CHAUDHARY BANSI LAL UNIVERSITY, PREM NAGAR, BHIWANI

SCHEME AND SYLLABI OF EXAMINATIONS FOR FIVE-YEAR INTEGRATED (B.SC-M.SC) IN MATHEMATICS

WITH EFFECT FROM THE SESSION 2025-26 & 2026-27

(As per NEP)

DEPARTMENT OF MATHEMATICS

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

Credit Structure for Five Year Integrated (B.Sc.-M.Sc.) Mathematics Programs

Structure of UG Program (First three years of Five Year Integrated (B.SC-M.Sc.) Mathematics Program)

Semester	Core Courses (CC) / Major Courses	Minor(MIC)/ Minor Vocational (VOC)Courses	Multidisciplinary courses (MDC)	Ability Enhancement courses (AEC)	Skill Enhancement Courses (SEC)/ Internship /Dissertation/ Research Project	Value-Added Courses (VAC)	Total Credits
I	CC - U1 @ 4 credits CC – U2 @ 4 credits	CC-M1 @ 4 credits	MDC1 @ 3 credits	AEC1 @ 2 credits	SEC1@ 3 credits	VAC1 @ 2 credits	22
II	CC – U3 @ 4 credits CC – U4 @ 4 credits	CC-M2 @ 4 credits	MDC2 @ 3 credits	AEC2 @ 2 credits	SEC2@ 3 credits	VAC2 @ 2 credits	22
• NCrF level: UG Certificate, Level 4.5 Students exiting the programme after second semester and securing 48 credits including 4 credits of summer internship will be awarded UG Certificate in the relevant Discipline/Subject							
III	CC – U5 @ 4 credits CC – U6 @ 4 credits CC – U7 @ 4 credits	CC-M3 @ 4 credits	MDC3 @ 3 credits	AEC3 @ 2 credits	SEC3@ 3 credits		24
IV	CC – U8 @ 4 credits CC – U9 @ 4 credits CC – U10 @ 4 credits CC – U11 @ 4 credits	CC-M4(VOC)@ 4 credits	--------------------	AEC4 @ 2 credits	--------------------	VAC4 @ 2 credits	24
• NCrF level: UG Diploma, Level 5 Students exiting the programme after fourth semester and securing 96 credits including 4 credits of summer internship will be awarded UG Diploma in the relevant Discipline/Subject							
V	CC – U12 @ 4 credits CC – U13 @ 4 credits CC – U14 @ 4 credits CC – U15 @ 4 credits	CC-M5(VOC)@ 4 credits	--------------------	--------------------	Internship1 @ 4 credits#	--------------------	24
VI	CC – U16 @ 4 credits CC – U17 @ 4 credits CC – U18 @ 4 credits CC – U19 @ 4 credits	CC-M6(VOC)@ 4 credits	--------------------	--------------------	--------------------	--------------------	20
• NCrF level: UG Degree, Level 5.5 Students will be awarded 3-year UG Degree in relevant major Discipline/Subject upon securing 136 credits.							

Note:#Four credits of internship earned by a student during summer internship after 2d semester or 4th semester will be counted in 5th semester of a student who pursue 3 year UG Programmes without taking exit option.

Structure of PG Program (Last two years of Five Year Integrated (B.Sc. - M.Sc.) Program)

First year of two-year PG programme/B.Sc. (Hons./Hons with research)(NCrF Level 6.0)

Semester	Core Courses (CC) / Elective Courses	Minor Vocational (VOC)Courses/ Internship		Research Project / Dissertation	Research Thesis	Value-Added Courses (VAC)/ Indian Knowledge System (IKS)/ Employability and Entrepreneurship Skills Courses (EEC)	Total Credits
VII	CC-P1 @ 4 credits CC-P2 @ 4 credits CC-P3 @ 4 credits CC-P4 @ 4 credits CC-P5 @ 4 credits	CC-M7 (VOC) @ 4 credits OR Internship 2@ 4 credits	--------------------	--------------------	--------------------	--------------------	24
VIII Option-I	CC-P6 @ 4 credits CC-P7 @ 4 credits CC-P8 @ 4 credits CC-P9 @ 4 credits CC-P10@4 credits	CC-M8 (VOC) @ 4 credits OR Internship 3@ 4 credits	--------------------	--------------------	--------------------	VAC/IKS@ 2 credits	26
OR							
VIII Option-II	CC-P6 @ 4 credits CC-P7 @ 4 credits	CC-M8 (VOC) @ 4 credits OR Internship 3@ 4 credits		Research Project / Dissertation @ 12 Credits		VAC/IKS@ 2 credits	26

Students who exit after four year will be awarded B.Sc. Hons./ Hons. with research.
Student who has chosen option-II in VIII semester will have to select option-III in Second year of two-year PG programme

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Second year of two-year PG programme (NCrF Level 6.5)

(STUDENT SHOULD SELECT ANY ONE OPTION FOR THE SECOND YEAR OF 2YEAR PG PROGRAM)

Only Course Work							
Option 1	IX	CC-P11 @ 4 credits CC-P12 @ 4 credits CC-P13 @ 4 credits DEC-P14 @ 4 credits DEC-P 15 @ 4 credits	--------------------	--------------------	--------------------	EEC @ 2 credits	22
	X	CC-P16 @ 4 credits CC-P17 @ 4 credits CC-P18 @ 4 credits DEC-P19 @ 4 credits DEC-P20 @ 4 credits	--------------------	--------------------	--------------------	--------------------	20
Course work and Research							
Option II	IX	CC-P11 @ 4 credits CC-P12 @ 4 credits CC-P13 @ 4 credits DEC-P14 @ 4 credits DEC-P15 @ 4 credits	--------------------	--------------------	--------------------	EEC @ 2 credits	22
	X	--------------------	--------------------	--------------------	Research Thesis @ 20 credits	--------------------	20
Only Research							
Option III	IX	--------------------	--------------------	--------------------	Research Thesis @ 20 credits	EEC @ 2 credits	22
	X	--------------------	--------------------	--------------------	Research Thesis @ 20 credits	--------------------	20

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NOTE:

CC /MC	**Core Course/Major Course:** Credit of a Core Courses/major courses could be the combination of lecture credits, tutorial credits, and practical credits.
DEC	**Discipline Specific Elective Course (DEC):**Credit of a DEC could be the combination of lecture credits, tutorial credits, and practical credits.
CC-M including VOC	Minor Course(CC-M)with minimum 24 Credits including Vocational Course(VOC)
MDC	**Multidisciplinary Course:** All students must undergo introductory level multidisciplinary courses relating to **Natural Sciences, Physical Sciences, Humanities, Arts & Social Sciences, Commerce & Management, Interdisciplinary Studies** during first three semesters. Students are not allowed to choose or repeat course already studied in the higher secondary level (12th class) or opted as major and minors stream under this category.
AEC	**Ability Enhancement Course:** Ability Enhancement (Language) courses may be designed to achieve competency in the Modern Indian Language and English, with a special emphasis on language and communication skills.
SEC	**Skill Enhancement Course:** Skill Enhancement Courses may be primed to impart practical skills, hands-on training, soft skills,etc., to enhance the student's employability.
Internship	Internships will require 120 hours (1 credit: 30 hrs. of engagement) of involvement working withlocalindustry,governmentorprivateorganizations,businessorganizations,artists,craftspersons,andsimilarentitiesduringsummervacation .
Research Project / Dissertation	**Guidelines for Research Project / Dissertation will be followed as per ordinance of Five Year Integrated(B.Sc.-M.Sc.) Programme of the University.**
Research Thesis	**Research Thesis** for PG Degree will be completed in the ninth/tenth semester under the guidance of a faculty member. **Guidelines for Research Thesis will be followed as per ordinance of Five Year Integrated Programme of the University.**
VAC	All UG students must undergo at least three Value Added Courses (VAC)

Major and Minor courses in I& II Semesters will have Foundation or Introductory level courses. Major and Minor courses in III & IV semesters will be Intermediate Level Courses. Whereas Major and minor courses in V & VI shall be of higher level courses and in VII, VIII, IX & X semesters, advanced level courses will be offered.

Scheme and Syllabus of Five Year Integrated(B.Sc.-M.Sc.) Programme in Mathematics:2026-27

Core Courses(CC) & Minor Courses (CC-M)	Nomenclature of Course	Course Code	Credits Distribution			Total Credits	Workload			Total Workload	Marks				Total Marks
			L	T	P		L	T	P		Theory		Practical		
											Internal	External	Internal	External	
	Semester I														
CC -U1	Algebra	25/26 MSMA101 (common to batch 2025 onwards)	3	0	1	4	3	0	2	3+2	20	50	10	20	100
CC -U2	Calculus	26 IMSMA102	3	1	0	4	4	0	0	4	30	70	-	-	100
CC-M1	Descriptive Statistics	25/26 IMSST101 (common to batch 2025 onwards)	3	0	1	4	3	0	2	3+2	20	50	10	20	100
MDC1	From Available pool of Multidisciplinary Courses of the University/SWAYAM/ MOOCS from a subject of different discipline as per NEP.														
AEC1	From Available pool of Ability Enhancement Courses as per NEP														
SEC1	From Available pool of Skill Enhancement Courses as per NEP														
VAC1	From Available pool of Value Added Courses as per NEP														

Scheme and Syllabus of Five Year Integrated (B.Sc.- M.Sc.) Programme in Mathematics:2025-26 & 2026-27 onwards

Core Courses(CC) & Minor Courses (CC-M)	Nomenclature of Course	Course Code	Credits Distribution L	Credits Distribution T	Credits Distribution P	Total Credits	Workload L	Workload T	Workload P	Total Workload	Marks: Theory Internal	Marks: Theory External	Marks: Practical Internal	Marks: Practical External	Total Marks
	Semester II														
CC-U3	Multivariable Calculus	26IMSMA201	3	1	0	4	4	0		4	20	50	10	20	100
CC-U4	Number Theory and Trigonometry	25/26 IMSMA202	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-M2	Statistical Methods	25/26 IMSST201	3	0	1	4	3	0	2	3+2	20	50	10	20	100
MDC2 @ 3 credits	From Available pool of Multidisciplinary Courses of the University/SWAYAM/ MOOCS from a subject of different discipline as per NEP.														
AEC2	From Available pool of Ability Enhancement Courses as per NEP *N														
SEC2	From Available pool of Skill Enhancement Courses as per NEP														
VAC2	From Available pool of Value Added Courses as per NEP														
	Semester III														
CC-U5	Ordinary Differential Equations-I	25/26 IMSMA301	3	1	0	4	3	0	1	3+1	30	70	-	-	100
CC-U6	Advanced Calculus	25 IMSMA302 (For 2025 batch only)	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-U6	Vector Calculus	26 IMSMA302	3	1	0	4	4	0	0	4	30	70			100
CC-U7	Solid Geometry	25/26 IMSMA303	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-M3	Probability Theory	25/26 IMSST301	3	1	0	4	3	1	0	3+1	30	70	-	-	100
MDC3 @ 3 credits	From Available pool of Multidisciplinary Courses of the University/SWAYAM/ MOOCS from a subject of different discipline as per NEP.														
AEC3	From Available pool of Ability Enhancement Courses as per NEP														
SEC3	From Available pool of Skill Enhancement Courses as per NEP														

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	Semester IV													
CC-U8	Partial Differential Equations-I	25/26 IMSMA401	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-U9	Real Analysis	25/26 IMSMA402	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-U10	Statics	25/26 IMSMA403	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-U11	Groups and Rings	25/26 IMSMA404	3	1	0	4	3	0	1	3+1	30	70	-	-	100
CC-M4(VOC)	Probability Distributions	25/26 IMSST401	3	1	0	4	3	1	0	3+1	30	70	-	-	100
AEC4	From Available pool of Ability Enhancement Courses as per NEP														
VAC4	From Available pool of Value Added Courses as per NEP														
	Semester V														
CC-U12	Special Functions and Integral Transformations	25/26 IMSMA501	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-U13	Sequences and Series	25/26 IMSMA502	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-U14	Linear Algebra	25/26 IMSMA503	3	1	0	4	3	0	1	3+1	30	70	-	-	100
CC-U15	Dynamics	25/26 IMSMA504	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-M5 (VOC)	Testing of Hypothesis	25/26 IMSST501	3	0	1	4	3	0	2	3+2	20	50	10	20	100
	Semester VI														
CC-U16	Hydrostatics	25/26 IMSMA601	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-U17	Numerical Analysis	25/26 IMSMA602	3	0	1	4	3	0	2	3+2	20	50	10	20	100
CC-U18	Metric Spaces	25/26 IMSMA603	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-U19	Complex Analysis	25/26 IMSMA604	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-M6 (VOC)	Design of Experiments	25/26 IMSST601	3	0	1	4	3	0	2	3+2	20	50	10	20	100
	Semester VII														
CC-P1	Abstract Algebra	25/26 IMSMA701	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-P2	Mathematical Analysis	25/26 IMSMA702	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-P3	Discrete Mathematics	25/26 IMSMA703	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-P4	Ordinary Differential Equations-II	25/26 IMSMA704	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-P5	Mechanics	25/26 IMSMA705	3	1	0	4	3	1	0	3+1	30	70	-	-	100

CC-M7 (VOC)	Statistical Inference	25/26 IMSST701	3	1	0	4	3	1	0	3+1	30	70	-	-	100
	Semester VIII														
CC-P6	Topology	25/26 IMSMA801	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-P7	Analytical Number Theory	25/26 IMSMA802	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-P8	Integral Equations and Calculus of Variations	25/26 IMSMA803	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-P9	Partial Differential Equations-II	25/26 IMSMA804	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-P10	Differential Geometry	25/26 IMSMA805	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-M8 (VOC)	Optimization Techniques	25/26 IMSST801	3	1	0	4	3	1	0	3+1	30	70	-	-	100
	Semester IX (For Option I and II)														
CC-P11	Measure and Integration Theory	25/26 IMSMA901	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-P12	Fluid Dynamics	25/26 IMSMA902	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-P13	Mechanics of Solids-I	25/26 IMSMA903	3	1	0	4	3	1	0	3+1	30	70	-	-	100
	Any One of the Following														
DEC-P14	Mathematical Modeling	25/26 IMSMA904	3	1	0	4	3	1	0	3+1	30	70	-	-	100
	Bio-Mechanics	25/26 IMSMA905	3	1	0	4	3	1	0	3+1	30	70	-	-	100
	Financial Mathematics	25/26 IMSMA906	3	1	0	4	3	1	0	3+1	30	70	-	-	100
	Any One of the Following														
DEC-P15	Finite Element Analysis	25/26 IMSMA907	3	1	0	4	3	1	0	3+1	30	70	-	-	100
	Graph Theory with applications	25/26 IMSMA908	3	1	0	4	3	1	0	3+1	30	70	-	-	100
	Fuzzy Set Theory	25/26 IMSMA909												-	
	Semester X (Option -I)														
CC-P16	Functional Analysis	25/26 IMSMA1001	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-P17	Mechanics of Solids-II	25/26 IMSMA1002	3	1	0	4	3	1	0	3+1	30	70	-	-	100
CC-P18	Advanced Fluid Dynamics	25/26 IMSMA1003	3	1	0	4	3	1	0	3+1	30	70	-	-	100
	Any One of the Following														
DEC-P19	Methods of Applied Mathematics	25/26 IMSMA1004	3	1	0	4	3	1	0	3+1	30	70	-	-	100
	Algebraic Number	25/26 IMSMA1005	3	1	0	4	3	1	0	3+1	30	70	-	-	100

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	Theory													
	Theory of Field Extensions	25/26 IMSMA1006	3	1	0	4	3	1	0	3+1	30	70	-	-	100
	Any One of the Following													
DEC-P20	Mathematical Aspects of Seismology	25/26 IMSMA1007	3	1	0	4	3	1	0	3+1	30	70	-	-	100
	Coding Theory	25/26 IMSMA1008	3	1	0	4	3	1	0	3+1	30	70	-	-	100
	Fourier and Wavelet Analysis	25/26 IMSMA1009	3	1	0	4	3	1	0	3+1	30	70	-	-	100
Semester X (Option -II)															
Research Thesis @20 credits	Research Thesis	25/26 IMSMA10RT	0	0	20	20	-	-	-	*	--	--	150	350	500
Semester IX (Option -III)															
Research Thesis @20 credits	Research Thesis	25/26 IMSMA9RT	0	0	20	20	-	-	-	*	--	--	150	350	500
Semester X (Option -III)															
Research Thesis @20 credits	Research Thesis	25/26 IMSMA10RT	0	0	20	20	-	-	-	*	--	--	150	350	500

N : Number of Groups in the Class
L: Lecture; T: Tutorial; P: Practical

* **For Research theses,** the teaching hours/workload of 1 hour per week will be counted for the teacher supervising 2-3 students and a teacher can supervise maximum 16 students for supervising dissertation/project/ Thesis.

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Semester - I

Name of the Course: Algebra	Course Code: 25/26 IMSMA101	Credit: 4
Maximum Marks: **Theory: 20(Internal)+50(External)=70** **Practical: 10(Internal)+20(External)=30**	**Time of Examinations: 3 Hours**	

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1 Determine the type of matrices and compute the elementary operations on the matrices. Compute the Eigen values, Eigen function, characteristic equation and minimal polynomial of a given matrix.

CLO2 Use the concept of rank of matrices to solve systems of linear equations.

CLO3 Familiar with transformation of equation which is very helpful to find the solution of the given problem.

CLO4 Use the Descartes's rule of sign to find the nature of roots.

Section – I

Symmetric, Skew-symmetric, Hermitian and skew Hermitian matrices. Elementary Operations on matrices. Rank of a matrices. Inverse of a matrix. Linear dependence and independence of rows and columns of matrices. Row rank and column rank of a matrix. Eigenvalues, eigenvectors and the characteristic equation of a matrix. Minimal polynomial of a matrix. Cayley Hamilton theorem and its use in finding the inverse of a matrix.

Section-II

Applications of matrices to a system of linear (both homogeneous and non-- homogeneous) equations. Theorems on consistency of a system of linear equations. Unitary and Orthogonal Matrices, Bilinear and Quadratic forms.

Section-III

Relations between the roots and coefficients of general polynomial equation in one variable. Solutions of polynomial equations having conditions on roots. Common roots and multiple roots. Transformation of equations.

Section-IV

Nature of the roots of an equation Descarte's rule of signs. Solutions of cubic equations (Cardon's method). Biquadratic equations and their solutions.

Practical/ Computational Work
(Based on course Algebra)

Practical: 10(Internal)+20(External)=30

There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.

Distribution of Marks will be as follows:

i) Written Practical/ Lab work : 10 Marks

ii) Viva-voce and practical record: 10 Marks

List of Practicals

Following is the list of programmes to be performed in the Lab using MATRIX/ PYTHON/ MATLAB:

1. Practical based on addition, multiplication of Matrices.
2. Practical based on inverse, transpose.
3. Practical based on determinant, rank.
4. Practical based on eigenvectors, eigenvalues.
5. Practical based on Characteristic equation and verification of Cayley Hamilton equation.
6. Practical based on system of linear equations.
7. Practical based on System of Homogenous Equation.
8. Practical based on System of Non- Homogenous Equation.
9. Practical based on Solutions of cubic equations.
10. Practical based on Solutions of Biquadratic equations.

References:

1. Dickson, Leonard Eugene (1922). First Course in The Theory of Equations. John Wiley & Sons, Inc. New York. The Project Gutenberg EBook.
2. S. H. Friedberg, A. L. Insel and L. E. Spence, Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi.
3. Richard Bronson, Theory and Problems of Matrix Operations, Tata McGraw Hill.
4. H.S. Hall and S.R. Knight : Higher Algebra, H.M. Publications 1994.
5. Shanti Narayan : A Text Books of Matrices.
6. Chandrika Prasad : Text Book on Algebra and Theory of Equations. Pothishala Private Ltd., Allahabad.
7. S. H. Friedberg, A. L. Insel and L. E. Spence, Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi.
8. Richard Bronson, Theory and Problems of Matrix Operations, Tata McGraw Hill.
9. B. Kolman, David R. Hill, Introductory Linear Algebra An Applied First Course, 8th Edition, Prentice Hall.
10. Jim DeFranza and Dan Gagliardi, Introduction to Linear Algebra with Applications, McGraw Hill Education (India) Pvt Ltd, New Delhi.

Semester - I

Name of the Course	**Calculus**	**Course Code**	**26 IMSMA 102**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1 Understand the method of successive differentiation and Taylor series expansions.
CLO2 Be familiar with concepts of asymptotes, curvature and singular points.
CLO3 Apply the concepts of calculus for tracing and rectification of the curves in cartesian, parametric and polar coordinates.
CLO4 Understand the concepts of functions of several variables, their continuity and various properties.

Section – I

Definition of the limit of a function. Basic properties of limits, Continuous functions and classification of discontinuities. Differentiability. Successive differentiation. Leibnitz theorem. Maclaurin and Taylor series expansions.

Section – II

Asymptotes in Cartesian coordinates, intersection of curve and its asymptotes, asymptotes in polar coordinates. Curvature, radius of curvature for Cartesian curves, parametric curves, polar curves. Newton's method. Radius of curvature for pedal curves. Tangential polar equations. Centre of curvature. Circle of curvature. Chord of curvature, evolutes. Tests for concavity and convexity. Points of inflexion. Multiple points. Cusps, nodes & conjugate points. Type of cusps.

Section – III

Tracing of curves in Cartesian, parametric and polar co-ordinates. Reduction formulae. Rectification, intrinsic equations of curve.

Section – IV

Quadrature (area) Sectorial area. Area bounded by closed curves. Volumes and surfaces of solids of revolution. Theorems of Pappu's and Guilden.

References:

1. G.B Thomas and R.L. Finney, Calculus, 9th edition, Pearson Education Delhi,2005
2. H. Anton, I. Birens and S. Davis, Calculus, John Wiley and Sons, Inc., 2002
3. M.J Strauss, G.L. Bradley and K.J Smith, Calculus, 3rd edition, Dorling Kindersley (India) P Ltd (Pearson Education), Delhi, 2007
4. R. Courant and F. John, Introduction to Calculus and Analysis,(Volume I &II), Springer-Verlag, New York, Inc 1989
5. Murray R. Spiegel ,Theory and Problems of Advanced Calculus. Schaun's Outline series. Schaum Publishing Co., New York.
6. N. Piskunov ,Differential and integral Calculus. Peace Publishers, Moscow.

Semester - I

Name of the Course: Descriptive Statistics	**Course Code: 25/26 IMSST101**	**Credit:4**
Maximum Marks: **Theory: 20(Internal)+50(External)=70** **Practical: 10(Internal)+20(External)=30**	**Time of Examinations: 03 Hours**	

Note:

Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Explain the nature, scope, and importance of statistics, classify different types of data, and represent data effectively using tabular and graphical techniques.

CLO 2: Compute and interpret measures of central tendency, analyze their properties, and evaluate their suitability for different data sets.

CLO 3: Determine partition values and apply appropriate measures of dispersion to assess variability and consistency in statistical data.

CLO 4: Calculate moments and use measures of skewness and kurtosis to analyze the shape and characteristics of frequency distributions.

Section – I

Introduction of Statistics: Nature, scope, and importance of statistics; Types of data; Classification and tabulation of data.

Graphical representation of data: Bar Charts, Histograms, frequency polygon, frequency curve and ogives. Pie-Chart, Stem- and- Leaf and Box plots.

Section – II

Measures of Central Tendency: Introduction and significance; Mean, median, mode, geometric mean, harmonic mean; Properties and applications of central tendency; Merits and demerits of each measure; Relationship between mean, median, and mode.

Section – III

Partition Values: Quartiles, deciles and percentiles.

Measures of Dispersion: Absolute and relative measures of range, quartile deviation, mean deviation, variance and standard deviation; coefficient of variation. Characteristics for an Ideal Measure of Dispersion.

Section – IV

Moments, Skewness and Kurtosis: Raw and central Moments; derivation of their relationships, effect of change of origin and scale on moments, Sheppard's correction for moments (without derivation), Charlier's checks; Measures of Skewness and Kurtosis.

Practical/ Computational Work

(Based on course Descriptive Statistics)

Practical: 10(Internal)+20(External)=30

There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.

Distribution of Marks will be as follows:

i) Written Practical/ Lab work : 10 Marks

ii) Viva-voce and practical record: 10 Marks

List of Practicals

Following is the list of programmes to be performed in the Lab using MS-excel:

1. Diagrammatic Representation of Statistical Data Problems Based on Simple and Subdivided Bar Diagrams, Pie Diagram.
2. Graphical Representation of Statistical Data through Histogram, Frequency Polygon and Frequency Curve.
3. Representation of statistical data through Box plot.
4. Computation of Measures of Central Tendency mean, median and mode
5. Partition Values: Quartiles, deciles and percentiles
6. Various Measures of Dispersion. Use of an Appropriate Measure and Interpretation of Results.
7. Moments
8. Measures of Skewness
9. Measures of Kurtosis.

References:

1. Gupta, S.C. and Kapoor,V.K.(2020):FundamentalsofMathematicalStatistics,SultanChand&Sons,New Delhi.
2. Mukhopadhyay,P.(2020):MathematicalStatistics,BooksandAlliedPrivateLimited,Kolkata.
3. Kapoor,J.N.andSaxena,H.C.(2020):MathematicalStatistics,SultanChand&Sons,NewDelhi.
4. Ross, S.M.(2017):Introductory Statistics, Academic Press, Elsevier.
5. Gun,A.M.,Gupta,M.K.andDasgupta,B.(2016):FundamentalofStatistics,Vol.I,TheWorldPress Private Limited, Kolkata.
6. Gupta S. C. (2024): Fundamentals of Statistics, Himalaya Publishing House.
7. R.Vidya: Descriptive Statistics, NPTEL Swayam Portal (URL:https://onlinecourses.swayam2.ac.in/cec21_ma01/preview)

PGBOS&R on 07-07-2026

Semester - II
Session: 2026-27

Name of the Course	**Multivariable Calculus**	**Course Code**	**26 IMSMA 201**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO1 Learn conceptual variations while advancing from one variable to several variables in calculus.
CLO2 Apply multivariable calculus in optimization problems
CLO3 Inter-relationship amongst the line integral, double and triple integral formulations.
CLO4 Applications of multivariable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc

Section – I

Continuity, Sequential Continuity, properties of continuous functions, Uniform continuity, chain rule of differentiability. Mean value theorems; Rolle's Theorem and Lagrange's mean value theorem and their geometrical interpretations. Taylor's Theorem with various forms of remainders, Darboux intermediate value theorem for derivatives, Indeterminate forms.

Section – II

Limit and continuity of real valued functions of two variables. Partial differentiation. Total Differentials; Composite functions & implicit functions. Change of variables. Homogenous functions & Euler's theorem on homogeneous functions. Taylor's theorem for functions of two variables.

Section – III

Differentiability of real valued functions of two variables. Schwarz and Young's theorem. Implicit function theorem. Maxima, Minima and saddle points of two variables. Lagrange's method of multipliers.

Section – IV

Curves: Tangents, Principal normals, Binormals, Serret-Frenet formulae. Locus of the centre of curvature, Spherical curvature, Locus of centre of Spherical curvature, Involutes, evolutes, Bertrand Curves. Surfaces: Tangent planes, one parameter family of surfaces, Envelopes.

References:

1. G.B Thomas and R.L. Finney, Calculus, 9th edition, Pearson Education Delhi,2005
2. H. Anton, I. Birens and S. Davis, Calculus, John Wiley and Sons, Inc., 2002
3. James Stewart (2012). Multivariable Calculus (7th edition). Brooks/Cole. Cengage, (Textbook).
4. Jerrold Marsden, Anthony J. Tromba & Alan Weinstein (2009). Basic Multivariable Calculus, Springer India Pvt. Limited.
5. Monty J. Strauss, Gerald L. Bradley & Karl J. Smith (2011). Calculus (3rd edition). Pearson Education. Dorling Kindersley (India) Pvt. Ltd..
6. K,Ahmad and P. Sharma(2023). Calculus, New Age International Publisher, New Delhi

Semester - II

Name of the Course	Number Theory and Trigonometry	Course Code	25/26 IMSMA202
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	3 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand the concepts of congruences, residue classes, least residues, and perform modular arithmetic operations (addition, subtraction, multiplication, and powers).

CLO2: Determine and apply multiplicative inverses modulo m to solve linear congruences.

CLO3: Work with the trigonometric form of complex numbers, including the application of De Moivre's formula for powers and roots.

CLO4: Represent complex numbers in Euler's exponential form $re^{i\theta}$ and use it for efficient computation.

Section – I

Divisibility, G.C.D.(greatest common divisors), L.C.M.(least common multiple)
Primes, Fundamental Theorem of Arithemetic. Linear Congruences, Fermat's theorem. Wilson's theorem and its converse. Linear Diophanatine equations in two variables.
Complete residue system and reduced residue system modulo m. Euler's ø function Euler's generalization of Fermat's theorem. Chinese Remainder Theorem.

Section – II

Quadratic residues. Legendre symbols. Lemma of Gauss; Gauss reciprocity law. Greatest integer function [x]. The number of divisors and the sum of divisors of a natural number n (The functions d(n) and σ(n)). Moebius function and Moebius inversion formula.

Section - III

De Moivre's Theorem and its Applications. Expansion of trigonometrical functions. Direct circular and hyperbolic functions and their properties.

Section – IV

Inverse circular and hyperbolic functions and their properties. Logarithm of a complex quantity. Gregory's series. Summation of Trigonometry series.

References:

1. S.L. Loney, Plane Trigonometry Part – II, Macmillan and Company, London.
2. R.S. Verma and K.S. Sukla, Text Book on Trigonometry, Pothishala Pvt. Ltd. Allahabad.
3. Ivan Ninen and H.S. Zuckerman, An Introduction to the Theory of Numbers.

Semester - II

Name of the Course	Statistical Methods	Course Code	25/26 IMSST201
Maximum Marks	Theory: 20(Internal)+50(External)=70 Practical: 10(Internal)+20(External)=30	Time of Examinations	03 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand and analyze the association of attributes, and measure correlation to interpret statistical relationships.

CLO2: Apply regression analysis and the method of least squares to model relationships between variables

CLO3: Interpret statistical results and apply them to practical contexts for informed decision-making.

CLO4: Utilize statistical methods effectively in real-world applications, demonstrating both theoretical knowledge and practical competence.

Section – I

Theory of Attributes: Notations and Terminology, Contingency Table, Class Frequencies, Ultimate Class Frequencies, Consistency; Association of Attributes, Independence, Methods of determining association: Frequency method, proportion method, Yule's coefficient of association, coefficient of colligation and coefficient of contingency.

Section – II

Correlation for Bivariate Data: Concept and types of correlation, Scatter diagram, Karl Pearson's Coefficient of correlation and Spearman's rank correlation coefficient. Difference between correlation and association

Section – III

Linear Regression: Concept of regression analysis, derivation of two lines of regression, properties of regression coefficients, standard error of estimate obtained from regression line, correlation coefficient between observed and estimated values. Angle between two lines of regression. Difference between correlation and regression.

Section – IV

Principle of Least Squares: Concept of error and residuals, Purpose of the least squares method, Fitting of straight line, Polynomials and Exponential Curves.
Partial and Multiple Correlation (Three Variables Only).

Practical/ Computational Work
(Based on course Statistical Methods)

Practical: 10(Internal)+20(External)=30
There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.
Distribution of Marks will be as follows:
i) Written Practical/ Lab work : 10 Marks
ii) Viva-voce and practical record: 10 Marks

List of Practicals

Following is the list of programmes to be performed in the Lab using MS-excel:

1. Consistency of Data up to Two Attributes. Concepts of Independence and Association of Two Attributes.
2. Methods of determining association: Frequency method, proportion method, Yule's coefficient of association, coefficient of colligation and coefficient of contingency.
3. Bivariate Data: Scatter Diagram, Plotting and Interpretation.
4. Calculation of Product Moment Correlation Coefficient
5. Correlation Ratio, Rank Correlation.
6. Calculation of Regression Coefficients.
7. Fitting of Regression Lines by Least Squares.
8. Fitting of straight line, Polynomials and Exponential Curves by Least Squares.
9. Calculation of Partial and Multiple Correlation Coefficients for Three Variables.

References:

1. Montgomery, C.D. and Runger, C.G. (2021): Applied Statistics and Probability for Engineers, John Wiley & Sons, New Delhi
2. Gupta, S.C. and Kapoor, V. K. (2020): Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
3. Ross, S.M. (2017): Introductory Statistics, Academic Press, Elsevier.
4. Mukhopadhyay, P (2020): Applied Statistics, Books and Allied Private Limited, Kolkata.
5. Gupta, S.C. and Kapoor, V. K. (2020): Fundamentals of Applies Statistics, Sultan Chand & Sons, New Delhi.

Semester - III
Session: 2025-26

Name of the Course	**Ordinary Differential Equations-I**	**Course Code**	**25/26 IMSMA301**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand the formation of differential equations and solve exact differential equations using integrating factors.

CLO2: Solve first-order but not first-degree equations, including Lagrange's and Clairaut's equations, along with other standard forms.

CLO3: Apply the concepts of auxiliary equations and particular integrals to solve linear differential equations with constant coefficients.

CLO4: Analyze and solve higher-order linear differential equations, ordinary simultaneous differential equations, and total differential equations using appropriate methods.

Section – I

Geometrical meaning of a differential equation. Exact differential equations. Integrating factors. First order higher degree equations solvable for x,y,p. Lagrange's equations, Clairaut's equations. Equation reducible to Clairaut's form. Singular solutions.

Section – II

Orthogonal trajectories: Cartesian coordinates and polar coordinates. Self-orthogonal family of curves. Linear ordinary differential equations with constant coefficients. Homogeneous linear ordinary differential equations. Equations reducible to homogeneous.

Section - III

Linear differential equations of second order: Reduction to normal form. Transformation of the equation by changing the dependent variable/the independent variable. Solution by operators of non-homogeneous linear differential equations. Reduction of order of a differential equation. Method of variations of parameters. Method of undetermined coefficients.

Section – IV

Ordinary simultaneous differential equations. Solution of simultaneous differential equations involving operators x (d/dx) or t (d/dt) etc. Simultaneous equation of the form dx/P = dy/Q = dz/R.
Total differential equations. Condition for Pdx + Qdy +Rdz = 0 to be exact. General method of solving Pdx + Qdy + Rdz = 0 by taking one variable constant. Method of auxiliary equations

References:

1. Belinda Barnes and Glenn R. Fulford (2009). Mathematical modeling with case Studies, A Differential equation Approach using Maple and Matlab (2d Edition). Taylor and Francis group, London and New York.
2. C.H. Edwards and D.E. Penny (2005). Differential equations and Boundary value problems Computing and Modeling. Person Education India.
3. Martha L Abell, James P Braselton (2004). Differential equations with Mathematica (3rd edition). Elsevier Academic Press.
4. B. Rai & D.P. Chaudhary: Ordinary Differential Equations, Narosa, Publishing House Pvt. Ltd.
5. D.A. Murray (1967). Introductory Course in Differential Equations. Orient Longaman (India).
6. A.R.Forsyth (1948). A Treatise on Differential Equations (6th Edition). Machmillan and Co. Ltd. London.

7. E.A. Codington (1989). An Introduction to Ordinary Differential Equations. Dover Publications, New York.
8. S.L.Ross (1984). Differential Equations (3rd Edition). John Wiley and Sons.
9. Frank Ayres (1972). Theory and Problems of Differential Equations, McGraw Hill Book Company.

Semester - III
Session: 2025-26

Name of the Course	**Advanced Calculus**	**Course Code**	**25 IMSMA302**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1 Understand the concepts of continuity, uniform continuity and their related theorems.
CLO2 Describe the concepts of limit, continuity and differentiability of real valued function of two variables.
CLO3 Explain maxima, minima and saddle pointes of two variables and Lagrange's method of multipliers.
CLO4 Determine the tangent, principle normal, locus of curvature, Bertrand curves, tangent plains and apply them to different problems.

Section – I

Continuity, Sequential continuity, Properties of continuous functions, Uniform continuity, Chain rule of differentiability. Mean value theorems: Rolle's Theorem and Lagrange's mean value theorem and their geometrical interpretations. Taylor's Theorem with various forms of remainders, Darboux intermediate value theorem for derivatives, Reduction formulae. Rectification, Intrinsic equations of curve.

Section – II

Limit and continuity of real valued functions of two variables. Partial differentiation. Total Differentials: Composite functions & Implicit functions. Change of variables. Homogenous functions & Euler's theorem on homogeneous functions. Taylor's theorem for functions of two variables.

Section - III

Differentiability of real valued functions of two variables. Schwarz and Young's theorem. Implicit function theorem. Maxima, Minima and saddle points of two variables. Lagrange's method of multipliers.

Section – IV

Curves: Tangents, Principal normals, Binormals, Serret-Frenet formulae. Locus of the centre of curvature, Spherical curvature, Locus of centre of Spherical curvature, Involutes, Evolutes, Bertrand Curves. Surfaces: Tangent planes, One parameter family of surfaces, Envelopes.

References:

1. C.E. Weatherburn: Differential Geometry of three dimensions, Radhe Publishing House, Calcutta.
2. Gabriel Klaumber: Mathematical analysis, Mrcel Dekkar, Inc., New York, 1975.
3. R.R. Goldberg: Real Analysis, Oxford & I.B.H. Publishing Co., New Delhi, 1970.
4. Gorakh Prasad: Differential Calculus, Pothishala Pvt. Ltd., Allahabad.
5. S.C. Malik : Mathematical Analysis, Wiley Eastern Ltd., Allahabad.
6. Shanti Narayan: A Course in Mathemtical Analysis, S.Chand and company, New Delhi.
7. Murray, R. Spiegel: Theory and Problems of Advanced Calculus, Schaum Publishing co., New York.

SEMESTER III

Name of the Course: Vector Calculus	Course Code	26 IMSMA302
Maximum Marks: Theory: 30(Internal)+70(External)=100	Time of Examinations: 3 Hours	

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1 Find the derivative along a curve and directional derivatives.

CLO2 Calculate and interpret gradient, divergence, curl and their related vector identities.

CLO3 Be familiar with gradient, divergence, curl and laplacian operators in terms of orthogonal curvilinear coordinates.

CLO4 Use theorems of Gauss, Green and Stokes to solve integrals.

Section – I

Scalar and vector product of three vectors, product of four vectors. Reciprocal vectors. Partial derivative, Vector differentiation. Scalar Valued point functions, Vector valued point functions,. Curves in space: Tangent, Principal Normal, Binormal, Curvature, Torsion,Serret-Frenet Formulae

Section – II

Gradient of a scalar point function, geometrical interpretation of grad, gradient as a point function. Tangent planes and Normal lines, derivative along a curve, directional derivatives, Divergence and curl of vector point function, characters of Div$\vec{f}$ and curl$\vec{f}$ as point function, examples. Gradient, divergence and curl of sums and product and their related vector identities. Laplacian operator.

Section – III

Line integrals, independent of the path, Green Theorem and problem based on Green Theorem. Surface integral, Stokes' theorem and problem based on Stokes' theorem, Gauss theorem and problems based on Gauss theorem

Section – IV

Locus of the centre of curvature, Spherical curvature, Locus of centre of Spherical curvature, Involutes, Evolutes, Bertrand Curves. Surfaces: Tangent planes, One parameter family of surfaces, Envelopes.

References:

1. Murrary R. Spiegal , Theory and Problems of Advanced Calculus, Schaum Publishing Company, New York.
2. Murrary R. Spiegal , Vector Analysis, SchaumPublisghing Company, New York.
3. N. Saran and S.N. Nigam, Introduction to Vector Analysis, Pothishala Pvt. Ltd., Allahabad.
4. Shanti Narayna , A Text Book of Vector Calculus. S. Chand & Co., New Delhi
5. Dennis G. Zill ,Advanced Engineering Mathematics, 6th Edition, Jones & Bartlett learning

Semester - III

Name of the Course	**Solid Geometry**	**Course Code**	**25/26 IMSMA303**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

- **Course Learning Outcomes (CLO):**

CLO1: Derive systems of conics, confocal conics, and polar equations of conics.
CLO2: Determine tangents, normals, chords of contact, and poles of lines for conics.
CLO3: Understand the geometry of three-dimensional surfaces such as spheres, cones, and cylinders, and obtain equations of tangent planes, director spheres, normals, and enveloping surfaces.
CLO4: Describe and analyze circular sections, plane sections of conicoids, generating lines, confocal conicoids, and reductions of second-degree equations.

Section – I

General equation of second degree. Tracing of conics. Tangent at any point to the conic, Chord of contact, pole of line to the conic, Director circle of conic. System of conics. Confocal conics. Polar equation of a conic, Tangent and normal to the conic.

Section – II

Sphere: Plane section of a sphere. Sphere through a given circle. Intersection of two spheres, Radical plane of two spheres. Co-axial system of spheres.
Cones. Right circular cone, Enveloping cone and reciprocal cone.
Cylinder: Right circular cylinder and enveloping cylinder.

Section - III

Central Conicoids: Equation of tangent plane. Director sphere. Normal to the conicoids. Polar plane of a point. Enveloping cone of a conicoid. Enveloping cylinder of a conicoid.

Section – IV

Paraboloids: Circular section, Plane sections of conicoids.
Generating lines. Confocal conicoid. Reduction of second degree equations.

References:

1. R.J.T. Bill, Elementary Treatise on Coordinary Geometry of Three Dimensions, MacMillan India Ltd. 1994.
2. P.K. Jain and Khalil Ahmad: A Textbook of Analytical Geometry of Three Dimensions, Wiley Eastern Ltd. 1999.

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Semester - III

Name of the Course	**Probability Theory**	**Course Code**	**25/26 IMSST301**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand the fundamentals of probability, random variables, probability mass functions, and density functions.
CLO2: Apply probability theory to real-life problems, including the formulation of generating functions and related inequalities.
CLO3: Interpret and analyze statistical relationships through the applications of the Law of Large Numbers and the Central Limit Theorem.
CLO4: Demonstrate the ability to apply probability concepts and statistical methods in practical contexts for problem-solving.

Section – I

Random Experiment, Sample Space, Events – Simple, Composite, Mutually Exclusive and Exhaustive Events, Various Definitions of Probability, Properties of Probability Function, Addition Theorem, Boole's and Bonferroni's Inequalities, Conditional Probability, Independence of Events, Multiplication Theorem, Bayes' Theorem.

Section – II

Random Variables and Distribution Functions, Probability Mass Function, Probability Density Function, Two Dimensional Random Variables- Joint, Marginal and Conditional Distributions, Independence of Random Variables. Moments of Random Variables: Expectation, Variance, Covariance, Conditional and Marginal Expectation.

Section – III

Probability and Moment Generating Function and Their Properties, Cumulants, Characteristic Function and Its properties, Continuity Theorem, Inversion Theorem, Uniqueness Theorem of Characteristic Function, Moment Inequalities of Hölder, Minkowski, Jensen's, Cauchy- Schwartz and Lyapunov's.

Section – IV

Modes of Convergence: Convergence in Probability, Almost Surely, in the rth Mean and in Distribution, Their Relationship. Probability Inequalities of Chebychev and Markov, Weak Law of large numbers: Chebychev's, Bernoulli's and Khintchine's Weak Law of Large Numbers, Necessary and Sufficient Conditions for the WLLN, Borel Cantelli Lemma, Kolmogorov Inequality, Strong Law of Large Numbers: Kolmogorov's Theorem. Central Limit Theorem: Lindeberg - Levy and Demoivre- Laplace Forms of CLT.

References:

1. Ross, S.M. (2016): A First Course in Probability, Pearson Education, India.
2. Biswas, D. (2016): Probability and Statistics, Vol. I, New Central Book Agency, New Delhi.
3. Palaniammal, S. (2011): Probability and Random Processes, Prentice Hall India Learning Private Limited, Delhi.
4. Gupta, S.C. and Kapoor, V. K. (2020): Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
5. Kapoor, J.N. and Saxena, H.C. (2020): Mathematical Statistics, Sultan Chand & Sons, New Delhi.
6. Mukhopadhyay, P. (2020): Mathematical Statistics, Books and Allied Private Limited, Kolkata.
7. Dharmaraja, S.: Introduction to Probability and Statistics, NPTEL Swayam Portal (URL:

https://onlinecourses.nptel.ac.in/noc22_ma81/preview)

Semester - IV

Name of the Course	**Partial Differential Equations-I**	**Course Code**	**25/26 IMSMA401**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Solve Lagrange's linear equations using Charpit's general method and Jacobi's method, and classify partial differential equations with transformations into canonical forms.

CLO2: Apply Monge's method to solve second-order partial differential equations and understand the role of characteristic equations and characteristic curves.

CLO3: Solve classical partial differential equations such as Laplace's equation, wave equation, and diffusion equation using appropriate techniques.

CLO4: Analyze and apply advanced methods for partial differential equations to model and interpret physical and mathematical problems.

Section – I

Partial differential equations: Formation, Order and degree, Linear and Non-Linear Partial differential equations of the first order, Complete solution, Singular solution, General solution, Solution of Lagrange's linear equations, Charpit's method. Compatible systems of first order equations, Jacobi's method.

Section – II

Linear partial differential equations of second and higher orders, Linear and non-linear homogeneous and non-homogeneous equations with constant coefficients, Partial differential equation with variable co-efficients reducible to equations with constant coefficients, Complimentary functions and particular Integrals, Equations reducible to linear equations with constant coefficients.

Section - III

Classification of linear partial differential equations of second order, Hyperbolic, Parabolic and Elliptic types, Reduction of second order linear partial differential equations to Canonical (Normal) forms and their solutions, Solution of linear hyperbolic equations, Monge's method for partial differential equations of second order.

Section – IV

Cauchy's problem for second order partial differential equations, Characteristic equations and characteristic curves of second order partial differential equations, Method of separation of variables: Laplace's equation, Wave equation (one and two dimensions), Diffusion (Heat) equation (one and two dimension) in Cartesian Co-ordinate system.

References:

1. D.A. Murray: Introductory Course on Differential Equations, Orient Longman, (India), 1967
2. Erwin Kreyszing : Advanced Engineering Mathematics, John Wiley & Sons, Inc., New York, 1999
3. A.R. Forsyth : A Treatise on Differential Equations, Macmillan and Co. Ltd.
4. Ian N.Sneddon : Elements of Partial Differential Equations, McGraw Hill Book Company, 1988
5. Frank Ayres : Theory and Problems of Differential Equations, McGraw Hill Book Company, 1972
6. J.N. Sharma & Kehar Singh : Partial Differential Equations

Semester - IV

Name of the Course	**Real Analysis**	**Course Code**	**25/26 IMSMA402**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO1 Understand various properties related with supremum and infimum of sets.
CLO2 Apply the concepts of integration to real life problems.
CLO3 Construct and interpret various proper and improper integrals.
CLO4 Understand how real numbers provide a complete ordered field and to explain the fundamental concepts of real analysis.

Section – I

Finite and infinite sets, Countable and uncountable sets, Bounded sets, Suprema and infima, Completeness property of R, Archimedean property of R.

Section – II

Riemann integral, Integrabililty of continuous and monotonic functions, Fundamental theorem of integral calculus. Mean value theorems of integral calculus.

Section - III

Improper integrals and their convergence, Comparison tests, Abel's and Dirichlet's tests, Frullani's integral, Integral as a function of a parameter. Continuity, Differentiability and integrability of an integral of a function of a parameter..

Section – IV

Jacobians, Beta and Gamma functions, Double and Triple integrals, Dirichlet's integrals, Change of order of integration in double integrals,Applications of double integration,

References:

1. T.M. Apostol: Mathematical Analysis, Narosa Publishing House, New Delhi, 1985
2. R.R. Goldberg : Real analysis, Oxford & IBH publishing Co., New Delhi, 1970
3. D. Somasundaram and B. Choudhary : A First Course in Mathematical Analysis, Narosa Publishing House, New Delhi, 1997
4. Shanti Narayan : A Course of Mathematical Analysis, S. Chand & Co., New Delhi.
5. R.G. Bartle - D.R. Sherbet, Introduction to Real analysis, John Wiley & Sons.
6. J. E. Marsden- A. J. Tromba- A. Weinstein, Basic multi-variable calculus, Springer.
7. Ajit Kumar & S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014.
8. J. Stewart, Calculus, Brooke/Cole Publishing Co, 1994.

Semester - IV

Name of the Course	**Statics**	**Course Code**	**25/26 IMSMA403**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1 Understand the composition and resolution of forces.

CLO2 Apply the the conditions of equilibrium to solve problems on friction, centre of gravity and virtual work.

CLO3 Understand and solve the problems based on stable and unstable equilibrium Construct and interpret various proper and improper integrals.

CLO4 Understand the theory of forces in three dimensions and wrenches.

Section – I

Composition and resolution of forces. Parallel forces. Moments and Couples.

Section – II

Analytical conditions of equilibrium of coplanar forces. Friction. Centre of Gravity.

Section - III

Virtual work. Forces in three dimensions. Poinsots central axis.

Section – IV

Wrenches. Null lines and planes. Stable and unstable equilibrium.

References:

1. Loney S.L., 1912, Statics, Cambride University Press, London.
2. Verma R.S., 1962, A Text Book on Statics, Pothishala Pvt. Ltd.

Semester IV

Name of the Course	**Groups and Rings**	**Course Code**	**25/26 IMSMA404**
Maximum Marks	**Theory: 20(Internal)+50(External)=70** **Practical: 10(Internal)+20(External)=30**	**Time of Examinations**	**3 Hours**

Note:

Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Demonstrate understanding of the fundamental concepts of groups, including subgroups, cyclic groups, normal groups, and quotient groups.

CLO2: Apply the concepts of homomorphism, isomorphism, automorphisms, and inner automorphisms to analyze group structures.

CLO3: Describe and classify rings, subrings, Euclidean rings, and polynomial rings, and apply Eisenstein's criterion for irreducibility.

CLO4: Integrate the concepts of group theory and ring theory to solve algebraic problems and interpret their applications in mathematics.

Section-I

Definition of a group with example and simple properties of groups, Subgroups and subgroup criteria, Generation of groups, Cyclic groups, Cosets, Left and right cosets, Index of a subgroup, Coset decomposition, Lagrange's theorem and its consequences, Normal subgroups, Quotient groups.

Section-II

Homomorphisms, Isomophisms, Automorphisms and Inner automorphisms of a group, Automorphisms of cyclic groups, Permutations groups, Even and odd permutations, Alternating groups, Cayley's theorem.

Section -III

Introduction to ring, Subring, Integral domain and field, Characteristics of a ring, Ring homomorphism, Ideals (principle, prime and maximal) and Quotient ring, Field of quotients of an integral domain.

Section-IV

Euclidean ring, Polynomial ring, Polynomials over the rational field, The Eisenstein's criterion, Polynomial rings over commutative rings, Unique factorization domain, R unique factorization domain implies so is $R[X_1, X_2, \ldots, X_n]$.

Practical/ Computational Work
(Based on course Groups and Rings)

Practical: 10(Internal)+20(External)=30

There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.

Distribution of Marks will be as follows:

i) Written Practical/ Lab work : 10 Marks

ii) Viva-voce and practical record: 10 Marks

List of Practicals

Following is the list of programmes to be performed in the Lab using MATLAB:

1. Group verification (Program to check if a given set with a binary operation forms a group).
2. Verify group properties (Implement functions to check if a given set with an operation satisfy closure, associatively, identity and inverse properties).
3. Cayley table generation (Function to generate the Cayley table for a given group. This table visually represents the results of the group's binary operation on all pairs of elements).
4. Subgroup identification (Algorithm to identify all subgroups of a given group).
5. Cyclic group check (Program to determine if a given group is cyclic).
6. Cyclic group generation (Functions to generate cyclic groups and find their generators).
7. Group isomorphism (Program to determine whether two groups are isomorphic).
8. Ring verification (Program to verify if a given set with two binary operations i.e. addition and multiplication forms a ring).
9. Subgroup and subring test (Functions to verify if a subset is a subgroup or subring of a larger group or ring, respectively).
10. Ring homomorphism (Program to determine if a given mapping between two rings is a ring homomorphism).
11. Ideals in rings (Program to identify ideals in a given ring).
12. Practical based on polynomial rings.
13. Quotient groups and rings (Program to form quotient group and ring with given group and ring).

References:

1. I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
2. P.B. Bhattacharya, S.K. Jain and S.R. Nagpal, Basic Abstract Algebra (2d edition).
3. Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House.
4. I.S. Luther and I.B.S. Passi, Algebra, Vol.-II, Narosa Publishing House.

Semester - IV

Name of the Course	**Probability Distributions**	**Course Code**	**25/26 IMSST401**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:

Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Demonstrate understanding of probability distributions, including their properties, probability mass functions, and density functions.
CLO2: Apply probability distributions to practical problems and fit appropriate distributions to data.
CLO3: Analyze and determine relationships between different probability distributions.
CLO4: Compute and interpret statistical properties of probability distributions using suitable computational procedures.

Section 1

Discrete Distributions-I: Bernoulli, Binomial and Poisson Distributions: Functions and Properties such as Mean, Median, Mode, Variance, Standard Deviation, Moments up to Fourth Order, Moment Generating Function (M.G.F.), Cumulants up to Fourth Order, Cumulant Generating Function (C.G.F.), Probability Generating Function (P.G.F.), Characteristic Function (C.F.), Reproductive Property (Wherever Exists) and Their Real Life Applications, Poisson Approximation to Binomial Distribution.

Section 2

Discrete Distributions-II: Uniform, Negative Binomial, Geometric, Hyper-Geometric Distributions: Functions and Properties such as Mean, Median, Mode, Variance, Standard Deviation, Moments up to Fourth Order, M.G.F., Cumulants up to Fourth Order, C.G.F., P.G.F., C.F., Reproductive Property (Wherever Exists) and Their Real Life Applications, Lack of Memory Property for Geometric Distribution, Poisson Approximation to Negative Binomial Distribution, Binomial Approximation to Hyper-Geometric Distribution.

Section 3

Continuous Distributions-I: Rectangular, Exponential, Normal Distributions and Gamma Distribution: Functions and Properties such as Mean, Median, Mode, Variance, Standard Deviation, Moments up to Fourth Order, M.G.F., Cumulants up to Fourth Order, C.G.F., P.G.F., C.F., Reproductive Property (Wherever Exists) and Their Real Life Applications, Normal Distribution as a Limiting Case of Binomial and Poisson Distributions.

Section 4

Continuous Distributions-II: Beta First & Second Kind and Cauchy Distributions: Functions and Properties (Wherever Exists) such as Mean, Median, Mode, Variance, Standard Deviation, Moments up to Fourth Order, M.G.F., Cumulants up to Fourth Order, C.G.F., P.G.F., C.F., Reproductive Property (Wherever Exists) and Their Real Life Applications.

References:

1. Gupta, S.C. and Kapoor, V. K. (2020): Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
2. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2016): Fundamental of Statistics, Vol. I, The World Press Private Limited, Kolkata.
3. Mukhopadhyay, P. (2020): Mathematical Statistics, Books and Allied Private Limited, Kolkata.
4. Gupta, K.R. (2014): Statistics Volume – II, Atlantic Publisher, New Delhi.
5. Misra, N: Probability and Distributions, NPTEL Swayam Portal (URL: https://archive.nptel.ac.in/courses/111/104/111104032/)

Semester - V

Name of the Course	Special Functions and Integral Transformations	Course Code	25/26 IMSMA501
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	3 Hours

Note:

Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Demonstrate understanding of special functions and polynomials, including Bessel's functions, Legendre's polynomials, and Hermite's polynomials, along with their properties.
CLO2: Solve Bessel's, Legendre's, and Hermite's differential equations using appropriate methods.
CLO3: Apply Laplace transforms and inverse Laplace transforms to functions and use them to solve ordinary differential equations.
CLO4: Compute Fourier transforms of functions and apply them to solve partial differential equations such as Laplace, wave, and diffusion equations.

Section – I

Series solution of differential equations – Power series method, Definitions of Beta and Gamma functions. Bessel equation and its solution: Bessel functions and their properties-Convergence, recurrence, Relations and generating functions, Orthogonality of Bessel functions.

Section – II

Legendre and Hermite differentials equations and their solutions: Legendre and Hermite functions and their properties-Recurrence Relations and generating functions. Orhogonality of Legendre and Hermite polynomials. Rodrigues' Formula for Legendre & Hermite Polynomials, Laplace Integral Representation of Legendre polynomial.

Section – III

Laplace Transforms – Existence theorem for Laplace transforms, Linearity of the Laplace transforms, Shifting theorems, Laplace transforms of derivatives and integrals, Differentiation and integration of Laplace transforms, Convolution theorem; Inverse Laplace transforms, convolution theorem, Inverse Laplace transforms of derivatives and integrals, solution of ordinary differential equations using Laplace transform.

Section – IV

Fourier transforms: Linearity property, Shifting, Modulation, Convolution Theorem, Fourier Transform of Derivatives, Relations between Fourier transform and Laplace transform, Parseval's identity for Fourier transforms, solution of differential Equations using Fourier Transforms.

Books Recommended:

1. Erwin Kreyszing, Advanced Engineering Mathematics, John Wiley & Sons, Inc., New York, 1999
2. A.R. Forsyth, A Treatise on Differential Equations, Macmillan and Co. Ltd.
3. I.N. Sneddon, Special Functions on mathematics, Physics & Chemistry.
4. W.W. Bell, Special Functions for Scientists and Engineers.
5. I.N. Sneddon, The use of integral transform, McGraw Hill, 1972
6. Murray R. Spiegel, Laplace transform, Schaum's Series

Semester - V

Name of the Course	Sequences and Series	Course Code	25/26 IMSMA502
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	3 Hours

Note:

Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1 Explain the concept of sequences and their types.
CLO2 Identify the convergence of sequences and series of positive terms.
CLO3 Apply various important convergence tests to the given series.
CLO4 Understand the difference between conditional and absolute convergence of Alternating series.

Section – I (Foundations of Real Analysis)

Boundedness of the set of real numbers; least upper bound, greatest lower bound of a set, neighborhoods, interior points, isolated points, limit points, open sets, closed set, interior of a set, closure of a set in real numbers and their properties. Bolzano-Weiestrass theorem, Open covers, Compact sets and Heine-Borel Theorem.

Section-II (Sequences and their Convergence)

Sequence: Real Sequences and their convergence, Theorem on limits of sequence, Bounded and monotonic sequences, Cauchy's sequence, Cauchy general principle of convergence, Subsequences, Subsequential limits. Infinite series: Convergence and divergence of Infinite Series, Comparison Tests of positive terms Infinite series, Cauchy's general principle of Convergence of series, Convergence and divergence of geometric series, Hyper Harmonic series or p-series.

Section-III (Infinite Series and Convergence Tests)

Infinite series: D-Alembert's ratio test, Raabe's test, Logarithmic test, de Morgan and Bertrand's test, Cauchy's nth root test, Gauss Test, Cauchy's integral test, Cauchy's condensation test.

Section-IV (Advanced Series and Infinite Products)

Alternating series, Leibnitz's test, absolute and conditional convergence, Arbitrary series: abel's lemma, Abel's test, Dirichlet's test, Insertion and removal of parenthesis, re-arrangement of terms in a series, Dirichlet's theorem, Riemann's Re-arrangement theorem, Pringsheim's theorem (statement only), Multiplication of series, Cauchy product of series, (definitions and examples only) Convergence and absolute convergence of infinite products.

Books Recommended:

1. R.R. Goldberg , Real Analysis, Oxford & I.B.H. Publishing Co., New Delhi, 1970
2. S.C. Malik, Mathematical Analysis, Wiley Eastern Ltd., Allahabad.
3. Murray, R. Spiegel, Theory and Problems of Advanced Calculus, Schaum Publishing Co., New York
4. T.M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1985
5. Earl D. Rainville, Infinite Series, The Macmillan Co., New York.

Semester V

Name of the Course	Linear Algebra	Course Code	25/26 IMSMA503
Maximum Marks	Theory: 20(Internal)+50(External)=70 Practical: 10(Internal)+20(External)=30	Time of Examinations	3 Hours

Note:

Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1 Get familiar with vector spaces, subspaces and existence theorem for basis of a finitely generated vector space.

CLO 2 Describe the concepts of homomorphism, isomorphism and dual spaces.

CLO 3 Learn singular and non-singular linear transformations, eigen values and eigen vectors of linear transformations.

CLO 4 Understand the Gram Schmidt orthogonalization process, inner product spaces, orthogonal vectors, and orthogonal sets.

Section-I

Vector spaces, Subspaces, Sum and direct sum of subspaces, Linear span, Linearly Independent and dependent subsets of a vector space, Finitely generated vector space, Existence theorem for basis of a finitely generated vector space, Finite dimensional vector spaces.

Section-II

Invariance of the number of elements of bases sets, Dimensions, Quotient space and its dimension, Homomorphism and isomorphism of vector spaces, Linear transformations and linear forms on vector spaces, Vector space of all the linear transformations.

Section -III

Dual spaces, Bidual spaces, Annihilator of subspaces of finite dimensional vector spaces, Null space, Range space of a linear transformation, Rank and Nullity theorem.

Section-IV

Algebra of linear transformation, Minimal polynomial of a linear transformation, Singular and non-singular linear transformations, Matrix of a linear transformation, Change of basis, Eigen values and eigen vectors of linear transformations.

Practical/ Computational Work
(Based on course Linear Algebra)

Practical: 10(Internal)+20(External)=30

There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.

Distribution of Marks will be as follows:

i) Written Practical/ Lab work : 10 Marks
ii) Viva-voce and practical record: 10 Marks

List of Practicals

Following is the list of programmes to be performed in the Lab using MATLAB:

1. Basic vector operations (Programs to do vector addition, scalar multiplication).
2. Checking vector space properties (Program to check closure under addition and scalar multiplication property).
3. Span (Program to determining the set of all possible linear combinations of a set of vectors).
4. Linear independence (Programs to check if a set of vectors can be expressed as a linear combination of the others.).
5. Basis (Program to find a set of linearly independent vectors that span the entire vector space).
6. Subspaces (Program to verify if a subset of a vector space is itself a vector space).
7. Quotient space (Program to find basis of a quotient space).

8. Vector spaces isomorphism verification (Program to verify if the given linear transformation is isomorphism or not).
9. Practical based on evaluating sum and scalar multiplication of linear transformations.
10. Practical based on computing rank and nullity of a given linear transformation.
11. Practical based on verification of Rank-Nullity theorem.
12. Practical based on evaluating null Space and range space of a linear transformation
13. Practical based on plotting of linear transformation.
14. Practical based on identification of singular and non-singular linear transformations.
15. Practical based on finding eigen values and eigen vectors of a given linear transformation.

References:

1. I.N. Herstein,: Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975
2. P.B. Bhattacharya, S.K. Jain and S.R. Nagpal, Basic Abstract Algebra (2d edition).
3. Vivek Sahai and Vikas Bist, Linear Algebra, Narosa Publishing House.
4. I.S. Luther and I.B.S. Passi, Algebra, Vol.-II, Narosa Publishing House.
5. Kenneth M Hoffman, Ray Kunze, Linear Algebra, 2d Edition, PRENTICE-HALL, INC., Englewood Cliffs, New Jersey, 1971.

Semester V

Name of the Course	Dynamics	Course Code	25/26 IMSMA504
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	3 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO1 Students will be able to analyze particle motion in different directions, apply concepts of relative motion, and solve problems on simple harmonic motion and elastic strings..
CLO2 Students will be able to apply Newton's laws to problems involving mass, momentum, work, power, energy, and distinguish between conservative and impulsive forces.
CLO3 Students will be able to solve problems related to motion on plane curves, projectile motion, and apply vector methods to angular velocity.
CLO 4 Students will be able to analyze rigid body motion, central orbits, Kepler's laws, and describe particle motion in three dimensions using different coordinate systems.

Section – I

Velocity and acceleration along radial, Transverse, Tangential and Normal directions. Relative velocity and acceleration. Simple harmonic motion. Elastic strings.

Section – II

Mass, Momentum and Force. Newton's laws of motion. Work, Power and Energy. Definitions of Conservative forces and Impulsive forces.

Section - III

Motion on smooth and rough plane curves. Projectile motion of a particle in a plane. Vector angular velocity.

Section – IV

General motion of a rigid body. Central Orbits, Kepler laws of motion. Motion of a particle in three dimensions. Acceleration in terms of different co-ordinate systems

References:

1. S.L.Loney: An Elementary Treatise on the Dynamics of a Particle and a Rigid Bodies, Cambridge University Press, 1956
2. F. Chorlton: Dynamics, CBS Publishers, New Delhi
3. A.S. Ramsey: Dynamics Part-1&2, CBS Publisher & Distributors.

Semester - V

Name of the Course	**Testing of Hypothesis**	Course Code	**25/26 IMSST501**
Maximum Marks	**Theory: 20(Internal)+50(External)=70** **Practical: 10(Internal)+20(External)=30**	Time of Examinations	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Acquire knowledge of various sampling distributions and their applications in statistical inference.

CLO–2:Understand the basic concepts and procedures of hypothesis testing.

CLO–3:Develop the ability to apply large sample and small sample tests for statistical decision-making.

CLO–4:Gain skills to construct confidence intervals and apply one-sample and two-sample hypothesis tests for location problems.

Section – I

Population, Sample, Parameter, Statistic, Standard Error, Concepts of Statistical Hypothesis, Null and Alternative Hypotheses, Critical Region, Type of Errors, Level of Significance and Power of the Test, degree of freedom. One and Two Tailed Tests. Large Sample Tests and Confidence Intervals for Single Mean and Difference of Two Means, Single Proportion, Difference of Proportions. Standard Deviation

Section – II

Sampling Distribution: Student's t-Distribution. Properties and its Applications. Small Sample Tests and Confidence Intervals for Single Mean, Difference of dependent and independent sample Means and Paired Sample.

Section – III

Sampling Distribution: Chi-Square (χ^2)-Distribution, Definitions, Properties and its Applications. Chi-Square (χ^2)-test for Goodness of Fit and Independence of Attributes.

Section – III

Sampling Distribution: F-Distribution, Properties and its Applications. F-test for Equality of Variances. One Way and Two Way ANOVA.

Practical/ Computational Work

(Based on course Testing of Hypothesis)

Practical: 10(Internal)+20(External)=30
There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.
Distribution of Marks will be as follows:
i) Written Practical/ Lab work : 10 Marks
ii) Viva-voce and practical record: 10 Marks

List of Practicals

Following is the list of programmes to be performed in the Lab using MS-excel:

1. Perform Various Test to Check the Normality of a Dataset.
2. Use the z-distribution to Calculate Confidence Intervals for a Given Dataset and Understand Its Application in Hypothesis Testing.

3. Use the t-distribution to Calculate Confidence Intervals for a Given Dataset and Understand Its Application in Hypothesis Testing.
4. Practical problems on applications of t-test.
5. Explore the $\chi 2$ Distributions to Calculate Confidence Intervals for a Given Dataset and Understand Its Application in Hypothesis Testing.
6. Practical problems on Chi-Square test.
7. Explore the F to Calculate Confidence Intervals for a Given Dataset and Understand Its Application in Hypothesis Testing.
8. Implement One Way Analysis of Variance (ANOVA) to Compare Means across Multiple Groups.
9. Implement Two Way Analysis of Variance (ANOVA) to Compare Means across Multiple Groups.

References:

1. Gupta, S.C. and Kapoor, V. K. (2020): Fundamentals of Mathematical Statistics, Sultan Chand & Sons, New Delhi.
2. Mukhopadhyay, P. (2020): Mathematical Statistics, Books and Allied Private Limited, Kolkata.
3. Ross, S.M. (2017): Introductory Statistics, Academic Press, Elsevier.
4. Siegel, S., & Castellan, N.J. (1988). Nonparametric Statistics for Behavioral Sciences. McGraw-Hill Education.
5. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2016): Fundamental of Statistics, Vol. I, The World Press Private Limited, Kolkata.
6. Gun, A.M., Gupta, M.K. and Dasgupta, B. (2016): Fundamental of Statistics, Vol. II, The World Press Private Limited, Kolkata.

Semester VI

Name of the Course	**Hydrostatics**	**Course Code**	**25/26 IMSMA601**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO 1: Demonstrate a fundamental understanding of hydrostatics, including pressure, equilibrium, and the variation of pressure in static fluids, and apply these concepts to real-world scenarios.
CLO 2: Calculate the magnitude and location of hydrostatic pressure forces on both plane and curved submerged surfaces, and analyze pressure variation using absolute and gauge pressure concepts.
CLO 3: Evaluate the stability and response of floating structures to changes in geometry and weight distribution, and determine buoyant forces acting on floating bodies.
CLO 4: Explain the principles of buoyancy and floatation, and analyze the behavior of fluids under various conditions, including the standard atmosphere and gas laws.

Section – I
Pressure equation. Condition of equilibrium. Lines of force. Homogeneous and heterogeneous fluids. Elastic fluids. Surface of equal pressure. Fluid at rest under action of gravity. Rotating fluids.

Section – II
Fluid pressure on plane surfaces. Centre of pressure. Resultant pressure on curved surfaces. Equilibrium of floating bodies. Curves of buoyancy. Surface of buoyancy.

Section – III
Stability of equilibrium of floating bodies. Metacentre. Work done in producing a displacement. Vessels containing liquid.

Section – IV
Gas laws. Mixture of gases. Internal energy. Adiabatic expansion. Work done in compressing a gas. Isothermal atmosphere. Connective equilibrium.

Books Recommended:
1. S.L. Loney, An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies, Cambridge University Press, 1956.
2. A.S. Ramsey, Dynamics, Part I, Cambridge University Press, 1973.
3. W.H. Basant and A.S. Ramsey, A Treatise on Hydromechanics, Part I Hydrostatics, ELBS and G. Bell and Sons Ltd., London.

Semester VI

Name of the Course	Numerical Analysis	Course Code	25/26 IMSMA602
Maximum Marks	Theory: 20(Internal)+50(External)=70 Practical: 10(Internal)+20(External)=30	Time of Examinations	3 Hours

Note:

Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1 Obtain numerical solutions of algebraic and transcendental equations

CLO2 Find numerical solutions of system of linear equations and check the accuracy of the solutions

CLO3 Learn about various interpolating and extrapolating methods

CLO4 Solve initial and boundary value problems in differential equations using numerical methods

Apply various numerical methods in real life problems.

Section – I

Round-off error and computer arithmetic, Local and global truncation errors, Algorithms and convergence; Bisection method, False position method, Fixed point iteration method, Newton's method and secant method for solving equations.

Partial and scaled partial pivoting, Lower and upper triangular (LU) decomposition of a matrix and its applications, Thomas method for tridiagonal systems; Gauss-Jacobi, Gauss Seidel and successive over-relaxation (SOR) methods.

Section – II

Lagrange and Newton interpolations, Piecewise linear interpolation, Cubic spline interpolation, Finite difference operators, Gregory-Newton forward and backward difference interpolations.

Section – III

First order and higher order approximation for first derivative, Approximation for second derivative; Numerical integration: Trapezoidal rule, Simpson's rules and error analysis, Bulirsch-Stoer extrapolation methods, Richardson extrapolation.

Section – IV

Picard's method, Taylor Series method, Euler's method, Runge-Kutta methods, Higher order one step method, Multi-step methods; Finite difference method, Shooting method.

Practical/ Computational Work
(Based on course Numerical Analysis)

Practical: 10(Internal)+20(External)=30

There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.

Distribution of Marks will be as follows:

i) Written Practical/ Lab work : 10 Marks
ii) Viva-voce and practical record: 10 Marks

List of Practicals

Following is the list of programmes to be performed in the Lab using Python/SciLab/ MATLAB/Maxima:

- Write a program to implement the bisection method for finding roots of a nonlinear equation.
- Write a program to implement the false position (regula falsi) method for root finding.
- Write a program to implement the fixed-point iteration method.
- Write a program to implement Newton's method for solving equations.

- Write a program to implement the secant method for solving equations.
- Write a program to compare round-off and truncation errors for a simple function.
- Write a program to implement Gaussian elimination with partial pivoting.
- Write a program to implement Gaussian elimination with scaled partial pivoting.
- Write a program to implement LU decomposition for solving linear systems.
- Write a program to implement the Thomas algorithm for tridiagonal systems.
- Write a program to implement the Gauss–Jacobi iterative method.
- Write a program to implement the Gauss–Seidel iterative method.
- Write a program to implement the successive over-relaxation (SOR) method.
- Write a program to implement Lagrange interpolation.
- Write a program to implement Newton interpolation.
- Write a program to implement piecewise linear interpolation.
- Write a program to implement cubic spline interpolation.
- Write a program to implement finite difference operators (forward, backward, central).
- Write a program to implement Gregory–Newton forward difference interpolation.
- Write a program to implement Gregory–Newton backward difference interpolation.
- Write a program to implement the trapezoidal rule for numerical integration.
- Write a program to implement Simpson's 1/3 and 3/8 rules for numerical integration.
- Write a program to implement Richardson extrapolation for numerical integration.
- Write a program to implement Picard's method for solving first-order ODEs.
- Write a program to implement the Taylor series method for solving ODEs.
- Write a program to implement Euler's method for solving ODEs.
- Write a program to implement Runge–Kutta methods (2d and 4th order) for solving ODEs.
- Write a program to implement a higher-order one-step method (e.g., Runge–Kutta–Fehlberg).
- Write a program to implement a multistep method (e.g., Adams–Bashforth or Adams–Moulton).
- Write a program to implement the finite difference method for solving two-point boundary value problems.
- Write a program to implement the shooting method for solving boundary value problems.

References:

1. R. K. Gupta, Numerical methods: Fundamental and Applications, 1st Edition, Cambridge University Press, (Textbook).
2. M. K. Jain, S. R. K. Iyengar & R. K. Jain (2012). Numerical Methods for Scientific and Engineering Computation (6th edition). New Age International Publishers, (Textbook).
3. Brian Bradie (2006), A Friendly Introduction to Numerical Analysis. Pearson.
4. C. F. Gerald & P. O. Wheatley (2008). Applied Numerical Analysis (7th edition), Pearson Education, India.
5. F. B. Hildebrand (2013). Introduction to Numerical Analysis: (2d edition). Dover Publications.
6. Robert J. Schilling & Sandra L. Harris (1999). Applied Numerical Methods for Engineers Using MATLAB and C. Thomson-Brooks/Cole.

Semester VI

Name of the Course	Metric Spaces	Course Code	25/26 IMSMA603
Maximum Marks	Theory: 30(Internal)+70(External)=10	Time of Examinations	3 Hours

Note:

Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Explain the fundamental concepts of metric spaces, including metrics, open and closed sets, and neighbourhood systems.

CLO2: Determine the convergence and limit points of sequences in metric spaces.

CLO3: Analyze continuity and uniform continuity of functions in the context of metric spaces.

CLO4: Apply the concepts of compactness and completeness to solve related problems in metric spaces.

Section – I (Introduction to Metric Spaces)

Definition of a metric space, Examples of metric spaces (Euclidean, discrete, Usual metric space and l^p space).Bounded sequence in metric space and semi-metric space. Distance between point and subset, Distance between two subsets and diameter of a subset. Bounded and unbounded metric spaces.

Section-II (Topology Induced by a Metric)

Basis for a topology, Open and closed balls.Neighborhoods,Limit points, Interior points, Open and closed sets, Closure and interior and boundary points of a set. Sub-spaces of a metric space and their properties and examples, Equivalent metrices.

Section-III (Completeness, Continuity and Uniform Continuity in Metric Spaces)

Cauchy sequences, Convergent sequences, Complete metric spaces and Examples of complete/incomplete metric spaces.Subsequences and Cantor's intersection theorem. Nowhere dense set, first and second category space and Baire's category theorem.Contraction mapping principle (Banach Fixed Point Theorem) and applications of the contraction principle. Continuous functions between metric spaces, Uniform continuity and isometry.

Section-IV (Compactness and Connectedness in Metric Spaces)

Open cover, Subcover, Compact set and compact metric space. Sequentially compact metric space, Countable compact spaces and finite intersection property. ϵ-Net and total boundedness, Continuity and compactness theorem. Separated sets,Connected sets, Disconnected sets, Path-connectedness and their properties and examples. Component of a metric space, Continuity and connectedness theorem.

Books Recommended:

1. Munkres, J. R. (2000). Topology (2d ed.). Prentice Hall.
2. Rudin, W. (1976). Principles of Mathematical Analysis (3rd ed.). McGraw-Hill.
3. Simmons, G. F. (1963). Introduction to Topology and Modern Analysis. McGraw-Hill.
4. Royden, H. L., & Fitzpatrick, P. M. (2010). Real Analysis (4th ed.). Prentice Hall.
5. Kreyszig, E.(1978). Introductory Functional Analysis with Applications. John Wiley & sons.

Semester VI

Name of the Course	**Complex Analysis**	**Course Code**	**25/26 IMSMA604**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand complex numbers as an extension of real numbers, their geometrical interpretations, and analytic representation through power series.

CLO2: Demonstrate the concepts of complex differentiation and integration to solve problems and establish theoretical results.

CLO3: Apply the theory of residues to evaluate contour integrals and solve polynomial equations.

CLO4: Integrate the concepts of complex analysis to interpret and apply advanced results in mathematical problem-solving.

Section-I

Function of a complex variable, Continuity, Differentiability, Analytic functions and their properties, Cauchy-Riemann equations in cartesian and polar coordinates, Power series, Radius of convergence, Differentiability of sum function of a power series, Branches of many valued functions with special reference to argz, logz and z^a.

Section-II

Path in a region, Contour, Complex integration, Cauchy theorem, Cauchy integral formula, Extension of Cauchy integral formula for multiple connected domain, Poisson integral formula, Higher order derivatives, Complex integral as a function of its upper limit, Morera theorem, Cauchy inequality, Liouville theorem, Taylor theorem.

Section-III

Zeros of an analytic function, Laurent series, Isolated singularities, Cassorati-Weierstrass theorem, Limit point of zeros and poles. Maximum modulus principle, Schwarz lemma, Meromorphic functions, Argument principle, Rouche theorem, Fundamental theorem of algebra, Inverse function theorem.

Section-IV

Calculus of residues, Cauchy residue theorem, Evaluation of integrals of the types $\int_0^{2\pi} f(\cos t, \sin t)dt$, $\int_{-\infty}^{\infty} f(x)dx$, $\int_0^{\infty} f(x)\sin mx\,dx$ and $\int_0^{\infty} f(x)\cos mx\,dx$, Conformal mappings.
Space of analytic functions and their completeness, Hurwitz theorem, Montel theorem, Riemann mapping theorem.

References:

1. H.A. Priestly, Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.
2. J.B. Conway, Functions of One Complex Variable, Springer-Verlag, International Student-Edition, Narosa Publishing House, 2002.
3. Liang-Shin Hann & Bernand Epstein, Classical Complex Analysis, Jones and Bartlett Publishers International, London, 1996.
4. E.T. Copson, An Introduction to the Theory of Functions of a Complex Variable, Oxford University Press, London, 1972.
5. E.C. Titchmarsh, The Theory of Functions, Oxford University Press, London, 1939.
6. Ruel V. Churchill and James Ward Brown, Complex Variables and Applications, McGraw-Hill Publishing Company, 2009.
7. H.S. Kasana, Complex Variable Theory and Applications, PHI Learning Private Ltd, 2011.

8. Dennis G. Zill and Patrik D. Shanahan, A First Course in Complex Analysis with Applications, John Bartlett Publication, 2d Edition, 2010.

Semester - VI

Name of the Course	**Design of Experiments**	Course Code	**25/26 IMSST601**
Maximum Marks	**Theory: 20(Internal)+50(External)=70** **Practical: 10(Internal)+20(External)=30**	Time of Examinations	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Demonstrate proficiency in assessing the appropriateness of experimental designs and handling extraneous variables.

CLO2: Design and analyze experiments involving one-way and two-way classifications, including specific designs such as CRD, RBD, and LSD.

CLO3: Apply methods for estimating missing observations and conduct thorough analysis of experimental data.

CLO4: Understand and apply factorial experiments with two levels, including treatment allocation and analysis using Yate's technique.

Section – I

Linear Models: Standard Gauss Markov Models, Estimation of Parameters, Best Linear Unbiased Estimator, Method of Least Squares, Gauss-Markov Theorem, Variance-Covariance Matrix of Blues.

Section – II

General Theory of Analysis of Experimental Designs, Principles of Experimental Designs, Analysis of Variance for One- Way, Two -Way With One/M Observations Per Cell for Fixed and Random Effects Models, Post-Hoc Tests, Tukey's Test for Non-Additively.

Section – III

Analysis of Completely Randomized Design, Randomized Block Design and Latin Square Designs. Missing Plot Techniques and their Analyses for Randomized Block Design and Latin Square Designs.

Section – IV

Analysis of Covariance for CRD and RBD, Factorial Experiments: Definition, Advantages, Yate's Method for of Computing Factor's Effect, Analysis of 2^2,$2^3$and 2 Factorial Design, Confounding and Partial Confounding.

Practical/ Computational Work

(Based on course Statistical Methods)

Practical: 10(Internal)+20(External)=30
There will be five questions in all, and the students must attempt any three questions. The question paper will set on the spot jointly by the internal and external examiners.
Distribution of Marks will be as follows:
i) Written Practical/ Lab work : 10 Marks
ii) Viva-voce and practical record: 10 Marks

List of Practicals

Following is the list of programmes to be performed in the Lab using MS-excel:

1. Calculate the BLUE for a Given Linear Model using the Method of Least Squares on a Dataset.
2. Compute the Variance-Covariance Matrix of BLUEs for a Set of Parameters using a Dataset.
3. Conduct ANOVA on a Dataset with One-Way Variation, Considering both Fixed and Random Effects Models.
4. Conduct Two-Way ANOVA with One Observation per Cell on a Dataset considering both Fixed and Random Effects Models.
5. Conduct Two-Way ANOVA with m Observation per Cell on a Dataset considering both Fixed and Random Effects Models.
6. Design and Analyze an Experiment Following the Principles of CRD using a Given Dataset.
7. Implement a Randomized Block Design and Perform the Corresponding Analysis on a Dataset.
8. Design and Analyze an Experiment using Latin Square Designs, Incorporating Missing Plot Techniques.
9. Apply ANCOVA to Analyze Datasets with Covariates in both CRD and RBD Setups.
10. Design and Analyze a 22, 23 Factorial Experiment for Exploring Interactions and Main Effects.

References:

1. Dass, M.N., & Giri, N.C. (2017). Design and Analysis of Experiments. New Age International.
2. Dey, A. (1987). Theory of Block Designs. Wiley–Blackwell.
3. Raghavrao, D. (2002). Construction and Combinatorial Problems in Design of Experiments. Dover Publications Inc.
4. Gupta, S.C., & Kapoor, V.K. (2014). Fundamentals of Applied Statistics. Sultan Chand & Sons.
5. Montgomery, D.C. (2013). Design and Analysis of Experiments. Wiley.
6. Goon, A.M., Gupta, M.K., & Gupta B.D. (2013). Outline of Statistical Theory Vol. II. World Press.

Semester-VII

Name of the Course	**Abstract Algebra**	**Course Code**	**25/26 IMSMA701**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO): •

CLO1: Apply group theoretic reasoning to group actions and analyze canonical types of groups such as cyclic groups and permutation groups.

CLO2: Understand and evaluate properties of solvable and nilpotent groups, as well as Noetherian and Artinian modules and rings.

CLO3: Apply Sylow's theorems to describe the structure of finite groups and use homomorphisms and isomorphisms for groups and rings.

CLO4: Analyze and illustrate advanced structures including composition series, normal series, and subnormal series in groups and rings.

Section-I

Sylow theorems: p-groups, Sylow subgroups, Applications of Sylow theorems, Description of group of order p^2 and pq, Survey of groups upto order 15.

Section-II

Normal and subnormal series, Solvable series, Derived series, Solvable groups, Solvability of S_n-the symmetric group of degree $n \geq 2$, Central series, Nilpotent groups and their properties, Equivalent conditions for a finite group to be nilpotent, Composition series, Zassenhaus lemma, Jordan-Holder theorem.

Section-III

Modules, Cyclic modules, Simple and semi-simple modules, Schurs' lemma, Free modules, Modules over principal ideal domain and its applications to finitely generated abelian groups.

Section-IV

Noetherian and Artinian modules, Modules of finite length, Noetherian and Artinian rings, Hilbert basis theorem. $Hom_R(R,R)$, Nil and Nilpotent ideals, Opposite rings, Wedderburn – Artin theorem.

References:

1. I.S. Luther and I.B.S.Passi, Algebra, Vol. I-Groups, Vol. III-Modules, Narosa Publishing House (Vol. I – 2013, Vol. III –2013).
2. Charles Lanski, Concepts in Abstract Algebra, American Mathematical Society, First Indian Edition, 2010.
3. Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.
4. D.S. Malik, J.N. Mordenson, and M.K. Sen, Fundamentals of Abstract Algebra, McGraw Hill, International Edition, 1997.
5. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, Basic Abstract Algebra (2d Edition), Cambridge University Press, Indian Edition, 1997.
6. C. Musili, Introduction to Rings and Modules, Narosa Publication House, 1994.
7. N. Jacobson, Basic Algebra, Vol. I & II, W.H Freeman, 1980 (also published by Hindustan Publishing Company).
8. M. Artin, Algebra, Prentice-Hall of India, 1991.
9. Ian D. Macdonald, The Theory of Groups, Clarendon Press, 1968.

Semester-VII

Name of the Course	**Mathematical Analysis**	**Course Code**	**25/26 IMSMA702**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Understand Riemann Stieltjes integral, its properties and rectifiable curves.
CLO 2: Learn about pointwise and uniform convergence of sequence and series of functions and various tests for uniform convergence.
CLO 3: Find the stationary points and extreme values of implicit functions.
CLO 4: Be familiar with the chain rule, partial derivatives and concept of derivation in an open subset of R^n.

Section-I

Riemann-Stieltjes integral, Existence and properties, Integration and differentiation, The fundamental theorem of calculus, Integration of vector-valued functions, Rectifiable curves.

Section-II

Sequence and series of functions, Point wise and uniform convergence, Cauchy criterion for uniform convergence, Weirstrass Mtest, Abel and Dirichlet tests for uniform convergence, Uniform convergence and continuity, Uniform convergence and differentiation, Weierstrass approximation theorem.

Section-III

Power series, uniform convergence and uniqueness theorem, Abel theorem, Tauber theorem.

Functions of several variables, Linear Transformations, Euclidean space R^n, Derivatives in an open subset of R^n, Chain Rule, Partial derivatives, Continuously Differentiable Mapping, Young and Schwarz theorems.

Section-IV

Taylor theorem, Higher order differentials, Explicit and implicit functions, Implicit function theorem, Inverse function theorem, Change of variables, Extreme values of explicit functions, Stationary values of implicit functions, Lagrange multipliers method, Jacobian and its properties.

References:

1. Walter Rudin, Principles of Mathematical Analysis (3rd edition) McGraw-Hill, Kogakusha, 1976, International Student Edition.
2. T. M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1974.
3. H.L. Royden, Real Analysis, Macmillan Pub. Co., Inc. 4th Edition, New York, 1993.
4. G. De Barra, Measure Theory and Integration, Wiley Eastern Limited, 1981.
5. R.R. Goldberg, Methods of Real Analysis, Oxford & IBH Pub. Co. Pvt. Ltd, 1976.
6. R. G. Bartle, The Elements of Real Analysis, Wiley International Edition, 2011.
7. S.C. Malik and Savita Arora, Mathematical Analysis, New Age International Limited, New Delhi, 2012

Semester-VII

Name of the Course	**Discrete Mathematics**	**Course Code**	**25/26 IMSMA703**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:

Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand and apply discrete numeric functions, generating functions, and solve recurrence relations using algebraic and generating function methods.

CLO2: Analyze algebraic structures such as groups, rings, and lattices, and demonstrate understanding of their fundamental properties.

CLO3: Apply Boolean algebra to simplify logic expressions and design efficient digital circuits using Karnaugh maps and switching theory.

CLO4: Develop mathematical reasoning and problem-solving skills in number theory, including divisibility, modular arithmetic, congruences, and connect abstract concepts of discrete mathematics to real-world applications in computing and engineering.

Section – I

Discrete numeric functions, Generating functions, recurrence relations with constant coefficients. Homogeneous solution, particular relations, total rotation, Solution of recurrence relation by the method of generating functions.

Section-II

Semigroups, Lattices and their properties, lattice as algebraic system, Bounded, Complement and distributive lattices.

Section-III

Boolean algebra, definition and examples, properties, duality, distributive and complemented Calculus. Design and implementation of digital networks, switching circuits, Karnaugh map.

Section-IV

The division algorithm, different bases, the equation ax + by = n, the bracket function and binomial coefficients, the ϕ-function, the order of an integer modulo m, periodic decimals.

Books Recommended:

1. J.P. Tremblay & R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, McGraw-Hill Book Co., 1997.
2. J.L. Gersting, Mathematical Structures for Computer Science, (3rd edition), Computer Science Press, New York.
3. Seymour Lipschutz, Finite Mathematics (International edition 1983), McGraw-Hill Book Company, New York.
4. C.L. Liu, Elements of Discrete Mathematics, McGraw-Hilll Book Co.
5. Babu Ram, Discrete Mathematics, Vinayak Publishers and Distributors, Delhi, 2004.
6. Thomas Koshy, Elementary Number Theory with Applications, Academic Press is an imprint of Elsevier, London, 2007.
7. Neal H. McCoy, The Theory of Numbers, The Macmillan Company, New York Collier-Macmillan Limited, London, 1966.

Semester-VII

Name of the Course	**Ordinary Differential Equations-II**	**Course Code**	**25/26 IMSMA704**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand how fundamental laws of physics and chemistry can be formulated as differential equations.

CLO2: Identify different types of differential equations and apply analytical techniques to find their solutions.

CLO3: Demonstrate proficiency in solving exact differential equations using integrating factors and related methods.

CLO4: Explain the concept of stability in differential equations and analyze the behavior of solutions under varying conditions.

Section-I

Preliminaries: Initial value problem and equivalent integral equation. Lipschitz condition, Picard Fundamental existence and uniqueness theorem for dy/dt= f(t,y), Dependence of solutions on initial conditions and parameters, Solution of initial-value problems by Picard method.

Section-II

Sturm-Liouville BVPs, Sturms Separation and Comparison theorems, Lagrange's identity and Green's formula for second order differential equations, Properties of eigenvalues and eigen functions, Pruffer transformation.

Section-III

Adjoint systems, Self-adjoint equations of second order. Linear systems, Matrix method for homogeneous first order system of linear differential equations, Fundamental set and fundamental matrix, Wronskian of a system, Method of variation of constants for a nonhomogeneous system with constant coefficients, nth order differential equation equivalent to a first order system.

Section-IV

Nonlinear differential system, Plane autonomous systems and critical points, Classification of critical points – rotation points, foci, nodes, saddle points. Stability, Asymptotical stability and unstability of critical points. Almost linear systems, Liapunov function and Liapunov's method to determinestability for nonlinear systems, Periodic solutions and Floquet theory for periodic systems, Limit cycles, Bendixson non-existence theorem, Poincare-Bendixson theorem(Statement only), Index of a critical point.

References:

1. Boyce W.E. and Diprima R.C., Elementary Differential Equations and Boundary Value Problems, John Wiley and Sons, Inc., New York, 2009, 9th edition.
2. Coddington E.A. and Levinson N., Theory of Ordinary Differential Equations, Tata McGraw Hill, 2017.
3. Deo S.G., Lakshmikantham V. and Raghavendra V., Textbook of Ordinary Differential Equations, Tata McGraw Hill, 2017.
4. Goldberg J. and Potter M.C., Differential Equations – A System Approach, Prentice Hall, 1998
5. Hartman P., Ordinary Differential Equations, John Wiley & Sons, 1987.
6. Ross S.L., Differential Equations, John Wiley and Sons Inc., New York, 1984.
7. Simmons G.F., Differential Equations, Tata McGraw Hill, New Delhi, 2003.
8. Somasundram D., Ordinary Differential Equations, A First Course, Narosa Pub. Co., 2016.
9. J. M. Gelfand and S. V. Fomin, Calculus of Variations, Prentice Hall, New Jersy, 1963.

Semester-VII

Name of the Course	Mechanics	Course Code	25/26 IMSMA705
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	3 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand the continuum model of fluid flow, classify fluids and flows based on physical properties, and describe fluid motion using Eulerian and Lagrangian approaches.

CLO2: Derive and solve fundamental equations of fluid dynamics, including continuity, motion, vorticity, moving boundary surfaces, pressure, and impulsive action for inviscid fluids.

CLO3: Calculate velocity fields and forces on bodies for steady and unsteady flows, and apply concepts of velocity potential, stream function, and complex potential to solve two-dimensional flow problems.

CLO4: Represent and analyze source, sink, and doublet potentials in two and three dimensions, and study their images in impermeable surfaces.

Section – I

Moments and products of Inertia, Theorems of parallel and perpendicular axes, Angular momentum of a rigid body about a fixed point and about a fixed axes, Principal axes, Kinetic energy of a rigid body rotating about a fixed point, Momental ellipsoid- Equimomental systems, Coplanar distributions. Euler's dynamical equations for the motion of a rigid body about a fixed point, Further properties of Rigid body motion under no forces.

Section – II

Generalized co-ordinates. Holonomic and Non-holonomic systems. Scleronomic and Rheonomic systems. Lagrange's equations for a simple holonomic dynamical system, Lagrange's equations for conservative and impulsive forces. Kinetic energy as a quadratic functions of velocities. Generalized potential, Energy equation for conservative fields. Hamilton's canonical variables. Donkin's theorem. Hamilton canonical equations. Cyclic coordinates. Routh's procedure.

Section – III

Poisson Bracket. Poisson's Identity. Jacobi-Poisson Theorem. Hamilton's Principle. Principle of Least action. Poincare Cartan Integral invariant. Whittaker's equations. Jacobi's equations. Hamilton-Jacobi equation. Jacobi theorem. Method of Separation of variables. Lagrange Brackets, Canonical Transformations, Condition of canonical character of a transformation in terms of Lagrange and Poisson brackets. Invariance of Lagrange and Poisson brackets under canonical transformations.

Section – IV

Gravitation: Attraction and potential of rod, disc, spherical shells and sphere. Laplace and Poisson equations. Work done by self-attracting systems. Distributions for a given potential. Equipotential surfaces. Surface and solid harmonics. Surface density in terms of surface harmonics.

References:

1. F. Chorlton, A Text Book of Dynamics, CBS Publishers & Dist., New Delhi. 2004.
2. F. Gantmacher, Lectures in Analytic Mechanics, MIR Publishers, Moscow. 1975.
3. F. B. Hildebrand, Method of Applied Mathematics, Dover Publications,2012.

Semester - VII

Name of the Course	**Statistical Inference**	**Course Code**	**25/26 IMSST701**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Apply statistical reasoning to draw valid conclusions about populations based on samples, and understand key concepts such as estimation, unbiasedness, sufficiency, and consistency.
CLO2: Perform regression analysis to model and interpret relationships between variables.
CLO3: Explain and apply statistical hypothesis testing, including both parametric and non-parametric approaches.
CLO4: Demonstrate proficiency in conducting non-parametric tests and interpreting their results in practical contexts.

Section – I

Estimation: Introduction to the problem of estimation, Concepts of Unbiasedness, Sufficiency, Completeness, Consistency, Efficiency. Minimum Variance Unbiased Estimator (MVUE), Neymann Factorization theorem. Exponential Family of Distributions and its Properties, Rao-Blackwell and Lehmann-Scheffe theorems and their applications. Cramer-Rao inequality and MVB estimators (statement and applications).

Section – II

Methods of Estimation: Method of moments, method of maximum likelihood estimation, method of minimum Chi-square.

Statistical hypotheses, critical region, size and power of a test, most powerful test, randomized and non randomized test, Neyman Pearson lemma and its applications, uniformly most powerful unbiased test, Likelihood Ratio test and its applications, Power functions of UMP tests with simple illustrations.

Section – III

Order Statistics, their Marginal and Joint Distributions. Distributions of Median and Range. Moments of Order Statistics. Asymptotic Distribution of Order Statistics. Elements of decision problems: Loss function, risk function, estimation and testing viewed as decision problems. Bayes rule.

Section – IV

Non Parametric Tests: Ordinary Sign test, Wilcoxon Signed Rank test, and their Comparison (one sample and paired sample problems). General problem of Ties. Goodness of Fit problem : Chi-Square test and Kolmogrov–Smirnov one sample test, and their comparison. Two sample problem: Kolmogrov–Smirnov two sample test, Wald – Wolfwitz Run test, Mann –Whitency U test, Median test.

References:

1. Freund J.E. (1992): Mathematical Statistical, 5th Edition, Prentice Hall of India.
2. Hogg R.V. and Craig A.T. (2012): Introduction of Mathematical Statistics, 7th Edition, Collier Macmillon Publishers.
3. Mood A.M., Graybill E.A. and Bose D.C. (2011): Introduction to the Theory of Statistics, 3rd Edition, McGraw Hill.
4. Rao, C.R. (2001): Linear Statistical Inference and its Applications, 2d edition Wiley Eastern.
5. Rohtagi V.K. and A. K. Md. Ehsanes Saleh (2015): An Introduction to Probability and Statistics, 3rd Edition, John Wiley and Sons.
6. Goon A.M., Gupta M.K. and Dasgupta B. (2013) : An Outline of Statistical Theory, Vol. 2 The World Press Publishers Pvt. Ltd. Calcutta.

Semester -VIII

Name of the Course	Topology	Course Code	25/26 IMSMA801
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	03 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand the fundamental concepts of topological spaces and continuous functions, and learn to generate new topologies using bases.

CLO2: Describe and apply the concepts of homeomorphism and topological invariants to analyze equivalence of topological spaces.

CLO3: Demonstrate understanding of connectedness and compactness in topological spaces and their implications in analysis.

CLO4: Explain and apply separation axioms and their properties to classify and study different types of topological spaces.

Section-I

Definition and examples of topological spaces. Comparison of topologies on a set, Intersection and union of topologies on a set. Neighborhoods, Interior point and interior of a set, Closed set as a complement of an open set, Adherent point and limit point of a set, Closure of a set, Derived set, Properties of Closure operator, Boundary of a set , Dense subsets, Interior, Exterior and boundary operators. Alternative methods of defining a topology in terms of neighborhood system and Kuratowski closure operator.

Section-II

Relative(Induced) topology, Base and subbase for a topology, Base for Neighbourhood system. Continuous functions, Open and closed functions, Homeomorphism. Connectedness and its characterization, connected subsets and their properties, Continuity and connectedness, Components, locally connected spaces.

Section-III

Relative(Induced) topology, Base and subbase for a topology, Base for Neighbourhood system. Continuous functions, Open and closed functions, Homeomorphism. Connectedness and its characterization, connected subsets and their properties, Continuity and connectedness, Components, locally connected spaces.

Section-IV

First countable, second countable and separable spaces, hereditary and topological property, Countability of a collection of disjoint open sets in separable and second countable spaces, Lindelof theorem. T0, T1, T2 (Hausdorff) separation axioms, their characterization and basic properties.

References:

1. Patty C.W., 2009, Foundation of Topology, Jones & Bertlett.
2. Croom F.H., 2009. Principles of Topology, Cengage Learning.
3. Simmons G.F., 1963, Introduction to Topology and Modern Analysis, McGraw- Hill
4. Book Company.
5. Kelly J.L., 2000, General Topology, Springer Verlag, New York.
6. Munkres J.R., 2002, Toplogy, Pearson Education Asia.
7. Rao K.C., 2009,Topology, Narosa Publishing House Delhi.
8. Joshi K.D., 2006, Introduction to General Topology, Wiley Eastern Ltd.

Semester -VIII

Name of the Course	**Analytical Number Theory**	**Course Code**	**25/26 IMSMA802**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand classical results related to prime numbers and explore the irrationality of constants such as e and π.

CLO2: Study and analyze the algebraic properties of Un and Qn.

CLO3: Learn about Waring's problem, arithmetic functions, and perfect numbers, and evaluate their mathematical significance.

CLO4: Apply number theoretic methods to represent numbers by sums of squares and investigate related properties in two and four-square representations.

Section-I

Distribution of primes, Fermat and Mersenne numbers, Farey series and some results concerning Farey series, Approximation of irrational numbers by rationals, Hurwitz theorem, Irrationality of e and π.

Section-II

The arithmetic in Z_n, The group U_n, Primitive roots and their existence, the group U_{p^n} (p-odd) and U_2, The group of quadratic residues Q_n, Quadratic residues for prime power moduli and arbitrary moduli, The algebraic structure of U_n and Q_n.

Section-III

Riemann Zeta Function $\zeta(s)$ and its convergence, Application to prime numbers, $\zeta(s)$ as Euler product, Evaluation of $\zeta(2)$ and $\zeta(2k)$. Diophantine equations $ax + by = c$, $x^2+y^2 = z^2$ and $x^4+y^4 = z^4$, The representation of number by two or four squares, Waring problem, Four square theorem, The numbers g(k) & G(k), Lower bounds for g(k) & G(k).

Section-IV

Arithmetic functions $\phi(n)$, $\tau(n)$, $\sigma(n)$ and $\sigma_k(n)$, U(n), N(n), I(n), Definitions and examples and simple properties, Perfect numbers, Mobius inversion formula, The Mobius function μ_n, The order and average order of the function $\phi(n)$, $\tau(n)$ and $\sigma(n)$.

References:

1. G.H. Hardy and E.M. Wright, An Introduction to the Theory of Numbers. 2008
2. D.M. Burton, Elementary Number Theory. 2002
3. N.H. McCoy, The Theory of Number by McMillan. 1966
4. I. Niven, I. and H.S. Zuckermann, An Introduction to the Theory of Numbers. 1960
5. A. Gareth Jones and J Mary Jones, Elementary Number Theory, Springer Ed. 1998.

Semester -VIII

Name of the Course	**Integral Equations and Calculation of Variations**	**Course Code**	**25/26 IMSMA803**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Understand the methods to reduce Initial value problems associated with linear differential equations to various integral equations.

CLO 2: Categorise and solve different integral equations using various techniques.

CLO 3: Describe importance of Green's function method for solving boundary value problems associated with non-homogeneous ordinary and partial differential equations, especially the Sturm-Liouville boundary value problems.

CLO 4: Learn methods to solve various mathematical and physical problems using variational techniques.

Section-I

Linear Integral equations, Some basic identities, Initial value problems reduced to Volterra integral equations, Methods of successive substitution and successive approximation to solve Volterra integral equations of second kind, Iterated kernels and Neumann series for Volterra equations. Resolvent kernel as a series. Laplace transfrom method for a difference kernel. Solution of a Volterra integral equation of the first kind.

Section-II

Boundary value problems reduced to Fredholm integral equations, Methods of successive approximation and successive substitution to solve Fredholm equations of second kind, Iterated kernels and Neumann series for Fredholm equations. Resolvent kernel as a sum of series. Fredholm resolvent kernel as a ratio of two series. Fredholm equations with separable kernels. Approximation of a kernel by a separable kernel, Fredholm Alternative, Non homonogenous Fredholm equations with degenerate kernels.

Section-III

Green function, Use of method of variation of parameters to construct the Green function for a nonhomogeneous linear second order boundary value problem, Basic four properties of the Green function, Alternate procedure for construction of the Green function by using its basic four properties. Reduction of a boundary value problem to a Fredholm integral equation with kernel as Green function, Hilbert-Schmidt theory for symmetric kernels.

Section-IV

Motivating problems of calculus of variations, Shortest distance, Minimum surface of resolution, Brachistochrone problem, Isoperimetric problem, Geodesic. Fundamental lemma of calculus of variations, Euler equation for one dependent function and its generalization to 'n' dependent functions and to higher order derivatives. Conditional extremum under geometric constraints and under integral constraints.

References:

1. A.J. Jerri, Introduction to Integral Equations with Applications,A Wiley-Interscience Publication, 1999.
2. R.P. Kanwal, Linear Integral Equations, Theory and Techniques, Academic Press, New York.
3. W.V. Lovitt, Linear Integral Equations, McGraw Hill, New York.
4. F.B. Hilderbrand, Methods of Applied Mathematics, Dover Publications.
5. J.M. Gelfand and S.V. Fomin, Calculus of Variations, Prentice Hall, New Jersy, 1963.

Semester -VIII

Name of the Course	**Partial Differential Equations-II**	**Course Code**	**25/26 IMSMA804**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO 1: Understand the theory of partial differential equations
CLO 2: Categorise and solve different integral equations using various techniques.
CLO 3: Describe importance of Green's function method for solving boundary value problems associated with partial differential equations.
CLO 4: Learn methods to solve wave equation, heat equation and laplace equation using method of separation of variables, Fourier transforms, Numerical and approximate methods etc.

Section-I

First Order P.D.E.: Curves and surfaces, Genesis of first order P.D.E., Classification of integrals, Compatible systems, Charpit's method, Integral Surfaces through a Given curve, Quasi-Linear Equations, Method of separation of variables.

Section-II

Second Order P.D.E, Genesis of Second Order P.D.E., Classification of Second Order P.D.E.,
One Dimensional Wave Equation: Vibrations of an Infinite Strings, Vibrations of a Semi-Infinite String, Vibrations of a string of finite length.

Section-III

Laplace's Equations: Boundary Value problems, Maximum and Minimum Principles, The Cauchy Problem, The Dirichlet Problem for upper half plane, The Neumann Problem for upper half plane, The Dirichlet problem for a circle, The Dirichlet Exterior problem for a circle, The Neumann problem for a circle, the Dirichlet problem for a rectangle.

Section-IV

Heat Conduction Problem: Heat conduction- Infinite rod case, Heat conduction- finite rod case, Duhamel's principle, Heat Conduction Equation, Classification in the case of n-variables, Families of Equipotential Surfaces, Kelvin's Inversion theorem.

References:

1. E.T. Copson: Partial Differential Equations (Cambridge university press 1975)
2. I.N. Sneddon: Elements of partial differential equations (Mc-Graw Hill Book company1957)
3. Peter V O'Neil: Advanced Engineering Mathematics seventh edition
4. T. Amarnath: An elementary course in partial differential equations (Narosa Publishing House). Second edition 2003.
5. W.E. Williams: Partial Differential equations (Charendon press-oxford 1980)
6. Stanley J. Farlow: Partial Differential Equations for Scientists and Engineers(Dover Publications, INC, New York)
7. L.C. Evans: Partial Differential Equations(American Mathematical Society).

Semester – VIII

Name of the Course	**Differential Geometry**	**Course Code**	**25/26 IMSMA805**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:

Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Describe the basic features of curves and parametric families of surfaces in Euclidean space, including envelopes, edges of regression, and developable surfaces.
CLO2: Demonstrate understanding of the normal curvature of a surface and its connection with the first and second fundamental forms.
CLO3: Analyze surfaces of revolution, asymptotic lines, curvature and torsion, isometric parameters, and minimal curves.
CLO4: Apply the theory of geodesics, including their characterization, torsion, Bonnet's theorem, and implications for geodesic triangles.

Section – I

One Parameter family of Surfaces: Envelope, Characteristics, Edge of regression, Developable surfaces.
Developables Associated with a Curve: Osculating developable, Polar developable, Rectifying developable.

Section – II

Two- parameter Family of Surfaces:Envelope, Characteristics points,
Curvilinear coordinates, First order magnitudes, Directions on a surface, The normal, Second order magnitudes, Derivatives of n.

Section III

Curves on a Surface: Principal directions and curvatures, First and second curvatures, Euler's theorems, Dupin's indicatrix, The surfaces $z = f(x,y)$, Surface of revolution. Conjugate directions, Conjugate systems. Asymptotic lines, Curvature and torsion, Isometric parameters, Null lines, minimal curves.

Section IV

Geodesics and Geodesic Parallels:Geodesics: Geodesic property, Equation of Geodesics, Surface of revolution, Torsion of Geodesic.
Curves in Relation to Geodesics: Bonnet's theorem, Joachimsthal's theorems, Vector curvature, Geodesic curvature κ_g, Other formulae for κ_g, Bonnet's formula.

Books Recommended:

1. A.K. Singh and P.K. Mittal , A Textbook of Differential Geometry, Har-Anand Publications.
2. C.E. Weatherburn, Differential Geometry of Three Dimensions, Radhe Publishing House.
3. Erwin Kreyszig, Differential Geometry, Dover Publications Inc., New edition.

Semester VIII

Name of the Course	**Optimization Techniques**	**Course Code**	**25/26 IMSST801**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand and analyze the association of attributes, and measure correlation to interpret statistical relationships.

CLO2: Apply regression analysis and the method of least squares to model relationships between variables.

CLO3: Interpret statistical results and apply them to practical contexts for informed decision-making.

CLO4: Utilize statistical methods effectively in real-world applications, demonstrating both theoretical knowledge and practical competence.

Section – I

Convex Sets and Functions. Linear Programming Problems: Formulation, Examples and Forms. Properties of a Solution to the LPP. Development of Optimum Feasible Solution. Solution of LPP by Graphical and Simplex Methods.

Section – II

Artificial Variable Techniques: Big-M-Method and Two Phase Simplex Method. Degeneracy in LPP and its Resolution. The Revised Simplex Method. Duality in LPP: Symmetric and Un-Symmetric Dual Problems. Fundamental Duality Theorem. Complementary Slackness Theorem. Dual Simplex Method. Economic Interpretation of Duality.

Section – III

Post-Optimization Problems: Sensitivity Analysis and Parametric Programming. Integer Programming Problems (IPP). Gomory's Algorithm for Pure Integer Linear Programs. Solution of IPP by Branch and Bound Method. Applications of Integer Programming.

Section – IV

Transportation Problems: Mathematical Formulation and Fundamental Properties. Initial Basic Feasible Solution by North West Corner Rule, Lowest Cost Entry Method and Vogel's Approximation Method. Optimal Solution of Transportation Problems. Assignment Problems: Mathematical Formulation, Reduction Theorem and Solution by Hungarian Assignment Method.

References:

1. Gass, S.I. (2010). Linear Programming: Methods and Applications. Dover Publication.
2. Kambo, N.S. (1984). Mathematical Programming Techniques. Affiliated East-West Press.
3. Sinha, S.M. (2010). Mathematical Programming - Theory and Methods. Elsevier.
4. Bazaraa, M.S., Jarvis, J.J., & Sherali, H.D. (2011). Linear Programming and Network Flows. Wiley.
5. Hadley, G. (2002). Linear Programming. Narosa

Semester – IX (for Option-I and Option-II)

Name of the Course	**Measure and Integration Theory**	**Course Code**	**25/26 IMSMA901**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Describe the shortcomings of the Riemann integral and explain the advantages of the Lebesgue integral.

CLO2: Understand the fundamental concepts of measure theory, including Lebesgue measure and its properties.

CLO3: Apply Lebesgue integration techniques to functions and explore its connection with differentiation of monotonic functions and the indefinite integral.

CLO4: Use the fundamental theorem of calculus in the context of Lebesgue integration to analyze and solve problems in real analysis.

Section-I

Set functions, Intuitive idea of measure, Elementary properties of measure, Measurable sets and their fundamental properties. Lebesgue measure of aset of real numbers, Algebra of measurable sets, Borel set, Equivalent formulation of measurable set sin terms of open, Closed, F_σ and G_δ sets, Non measurable sets.

Section-II

Measurable functions and their equivalent formulations. Properties of measurable functions. Approximation of a measurable function by a sequence of simple functions, Measurable functions as nearly continuous functions, Egoroff theorem, Lusin theorem, Convergence in measure and F. Riesz theorem. Almostun iform convergence.

Section-III

Short comings of Riemann Integral, Lebesgue Integral of a bounded function over a set of finite measure and its properties. Lebesgue integral as a generalization of Riemann integral, Bounded convergence theorem, Lebesgue theorem regarding points of discontinuities of Riemann integrable functions, Integral of non-negative functions, Fatou Lemma, Monotone convergence theorem, General Lebesgue Integral, Lebesgue convergence theorem.

Section-IV

Vitali covering lemma, Differentiation of monotonic functions, Function of bounded variation and its representation as difference of monotonic functions, Differentiation of indefinite integral, Fundamental theorem of calculus, Absolutely continuous functions and their properties.

References:

1. Walter Rudin, Principles of Mathematical Analysis (3rd edition) McGraw-Hill, Kogakusha, , International Student Edition, 1976.
2. H.L. Royden, Real Analysis, Macmillan Pub. Co., Inc. 4th Edition, New York, 1993.
3. P. K. Jain and V. P. Gupta, Lebesgue Measure and Integration, New Age International (P) Limited Published, New Delhi, 1986.
4. G.De Barra, Measure Theory and Integration, Wiley Eastern Ltd., 1981.
5. R.R. Goldberg, Methods of Real Analysis, Oxford & IBH Pub. Co. Pvt. Ltd, 1976.
6. R. G. Bartle, The Elements of Real Analysis, Wiley International Edition, 2011.

Semester – IX (for Option-I and Option-II)

Name of the Course	**Fluid Dynamics**	**Course Code**	**25/26 IMSMA902**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand the continuum model of fluid flow, classify fluids and flows based on physical properties, and describe fluid motion using Eulerian and Lagrangian approaches.

CLO2: Derive and solve fundamental equations of fluid dynamics, including continuity, motion, vorticity, moving boundary surfaces, pressure, and impulsive action for inviscid fluids.

CLO3: Calculate velocity fields and forces on bodies for steady and unsteady flows, and apply velocity potential, stream function, and complex potential to solve two-dimensional flow problems.

CLO4: Represent and analyze source, sink, and doublet potentials in two and three dimensions, and study their images in impermeable surfaces.

Section – I

Kinematics - Eulerian and Lagrangian methods. Stream lines, path lines and streak lines. Velocity potential. Irrotational and rotational motions. Vortex lines. Equation of continuity. Boundary surfaces.

Section – II

Acceleration at a point of a fluid. Components of acceleration in cylindrical and spherical polar co-ordiantes, Pressure at a point of a moving fluid. Euler's and Lagrange's equations of motion. Bernoulli's equation. Impulsive motion. Stream function.

Section – III

Acyclic and cyclic irrotation motions. Kinetic energy of irrotational flow. Kelvin's minimum energy theorem. Axially symmetric flows. Liquid streaming past a fixed sphere. Motion of a sphere through a liquid at rest at infinity. Equation of motion of a sphere. Three-dimensional sources, sinks, doublets and their images. Stoke's stream function.

Section – IV

Irrotational motion in two-dimensions. Complex velocity potential. Milne-Thomson circle theorem. Two-dimensional sources, sinks, doublets and their images. Blasius theorem. Two- dimensional irrotation motion produced by motion of circular and co-axial cylinders in an infinite mass of liquid.

References:

1. F. Chorlton, Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985
2. M.E. O'Neill and F. Chorlton, Ideal and Incompressible Fluid Dynamics, Ellis Horwood Limited, 1986.
3. R.K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.
4. W.H. Besant and A.S. Ramsay, A Treatise on Hydromechanics Part I and II, CBS Publishers, New Delhi.
5. Bansi Lal, Theoretical Fluid Dynamics, Skylark Pub., New Delhi.

Semester – IX (for Option-I and Option-II)

Name of the Course	Mechanics of Solids-I	Course Code	25/26 IMSMA903
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	03 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO 1: Get familiar with Cartesian tensors, as generalization of vectors, and their properties which are used in the analysis of stress and strain to describe the phenomenon of solid mechanics.

CLO 2 Analyse the basic properties of stress and strain components, their transformations, extreme values, invariants and Saint-Venant principle of elasticity.

CLO 3 Demonstrate generalized Hooke's law for three dimensional elastic solid which provides the linear relationship between stress components and strain components.

CLO 4 Use different types of elastic symmetries to derive the stress-strain relationship for isotropic elastic materials for applications to architecture and engineering.

Section-I

Cartesian tensors: Cartesian tensors of different order, Properties of tensors, Symmetric and skew-symmetric tensors, Isotropic tensors of different orders and relation between them, Tensor invariants. Eigen-values and eigen vectors of a second order tensor, Scalar, vector, tensor functions, Comma notation, Gradiant, Divergence and Curl of a tensor field.

Section-II

Analysis of Stress: Stress vector, stress components. Cauchy equations of equilibrium. Stress tensor. Symmetry of stress tensor. Stress quadric of Cauchy. Principal stress and invariants. Maximum normal and shear stresses. Mohr's diagram. Examples of stress.

Section-III

Analysis of Strain: Affine transformations. Infinitesimal affine deformation. Geometrical interpretation of the components of strain. Strain quadric of Cauchy. Principal strains and invariants. General infinitesimal deformation. Saint-Venant's equations of Compatibility. Finite deformations. Examples of uniform dilatation, simple extension and shearing strain.

Section-IV

Equations of Elasticity: Hooke's law and its generalization. Hooke's law in media with one plane of symmetry, orthotropic and transversely isotropic media, Homogeneous isotropic media. Elastic moduli for isotropic media. Equilibrium and dynamic equations for an isotropic elastic solid. Beltrami-Michell compatibility equations, Strain energy function and its connection with Hooke's law. Clapeyron's theorem. Saint-Venant's Principle(statement only).

References:

1. A. E. H. Love, A Treatise on a Mathematical Theory of Elasticity, Dover Pub., New York.
2. A. S. Saada, Elasticity- Theory and applications, Pergamon Press,New York.
3. D.S. Chandersekhariah and L. Debnath, Continum Mechanics, Academic Press, 1994.
4. H. Jeffreys, Cartesian tensors.
5. I.S. Sokolnikoff, Mathematical Theory of Elasticity, Tata McGraw HillPublishing Company Ltd., New Delhi, 1977.
6. Shanti Narayan, Text Book of Tensors, S. Chand & Co.
7. Teodar M. Atanackovic and Ardeshiv Guran, Theory of Elasticity for Scientists and Engineers Birkhausev, Boston, 2000.
8. Y.C. Fung, Foundations of Solid Mechanics, Prentice Hall, New Delhi, 1965.
9. R.B. Hetnarski, J. Ignaczak; the Mathematical Theory of Elasticity, CRC Press, 2d Edition.
10. A.K. Mal & S.J. Singh, Deformation of Elastic Solids, Prentice Hall, New Jersey, 1991.

Semester – IX (for Option-I and Option-II)

Name of the Course	**Mathematical Modeling**	**Course Code**	**25/26 IMSMA904**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand the fundamental concepts of mathematical modeling and its role in representing real-world phenomena.

CLO2: Derive and apply solutions to problems using appropriate mathematical techniques for analyzing real-world data.

CLO3: Explore and evaluate applications of mathematics across diverse fields through modeling approaches.

CLO4: Develop problem-solving skills to connect mathematical models with practical scenarios, interpreting results for meaningful insights.

Section – I

Mathematical modeling: need, techniques, classification and illustrations; Mathematical modeling through ordinary differential equations of first order. Linear growth and Decay models. Non-Linear and Decay models.

Section – II

Epidemic spreading and compartment Population Dynamics, Epidemics models; mathematical modeling through systems of ordinary differential equations; mathematical modeling in economic, medicine, arm-race, battle.

Section – III

Mathematical modeling through ordinary differential equations of second order Planetary motion, Circular motion and motion of Satellites. Higher order (linear) models. Mathematical modeling through difference equations: Need, basic theory; mathematical modeling in probability theory, economics, finance, population dynamics and genetics.

Section – IV

Mathematical modeling through partial differential equations: simple models, mass-balance equations, variational principles, probability generating function, traffic flow problems, initial & boundary conditions.

References:

1. J.N. Kapur: Mathematical Modeling, Wiley Eastern Ltd., 1990
2. B. Albright;Mathematical Modeling with Excel, Jones & Bartlett,2010

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Semester – IX (for Option-I and Option-II)

Name of the Course	Bio-Mechanics	Course Code	25/26 IMSMA905
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	3 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand the concept of normal modes of vibration and apply techniques for decoupling equations of motion.

CLO2: Analyze fluid flow around airfoils and bluff bodies, interpreting aerodynamic characteristics and practical implications.

CLO3: Apply mathematical modeling to biomedical contexts, including the indicator dilution method, peristalsis, and tracer motion in pulmonary microcirculation.

CLO4: Integrate mathematical and physical principles to connect vibration analysis, fluid dynamics, and biomedical applications for solving real-world problems.

Section – I

Newton equations of motion, Mathematical modeling, Continuum approach, Segmental movement and vibrations, Lagrange equations, Normal modes of vibration, Decoupling of equations of motion. Flow around an airfoil, Flow around bluff bodies, Steady state aeroelastic problems, Transient fluid dynamics forces due to unsteady motion, Flutter.

Section – II

Kutta-Joukowski theorem, Circulation and vorticity in the wake, Vortex system associated with a finite wing in nonsteady motion, Thin wing in steady flow. Blood flow in heart, lungs, arteries, and veins, Field equations and boundary conditions, Pulsatile flow in arteries, Progressive waves superposed on a steady flow, Reflection and transmission of waves at junctions.

Section – III

Velocity profile of a steady flow in a tube, Steady laminar flow in an elastic tube, Velocity profile of Pulsatile flow, The Reynolds number, Stokes number, and Womersley number, Systematic blood pressure, Flow in collapsible tubes. Micro-and macrocirculation Rheological properties of blood, Pulmonary capillary blood flow, Respiratory gas flow, Intraction between convection and diffusion, Dynamics of the ventilation system.

Section – IV

Laws of thermodynamics, Gibbs and Gibbs – Duhem equations, Chemical potential, Entropy in a system with heat and mass transfer, Diffusion, Filtration, and fluid movement in interstitial space in thermodynamic view, Diffusion from molecular point of view. Mass transport in capillaries, Tissues, Interstitial space, Lymphatics, Indicator dilution method, and peristalsis, Tracer motion in a model of pulmonary microcirculation.

References:

1. Y.C. Fung, Biomechanics: Motion, Flow, Stress and Growth, Springer-Verlag, New York Inc., 1990.

Semester – IX (for Option-I and Option-II)

Name of the Course	Financial Mathematics	Course Code	25/26 IMSMA906
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	3 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand the fundamental concepts of financial mathematics and their role in modeling economic and financial systems.

CLO2: Apply advanced techniques such as Black–Scholes analysis, American options, and exotic options to evaluate financial instruments.

CLO3: Explore the applications of mathematical concepts in solving real-world economic and financial problems.

CLO4: Develop analytical and problem-solving skills to connect mathematical models with practical decision-making in finance.

Section – I

Fundamentals of Financial Mathematics, Asset Price Model.

Section – II

Black-Scholes Analysis, Variations on Black-Scholes models.

Section – III

Numerical Methods, American Option, Exotic Options.

Section – IV

Path-Dependent Options, Bonds and Interest Rate Derivatives, Stochastic calculus.

References:

1. I-Liang , Financial Mathematics, Chern Department of Mathematics, National Taiwan University
2. Sheldon M. Ross, An Introduction to Mathematical Finance, Cambridge Univ. Press.
3. Robert J. Elliott and P. Ekkehard Kopp. Mathematics of Financial Markets, Springer-Verlag, New York Inc.
4. Robert C. Marton, Continuous-Time Finance, Basil Blackwell Inc.
5. Daykin C.D., Pentikainen T. and Pesonen M., Practical Risk Theory for Actuaries, Chapman & Hall.
6. Steven C. Chapra ;Applied Numerical Methods with MATLAB, McGraw Hill Publ., 2004.

Semester – IX (for Option-I and Option-II)

Name of the Course	**Finite Element Analysis**	**Course Code:**	**25/26 IMSMA907 Credits:4**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO1: Understand the general theory of Finite Element method and its difference with finite difference method
CLO2: Use the role and significance of shape functions in finite element formulations and use of linear, quadratic, and cubic shape functions for interpolation
CLO3: Formulate some important 1, 2 and 3 dimensional elements.
CLO4: Apply the weighted residual and variational approaches in solving some boundary value problems

Section – I General theory of finite element methods, difference between finite element and finite difference methods, review of some integral formulae, concept of discretization, different coordinates, one dimensional finite elements, concept of shape functions, stiffness matrix, connectivity, boundary conditions, and equilibrium equation.	15 hrs
Section – II Numerical integration, construction of shape functions: linear elements (one dimensional bar element, two dimensional-triangular and rectangular elements, three dimensional tetrahedron element).	15 hrs
Section - III Higher order elements: one dimensional quadratic element, two dimensional triangular element, rectangular element, three dimensional tetrahedron element: quadratic element and higher order elements	15 hrs
Section – IV Weighted residual and variational approaches (Galerkin method, collocation method, Rayleigh Ritz method etc.), solving one-dimensional problems. Application of finite element methods for solving various boundary value problems, computer procedures for finite element analysis.	15 hrs

References:

1. Rao, S. S. The Finite Element Method in Engineering. 5th edition, Butterworth-Heinemann, 2017.
2. Hughes, T. J. R. The Finite Element Method (Linear Static and Dynamic Finite Element Analysis). Courier Corporation, 2007.
3. Zienkiewicz, O. C. and Taylor, R. L. The Finite Element Method: The Basis. Butterworth-Heinemann, 2000.
4. Smith, G. D. Numerical solution of Partial Differential Equations: Finite difference methods. Oxford Applied Mathematics and Computing Science Series, 1985.

Semester – IX (for Option-I and Option-II)

Name of the Course	**Graph Theory with Applications**	**Course Code**	**25/26 IMSMA 908**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO1: Identify and describe types of graphs and basic graph properties.
CLO2: Solve problems using concepts of connectivity, Euler and Hamiltonian paths.
CLO3: Apply spanning tree algorithms to real-life networks.
CLO4: Use coloring and planarity in graph-based applications like scheduling and layout designs.

Section I

Definition and representation of graphs, Types of graphs: simple, multigraph, pseudograph, complete, regular, bipartite, Degree of vertices, Handshaking Lemma, Subgraphs, complement, isomorphism of graphs.

Section-II

Walks, trails, paths, and circuits, Connected components, Eulerian and Hamiltonian graphs, Euler's theorem (with proof and examples), Hamiltonian paths and cycles (Dirac's and Ore's theorems – statements only), Applications: route planning, social network graphs.

Section-III

Definition and types of trees: rooted, binary, m-ary, Properties of trees, tree traversal algorithms (preorder, inorder, postorder), Spanning trees and their applications, Kruskal's and Prim's Algorithms (step-by-step process, with examples).

Section-IV

Vertex coloring, chromatic number, applications in timetabling and scheduling, Independent sets and cliques, Planar graphs: definitions, Euler's formula, regions, and faces, Kuratowski's theorem (statement only), dual graphs.

Books Recommended:

1. J.A. Bondy and U.S.R. Murty, Graph Theory with Applications, The Macmillan Press Ltd (UK) and Elsevier Science Publishing Co., Inc. (USA), 1976.
2. Douglas B. West, Introduction to Graph Theory, 2d Edition, Pearson, 2000.
3. Kenneth H. Rosen, Discrete Mathematics and Its Applications, 8th Edition, McGraw Hill, 2018.
4. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice-Hall of India Pvt. Ltd., 2004.

Semester –IX (for Option-I and Option-II)

Name of the Course	Fuzzy Set Theory	**Course Code**	**25/26 IMSMA909**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Draw parallels between crisp set operations and fuzzy set operations using characteristic and membership functions, and represent fuzzy sets with linguistic terms.

CLO2: Define and analyze mappings of fuzzy sets, including concepts such as α-level sets, convexity, normality, and support.

CLO3: Understand and apply fuzzy structures including fuzzy graphs, fuzzy relations, fuzzy morphisms, and fuzzy numbers.

CLO4: Demonstrate proficiency with the extension principle, its compatibility with α-level sets, and its application in fuzzy number arithmetic operations

Section-I

Definition of Fuzzy Set, Expanding Concepts of Fuzzy Set, Standard Operations of Fuzzy Set, Fuzzy Complement, Fuzzy Union, Fuzzy Intersection, Other Operations in Fuzzy Set, T- norms and T- conorms.

Section-II

Product Set, Definition of Relation, Characteristics of Relation, Representation Methods of Relations, Operations on Relations, Path and Connectivity in Graph, Fundamental Properties, Equivalence Relation, Compatibility Relation, Pre-order Relation, Order Relation, Definition and Examples of Fuzzy Relation, Fuzzy Matrix, Operations on Fuzzy Relation, Composition of Fuzzy Relation, α- cut of Fuzzy Relation, Projection and Cylindrical Extension, Extension by Relation, Extension Principle, Extension by Fuzzy Relation, Fuzzy distance between Fuzzy Sets.

Section-III

Graph and Fuzzy Graph, Fuzzy Graph and Fuzzy Relation, α- cut of Fuzzy Graph, Fuzzy Network, Reflexive Relation, Symmetric Relation, Transitive Relation, Transitive Closure, Fuzzy Equivalence Relation, Fuzzy Compatibility Relation, Fuzzy Pre-order Relation, Fuzzy Order Relation, Fuzzy Ordinal Relation, Dissimilitude Relation, Fuzzy Morphism, Examples of Fuzzy Morphism.

Section-IV

Interval, Fuzzy Number, Operation of Interval, Operation of α- cut Interval, Examples of Fuzzy Number Operation, Definition of Triangular Fuzzy Number, Operation of Triangular Fuzzy Number, Operation of General Fuzzy Numbers, Approximation of Triangular Fuzzy Number, Operations of Trapezoidal Fuzzy Number, Bell Shape Fuzzy Number.

References:

1. Kwang H. Lee, First Course on Fuzzy Theory and Applications, Springer International Edition, 2005.
2. H.J. Zimmerman, Fuzzy Set Theory and its Applications, Allied Publishers Ltd., New Delhi, 1991.
3. John Yen, Reza Langari, Fuzzy Logic-Intelligence, Control and Information, Pearson Education,1999.

Semester –IX (for Option-III)

Name of the Course	Research Thesis	Course Code	25/26 IMSMA9RT
Maximum Marks	Theory: 150(Internal)+350(External)=500	Time of Examinations	1 Hour

GUIDELINES:

Every student will have to do research work based on the topic assigned by the supervisor. At the end of the semester student will submit a "Report" based on his/her research work. Evaluation will be on the basis of pre assigned seminar and monthly progress reports (the format will be provided by the department) to their respective research guide. External evaluation will be carried by external examiner on the basis of presentation, viva-voce, and research report.

Topics for the research report: Teacher may assign research topics to the students in following areas:

- **i.** Lab-oriented
- **ii.** Computer and software-oriented
- **iii.** Survey-oriented
- **iv.** Study-oriented
- **v.** Combination of any of the above mentioned areas

Criteria for Evaluation:

a. Attendance (Minimum attendance required 75%)

Total Attendance (%)	Marks Awarded (Max marks 20)
>75-80	14
>80-85	16
>85-90	18
>90	20

b. Internal Evaluation- 130 Marks

i) Pre study seminar - 60 Marks
ii) Progress reports - 70 Marks

c. External evaluation- 350 Marks

i) Final seminar - 100 Marks
ii) Viva-voce - 100 Marks
iii) Research report - 150 Mark

Semester –X (for Option-I)

Name of the Course	Functional Analysis	Course Code	25/26 IMSMA1001
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	03 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Verify norms, completeness, compactness, bounded operators, continuity, convergence, and dual spaces.

CLO2: Distinguish Banach and Hilbert spaces, and decompose Hilbert spaces using orthogonal complements.

CLO3: Analyze orthonormal sets, represent bounded functionals via inner products, and classify operators (self-adjoint, unitary, normal).

CLO4: Extend functionals, compute adjoints, check reflexivity, and apply major theorems (uniform boundedness, open mapping, closed graph) with weak/strong convergence.

Section-I

Metric Space, sequences, Cauchy sequences, complete metric spaces and examples, Baire's theorem. Cantor intersection theorem and Banach fixed point principle, normed linear spaces. Banach spaces, examples of Banach spaces and subspaces.

Section-II

Continuity of linear maps, Equivalent norms, normed spaces of bounded Linear maps, bounded linear functionals, dual spaces of $l^p, \mathbb{R}^n$ and reflexivity, Hilbert spaces and examples, orthogonality, orthonormal sets, Bessel's inequality, Parsevals's theorem,the conjugate space of a Hilbert space.

Section-III

Representation of bounded functional on Hilbert space, adjoint operators, self-adjoint operators, normal and unitary operators, weak and strong convergence, completely continuous operators.

Section-IV

Hahn-Banach theorem and its applications, uniform boundedness principle, open mapping theorem, projections on Banach spaces, closed graph theorem. Adjoint operators, Reflexivity.

References:

1. A. Taylor and D. Lay, Introduction to functional analysis, Wiley, New York, 1980.
2. B.V. Limaye, Functional Analysis, 2d ed., New Age International, New Delhi, 1996.
3. C. Goffman and G. Pedrick, First course in functional analysis, Prentice-Hall, 1974.
4. E. Kreyszig, Introductory Functional Analysis with applications, John Wiley & Sons, NY, 1978.
5. J. B. Conway, A course in Functional Analysis, Springer-Verlag, Berlin, 1985.

Semester –X (for Option-I)

Name of the Course	Mechanics of Solids-II	Course Code	25/26 IMSMA1002
Maximum Marks	Theory: 30(Internal)+70(External)=100	Time of Examinations	03 Hours

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):
CLO 1: Be familiar with the concept of generalized plane stress and solution of two-dimensional biharmonic equations.
CLO 2: Solve the problems based on thick-walled tube under external and internal pressures.
CLO 3: Understand the concept of torsional rigidity, lines of shearing stress and solve the problems of torsion of beams with different cross-sections.
CLO 4: Describe Ritz method, Galerkin method, Kantrovich method and their applications to the torsional problems.

Section-I

Two-dimensional Problems: Plane strain and Plane stress. Generalized plane stress. Airy stress function for plane strain problems. General solutions of a Biharmonic equation. Stresses and displacements in terms of complex potentials. Thickwalled tube under external and internal pressures. Rotating shaft.

Section-II

Torsion of Beams: Torsion of cylindrical bars. Torsional rigidity. Torsion and stress functions. Lines of shearing stress, Simple problems related to circle, ellipse and equilateral triangle cross-section.

Section-III

Variational Methods: Reciprocal theorem of Betti and Rayleigh. Deflection of elastic string by Transverse load; Deflection of central line of Beam, Deflection of elastic membrane. The Ritz method-one & two dimensional, The Galerkin method, The method of Kantrovitch.

Section-IV

Viscoelasticity: Spring & Dashpot, Maxwell & Kelvin Models, Three parameter solid, Correspondence principle & its application to the Deformation of a viscoelastic Thick-walled tube in Plane strain.

References:

1. I.S. Sokolnikof, Mathematical theory of Elasticity, Tata McGraw Hill Publishing company Ltd. New Delhi, 1977.
2. Teodar M. Atanackovic and Ardeshiv Guran, Theory of Elasticity for Scientists and Engineers, Birkhausev, Boston, 2000.
3. A.K. Mal & S.J. Singh, Deformation of Elastic Solids, Prentice Hall, New Jersey, 1991.
4. C.A. Coluson, Waves.
5. A.S. Saada, Elasticity-Theory and Applications, Pergamon Press, New York, 1973.
6. D.S. Chandersekharian and L. Debnath, Continuum Mechanics, Academic Press.

Semester –X (for Option-I)

Name of the Course	**Advanced Fluid Dynamics**	**Course Code**	**25/26 IMSMA1003**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand vortex motion, its permanence, rectilinear vortices, vortex images, and specific vortex arrangements.

CLO2: Acquire knowledge of viscosity, shear stress–strain relations for Newtonian fluids, energy dissipation, and laminar versus turbulent flows.

CLO3: Derive and solve equations of motion for viscous fluid flow, particularly laminar flows in pipes and ducts, and apply them to mechanical engineering problems.

CLO4: Apply dimensional analysis and similitude to fluid dynamics, derive and solve boundary layer equations in two dimensions, and explain the significance of characteristic boundary layer parameters.

Section – I

Vortex motion. Kelvin's proof of permanence. Motions due to circular and rectilinear vortices. Spiral vortex. Vortex doublet. Image of a vortex. Centroid of vortices. Single and double infinite rows of vortices. Karman vortex street. Applications of conformal mapping to fluid dynamics.

Section – II

Stress components in a real fluid. Relation between Cartesian components of stress. Translational motion of fluid element. Rates of strain. Transformation of rates of strains. Relation between stresses and rates of strain. The co-efficient of viscosity and laminar flow.

Navier-Stoke's equations of motion. Equations of motion in cylindrical and spherical polar co-ordinates. Equation of energy. Diffusion of vorticity. Energy dissipation due to viscosity. Equation of state.

Section – III

Plane Poiseuille and Couette flows between two parallel plates. Theory of lubrication. Hagen Poiseuille flow. Steady flow between co-axial circular cylinders and concentric rotating cylinders. Flow through tubes of uniform elliptic and equilateral triangular cross-section. Flow in convergent and divergent chennals. Unsteady flow over a flat plate. Steady flow past a fixed sphere.

Section – IV

Dynamical similarity. Inspection analysis. Non-dimensional numbers. Dimensional analysis. Buckingham π-theorem and its application. Physical importance of non-dimensional parameters.

Prandtl's boundary layer. Boundary layer equation in two-dimensions. The boundary layer on a flat plate (Blasius solution). Characteristic boundary layer parameters. Karman integral conditions. Karman-Pohlhausen method.

Books Recommended:

1. F. Chorlton, Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985
2. J. L. Bansal, Viscous Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 2000.
3. O'Neill, M.E. and Chorlton, F., Viscous and Compressible Fluid Dynamics, Ellis Horwood Limited, 1989.
4. S.W. Yuan, Foundations of Fluid Mechanics, Prentice Hall of India Private Limited, New Delhi, 1976.
5. H. Schlichting, Boundary-Layer Theory, McGraw Hill Book Company, New York, 1979.
6. R.K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 1976.
7. G.K. Batchelor, An Introduction to Fluid Mechanics, Foundation Books, New Delhi, 1994.

Semester –X (for Option-I)

Name of the Course	**Methods of Applied Mathematics**	**Course Code**	**25/26 IMSMA1004**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1:Solve **Laplace, wave, and heat equations** in spherical and cylindrical coordinates using separation of variables and Fourier series.

CLO2: Apply **Fourier and Hankel transforms** to boundary value problems (BVPs) and initial value problems (IVPs).

CLO3:Analyze **steady-state temperature distributions**, heat/wave equations in unbounded domains, and solutions in cylinders and spheres.

CLO4:Understand and apply **moments and products of inertia**, angular momentum, principal axes, kinetic energy of rigid bodies, and boundary layer theory in applied contexts.

Section - I

Solution of 3D Laplace, wave and heat equations in spherical polar co-ordinates and cylindrical polar co-ordinates by the method of separation of variables. Fourier series solution of the wave equation, transformation of boundary value problems.

Section - II

Fourier series solution of the heat equation, steady-state temperature in plates, The heat and wave equations in unbounded domains, Fourier transform solution of boundary value problems. The heat equation in an infinite cylinder and in a solid sphere.

Section - III

Hankel transform of elementary functions. Operational properties of the Hankel transform. Applications of Hankel transforms to PDE.
Definition and basic properties of finite Fourier sine and cosine transforms, its applications to the solutions of BVP's and IVP's.

Section - IV

Moments and products of inertia, Angular momentum of a rigid body, principal axes and principal moment of inertia of a rigid body, kinetic energy of a rigid body rotating about a fixed point, Momental ellipsoid and equimomental systems, coplanar mass distributions, general motion of a rigid body.

Books Recommended:

1. A.J. Jerri, Introduction to Integral Equations with Applications.
2. Lokenath Debnath, Integral Transforms and their Applications, CRC Press, Inc., 1995.
3. Peter V. O'Neil, Advanced Engineering Mathematics, 4th Edition, An International Thomson Publishing Company.
4. I.N. Sneddon, Elements of Partial Differential Equations, Prentice Hall, McGraw Hill.
5. I.N. Sneddon, Special Functions of Mathematical Physics and Chemistry.
6. F. Chorlton, Dynamics, CBS publishers and Distributors.

Semester –X (for Option-I)

Name of the Course	**Algebraic Number Theory**	**Course Code**	**25/26 IMSMA1005**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Learn the arithmetic of algebraic number fields and prove fundamental results on integral bases and unique factorization into ideals.

CLO2: Factorize algebraic integers into irreducibles and obtain the ideals of algebraic number rings.

CLO3: Understand and apply the theory of ideals in algebraic number rings to study structural properties of number fields.

CLO4: Explore ramified and unramified extensions and analyze their related results in algebraic number theory.

Section-I

Algebraic Number and Integers : Gaussian integers and its properties, Primes and fundamental theorem in the ring of Gaussian integers, Integers and fundamental theorem in $Q(\omega)$ where $\omega^3 = 1$, Algebraic fields, Primitive polynomials, The general quadratic field $Q(\sqrt{m})$, Sections of $Q(\sqrt{2})$, Fields in which fundamental theorem is false, Real and complex Euclidean fields, Fermat theorem in the ring of Gaussian integers, Primes of $Q(\sqrt{2})$ and $Q(\sqrt{5})$.

Section-II

Countability of set of algebraic numbers, Liouville theorem and generalizations, Transcendental numbers, Algebraic number fields, Liouville theorem of primitive elements, Ring of algebraic integers, Theorem of primitive elements.

Section-III

Norm and trace of an algebraic number, Non degeneracy of bilinear pairing, Existence of an integral basis, Discriminant of an algebraic number field, Ideals in the ring of algebraic integers, Explicit construction of integral basis, Sign of the discriminant, Cyclotomic fields, Calculation for quadratic and cubic cases.

Section-IV

Integral closure, Noetherian ring, Characterizing Dedekind domains, Fractional ideals and unique factorization, G.C.D. and L.C.M. of ideals, Chinese remainder theorem, Dedekind theorem, Ramified and unramified extensions, Different of an algebraic number field, Factorization in the ring of algebraic integers.

References:

1. Esmonde and M Ram Murty, Problems in Algebraic Number Theory, GTM Vol. 190, Springer Verlag, 1999.
2. G.H. Hardy and E.M. Wright, An Introduction to the Theory of Numbers 2008
3. W.J. Leveque, Topics in Number Theory – Vols. I, III Addition Wesley. 2012
4. H. Pollard, The Theory of Algebraic Number, Carus Monogrpah No. 9, Mathematical Association of America. 1998
5. P. Riebenboim, Algebraic Numbers – Wiley Inter-science. 1972
6. E. Weiss, Algebraic Number Theory, McGraw Hill. 2012

Semester –X (for Option-I)

Name of the Course	**Theory of Field Extensions**	**Course Code**	**25/26 IMSMA1006**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**03 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Apply diverse properties of field extensions and establish their connection with Galois theory.

CLO2: Describe automorphisms and monomorphisms in field theory, and analyze their linear independence.

CLO3: Compute Galois groups in classical situations and interpret their structural significance.

CLO4: Solve polynomial equations by radicals and explore ruler-and-compass constructions through Galois theory.

Section-I

Extension of fields: Elementary properties, Simple Extensions, Algebraic and transcendental Extensions. Factorization of polynomials.

Section-II

Splitting fields, Algebraically closed fields, Separable extensions, Galios fields, Perfect fields.

Section-III

Galios theory: Automorphism of fields, Monomorphisms and their linear independence, Fixed fields.

Section-IV

Normal extensions, Normal closure of an extension, The fundamental theorem of Galois theory.

References:

1. I.S. Luther and I.B.S. Passi, Algebra, Vol. IV-Field Theory, Narosa Publishing House, 2012.
2. Ian Stewart, Galios Theory, Chapman and Hall/CRC, 2004.
3. Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.
4. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, Basic Abstract Algebra (2d Edition), Cambridge University Press, Indian Edition, 1997.
5. S. Lang, Algebra, 3rd editioin, Addison-Wesley, 1993.
6. Ian T. Adamson, Introduction to Field Theory, Cambridge University Press, 1982.
7. I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.

Semester –X (for Option-I)

Name of the Course	**Mathematical Aspects of Seismology**	**Course Code**	**25/26 IMSMA1007**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:

Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand the fundamental concepts of seismology and the mathematical approaches used to study seismic phenomena.

CLO2: Acquire knowledge of the structure and behavior of earth waves.

CLO3: Derive and analyze the equations governing spherical waves in seismology.

CLO4: Apply mathematical methods to interpret seismic data and model wave propagation in the Earth.

Section – I

Waves: General form of progressive waves, Harmonic waves, Plane waves, the wave equation. Principle of superposition. Progressive types solutions of wave equation. Stationary type solutions of wave equation in Cartesian, Cylindrical and Spherical coordinates systems. Equation of telegraphy. Exponential form of harmonic waves. D' Alembert's formula. Inhomogeneous wave equation.

Section – II

Introduction to Seismology: Earthquakes, Location of earthquakes, Causes of Earthquakes, Observation of Earthquakes, Aftershocks and Foreshocks, Earthquake magnitude, Seismic moment, Energy released by earthquakes, Interior structure of the Earth. Reduction of equation of motion to wave equations. P and S waves and their characteristics. Polarization of plane P and S waves.

Section – III

Surface waves: Rayleigh waves and Love waves. Snell's law of reflection and refraction. Reflection of plane P and SV waves at a free surface. Partition of reflected energy. Reflection at critical angles. Reflection and refraction of plane P and SH waves at Solid-Solid Interface.

Section – IV

Two dimensional Lamb's problems in an isotropic elastic solid: Area sources and Line Sources in an unlimited elastic solid. A normal force acts on the surface of a semi-infinite elastic solid, tangential forces acting on the surface of a semi-infinite elastic solid. Three dimensional Lamb's problems in an isotropic elastic solid: Area or Volume sources and Point sources in an unlimited elastic solid, Area or Volume source and Point source on the surface of semi-infinite elastic solid.

Books Recommended:

1. C.A. Coulson and A. Jefferey, Waves, Longman, New York, 1977.
2. M. Bath, Mathematical Aspects of Seismology, Elsevier Publishing Company, 1968.
3. W.M. Ewing, W.S. Jardetzky and F. Press, Elastic Waves in Layered Media, McGraw Hill Book Company, 1957.
4. C.M.R. Fowler, The Solid Earth, Cambridge University Press, 1990
5. P.M. Shearer, Introduction to Seismology, Cambridge University Press,(UK) 1999.
6. K. E. Bullen, B. A. Bolt, An Introduction to the theory of Seismology, 4th Edi., 1985.
7. A. Ben-Menahem, S.J. Singh; Seismic Waves and Sources, Springer-Verlag, 1981.

Semester –X (for Option-I)

Name of the Course	**Coding Theory**	**Course Code**	**25/26 IMSMA1008**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:
Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Apply discrete numeric functions, generating functions, and recurrence relations.

CLO2: Analyze algebraic structures such as groups, rings, and lattices.

CLO3: Use Boolean algebra to simplify logic and design digital circuits.

CLO4: Solve problems in number theory and connect discrete mathematics to computing and engineering applications.

Section – I

The communication channel, the coding problem, Types of codes, Block codes, Error-detecting and error-correcting codes, Linear codes, The Ham-Ming metric, Description of linear block codes by matrices, Dual codes.

Section-II

Standard array, Syndrome, Step-by-step decoding, Modular representation, Error-correction capabili-ties of linear codes.

Section-III

Bounds on minimum distance for block codes, Plotkin bound, Hamming sphere packing bound, Varshamov-Gilbert-Sacks bound.Bounds for burst-error detecting and correcting codes.

Section-IV

Important linear block codes, Hamming codes.Golay codes, Perfect codes, Quasi-perfect codes, Reed-Muller codes, Codes derived from Hadamard matrices, Product codes, Concatenated codes.

Books Recommended:

1. Raymond Hill, A First Course in Coding Theory, Oxford University Press, 1990.
2. Man Young Rhee, Error Correcting Coding Theory, McGraw Hill Inc., 1989.
3. F.J. Macwilliams and N.J. A. Sloane, The Theory of Error Correcting Codes, North- Holland, 2006.
4. W.W. Peterson and E.J. Weldon, Jr., Error-Correcting Codes. M.I.T. Press, Cambridge, Massachusetts, 1972.

Semester –X (for Option-I)

Name of the Course	**Fourier and Wavelet Analysis**	**Course Code**	**25/26 IMSMA1009**
Maximum Marks	**Theory: 30(Internal)+70(External)=100**	**Time of Examinations**	**3 Hours**

Note:

Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing four short answer type questions from all sections. Further, examiner will set two questions from each section and the candidates will be required to attempt one question from each Section. All questions will carry equal marks.

Course Learning Outcomes (CLO):

CLO1: Understand the concept and properties of Fourier transforms.

CLO2: Apply Fourier transforms to practical problems such as signal sampling.

CLO3: Use Fourier transforms in applications including antennas, geometrical optics, computer tomography, and probability theory.

CLO4: Develop problem-solving skills by connecting Fourier analysis to real-world scientific and engineering contexts.

Section I

Fourier Transform: The finite Fourier transform, the circle group T, convolution to T, (L1 (T),+,*) as a Banach algebra, convolutions to products, convolution on T, the exponential form of Lebesgue's theorem, Fourier transform : trigonometric approach, exponential form, Basics/examples. Fourier transform and residues, residue theorem for the upper and lower half planes, the Abel kernel, the Fourier map, convolution on R, inversion, exponential form, inversion, trigonometric form, criterion for convergence, continuous analogue of Dini's theorem, continuous analogue of Lipschitz's test, analogue of Jordan's theorem.

Section-II

(C,1) summability for integrals, the Fejer-Lebesgue inversion theorem,the continuous Fejer Kernel, the Fourier map is not onto, a dominated inversion theorem, criterion for integrability of f^Approximate identity for L1(R), Fourier Sine and Cosine transforms, Parseval's identities, the L2 theory, Parseval's identities for L2, inversion theorem for L2 functions, the Plancherel theorem, A sampling theorem, the Mellin transform, variations.

Section-III

Discrete Fourier transform, the DFT in matrix form, inversion theorem for the DFT, DFT map as a linear bijection, Parseval's identities, cyclic convolution, Fast Fourier transform for N=2k, Buneman's Algorithm, FFT for N=RC, FFT factor form.

Section-IV

Wavelets : orthonormal basis from one function , Multiresolution Analysis, Mother wavelets yield Wavelet bases, Haar wavelets, from MRA to Mother wavelet, Mother wavelet theorem, construction of scaling function with compact support, Shannon wavelets, Riesz basis and MRAs, Franklin wavelets, frames, splines, the continuous wavelet transform.

Books Recommended:

1. G. Bachman, L. Narici and E. Beckenstein : Fourier and Wavelet Analysis, Springer, 2000 Hernandez and G. Weiss : A first course on wavelets, CRC Press, New York, 1996
2. C. K. Chui: An introduction to Wavelets, Academic Press,1992
3. V. Meyer, Wavelets, algorithms and applications SIAM, 1993
4. M.V. Wickerhauser: Adapted wavelet analysis from theory to software, Wellesley, MA, A.K.
5. Peters, 1994
6. D. F. Walnut: An Introduction to Wavelet Analysis, Birkhauser, 2002
7. K. Ahmad and F.A. Shah: Introduction to Wavelets with
8. Applications, World Education Publishers, 2013.

Semester –X (for Option-II & III)

Name of the Course	Research Thesis	Course Code	25/26 IMSMA10RT
Maximum Marks	Theory: 150(Internal)+350(External)=500	Time of Examinations	1 Hour

GUIDELINES:

Every student will have to do research work based on the topic assigned by the supervisor. At the end of the semester student will submit a "Report" based on his/her research work. Evaluation will be on the basis of pre assigned seminar and monthly progress reports (the format will be provided by the department) to their respective research guide. External evaluation will be carried by external examiner on the basis of presentation, viva-voce, and research report.

Topics for the research report: Teacher may assign research topics to the students in following areas:

- **vi.** Lab-oriented
- **vii.** Computer and software-oriented
- **viii.** Survey-oriented
- **ix.** Study-oriented
- **x.** Combination of any of the above mentioned areas

Criteria for Evaluation:

d. Attendance (Minimum attendance required 75%)

Total Attendance (%)	Marks Awarded (Max marks 20)
>75-80	14
>80-85	16
>85-90	18
>90	20

e. Internal Evaluation- 130 Marks

iii) Pre study seminar - 60 Marks
iv) Progress reports - 70 Marks

f. External evaluation- 350 Marks

iv) Final seminar - 100 Marks
v) Viva-voce - 100 Marks
vi) Research report - 150 Mark

PGBOS&R on 07-07-2026