |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|

#### Suggested Evaluation Methods

| Internal Assessment: 15                                 |    | End Term Examination: 35                                       |    |
|---------------------------------------------------------|----|----------------------------------------------------------------|----|
| ➤ Theory                                                | 10 | ➤ Theory:                                                      | 20 |
| • Class Participation:                                  | 4  | Written Examination                                            |    |
| • Seminar/presentation/assignment/quiz/class test etc.: |    |                                                                |    |
| • Mid-Term Exam:                                        | 6  |                                                                |    |
| ➤ Practical:                                            | 5  | ➤ Practical:                                                   | 15 |
| • Class Participation:                                  | -- | Lab record, Viva-Voce, write-up and execution of the practical |    |
| • Seminar/Demonstration/Viva-voce/Lab records etc.:     | 5  |                                                                |    |

#### Part C-Learning Resources

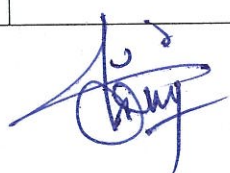
##### Recommended Books/e-resources/LMS:

1. Electronic Devices and Circuit Theory by Robert L. Boylestad, Louis Nashelsky
2. Electronic Principles by Albert P. Malvino, David J. Bates
3. Basic Electronics and Linear Circuits by N. N. Bhargava, D. C. Kulshreshtha, S. C. Gupta
4. Electronic Devices and Circuits by S. Salivahanan, N. Suresh Kumar, A. Vallavaraj
5. Electrical and Electronic Measurements and Instrumentation by A. K. Sawhney
6. Electronic Instrumentation by H. S. Kalsi
7. A Textbook of Applied Electronics by R. S. Sedha
8. The Art of Electronics by Paul Horowitz, Winfield Hill
9. Practical Physics by S. P. Singh
10. Electronic Measurements and Instrumentation by G. K. Mittal

| Session: 2025-26                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A- Introduction                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Name of the Programme                                                                        | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |               |
| Semester                                                                                     | 3 <sup>rd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Name of the Course                                                                           | General Physics Lab-I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |               |
| Course Code                                                                                  | 25PN-PHY-303 ✓                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |               |
| Course Type                                                                                  | CC-11                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |               |
| Level of the course                                                                          | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| Pre-requisite for the course (if any)                                                        | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |               |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to: | <b>CLO 303.1:</b> Demonstrate proficiency in the use of experimental and computational techniques to investigate electromagnetic, condensed matter, and nanomaterial systems.<br><b>CLO 303.2:</b> Perform measurements of optical, magnetic, electrical, and thermal properties of materials using appropriate experimental methods and instrumentation.<br><b>CLO 303.3:</b> Analyze experimental data and employ numerical and simulation tools to study physical phenomena and validate theoretical models.<br><b>CLO 303.4:</b> Characterize nanomaterials and optoelectronic devices using spectroscopic, microscopic, and diffraction-based techniques.<br><b>CLO 303.5:</b> Interpret experimental results, estimate physical parameters, and communicate scientific findings through laboratory reports and presentations. |           |               |
| Credits                                                                                      | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Practical | Total         |
|                                                                                              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 4         | 4             |
| Teaching Hours per week                                                                      | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 8         | 8             |
| Internal Assessment Marks                                                                    | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 30        | 30            |
| End Term Exam Marks                                                                          | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 70        | 70            |
| Max. Marks                                                                                   | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 100       | 100           |
| Examination Time                                                                             | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 4 hours   |               |
| Part B – Contents of the Course                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Practicals                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           | Contact Hours |



|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |     |
|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
|  | <p><b>Note: Depending upon the area of specialization, the student shall perform at least eight experiments, including a minimum of three experiments from the General Experiments list. The examiner shall allot one practical experiment at the time of the End-Term Examination.</b></p> <p><b>General Experiments</b></p> <ol style="list-style-type: none"> <li>1. Numerical solution of Laplace equation and visualization of equipotential surfaces.</li> <li>2. Simulation of electric fields of dipole and quadrupole configurations.</li> <li>3. Simulation of electromagnetic wave propagation in free space.</li> <li>4. Simulation of TE and TM modes in rectangular waveguides.</li> <li>5. Simulation of electric dipole radiation pattern.</li> <li><b>6. Determination of dielectric constant.</b></li> <li>7. Verification of Brewster's angle.</li> <li>8. Polarization of light using Malus' law.</li> <li>9. Measurement of refractive index using prism or laser techniques.</li> </ol> <p><b>Condensed Matter Physics</b></p> <p>CM1. To determine the Lande's g factor of DPPH using ESR spectrometer.</p> <p>CM2. To determine magneto resistance of a Bismuth crystal as a function of magnetic field.</p> <p>CM3. To determine the heat capacity of solids.</p> <p>CM4. Measurement of Hall Coefficient of a given semiconductor: Identification of type of semiconductor and estimation of charge carrier.</p> <p>CM5. To verify Faraday Law using He-Ne Laser.</p> <p>CM6. To determine the dielectric constant of different solid samples.</p> <p>CM7. Determination of <math>e/m</math> by normal Zeeman effect using Feby Perot Etalon</p> <p><b>Nanomaterial Laboratory</b></p> <p>NM1. To study the characteristics of optoelectronic devices ( Photo-diodes, Photo-detectors, LDR).</p> <p>NM2. To study the characteristics (illumination characteristics, I-V characteristics, Power-load) of a solar cell.</p> <p>NM3. Least square fitting of a given data (linear fitting)</p> <p>NM4. Analysis of TEM image using open source.</p> <p>NM5. Analysis of Raman spectra by using open source.</p> <p>NM6. Analysis of XRD pattern of nanomaterials and estimation of particle size by using Debye-Scherrer's formula.</p> <p>NM7. To determine Planck's Constant (<math>h</math>) by measuring the voltage drop across light-emitting diodes (LEDs) of different colors.</p> <p>NM8 Thermo-luminescence study</p> | 120 |
|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|







| Session: 2025-26                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A- Introduction                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Name of the Programme                                                                        | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |               |
| Semester                                                                                     | 3 <sup>rd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Name of the Course                                                                           | Physics Lab-III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Course Code                                                                                  | 25PN-PHY-306 ✓                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |               |
| Course Type                                                                                  | PC-3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |               |
| Level of the course                                                                          | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| Pre-requisite for the course (if any)                                                        | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |               |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to: | <b>CLO 306.1:</b> Perform spectroscopic, radiation detection, and electronic circuit experiments using appropriate instruments and experimental techniques.<br><b>CLO 306.2:</b> Analyze atomic and molecular spectra to determine spectroscopic constants and interpret fine structure, rotational, vibrational, and fluorescence phenomena.<br><b>CLO 306.3:</b> Measure and evaluate radiation-related parameters such as attenuation coefficients, detector characteristics, counting statistics, source strength, and detector resolution.<br><b>CLO 306.4:</b> Design, construct, and test analog and digital electronic circuits using operational amplifiers, logic gates, flip-flops, encoders, decoders, multiplexers, and comparators.<br><b>CLO 306.5:</b> Analyze experimental data, estimate physical parameters and uncertainties, and communicate scientific findings through laboratory reports and presentations. |           |               |
| Credits                                                                                      | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Practical | Total         |
|                                                                                              | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 4         | 4             |
| Teaching Hours per week                                                                      | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 8         | 8             |
| Internal Assessment Marks                                                                    | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 30        | 30            |
| End Term Exam Marks                                                                          | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 70        | 70            |
| Max. Marks                                                                                   | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 100       | 100           |
| Examination Time                                                                             | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 4 hours   |               |
| Part B – Contents of the Course                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Practicals                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           | Contact Hours |

12  
Chauhan

✓

Prashant

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <p><b>Note: Depending upon the area of specialization, the student shall perform at least eight experiments, including a minimum of three experiments from the General Experiments list. The examiner shall allot one practical experiment at the time of the End-Term Examination.</b></p> <p><b>General Experiments</b></p> <ol style="list-style-type: none"> <li>1. Determination of the Rydberg constant.</li> <li>2. Study of helium spectrum.</li> <li>3. Study of sodium doublet and fine structure.</li> <li>4. Analysis of rotational spectra of diatomic molecules.</li> <li>5. Analysis of vibrational spectra of diatomic molecules.</li> <li>6. Determination of molecular constants from spectroscopic data.</li> <li>7. Study of fluorescence and phosphorescence.</li> <li>8. Analysis of Zeeman effect/ Computer-based Zeeman effect.</li> </ol> <p><b>Radiation Physics</b></p> <p>RH1. <math>\chi^2</math>- Statistics using G. M. Counter</p> <p>RH2. Range of alpha particles in air using Spark Counter.</p> <p>RH3. Resolving Time of G. M. Counter set-up.</p> <p>RH4. Resolving Time of a Fast Coincidence Circuit.</p> <p>RH5. (a) Thickness of Al Sheet using G. M. Counter. (b) Gamma Ray Absorption Experiment.</p> <p>RH6. Study of Energy Resolution of Gamma Ray Detector as a function of <math>E_\gamma</math>.</p> <p>RH7. Determination of Characteristics of GM tube and its operating voltage, plateau length and slop.</p> <p>RH8. Linear and mass attenuation coefficient of gamma radiation.</p> <p>RH9. Linear and mass attenuation coefficients for the beta particles.</p> <p>R10. To study the count rate per second with change of applied voltage for a GM counter.</p> <p>RH11. To determine the strength of an <math>\alpha</math>-source using SSNTD.</p> <p>RH12. To study nuclear statistics using SSNTD.</p> <p>RH13. To study the background radiation by portable dosimeter</p> <p><b>Electronics Laboratory</b></p> <p>EC1. Design and verify a Hartley oscillator using BJT.</p> <p>EC2. Design and verify a Colpitts oscillator using BJT.</p> <p>EC3. Determine frequency stability of LC oscillators.</p> <p>EC4. Compare Hartley and Colpitts oscillators experimentally.</p> <p>EC5. Study of Op-Amp characteristics using IC 741 Operational Amplifier.</p> <p>EC6. OPAMP-II: Applications as Adder and Subtractor.</p> <p>EC7. OPAMP-II: Applications as Differentiator and integrator.</p> <p>EC8. To design adder and subtractor (half/full) using logic gates.</p> <p>EC9. To study the use of digital comparator.</p> <p>EC10. To study various displays on a bread-board Assembling circuits.</p> | <p>120</p> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|



| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A - Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Name of the Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |               |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 4 <sup>th</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Atomic & Molecular Physics-II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |               |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 25PN-PHY-401                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | CC-12                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |               |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |               |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <p><b>CLO 302.1:</b> Map atomic energy states, quantum numbers, and selection rules to explain the fine and hyperfine spectra of alkali and helium systems.</p> <p><b>CLO302.2:</b> Analyze atomic behavior in magnetic and electric fields, distinguishing between Zeeman, Paschen–Back, and Stark effects.</p> <p><b>CLO 302.3:</b> Classify molecular geometry and interpret the rotational spectra of rigid and non-rigid diatomic rotators, including isotope effects.</p> <p><b>CLO 302.4:</b> Apply harmonic and anharmonic (Morse) models to determine vibrational energy levels and decode the PQR branches of vibrating rotators.</p> <p><b>CLO 302.5:</b> Describe electronic band structures, calculate dissociation energies, and utilize the Franck-Condon principle and Fortrat parabolas.</p> <p><b>CLO 302.6 :</b> Construct Jablonski diagrams to evaluate radiative (fluorescence, phosphorescence) and non-radiative molecular transitions.</p> |           |               |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Practical | Total         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0         | 4             |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 0         | 4             |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0         | 30            |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0         | 70            |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0         | 100           |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |               |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| <p><b>Instructions for Paper- Setter:</b> The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |               |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           | Contact Hours |



|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |    |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| I   | <b>X-Rays and Raman Spectroscopy:</b> The origin of X-Rays, X-Ray emission spectra, Dependence of position of Emission lines on the atomic number, X-Ray emission (Doublet) spectra, Satellites, Continuous X-ray Emission, X-Ray Absorption spectra.<br>Raman Effect - quantum theory – molecular polarizability, pure rotational Raman spectra of diatomic molecules - vibration rotation Raman Spectrum of diatomic molecules, Intensity alternation in Raman spectra of diatomic molecules, application of Raman spectroscopy in the structure determination of simple molecules. | 15 |
| II  | <b>NMR and Mossbauer Spectroscopy:</b> NMR: Basic principles, spin-spin and spin-lattice relaxation times, chemical shift and spin-spin coupling, Applications of NMR spectroscopy. Mossbauer spectrometer, Isomer nuclear transition, resonance fluorescence, Mossbauer Effect, Mossbauer nuclei, Isomer shift, quadruple splitting, magnetic hyperfine structure, application of Mossbauer spectroscopy.                                                                                                                                                                            | 15 |
| III | <b>ESR Spectroscopy and Laser:</b> ESR spectrometer, substances which can be studied by ESR, Resonance condition, Relaxation mechanisms, Features of ESR spectra (a) the g factor (b) Fine structure (c) hyperfine structure (d) ligand hyperfine structure. Applications of ESR; LASER, spontaneous and stimulated emission, absorption, Einstein coefficient, properties of laser beams, laser application in holography, laser induced fusion.                                                                                                                                     | 15 |
| IV  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |    |

#### Suggested Evaluation Methods

| Internal Assessment: 30                                 |    | End Term Examination: 70 |    |
|---------------------------------------------------------|----|--------------------------|----|
| ➤ Theory                                                | 30 | ➤ Theory:                | 70 |
| • Class Participation:                                  | 5  | Written Examination      |    |
| • Seminar/presentation/assignment/quiz/class test etc.: | 10 |                          |    |
| • Mid-Term Exam:                                        | 15 |                          |    |

#### Part C-Learning Resources

1. Atomic and Molecular Spectroscopy by V.K Jain.
2. Atomic and Molecular Spectroscopy by Raj Kumar.
3. Molecular structure & spectroscopy by G. Aruldas.
4. Fundamentals of molecular spectroscopy by Colin N. Banwell& Elaine M. McCash.
5. Introduction to Atomic spectra by H.E. White
6. Spectra of diatomic molecules by Gerhard Herzberg
7. Concepts of Modern Physics by Arthur Beiser .

| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A - Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |               |
| Name of the Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 4 <sup>th</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |               |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Statistical Mechanics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |               |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 25PN-PHY-402                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |               |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | CC-13                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |               |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |               |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           |               |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <p><b>CLO 402.1:</b> Explain the fundamental concepts of statistical mechanics and ensemble theory and their relation to thermodynamics.</p> <p><b>CLO 402.2:</b> Apply microcanonical, canonical, and grand canonical ensembles to determine thermodynamic properties of classical systems.</p> <p><b>CLO 402.3:</b> Analyze quantum statistical systems using Fermi-Dirac and Bose-Einstein statistics and their applications.</p> <p><b>CLO 402.4:</b> Employ cluster expansion and virial methods to study interacting gases and equations of state.</p> <p><b>CLO 402.5:</b> Interpret phase transitions, critical phenomena, fluctuations, and correlations in many-particle systems.</p> |           |               |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Practical | Total         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0         | 4             |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 0         | 4             |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 30                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 0         | 30            |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 0         | 70            |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 100                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0         | 100           |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |               |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |               |
| <p><b>Instructions for Paper- Setter:</b> The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |               |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           | Contact Hours |



|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |    |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| I   | <b>Foundations of Statistical Mechanics:</b> The macroscopic and microscopic states, Postulate of equal a priori probability, Contact between statistics and thermodynamics, Entropy of mixing and the Gibbs paradox, Sackur-Tetrode equation; Ensemble theory: Concept of ensemble, Phase space, Density function, Ensemble average, Liouville's theorem, Stationary ensemble; The microcanonical ensemble, Application to the classical ideal gas; The canonical ensemble, Canonical partition function, Thermodynamics of a system of non-interacting classical harmonic oscillators and magnetic system using canonical ensemble, Calculation of statistical quantities                                                                                                                                                                                                                                                       | 15 |
| II  | <b>Classical Ensembles:</b> The Grand canonical ensemble and grand canonical partition function, Calculation of statistical quantities, Thermodynamics of a system of classical ideal gas using grand canonical ensemble, Energy and density fluctuations; Quantum-mechanical ensemble theory: Density matrix, Equation of motion for density matrix, Quantum-mechanical ensemble average; Statistics of indistinguishable particles, Two types of quantum statistics- Fermi-Dirac and Bose-Einstein statistics, Fermi-Dirac and Bose-Einstein distribution functions using microcanonical and grand canonical ensembles (ideal gas only), Statistics of occupation numbers; Ideal Bose gas: Internal energy, Equation of state, Bose-Einstein Condensation and its critical conditions; Bose-Einstein condensation in ultra-cold atomic gases: its detection and thermodynamic properties; Black body radiations, liquid Helium. | 15 |
| III | <b>Quantum Ensembles and Interacting systems:</b> Ideal Fermi gas: Internal energy, Equation of state, Completely degenerate Fermi gas, electron gas in metals, thermionic emission; Cluster expansion method for a classical gas, Simple cluster integrals, Mayer-Ursell relations, Virial expansion of the equation of state, Van der Waal's equation, Validity of cluster expansion method.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 15 |
| IV  | <b>Phase transitions:</b> Construction of Ising model, Solution of Ising model in the Bragg-William approximation; Critical exponents, Landau theory of phase transition, Scaling hypothesis; One and two-dimensional Ising model; Thermodynamic fluctuations and their probability distribution law, Spatial correlations in a fluid, Connection between density fluctuations and spatial correlations; Brownian motion.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 15 |

#### Suggested Evaluation Methods

| Internal Assessment: 30                                 |    | End Term Examination: 70 |    |
|---------------------------------------------------------|----|--------------------------|----|
| ➤ Theory                                                | 30 | ➤ Theory:                | 70 |
| • Class Participation:                                  | 5  | Written Examination      |    |
| • Seminar/presentation/assignment/quiz/class test etc.: | 10 |                          |    |
| • Mid-Term Exam:                                        | 15 |                          |    |

#### Part C-Learning Resources

1. Statistical Mechanics by R. K. Pathria (2<sup>nd</sup> edition)
2. Statistical Mechanics by R. K. Pathria and P. D. Beale (3<sup>rd</sup> edition)
3. Statistical and Thermal Physics by F. Reif
4. Statistical Mechanics by K. Huang
5. Statistical Mechanics by L. D. Landau and I. M. Lifshitz
6. Statistical Mechanics by R. Kubo
7. Electronic Structure: Basic Theory and Practical Methods by Richard M. Martin.
8. Density Functional Theory: A Practical Introduction by David S. Sholl and Janice A. Steckel.
9. Understanding Molecular Simulation: From Algorithms to Applications by Daan Frenkel and Berend Smit.
10. Materials Informatics by Krishna Rajan.

*[Signature]*

*[Signature]*

*[Checkmark]*



| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |       |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------|
| Part A - Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |       |
| Name of the Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |       |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 4 <sup>th</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |       |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Condensed Matter Physics-II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |       |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 25PN-PHY-403CM                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |       |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | DEC-5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |       |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |       |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |       |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                   | <p><b>CLO 403CM.1:</b> Analyze electron transport in solids using semi-classical band theory, scattering mechanisms, relaxation time approximation, and Boltzmann transport formalism.</p> <p><b>CLO 403CM.2:</b> Explain electrical and thermal transport phenomena in metals and semiconductors, including conductivity, resistivity, thermoelectric effects, and the Wiedemann–Franz law.</p> <p><b>CLO 403CM.3:</b> Describe the physical principles governing low-dimensional and nanoscale systems, including quantum confinement, reduced-dimensional density of states, conductance quantization, resonant tunneling, and Coulomb blockade effects.</p> <p><b>CLO 403CM.4:</b> Interpret the electronic structure of interacting electron systems using Hartree and Hartree–Fock approximations, self-consistent field methods, exchange interactions, and screening phenomena in electron gases.</p> <p><b>CLO 403CM.5:</b> Apply modern computational approaches such as Density Functional Theory (DFT), molecular dynamics, and Monte Carlo methods to investigate the electronic and structural properties of condensed matter systems.</p> <p><b>CLO 403CM.6:</b> Evaluate the role of computational materials science, materials informatics, machine learning, and artificial intelligence in accelerating materials discovery and predicting material properties.</p> |           |       |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Practical | Total |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 1         | 4     |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 2         | 5     |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 20                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 10        | 30    |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 50                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 20        | 70    |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 30        | 100   |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |       |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |       |
| <b>Instructions for Paper- Setter:</b> The examiner will set 7 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 4 parts covering entire syllabus (4x2 = 08 Marks). The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 4 questions; selecting one question from each unit and the |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |       |

compulsory question. All questions (except compulsory question) will carry equal marks.

| Unit | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Contact Hours |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| I    | <p><b>Semi-classical Electron Dynamics:</b> Motion of electrons in energy bands, Effective mass tensor, Electron velocity and acceleration in bands, Holes and current transport, Elastic scattering, Inelastic scattering, Electron-electron scattering, Relaxation time approximation</p> <p><b>Boltzmann Transport Theory:</b> Boltzmann transport equation, Linearized Boltzmann equation, Electrical conductivity of metals, Temperature dependence of resistivity, Matthiessen's rule</p> <p><b>Thermoelectric Phenomena:</b> Seebeck effect, Peltier effect, Thomson effect, Thermopower, Wiedemann-Franz law, Thermoelectric materials and applications</p>                                                                                                                                                                                                                             | 12            |
| II   | <p><b>Nanostructures:</b> Classification and synthesis of nanostructures (overview), Quantum confinement, Density of states in reduced dimensions</p> <p><b>Characterization Techniques (Principles):</b> Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), Optical Microscopy, Scanning Tunneling Microscopy (STM), Atomic Force Microscopy (AFM)</p> <p><b>One-Dimensional Systems:</b> One-dimensional sub-bands, Van Hove singularities, Coulomb interactions in 1D metals, Lattice coupling effects, Conductance quantization, Landauer formula, Resonant tunneling, Localization and coherence effects, Ohm's law from incoherent addition</p> <p><b>Zero-Dimensional Systems (Quantum Dots):</b> Quantized energy levels, Semiconductor quantum dots, Metallic quantum dots, Optical spectra of quantum dots, Charging energy, Coulomb blockade phenomenon</p> | 12            |
| III  | <p><b>Many-Electron Hamiltonian:</b> Electronic and ionic contributions, Born-Oppenheimer approximation, Electron-electron interactions</p> <p><b>Hartree Theory:</b> Hartree equations, Self-consistent field concept, Variational principle and Hartree approximation, Hartree-Fock Approximation: Exchange interaction, Hartree-Fock equations, Hartree-Fock theory of free electron gas, One-electron energy, Bandwidth and density of states, Effective mass, Ground-state energy, Exchange energy, Correlation energy (concept only)</p> <p><b>Screening in Electron Gas:</b> Dielectric function, Thomas-Fermi screening, Lindhard response function, Lindhard screening theory, Friedel oscillations, Frequency-dependent screening (qualitative)</p>                                                                                                                                   | 18            |
|      | <p><b>Practical</b></p> <ol style="list-style-type: none"> <li>1. Study of Temperature Dependence of Electrical Resistivity</li> <li>2. Determination of the Seebeck Coefficient of a Thermocouple/Thermoelectric Material</li> <li>3. Verification of Wiedemann-Franz Law</li> <li>4. Density of States in Different Dimensions.</li> <li>5. Analysis of SEM Images</li> <li>6. Analysis of TEM Images</li> <li>7. Study of Quantum Confinement in Quantum Dots</li> <li>8. Analysis of XRD Data of Nanomaterials</li> <li>9. Study of Conductance Quantization Using Simulation</li> <li>10. Study of Optical Spectra of Quantum Dots or Nanomaterials</li> </ol>                                                                                                                                                                                                                             | 30            |

|                                                                                                                                           |    |                                                                |    |
|-------------------------------------------------------------------------------------------------------------------------------------------|----|----------------------------------------------------------------|----|
| Note: Student will perform at least four experiments. The examiner will allot one Practicum at the time of end term examination.          |    |                                                                |    |
| Suggested Evaluation Methods                                                                                                              |    |                                                                |    |
| Internal Assessment: 30                                                                                                                   |    | End Term Examination: 70                                       |    |
| ➤ Theory                                                                                                                                  | 20 | ➤ Theory:                                                      | 50 |
| • Class Participation:                                                                                                                    | 5  | Written Examination                                            |    |
| • Seminar/presentation/assignment/quiz/class test etc.:                                                                                   | 5  |                                                                |    |
| • Mid-Term Exam:                                                                                                                          | 10 |                                                                |    |
| ➤ Practicum                                                                                                                               | 10 | ➤ Practicum:                                                   | 20 |
| • Class Participation:                                                                                                                    | -- | Lab record, Viva-Voce, write-up and execution of the practical |    |
| • Seminar/Demonstration/Viva-voce/Lab records etc.:                                                                                       | 10 |                                                                |    |
| Part C-Learning Resources                                                                                                                 |    |                                                                |    |
| 1. Introduction to solid state Physics, 7 <sup>th</sup> Edition by Charles Kittel                                                         |    |                                                                |    |
| 2. Solid State Physics by Neil W. Ashcroft and N. David Mermin                                                                            |    |                                                                |    |
| 3. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth                                                  |    |                                                                |    |
| 4. Principles of the Theory of Solids (2nd edition) by J. M. Ziman                                                                        |    |                                                                |    |
| 5. Condensed Matter Physics by Michael P. Marder                                                                                          |    |                                                                |    |
| 6. Advanced Solid State Physics by P. Phillips                                                                                            |    |                                                                |    |
| 7. Semiconductor Physics and Devices by Donald A. Neamen.                                                                                 |    |                                                                |    |
| 8. Optical Properties of Solids by Mark Fox.                                                                                              |    |                                                                |    |
| 9. Principles and Applications of Ferroelectrics and Related Materials by M. E. Lines and A. M. Glass.                                    |    |                                                                |    |
| 10. Electronic Transport in Mesoscopic Systems by Supriyo Datta.                                                                          |    |                                                                |    |
| 11. Magnetism in Condensed Matter by Stephen Blundell.                                                                                    |    |                                                                |    |
| 12. Nanostructures and Nanotechnology by Douglas Natelson. Electronic Structure: Basic Theory and Practical Methods by Richard M. Martin. |    |                                                                |    |
| 13. Density Functional Theory: A Practical Introduction by David S. Sholl and Janice A. Steckel.                                          |    |                                                                |    |
| 14. Understanding Molecular Simulation: From Algorithms to Applications by Daan Frenkel and Berend Smit.                                  |    |                                                                |    |
| 15. Materials Informatics by Krishna Rajan.                                                                                               |    |                                                                |    |



| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A - Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |               |
| Name of the Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |               |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 4 <sup>th</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |               |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Electronics-II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |               |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 25PN-PHY-403EC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |               |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | DEC-5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |               |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |               |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |               |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <p><b>CLO 403EC.1:</b> Understand the fundamentals of digital electronics, distinguish between analog and digital signals, and perform conversions.</p> <p><b>CLO 403EC.2:</b> Design and analyze combinational logic circuits using basic digital building blocks.</p> <p><b>CLO 403EC.3:</b> Design and analyze sequential logic circuits using basic digital building blocks.</p> <p><b>CLO 403EC.4:</b> Analyze the operation of flip-flops, registers, and counters, and apply sequential logic concepts in the design of digital systems.</p> <p><b>CLO 403EC.5:</b> Understand the architecture and operation of the 8085 microprocessor.</p> <p><b>CLO 403EC.6:</b> Understand the perform memory and I/O interfacing, and develop simple assembly language programs for various applications by using 8085 microprocessor.</p> |           |               |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Practical | Total         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1         | 4             |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 2         | 5             |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 20                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 10        | 30            |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 50                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 20        | 70            |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 30        | 100           |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |               |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |               |
| <b>Instructions for Paper- Setter:</b> The examiner will set 7 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 4 parts covering entire syllabus (4x2= 08 Marks). The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions (except compulsory question) will carry equal marks. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |               |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           | Contact Hours |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |    |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| I   | <b>Number system and Combinational circuits:</b> Digital signals, properties of digital signal: switching time, time period and frequency, duty cycle, difference between analog signal and digital signals. Number system: types of number system (binary, octal, decimal, and hexadecimal), conversion between different number systems, complement of a number system, Binary coded decimal (BCD), Binary to gray and gray to binary conversion. Half adder, full adder, Half-subtractor, Full subtractor, multiplexer, De-multiplexer, Encoder, Decoder, Comparator, Parity checker and generator.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 15 |
| II  | <b>Sequential circuits:</b> Flip-Flops (FF): RS latch, clocked RS flip-flop, J-K flip-flop, race around condition in J-K flip-flop, T-FF, D-FF, Characteristics equations for flip-flops, Master slave flip-flop. Registers: Shift registers and its applications. Counters: Parameters (mode, time period, frequency, and duty cycle), types of counter: asynchronous, synchronous.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 15 |
| III | <b>Microprocessor 8085:</b> Buffer registers, Bus organized computers, Microprocessor ( $\mu$ P) 8085 Architecture, memory interfacing, interfacing I/O devices. Assembly language programming: Instruction classification, op code and operand, fetch and execute cycle, timing diagram, machine cycle, instruction cycle and T states, Data transfer, logic and branch operations- Programming examples.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 15 |
| IV  | <b>Practical</b> <ol style="list-style-type: none"> <li>To study and Verify basic logic gates (AND, OR, NOT, NAND, NOR, XOR, XNOR).</li> <li>Design and verify a Half Adder.</li> <li>Design and verify a Full Adder.</li> <li>Design and verify a Half Subtractor.</li> <li>Design and verify a Full Subtractor.</li> <li>Verify operation of SR Flip-Flop.</li> <li>Verify operation of JK Flip-Flop.</li> <li>Verify operation of D Flip-Flop.</li> <li>Verify operation of T Flip-Flop.</li> <li>Write an 8085 program to add two 8-bit numbers.</li> <li>Write an 8085 program to add two 16-bit numbers.</li> <li>Write an 8085 program to subtract two 8-bit numbers.</li> <li>Write an 8085 program to multiply two 8-bit numbers using repeated addition.</li> <li>Write an 8085 program to divide two 8-bit numbers using repeated subtraction.</li> <li>Write an 8085 program to find the 1's complement and 2's complement of a number.</li> </ol> <p><b>Note:</b> Student will perform at least four experiments. The examiner will allot one Practicum at the time of end term examination.</p> | 30 |

#### Suggested Evaluation Methods

| Internal Assessment: 30                                 |    | End Term Examination: 70            |    |
|---------------------------------------------------------|----|-------------------------------------|----|
| ➤ Theory                                                | 20 | ➤ Theory:                           | 50 |
| • Class Participation:                                  | 5  | Written Examination                 |    |
| • Seminar/presentation/assignment/quiz/class test etc.: | 5  |                                     |    |
| • Mid-Term Exam:                                        | 10 |                                     |    |
| ➤ Practicum                                             | 10 | ➤ Practicum:                        | 20 |
| • Class Participation:                                  | -- | Lab record, Viva-Voce, write-up and |    |

|                                                     |                                                                                        |                            |
|-----------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------|
| • Seminar/Demonstration/Viva-voce/Lab records etc.: | 10                                                                                     | execution of the practical |
| <b>Part C-Learning Resources</b>                    |                                                                                        |                            |
| 1.                                                  | Microprocessor Architecture, Programming and Applications with 8085, R.S. Gaonkar, PHI |                            |
| 2.                                                  | Electronic Devices and Circuits Theory, Robert Boylested and Louis Nashelsky,          |                            |
| 3.                                                  | Integrated Electronics by J. Millman and C.C Halkias (Tata – McGraw Hill)              |                            |
| 4.                                                  | Fundamentals of electronics by J. D. Ryder (Prentice Hall Publication)                 |                            |
| 5.                                                  | Fundamentals of Microprocessor and Microcomputer : B. Ram.                             |                            |
| 6.                                                  | Microprocessor System the 8086/8088 Family : Liu and Gibson.                           |                            |
| 7.                                                  | Microprocessor Architecture Programming and Application : R.S. Goanker.                |                            |
| 8.                                                  | Introduction to microprocessor: A.P. Mathur.                                           |                            |

| Session: 2025-26                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |       |
|----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------|
| Part A - Introduction                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |       |
| Name of the Programme                                                                        | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |       |
| Semester                                                                                     | 4 <sup>th</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |       |
| Name of the Course                                                                           | Computational Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |       |
| Course Code                                                                                  | 25PN-PHY-404CP                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |           |       |
| Course Type                                                                                  | DEC-6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |       |
| Level of the course                                                                          | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |       |
| Pre-requisite for the course (if any)                                                        | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |       |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to: | <p><b>CLO 404CP.1:</b> Explain the sources of numerical errors and apply numerical methods for differentiation, integration, interpolation, and curve fitting.</p> <p><b>CLO 404CP.2:</b> Apply numerical techniques to solve algebraic equations and ordinary differential equations encountered in physical systems.</p> <p><b>CLO 404CP.3:</b> Employ matrix methods to solve systems of linear equations and determine eigenvalues and eigenvectors of matrices.</p> <p><b>CLO 404CP.4:</b> Develop computational models and simulations of selected physical systems using numerical techniques.</p> <p><b>CLO 404CP.5:</b> Demonstrate proficiency in scientific programming using Fortran for solving physics and mathematical problems.</p> |           |       |
| Credits                                                                                      | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Practical | Total |
|                                                                                              | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 1         | 4     |
| Teaching Hours per week                                                                      | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 2         | 5     |
| Internal Assessment Marks                                                                    | 20                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 10        | 30    |



|                     |         |    |     |
|---------------------|---------|----|-----|
| End Term Exam Marks | 50      | 20 | 70  |
| Max. Marks          | 70      | 30 | 100 |
| Examination Time    | 3 hours |    |     |

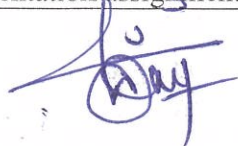
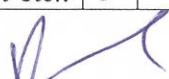
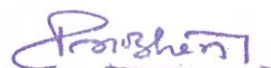
### Part B-Contents of the Course

**Instructions for Paper- Setter:** The examiner will set 7 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 4 parts covering entire syllabus ( $4 \times 2 = 08$  Marks). The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 4 questions; selecting one question from each unit and the compulsory question. All questions (except compulsory question) will carry equal marks.

| Unit | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Contact Hours |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| I    | <b>Interpolation and extrapolation:</b> Finite difference operators, forward difference, backward difference, central differences.<br><b>Differentiation:</b> Numerical differentiation using Newton's forward difference formula, Backward difference formula.<br><b>Integration:</b> Trapezoidal rule, Simpson's 1/3 and 3/8 rule, Gauss-Legendre quadrature method.<br><b>Curve Fitting:</b> Error, type of Errors, Propagation of errors, Least-square curve fitting, straight line and polynomial fits.                                                                                                                                                                                                                                                                                                                     | 15            |
| II   | <b>Numerical solution of ordinary differential equations:</b> Euler's method, modified Euler's method, Taylor's series method, Forth-order Runge Kutta method, Picard's method.<br><b>Solution of simultaneous linear equations:</b> Gaussian Elimination method, Pivoting, Gauss Jordan elimination method, Matrix inversion, Eigen values and Eigen vectors: Jacobi's method for symmetric matrix.                                                                                                                                                                                                                                                                                                                                                                                                                             | 15            |
| III  | <b>Computer fundamentals and programming with fortran</b><br><b>Basic computer organization:</b> Input and output units, Storage unit, Arithmetic Logic unit, Control unit, Central processing unit.<br><b>Fortran programming:</b> Compilers, interpreters, Integer and Floating point arithmetic; Fortran variables; Real and Integer variables, Data types, Arithmetic & logical expression, Input-output statements, control statements, Do loop, Arrays and subscripted variables, functions and subroutines.                                                                                                                                                                                                                                                                                                               | 15            |
|      | <b>Practical</b> <ol style="list-style-type: none"> <li>1. Numerical Integration.</li> <li>2. Numerical Differentiation.</li> <li>3. Propagation of error.</li> <li>4. Least Square fitting (Linear and Non-linear).</li> <li>5. Solution of ordinary differential equation using Taylor's series method.</li> <li>6. Solution of ordinary differential equation using Runge-Kutta method.</li> <li>7. Solution of ordinary differential equation using Euler's method.</li> <li>8. Solution of Simultaneous Linear Algebraic equations by Gauss-Jordan elimination method.</li> <li>9. Finding eigenvalues and eigenvectors of square matrices using Jacobi's method.</li> </ol> <p><b>Note:</b> Student will perform at least Four experiments. The examiner will allot one Practicum at the time of end term examination.</p> | 30            |

### Suggested Evaluation Methods

| Internal Assessment: 30                                 |    | End Term Examination: 70 |    |
|---------------------------------------------------------|----|--------------------------|----|
| ➤ Theory                                                | 20 | ➤ Theory:                | 50 |
| • Class Participation:                                  | 5  | Written Examination      |    |
| • Seminar/presentation/assignment/quiz/class test etc.: | 5  |                          |    |

|                                                                                            |           |                                                                |           |
|--------------------------------------------------------------------------------------------|-----------|----------------------------------------------------------------|-----------|
| • Mid-Term Exam:                                                                           | 10        |                                                                |           |
| ➤ <b>Practicum</b>                                                                         | <b>10</b> | ➤ <b>Practicum:</b>                                            | <b>20</b> |
| • Class Participation:                                                                     | --        | Lab record, Viva-Voce, write-up and execution of the practical |           |
| • Seminar/Demonstration/Viva-voce/Lab records etc.:                                        | 10        |                                                                |           |
| <b>Part C-Learning Resources</b>                                                           |           |                                                                |           |
| 1. Fortran Programming and Numerical Methods by R. C. Desai                                |           |                                                                |           |
| 2. Computer Applications in Physics by Suresh Chandra                                      |           |                                                                |           |
| 3. Fortran 77 and Numerical Methods by C. Xavier                                           |           |                                                                |           |
| 4. Introduction to Computational Physics by M. L. De Jong                                  |           |                                                                |           |
| 5. Computational Physics: An Introduction by R. C. Verma, P. K. Ahluwalia and K. C. Sharma |           |                                                                |           |
| 6. Introductory Methods of Numerical Analysis by S. S. Sastry                              |           |                                                                |           |
| 7. Computer Oriented Numerical Methods by V. Rajaraman                                     |           |                                                                |           |
| 8. Numerical Methods by C. Balachandra Rao and C. K. Santha                                |           |                                                                |           |

| Session: 2025-26                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |       |
|----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-------|
| Part A - Introduction                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |       |
| Name of the Programme                                                                        | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |       |
| Semester                                                                                     | 4 <sup>th</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |       |
| Name of the Course                                                                           | Thin Films and Sensors                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |       |
| Course Code                                                                                  | 25PN-PHY-404TS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |       |
| Course Type                                                                                  | DEC-6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |       |
| Level of the course                                                                          | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |       |
| Pre-requisite for the course (if any)                                                        | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |       |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to: | <p><b>CLO 404TS.1:</b> Understand the significance, applications, and growth mechanisms of thin films and nanostructured materials.</p> <p><b>CLO 404TS.2:</b> Explain the principles of thin-film deposition, coating technologies, and nanotechnology.</p> <p><b>CLO 404TS.3:</b> Compare various coating and deposition techniques and select suitable methods for specific applications.</p> <p><b>CLO 404TS.4:</b> Apply thin-film deposition and synthesis techniques for the development of advanced materials and coatings.</p> <p><b>CLO 404TS.5:</b> Analyze the design requirements, industrial applications, and emerging research trends in thin-film and coating technologies.</p> |           |       |
| Credits                                                                                      | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Practical | Total |



|                           |         |   |     |
|---------------------------|---------|---|-----|
|                           | 4       | 0 | 4   |
| Teaching Hours per week   | 4       | 0 | 5   |
| Internal Assessment Marks | 30      | 0 | 30  |
| End Term Exam Marks       | 70      | 0 | 70  |
| Max. Marks                | 100     | 0 | 100 |
| Examination Time          | 3 hours |   |     |

### Part B-Contents of the Course

**Instructions for Paper- Setter:** The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 7 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions will carry equal marks.

| Unit | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Contact Hours |
|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| I    | <b>Thin Film Science and basic components:</b> Definition and importance of thin films; classification of thin films; nucleation and growth processes; Film growth modes; Surface energy, adhesion, and wettability; Bottom-up approach vs Top-down approach; vacuum chambers; valves; seals: o-rings, metal seals; substrate: purpose, selection, preparation; Mask: purpose, selection, preparation; thickness measurements.                                                                                                                                                                                                                                                                                                       | 15            |
| II   | <b>Vacuum science, pumping systems, and gauges:</b> Definition and importance of vacuum in science and industry, gas laws and kinetic theory; Vacuum pumps: rotary vane pump, diffusion pump, turbo-molecular pumps, ion pump, Cryopump – their operating principles and design; vacuum measurement and gauges: pirani gauge (thermal conductivity gauge), thermocouple gauge, ionization gauge (penning gauge).                                                                                                                                                                                                                                                                                                                     | 15            |
| III  | <b>Thin Film Deposition Techniques:</b> Physical Deposition Techniques: Thermal evaporation, Flash evaporation, Electron beam evaporation, Sputtering (DC and RF), Molecular beam epitaxy (MBE), Pulsed laser deposition; Chemical Deposition Techniques: Chemical vapor deposition (CVD), Plasma-enhanced CVD, Atomic layer deposition (ALD), Sol-gel, Spray pyrolysis, Dip Coatings, Spin Coatings.                                                                                                                                                                                                                                                                                                                                | 15            |
| IV   | <b>Emerging Trends and Applications of Thin films:</b> Overview of emerging trends and applications of thin films as Optical coatings: Antireflection coatings, High-reflectivity coatings, Optical filters; Thin Films for Energy Applications: Thin-film photovoltaics, Perovskite solar cells, Transparent conducting oxides, Thin film thermoelectric devices, Thin Film Energy storage devices; Thin Films in Optoelectronics: Flat Panel Displays, LEDs, Photodetectors; Flexible and wearable thin Film; Thin Film Sensors: Gas sensors, Humidity sensors, temperature sensors; Protective coatings: Corrosion-resistant coatings; Wear-resistant coatings; Thermal barrier coatings; Hydrophobic and Self-Cleaning Coatings. | 15            |

### Suggested Evaluation Methods

| Internal Assessment: 30                                 |    | End Term Examination: 70 |    |
|---------------------------------------------------------|----|--------------------------|----|
| ➤ Theory                                                | 30 | ➤ Theory:                | 70 |
| • Class Participation:                                  | 5  | Written Examination      |    |
| • Seminar/presentation/assignment/quiz/class test etc.: | 5  |                          |    |
| • Mid-Term Exam:                                        | 15 |                          |    |



### Part C-Learning Resources

1. Thin Film Technology Handbook by Elshabini-Riad, A. A. R. and Barlow III, F. D.
2. Thin-Film Deposition: Principles and Practice by Smith, D. L.
3. Handbook of Deposition Technologies for Films and Coatings by Bunshah, R. F. (Ed.)
4. Thin Films and Coatings by Zhang, S.
5. The World of Thin Film Coatings by Basu, A.
6. Vacuum Technology by Roth, A.
7. Thin Film Phenomena by Chopra, K. L.
8. Nanostructures and Nanomaterials: Synthesis, Properties and Applications by Cao, G.
9. Optical Processes in Semiconductors by Pankove, J. I.
10. Handbook of Modern Sensors: Physics, Designs, and Applications by Fraden, J.
11. Sensors and Transducers by Patranabis, D.
12. Handbook of Deposition Technologies for Films and Coatings by Bunshah, R. F. (Ed.)
13. Materials Science of Thin Films: Deposition and Structure by Ohring, M.
14. Thin-Film Deposition: Principles and Practice by Smith, D. L.
15. Thin Film Processes II by Hoffmann, A. and Singh, M.
16. Handbook of Physical Vapor Deposition (PVD) Processing by Mattox, D. M.
17. Principles of Electronic Materials and Devices by Kasap, S. O.
18. Handbook of Thin Film Technology by Maissel, L. I. and Glang, R. (Eds.)
19. Solid State Electronic Devices by Streetman, B. G. and Banerjee, S. K.
20. • Thin Film Processes by Vossen, J. L. and Kern, W. (Eds.)

### Session: 2025-26

#### Part A-Introduction

|                                       |                                    |
|---------------------------------------|------------------------------------|
| Name of Programme                     | M. Sc. Physics                     |
| Semester                              | 4 <sup>th</sup>                    |
| Name of the Course                    | Experimental Techniques in Physics |
| Course Code                           | 25PN-PHY-405ET                     |
| Course Type                           | DEC-7                              |
| Level of the course                   | 500-599                            |
| Pre-requisite for the course (if any) | --                                 |



|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |                      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|----------------------|
| Course Learning Outcomes (CLOs)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>CLO 405ET.1:</b> Explain the working principles and applications of advanced experimental techniques such as X-ray diffraction (XRD), electron microscopy (TEM), photoluminescence, FTIR, and Raman spectroscopy for the characterization of materials.<br><b>CLO 405ET.2:</b> Analyze surface and structural properties of materials using surface analytical techniques including XPS, AES, EXAFS, NEXAFS, SIMS, RBS, and LEED.<br><b>CLO 405ET.3:</b> Apply statistical and computational methods for data analysis, including error analysis, least-squares fitting, curve fitting, chi-square testing, and modulation techniques.<br><b>CLO 405ET.4:</b> Describe the principles and applications of advanced spectroscopic and scanning probe techniques such as ESR, NMR, STM, AFM, and STS for material characterization.<br><b>CLO 405ET.5:</b> Perform, analyze, and interpret experimental data obtained from characterization techniques and optoelectronic device studies using appropriate software tools and scientific methodologies. |           |                      |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Practical | Total                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 1         | 4                    |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 2         | 5                    |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 20                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 10        | 30                   |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 50                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 20        | 70                   |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 30        | 100                  |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |                      |
| <b>Part B-Contents of the Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |                      |
| <b>Instructions for Paper- Setter:</b> The examiner will set 7 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus (4x2 =08 Marks). The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory question. All questions (except compulsory question) will carry equal marks. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |                      |
| <b>Unit</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Topics</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           | <b>Contact Hours</b> |
| I                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Experimental Techniques to observe the defects in Lattice:</b> Electron Microscopy: Transmission Electron Microscope (TEM), Secondary Electron Microscope (SEM) and X-ray Diffraction Technique, Experimental methods of observing dislocations and stacking faults.<br><b>Optical Techniques:</b> Photo Luminescence, FTIR and Raman Spectroscopic techniques.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           | 15                   |
| II                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Data Interpretation and Analysis:</b> Precision and Accuracy, Error Analysis, Propagation of Errors.<br><b>Curve fitting:</b> Least Squares fitting. Linear and Non-linear curve fitting, Chi-square test.<br><b>Modulation Techniques:</b> Amplitude Modulation, Frequency Modulation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           | 15                   |
| III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Surface Analytical Techniques:</b> Electron Spectroscopies-Auger, XPS (ESCA), UV-photo emission, Secondary Ion Mass Spectroscopy (SIMS), Rutherford Back Scattering (RBS)<br><b>Spectroscopic and Scanning Probe Techniques:</b> Detailed study of spectroscopic techniques: ESR(electron spin resonance) and NMR.<br><b>Scanning Probe Techniques:</b> STM (Scanning Tunneling Microscopy), AFM (Atomic Force Microscopy), STS (Scanning Tunneling Spectroscopy)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           | 15                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Practical</b><br>1. Study of propagation of errors and uncertainty analysis in experimental measurements.<br>2. Least-squares fitting and curve fitting of non-linear data.<br>3. Determination of resonance frequency using Electron Spin Resonance (ESR) spectroscopy.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |           | 30                   |



|                                                                                                                                         |                                                                                                      |  |
|-----------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|--|
| 4.                                                                                                                                      | Analysis of Scanning Electron Microscope (SEM) images using open-source software tools.              |  |
| 5.                                                                                                                                      | Study of amplitude modulation (AM) and frequency modulation (FM), and their demodulation techniques. |  |
| 6.                                                                                                                                      | Analysis and interpretation of Nuclear Magnetic Resonance (NMR) spectral data.                       |  |
| 7.                                                                                                                                      | Analysis of photoluminescence (PL) spectra for material characterization.                            |  |
| 8.                                                                                                                                      | Analysis of UV-Visible absorption spectra and determination of optical properties.                   |  |
| 9.                                                                                                                                      | Identification and analysis of crystal defects using microscopy techniques.                          |  |
| 10.                                                                                                                                     | Measurement of temperature-dependent Hall coefficient of a semiconductor sample.                     |  |
| <b>Note: Student will perform at least four experiments. The examiner will allot one Practicum at the time of end term examination.</b> |                                                                                                      |  |

#### Suggested Evaluation Methods

| Internal Assessment: 30                                 |    | End Term Examination: 70                                       |    |
|---------------------------------------------------------|----|----------------------------------------------------------------|----|
| ➤ Theory                                                | 20 | ➤ Theory:                                                      | 50 |
| • Class Participation:                                  | 05 | Written Examination                                            |    |
| • Seminar/presentation/assignment/quiz/class test etc.: | 05 |                                                                |    |
| • Mid-Term Exam:                                        | 10 |                                                                |    |
| ➤ Practical:                                            | 10 | ➤ Practical:                                                   | 20 |
| • Class Participation:                                  | -- | Lab record, Viva-Voce, write-up and execution of the practical |    |
| • Seminar/Demonstration/Viva-voce/Lab records etc.:     | 10 |                                                                |    |

#### Part C-Learning Resources

##### Recommended Books/e-resources/LMS:

1. Crystal Growth and Characterization by R. Ueda and J.B. Mullin
2. Experimental Techniques of Surface Science by Woodruff and Delchar
3. Solid State Physics by Ibach and Luth
4. Solid Surfaces by Ibach
5. Physics at Surfaces by Zangwill
6. Solid State Physics by Puri&Babbar
7. X-ray Crystallography by Azaroff

*[Signature]*

*[Signature]*

*[Signature]*



| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|--------------|
| Part A - Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |              |
| Name of the Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |              |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 4 <sup>th</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |              |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Fundamentals of Energy Systems and Clean Power                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |              |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 25PN-PHY-405FE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |           |              |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | DEC-7                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |              |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |              |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |              |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <p><b>CLO 405FE.1:</b> Explain the fundamentals of energy, energy conversion, and conventional and renewable energy resources.</p> <p><b>CLO 405FE.2:</b> Analyze the principles, characteristics, and performance of electrochemical batteries and energy storage systems.</p> <p><b>CLO 405FE.3:</b> Evaluate the operation, materials, and applications of supercapacitors and hybrid energy storage technologies.</p> <p><b>CLO 405FE.4:</b> Explain the electrochemical principles, types, and applications of fuel cells and hydrogen-based energy systems.</p> <p><b>CLO 405FE.5:</b> Analyze various energy harvesting mechanisms and their applications in sustainable energy technologies.</p> <p><b>CLO 405FE.6:</b> Assess integrated energy conversion, storage, and harvesting systems for modern applications such as electric vehicles, smart grids, and IoT devices.</p> |           |              |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Practical | Total        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 1         | 4            |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 2         | 5            |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 20                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 10        | 30           |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 50                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 20        | 70           |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 70                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 30        | 100          |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 3 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |           |              |
| Part B-Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |              |
| <b>Instructions for Paper- Setter:</b> The examiner will set 7 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of 4 parts covering entire syllabus (4x2 = 08 marks). The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 4 questions; selecting one question from each unit and the compulsory question. All questions (except compulsory question) will carry equal marks. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |              |
| Unit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Topics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           | Contact Hour |

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |    |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| I   | <b>Fundamentals of Energy and Energy Resources:</b> Energy and power: concepts and units, Global energy demand and sustainability, Energy conversion and efficiency, Exergy and energy quality, Environmental impact of energy utilization, Conventional Energy Sources: Fossil fuels and thermal power plants, Nuclear energy and nuclear reactors, Environmental issues and carbon emissions, Renewable Energy Sources: Solar energy, Wind energy, Hydropower, Biomass energy, Geothermal and ocean energy                                                                                                                                                                                                                                                                                                                                                                   | 15 |
| II  | <b>Energy Storage Technologies:</b> Electrochemical Batteries, Fundamentals of electrochemical energy storage, Cell voltage and thermodynamics, Electrode-electrolyte interfaces, Primary and secondary batteries, Lead-acid batteries, Nickel-Cadmium and Nickel-Metal Hydride batteries, Lithium-ion batteries, Lithium-polymer batteries, Solid-state batteries, Battery charging and discharging characteristics, Battery management systems (BMS), Safety issues and thermal runaway<br><b>Supercapacitors:</b> Fundamentals of capacitors and energy storage, Electric double-layer capacitors (EDLCs), Pseudocapacitors, Hybrid supercapacitors, Materials for supercapacitors, Activated carbon, Graphene, Carbon nanotubes, Metal oxides, Energy density and power density, Ragone plots. Applications in electric vehicles and grid storage, Hybrid Storage Systems. | 15 |
| III | <b>Fuel Cells and Energy Harvesting Technologies:</b> Fuel Cells, Fundamentals of fuel cells, Electrochemical principles, Thermodynamics and efficiency, Hydrogen economy, <b>Types of Fuel Cells:</b> Proton Exchange Membrane Fuel Cell (PEMFC), Alkaline Fuel Cell (AFC), Phosphoric Acid Fuel Cell (PAFC), Molten Carbonate Fuel Cell (MCFC), Solid Oxide Fuel Cell (SOFC), Fuel Cell Components: Electrodes, Electrolytes, Catalysts, Bipolar plates, Fuel Cell Applications: Transportation, Portable electronics, Distributed power generation                                                                                                                                                                                                                                                                                                                          | 15 |
|     | Practical:<br><ol style="list-style-type: none"> <li>1. Charge-discharge characteristics of rechargeable batteries.</li> <li>2. Determination of capacitance and ESR of supercapacitors.</li> <li>3. Simulation of lithium-ion battery performance.</li> <li>4. Fabrication and testing of a simple microbial fuel cell.</li> <li>5. Characterization of PEM fuel cell efficiency.</li> <li>6. Piezoelectric energy harvesting experiment.</li> <li>7. Solar cell I-V curve measurement.</li> <li>8. MATLAB/Python simulation of hybrid battery-supercapacitor systems.</li> <li>9. Thermoelectric generator characterization.</li> <li>10. Design study of energy storage for electric vehicles.</li> </ol> <b>Note: Student will perform at least four experiments. The examiner will allot one Practicum at the time of end term examination.</b>                           | 30 |

#### Suggested Evaluation Methods

| Internal Assessment: 30                                 |    | End Term Examination: 70                                       |    |
|---------------------------------------------------------|----|----------------------------------------------------------------|----|
| ➤ Theory                                                | 20 | ➤ Theory:                                                      | 50 |
| • Class Participation:                                  | 5  | Written Examination                                            |    |
| • Seminar/presentation/assignment/quiz/class test etc.: | 5  |                                                                |    |
| • Mid-Term Exam:                                        | 10 |                                                                |    |
| ➤ Practical:                                            | 10 | ➤ Practical:                                                   | 20 |
| • Class Participation:                                  | -- | Lab record, Viva-Voce, write-up and execution of the practical |    |
| • Seminar/Demonstration/Viva-voce/Lab records etc.:     | 10 |                                                                |    |

#### Part C-Learning Resources

*[Signature]*

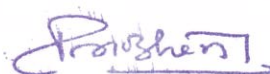
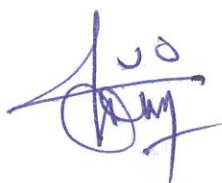
*[Signature]*

*[Signature]*



**Recommended Books/e-resources/LMS:**

1. Renewable Energy Resources by John Twidell and Tony Weir.
2. Energy Harvesting Technologies by Shashank Priya and Daniel J. Inman (Eds.).
3. Energy Storage by Robert A. Huggins.
4. Fuel Cell Fundamentals by Ryan O'Hayre et al.
5. Physics of Solar Cells by Peter Würfel.
6. Non-Conventional Energy Sources by G. D. Rai.
7. Renewable Energy Sources and Emerging Technologies by D. P. Kothari, K. C. Singal and Rakesh Ranjan.
8. Solar Energy: Fundamentals, Design, Modelling and Applications by G. N. Tiwari.
9. Renewable Energy Engineering and Technology by V. V. N. Kishore.
10. Electrochemical Supercapacitors: Scientific Fundamentals and Technological Applications by B. E. Conway.



| Session: 2025-26                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|---------------|
| Part A- Introduction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |               |
| Name of the Programme                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | M.Sc. Physics                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |               |
| Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 3 <sup>rd</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |               |
| Name of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Physics Lab-IV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |               |
| Course Code                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 25PN-PHY-406                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |               |
| Course Type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | PC-4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |           |               |
| Level of the course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 500-599                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |               |
| Pre-requisite for the course (if any)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | --                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |               |
| Course Learning Outcomes (CLO)<br>After completing this course, the learner will be able to:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>CLO 406.1:</b> Perform experiments to investigate thermal radiation, statistical phenomena, and transport processes.<br><b>CLO 406.2:</b> Apply computational techniques to simulate classical and quantum statistical systems.<br><b>CLO 406.3:</b> Utilize XRD, Raman, NMR, and ESR techniques for material characterization.<br><b>CLO 406.4:</b> Fabricate and characterize thin films using vacuum and coating techniques.<br><b>CLO 406.5:</b> Measure and analyze electrical, dielectric, thermal, and structural properties of materials.<br><b>CLO 406.6:</b> Interpret experimental data and communicate scientific results effectively. |           |               |
| Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Theory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Practical | Total         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 4         | 4             |
| Teaching Hours per week                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 8         | 8             |
| Internal Assessment Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 30        | 30            |
| End Term Exam Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 70        | 70            |
| Max. Marks                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 100       | 100           |
| Examination Time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 4 hours   |               |
| Part B – Contents of the Course                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |               |
| Practicals                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           | Contact Hours |
| <b>Note: Depending upon the area of specialization, the student shall perform at least eight experiments, including a minimum of three experiments from the General Experiments list. The examiner shall allot one practical experiment at the time of the End-Term Examination.</b><br>1.<br>2. Determination of Boltzmann Constant using PN Junction Diode Characteristics.<br>3. Study of Blackbody Radiation using Tungsten Filament Lamp.<br>4. Determination of Stefan–Boltzmann Constant.<br>5. Observation and Analysis of Brownian Motion of Microparticles.<br>6. Study of Thermionic Emission from a Vacuum Diode.<br>7. Simulation of Maxwell–Boltzmann Velocity Distribution.<br>8. Simulation of Fermi–Dirac and Bose–Einstein Distribution Functions.<br>9. Simulation of Random Walk and Brownian Motion.<br>10. Determination of Wavelength of X-rays and Verification of |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           | 120           |



|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |  |
|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
|  | <p>Bragg's Law.</p> <ol style="list-style-type: none"> <li>10. Recording and Analysis of Raman Spectrum of a Simple Molecule.</li> <li>11. Determination of Chemical Shift and Relaxation Times using NMR Spectroscopy.</li> <li>12. ESR Spectrum of DPPH and Determination of the g-Factor.</li> <li>13. Preparation of Thin Films by Thermal Vacuum Evaporation.</li> <li>14. Vacuum Measurement using Pirani Gauge and Rotary Pump Characteristics.</li> <li>15. Preparation of Thin Films by Spin Coating.</li> <li>16. Four-Probe Measurement of Thin Film Resistivity.</li> <li>17. Band Gap of a given semiconductor material using Four-Probe method.</li> <li>18. To study the conductivity of the given material by using two probe method.</li> <li>19. Lattice parameter and Miller Indices using XRD.</li> <li>20. To study the dielectric constant as a function of temperature and determine the Curie temperature.</li> <li>21. To determine the band gap using any open source software.</li> <li>22. To study the Lead Tin phase diagram.</li> <li>23. To study the modulus of rigidity and internal friction in metals as a function of temperature.</li> </ol> |  |
|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|

**Note:** Students will perform the laboratory experiments (Semester III and IV) prescribed for their chosen specialization/elective. The list of experiments and detailed procedures shall be as specified in the laboratory manual provided for the respective specialization.