Sardar Patel University Mandi

District Mandi -175001 (HP) India

www.spumandi.ac.in

(Established Under H.P. Legislative Assembly Act 03 of 2022)

Syllabus for
M.A./M.Sc. Mathematics
CBCS (2 Years)
Session 2022-23 Onwards

Faculty of Social Sciences
Sardar Patel University Mandi (HP)

Himachal Pradesh University
Department of Mathematics & Statistics
M. Sc. (Mathematics)
w.e.f. 2022-2023

PROGRAMME OUTCOMES (PO):

PO1: Critical Thinking: To develop critical thinking and prepare them to carry out scientific investigation objectively. Critically evaluate practices and theories by following mathematical approaches.

PO2: Knowledge Skill: To develop skills among the students to formulate hypothesis, modeling, solutions and validate, and draw conclusions.

PO3: Communication Skills: To inculcate the communication skills to express mathematical ideas.

PO4: Social Responsibility: To enlightened the students to serve the society by helping them by using mathematical knowledge in their life.

PO5: Analytical Reasoning: To equip the students for demonstration of quantitative and analytical reasoning skills.

PO6: Lifelong Learning: To inculcate the habit of self-learning through self-directed learning and through peer discussion and adapting to the changing academic environment and demands.

PO7: Leadership Qualities: To develop the team spirit and leadership quality to work effectively as an individual and as a leader in diverse situations.

PO8: Research Skills: Prepare students for pursuing research in various fields of mathematics and research-oriented career.

PO9: Ethics: The students are educated to follow the moral and ethical values in their behavior and professional life.

PROGRAMME SPECIFIC OUTCOMES (PSO):

At the end of the program, the students will be able to

PSO1: Apply the knowledge of mathematical concepts and mathematical tools and techniques in interdisciplinary fields to solve the real-world problems.

PSO2: Enrich the abstract mathematical concepts and explore the possibility for further investigations.

PSO3: Modeling the real-world problems mathematically and use the inferences for improvement of quality of life

PSO4: Identify challenging problems in mathematics and work on them.

PSO5: Pursue research in pure/applied mathematics.

PSO6: Work hard to acquire mathematical knowledge and skills suitable to professional activities and follow highest standards of ethical values.

PSO7: Qualify national level tests like NET/GATE etc.

PSO8: Effectively communicate and explore ideas of mathematics for propagation of knowledge and popularization of mathematics in the society.

STRUCTURE OF THE DEGREE

The M. Sc. Mathematics Degree is a two-year course divided into four semesters.

YEAR	SEMESTER	SEMESTER
First Year	Semester I	Semester II
Second Year	Semester III	Semester IV

COURSE CREDIT SCHEME

Types of Courses	Nature	Total Courses	Credits of each course	Total Credits
Core Courses (CC)	Compulsory	16	5	80
Departmental Elective Courses (DEC) (Select 4 out of 8)	Elective Courses	04	5	20
Project (***For Regular students only***) Or **One Additional Course** (***For ICDEOL & Private students only***)	Compulsory	01	5	05
Total Credits				105

SEMESTER-WISE COURSES

SEMESTER-I		SEMESTER-II	
M-101	Real Analysis	M-201	Measure Theory and Integration
M-102	Advanced Algebra	M-202	Field Theory
M-103	Ordinary Differential Equations	M-203	Partial Differential Equations
M-104	Operations Research	M-204	Linear Algebra and Matrix Analysis
M-105	Fluid Dynamics	M-205	Mathematical Statistics
SEMESTER-III		**SEMESTER-IV**	
M-301	Complex Analysis	M-401	Functional Analysis
M-302	Classical Mechanics	M-402	Integral Equations and Calculus of Variations
M-303	Topology	M-403	Advanced Discrete Mathematics
(Choose any one of the following two)		**(Choose any one of the following two)**	
M-304A	Magneto Fluid Dynamics	M-404A	Differential Geometry
M-304B	Cryptography	M-404B	Coding Theory
(Choose any one of the following two)		**(Choose any one of the following two)**	
M-305A	Analytical Number Theory	M-405A	Solid Mechanics
M-305B	Wavelet Theory	M-405B	Non-Linear Programming Problems
		Choose Project or Additional Course	
		M-406	Project (***For Regular students only***)
		M-407 (**Additional Course**)	Topics in Applied Mathematics (***For ICDEOL & Private students only***)

SEMESTER-WISE COURSES AND CREDIT DISTRIBUTION

SEMESTER-I

Total Credits: 25

Sr. No.	Course Code	Course Title	Total Credits
Core Courses			
1	M-101	Real Analysis	5
2	M-102	Advanced Algebra	5
3	M-103	Ordinary Differential Equations	5
4	M-104	Operations Research	5
5	M-105	Fluid Dynamics	5

SEMESTER-II

Total Credits: 25

Sr. No.	Course Code	Course Title	Total Credits
Core Courses			
1	M-201	Measure Theory and Integration	5
2	M-202	Field Theory	5
3	M-203	Partial Differential Equations	5
4	M-204	Linear Algebra and Matrix Analysis	5
5	M-205	Mathematical Statistics	5

SEMESTER-III

Total Credits: 25

Sr. No.	Course Code	Course Title	Total Credits
Core Courses			
1	M-301	Complex Analysis	5
2	M-302	Classical Mechanics	5
3	M-303	Topology	5
Elective Courses			
4	**Elective-1 (Choose any one of the following two)**		
	Course Code	**Course Title**	
(i)	M-304A	Magneto Fluid Dynamics	5
(ii)	M-304B	Cryptography	5
5	**Elective-2 (Choose any one of the following two)**		
	Course Code	**Course Title**	
(i)	M-305A	Analytical Number Theory	5
(ii)	M-305B	Wavelet Theory	5

SEMESTER-IV

Total Credits: 30

Sr. No.	Course Code	Course Title	Total Credits
Core Courses			
1	M-401	Functional Analysis	5
2	M-402	Integral Equations and Calculus of Variations	5
3	M-403	Advanced Discrete Mathematics	5
Elective Courses			
	Elective -3 (Choose any one of the following two)		
	Course Code	**Course Title**	
(i)	M-404A	Differential Geometry	5
(ii)	M-404B	Coding Theory	5
5	**Elective-4 (Choose any one of the following two)**		
	Course Code	**Course Title**	
(i)	M-405A	Solid Mechanics	5
(ii)	M-405B	Non-Linear Programming Problems	5
6	M-406*	Project (*For Regular students only*)	5
	M-407#	Topics in Applied Mathematics (*For ICDEOL & Private students only*)	5

* All the Regular students are required to undertake a Project M-406 of 5 credits allotted by the Mentor/Teacher at the end of 3rd Semester and shall require to submit it by the end of 4th Semester before the commencement of End Semester Examinations. Projects shall be on the topics related to the course contents learnt by the student during his M.Sc. Degree.

\# All the ICDEOL and Private students shall opt an additional course M-407 of 5 credits in 4th semester.

END SEMESTER EXAMINATION (ESE) AND INTERNAL ASSESSMENT (IA) SCHEME OF TWO YEARS M. Sc. MATHEMATICS DEGREE

Scheme of Examination for Each Course

1. The medium of Instructions and Examinations shall be English only.

2. ESE & Practical Examinations shall be conducted at the end of each semester as per the Academic Calendar notified by H. P. University, Shimla-5, time to time.

3. Each course of 5 credits will carry 100 marks and will have following components:

(For Courses without Practical)

I. Theory

End Semester Examination (ESE) — 80 marks

II. Internal Assessment (IA)* — 20 marks

(a) Assignment/Class Test/ Mid-Term Examination — 15 marks

(b) Attendance — 05 marks

Note:

1. For Private students, each course will be of 100 marks.
2. *For ICDEOL students, the Internal Assessment will be of 20 marks based on the assignment in each subject.

III. Project — 100 marks

Evaluation of Project : — 70 marks
Viva- Voce : — 30 marks
(See the guidelines for the Project)

4. Minimum Pass Percentage in each component (ESE, IA & Project (both Evaluation of the Project & Viva-voce)) shall be 40% separately.

5. Criterion for Class-room attendance (05 marks), 75% Attendance is minimum eligibility condition.

(i)	Attendance 75% and above to 80%	:	3 marks
(ii)	Attendance above 80% to 90%	:	4 marks
(iii)	Attendance above 90%	:	5 marks

Pattern of Theory Examination

Each theory paper will be divided into three sections. Nine questions will be set in all. Each section will contain three questions. The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Guidelines of Project Evaluation and Viva-voce Examination

1. (a) For the students of P. G. Centre, H. P. University, Project shall be evaluated by the respective Mentor/Teacher.

   (b) The Viva-voce Examination of these students shall be conducted by the following committee:
   - (i) Chairman of the Department,
   - (ii) Mentor of the Student,
   - (iii) Any teacher of the Department.
2. For the students of the affiliated colleges with H. P. University, the Chairman of the Department of Mathematics, Himachal Pradesh University, shall nominate a teacher of the Department to conduct Viva-voce. The other members of the Viva-voce Examination committee will comprise of the following:
   - (i) Senior most teacher of the subject in the college,
   - (ii) Mentor of the student.

   The Project shall be evaluated by the Mentor / Teacher.
3. The remuneration for the Evaluation of the Project and conducting of Viva-voce Examination in the respective Institutes/Outside institutes shall be paid as per the existing H. P. University Rules for the same.

DETAILED SYLLABUS SEMESTER-WISE

M.Sc. (Mathematics) First Semester

Course Code	M-101 (5 Credits)
Name of the Course	**Real Analysis**
Type of the Course	Core Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: On completion of the Course, students will be able to

CO1 Develop the understanding of Reimann Stieltjes integrals so as to relate Riemann-integral and Reimann Stieltjes integral. Also understand the partial integration theorem to evaluate R-S integrals of functions.

CO2 Understand the knowledge about term by term integration and term by term differentiation for evaluating uniform convergence of series of real valued functions.

CO3 Have the knowledge of methods to examine uniform convergence of sequences and series of real valued functions such as Cauchy criteria, Weiestrass M-test, Abel and Dirichlet's test for uniform convergence with idea about the uniform convergence of sequence and series of functions.

CO4 Understand the relation between uniform convergence and continuity, uniform continuity and differentiation and integration of sequences of real valued functions.

CO5 Have the knowledge of the concepts of complete metric space, perfect set and connected set.

CO6 Understand the Stone-Weierstrass theorem to examine the uniform convergence of polynomials in real variables.

CO7 Have the idea about rectifiable curves to evaluate lengths.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√	√	√	√	√		√	
CO2	√	√	√	√	√	√		√	
CO3	√	√	√	√	√	√		√	
CO4	√	√	√	√	√	√		√	
CO5	√	√	√	√	√	√		√	
CO6	√	√	√	√	√	√		√	
CO7	√	√	√	√	√	√		√	

Core Course: Real Analysis

Section – I

Convergent Sequences. Sub-sequences. Cauchy Sequences (in metric spaces). Absolute Convergence. Addition and Multiplication of Series. Rearrangements of Series of Real Number. Power series, Uniqueness Theorem for Power Series. Abel's and Taylor's Theorems.
Continuity, Limits of Functions (in Metric Spaces). Continuous Functions, Continuity, Uniform Continuity and Compactness. Limit Inferior and Limit Superior. Integral Test. Comparison Test.

Section – II

The Riemann-Stieltjes Integral

Definition and Existence of Riemann-Stieltjes Integral. Properties of The Integral. Integration and Differentiation. The Fundamental Theorem of Calculus. Change of Variable. Rectifiable Curves.

Section-III

Sequences and Series of Functions

Problem of Interchange of Limit Processes for Sequences of Functions, Pointwise and Uniform Convergence, Cauchy Criterion for Uniform Convergence. Weierstrass M-Test. Abel's and Dirichlet's Tests for Uniform Convergence. Uniform Convergence and Continuity. Uniform Convergence and Riemann – Stieltjes Integration. Uniform Convergence andDifferentiation. The Weierstrass Approximation Theorem.

Text Book:

1. Walter Rudin, Principles of Mathematical Analysis (3rd Edition), McGraw-Hill, Kogakusha, 1976, International Student Edition, (Chapter 6: §§ 6.1 to 6.27, Chapter 7: §§7.1 to 7.18, 7.26 – 7.32, Chapter 3 § 3.1-3.25, 3.45-3.55 Chapter 4§ 4.1-4.20, Chapter8§§8.1-8.5

Reference Books:

1. T.M. Apostol, "Mathematical Analysis", Narosa publishing House, New Delhi, 1985.
2. S. Lang, Analysis-I, Addison – Wesley Publishing Company, Inc. 1969
3. Robert G. Bartle, Donald R. Sherbest, "Introduction to Real Analysis (Fourth Edition-(2015)", John Wiley & Sons, Inc.
4. S.C. Malik, Savita Arora, "Mathematical Analysis (Third edition-2008)", New Age International (P) Ltd., New Delhi.

M.Sc. (Mathematics) First Semester

Course Code	M-102 (5 Credits)
Name of the Course	**Advanced Algebra**
Type of the Course	Core Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: On completion of the course, students shall be able to

CO1 Develop the understanding about the importance of group actions on sets.

CO2 Describe the normal series, solvable groups, nilpotent groups and their applications to characterize some classes of groups.

CO3 Have the broad idea about direct sum and direct product of groups.

CO4 Have the knowledge about finitely generated Abelian groups which are decomposable as a finite direct sum of cyclic groups which enables the students to find the number of non-isomorphic Abelian groups of given order.

CO5 Understand the Sylow Theorems and their applications: in particular, the existence of a simple group of a given order.

CO6 Provide the comprehensive understanding of ring theory and some special classes of rings such as Quotient rings, Euclidean rings, ring of Gaussian integers and Polynomial rings over the Rational fields and Commutative rings.

CO7 Have knowledge of the concept of Modules, free modules, completely reducible modules and Quotient modules.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√	√	√	√	√		√	
CO2	√	√	√	√	√	√		√	
CO3	√	√	√	√	√	√		√	
CO4	√	√	√	√	√	√		√	
CO5	√	√	√	√	√	√		√	
CO6	√	√	√	√	√	√		√	
CO7	√	√	√	√	√	√		√	

Core Course: Advanced Algebra

Section –I

Conjugacy and G-Sets. Normal Series, Solvable Groups, Nilpotent Groups, Direct Products, Finitely Generated Abelian Groups, Invariants of a Finite abelian Groups, Sylow Theorems, Groups of Orders p^2, pq.

Section – II

Definition and Examples of Rings, Some Special Classes of Rings, Homomorphisms, Ideals and Quotient Rings, More Ideals and Quotient Rings and The Field of Quotients of an Integral Domain.

Euclidean Rings, a Particular Euclidean Ring, Polynomial Rings, Polynomials over the Rational Field, Polynomial Rings over Commutative Rings.

Section – III

Definition and examples, Submodules and direct sums, homomorphisms and quotient modules, Completely reducible modules, Free modules.

Text Books:

1. P.B. Bhattacharya, S.K. Jain & S.R. Nagpal, Basic Abstract Algebra, 2nd Edition, Cambridge University Press (§§107-152).
2. I.N. Herstein, 'Topics in Algebra', Second Edition), John Wiley & Sons, New York (§§ 3.1 to 3.11).
3. Kenneth Hoffman & Ray Kunze, 'Linear Algebra', Second Edition, Prentice-Hall of India Private Limited, New Delhi (§§ 8.4, 8.5, 9.1 to 9.5).

M.Sc. (Mathematics) First Semester

Course Code	M-103 (5 Credits)
Name of the Course	**Ordinary Differential Equations**
Type of the Course	Core Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: On completion of the above course, the students will be able to

CO1 Assure the existence and uniqueness of the solution of an initial value problem in order to save the time and energy.

CO2 Handle the Sturm-Liouville Boundary Value Problems and to construct the orthonormal functions which can be used to expand any function as infinite series of these functions.

CO3 Investigate the nonlinear differential equations and the corresponding nonlinear autonomous systems and their critical points which are helpful in predicting the nature of the solution of the nonlinear differential equations.

CO4 Understand the various theoretical concepts of homogeneous and non-homogeneous ordinary differential equations e.g. linear dependence and linear independence of the solutions, Wronskian, the separation and comparison theorems etc.

CO5 Understand the concept and applications of eigen value problems.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√	√		√	√		√	
CO2	√	√	√		√			√	
CO3	√	√	√		√	√		√	
CO4	√	√	√		√			√	
CO5	√	√	√		√	√		√	

Core Course: Ordinary Differential Equations

Section –I

Existence and Uniqueness Theory

Some Concepts from Real Function Theory. The Fundamental Existence and UniquenessTheorem. Dependence of Solutions on Initial Conditions and on the Function f. Existence and Uniqueness Theorems for Systems and Higher-Order equations.

The Theory of Linear Differential Equations

Introduction. Basic Theory of the Homogeneous Linear System. Further Theory of the Homogeneous Linear System. The Nonhomogeneous Linear System. Basic Theory of the nth-Order Homogeneous Linear Differential Equation. The nth-Order Nonhomogeneous Linear equation.

Section –II

Sturm-Liouville Boundary-Value Problems

Sturm-Liouville Problems. Orthogonality of Characteristic Functions. The Expansion of aFunction in a Series of Orthonormal Functions.

Strumian Theory

The separation theorem, Sturm's fundamental theorem Modification due to Picone, Conditions for Oscillatory or non-oscillatory solution, First and Second comparison theorems. Sturm's Oscillation theorems. Application to Sturm Liouville System.

Section – III

Nonlinear Differential Equations

Phase Plane, Paths, and Critical Points. Critical Points and paths of Linear Systems. Critical Points and Paths of Nonlinear Systems. Limit Cycles and Periodic Solutions. TheMethod of Kryloff and Bogoliuboff.

Text Books:

1. S.L. Ross, Differential Equations, Third Edition, John Wiley & Sons, Inc., (Chapter 10: §§ 10.1 to 10.4; Chapter 11: §§ 11.1 to 11.8; Chapter 12: §§ 12.1 to 12.3; Chapter 13: §§ 13.1 to 13.5).
2. E.L. Ince, Ordinary Differential Equations, Dover Publication Inc. 1956 (Chapter X: §§ 10.1 to 10.6.1)

Reference Books:

1. W. Boyce and R. Diprima, Elementary Differential Equations and Boundary value Problems, 3rd Ed. New York, (1977).
2. E.A. Coddington, An Introduction to Ordinary Differential Equations, 2nd Ed. Prentice Hall of India Pvt. Ltd., Delhi, (1974).

M.Sc. (Mathematics) First Semester

Course Code	M-104 (5 Credits)
Name of the Course	**Operations Research**
Type of the Course	Core Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Outcomes: After the completion of the course, students are able to

CO1 Understand the history and applications and uses of OR techniques in decision making.

CO2 Understand the convex set theory to find the optimal Basic feasible solution of LPP. Modelled the real-world problems as linear programming problems (LPP) and solve them by different OR techniques and tools

CO3 Solve the LPP graphically, and use of Simplex Method, Big-M Method, Dual Simplex method. Learn Duality Theory and solution of LPP by duality theory.

CO4 Formulate the Integer Programming, Assignment and Transportation problems models and their solutions by different methods or algorithms.

CO5 Understand the basic concepts and derive results related to Queueing systems, Queueing problem, the Poisson process and its properties.

CO6 Understand the importance of the Revised Simplex Method and learn the basic concepts of the method to solve the Linear Programming Problem.

CO7 Learn and use the various Operations Research models in solving various decision analysis problems modelled form the real-world domain using different algorithms, OR tools and techniques.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	√	√	√	√	√	√			
CO2	√	√	√	√	√	√		√	
CO3	√	√	√	√	√	√	√	√	
CO4	√	√	√	√	√	√	√	√	
CO5	√	√	√	√	√	√	√	√	
CO6	√	√	√	√	√	√	√	√	
CO7	√	√	√	√	√	√	√	√	

Core Course: Operations Research

Section –I

Operations Research (OR): Brief Idea about: Introduction, origin and History of OR, Scientific Methods, Modelling in OR, OR models, Methodology of OR, OR in Decision making, and Applications of OR

Convex sets and their properties: convex sets, Hyperplane, and hyperspheres, Open and Close half-spaces, Theorem on; Convex sets, Convex polyhedron, feasible, basic feasible and optimal solutions, extreme points.

Linear Programming Problem (LPP): Mathematical formulation of LPP, Graphical solution of LPP, Simplex Method, Charnes Big M Method, Two-phase Method, Degeneracy, Unrestricted variables, unbounded solutions, Revised Simples Method (Standard for-I)

Duality theory: Concept of duality in LPP, Dual LPP, fundamental properties of Dual problems, Duality theorems, Complementary slackness, Dual simplex algorithm, Advantages of Duality.

Section – II

Dual Simplex Method: computational procedure of dual Simplex Method

Integer programming (IPP): Pure and Mixed IPP, Gomory's Method, Geometrical Interpretation of Cutting plane method, Branch, and Bound Method.

Transportation Problem (TP): Mathematical formulation, Basic feasible solutions of TPs by North–West corner method, Least cost-Method, Vogel's approximation method. Unbalanced TP, Optimality test of Basic Feasible Solution (BFS) by U-V method, Degeneracy in TP.

Assignment Problem (AP): Mathematical formulation, assignment methods, Hungarian method, Unbalanced AP; Rule to draw minimum numbers of lines, illustrative problems, Traveling Salesman Problem

Section – III

Game theory: Two-person, zero-sum games, The maximin – minimax principle, pure strategies, mixed strategies, Graphical solution of 2xn and mx2 games, Dominance property, General solution of $m \times n$ rectangular games, Linear programming problem of GP.

Queueing Theory: Queueing systems, Queueing problem, Transient and steady states, Probability Distributions in Queueing systems. Poisson process (pure birth process), Properties of Poisson's arrivals, Exponential process, Markovian property, Pure death process, Service time distribution, Erlang service time distribution, Solution of Queueing Models: (M |(M |1) : (∞ |FCFS), (Birth and Death Model).

Text Books:

1. S.D. Sharma, Operations Research, Kedar Nath Ram Nath & Co. 14^{th} Edition 2004 (Scope as in relevant sections of Chapters: 1, 3 to 8,10 to 12, 19, 23).
2. Kanti Swarup, P.K. Gupta and Manmohan, Operations Research, Sultan Chand & Sons 12^{th} Edition, 2004 (Scope as in relevant sections of Chapters 0, 02 to 08 & 10, 11 & 17).

Reference Books:

1. G. Hadley, Linear Programming, Narosa Publishing House (2002).
2. H.A. Taha, Operations Research: An Introduction, Prentice Hall of India Pvt. Ltd., 7^{th} Edition, 2004.
3. J.K. Sharma, Operations Research, Macmillan India Pvt. Ltd. 2003

M.Sc. (Mathematics) First Semester

Course Code	M-105 (5 Credits)
Name of the Course	**Fluid Dynamics**
Type of the Course	Core Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: When the course is completed, the student will be able to

CO1 Define types of fluids, Lagrangian and Eulerian method of describing fluid motion. Motion of the fluid element: Translation, rotation and deformation Stream lines path lines and streak lines, Material derivative, Acceleration Components of fluid particle in Cartesian.

CO2 Tell about Cylindrical and Spherical polar coordinates (without proof). Vorticity vector, Vortex Lines, rotational and irrotational motion. Velocity, Potential boundary surface, Boundary condition. Irrotational Motion in two-dimensional.

CO3 Describe Stream function, Physical significance of stream function, Complex velocity potential, Sources, sinks, doublets, and their images in two dimensional.

CO4 Understand about Continuum hypothesis, Newton's Law of Viscosity, Some Cartesian Tensor Notations, Thermal Conductivity, Generalized Heat conduction.

CO5 Derive and analyse Equation of State, Equation of Continuity, Navier – Stokes (NS) Equations, Equation of Energy. Vorticity and Circulation (Kelvin's Circulation Theorem).

CO6 Know about Dynamical Similarity (Reynold's Law), Inspection Analysis- Dimensional Analysis, Buckingham – π - Theorem, and its Applications π –products and coefficients, Non-dimensional parameters and their physical importance.

CO7 Derive Exact Solutions of the N S Equations, Steady Motion between parallel plates (a) Velocity distribution, (b) Temperature Distribution, Plane Couette flow, plane Poiseuille flow, generalized plane Couette flow. Flow in a circular pipe (Hagen-Poiseuille flow (a) velocity distribution (b) Temperature distribution and theory of very slow motion: Flow past a sphere (Stokes' and Oseen' flow).

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√		√		√	√	√	
CO2	√	√	√		√	√	√	√	
CO3	√	√	√	√		√	√	√	
CO4	√	√	√		√	√	√	√	
CO5	√	√	√	√	√	√	√	√	
CO6	√	√		√	√		√	√	
CO7	√	√	√	√			√	√	

Core Course: Fluid Dynamics

Section-I

Types of fluids, Lagrangian and Eulerian method of describing fluid motion, most general motion of the fluid element: translation, rotation and deformation. Stream lines, path lines and streak lines, material derivative, acceleration components of fluid particle in cartesian, cylindrical and spherical polar coordinates (without proof), vorticity vector, vortex lines, rotational and irrotational motion. Velocity, potential boundary surface, boundary condition. Irrotational motion in two-dimensional, stream functions, complex velocity potential, sources, sinks, doublets and their images in two dimensional.

Section-II

Continuum hypothesis, Newton's law of viscosity, some cartesian tensor notations. Stress Analysis: Stress at a point, Stress in a fluid at rest, Stress in a fluid in motion, Relation between stress and rate of strain components (Stokes' Law of Friction), Thermal conductivity, Generalized law of heat conduction. Fundamental Equations of the flow of viscous fluids: Introduction, Equation of State, Equation of continuity, Equations of motion (Navier-Stokes Equations), Equation of energy, Vorticity and Circulation (Kelvin's Circulation Theorem).

Section-III

Dynamical similarity (Reynolds law), Inspection analysis, Dimensional analysis, Buckingham π theorem and its application, π product and coefficients, Non-dimensional parameter and their physical importance. Exact solution of the N-S Equations, Steady motion between the parallel plates (a) velocity distribution, (b) Temperature distribution, Plane couette flow, Plane Poiseuille flow, Generalized plane Couette flow. Flow in a circular pipe (Hagen-Poiseuille flow) (a) Velocity distribution, (b) temperature distribution. Theory of very slow motion: Flow past a sphere (Stokes' and Oseen' flow.

Text-Books:

1. J.L. Bansal, Viscous fluid dynamics, Oxford and IBH Publishing Company Pvt. Ltd., (1977).
2. F. Chorlton, Text book of fluid dynamics, CBS Publishers and distribution (2000).

Reference Books:

1. G.K. Batchelor, An introduction to fluid dynamics, Cambridge University press, (1970).
2. C.S. Yih, Fluid Mechanics, McGraw-Hill Book Company.
3. S.W. Yuan, Foundation of Fluid Mechanics, PHI Pvt Ltd. New Delhi (1969).

M.Sc. (Mathematics) Second Semester

Course Code	M-201 (5 Credits)
Name of the Course	**Measure Theory and Integration**
Type of the Course	Core Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: On completion of the Course, students shall be able to

CO1 Have the understanding about the importance of outer measure on measure of sets, real-valued functions, positive and negative parts of a function, Characteristic function of a set, limit superior and inferior of sequence of measurable functions.

CO2 Provide the comprehensive understanding of three principles of Littlewood, Egoroff, Lusin and Frechet theorems.

CO3 Define the Lebesgue integral of a bounded function over a set and to prove the linearity, additivity, monotonicity and triangle inequality properties under a variety of defining property of the functions.

CO4 Understand Fatou's lemma, Monotone convergence theorem, Lebesgue dominated convergence theorem and its generalization and Riesz theorem on convergence in measure.

CO5 Understand Vitali Lemma and its application in particular, the Lebesgue theorem; existence of functions of Bounded Variation and Jorden Decomposition theorem, Jensen's inequality.

CO6 Have knowledge of differentiation, existence of partial derivatives and continuously differential functions of vector valued function of several variables.

CO7 Understand the implicit function theorem and their applications; in particular, existence of a unique solution of implicit equations near the mentioned point.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√	√	√	√	√		√	
CO2	√	√	√	√	√	√		√	
CO3	√	√	√	√	√	√		√	
CO4	√	√	√	√	√	√		√	
CO5	√	√	√	√	√	√		√	
CO6	√	√	√	√	√	√		√	
CO7	√	√	√	√	√	√		√	

Core Course: Measure Theory and Integration

Section-I

Functions of Several Variables

Linear Transformation, The Space of Linear Transformations on $\mathbf{R}^n$ to $\mathbf{R}^m$ as a Metric Space. Differentiation of Vector-valued Functions, Differentiation of a Vector-valued Function of Several Variables, Partial Derivatives, The Contraction Principle, The Inverse Function Theorem, The Implicit Function Theorem.

Differentiation and Integration

Introduction on Differentiation of Monotone Functions, Functions of Bounded Variation. Differentiation of an Integral, Absolute Continuity, Convex Functions.

Section –II

Lebesgue Measure

Introduction, Outer measure, Measurable sets and Lebesgue measure, Countable Additivity, A non-measurableset, Measurable functions, Littlewood's three principles.

Section – III

The Lebesgue Integral

The Riemann integral, The Lebesgue Integral of Simple Functions, The Lebesgue Integral of a Bounded Function Over a Set of Finite Measure, The Integral of Nonnegative Functions, The General Lebesgue Integral, Convergence in Measure.

Text Book:

1. H.L. Royden, Real Analysis, Third Edition, Prentice-Hall of India, Private Limited, New Delhi – 110 001 (1995), (Scope as in relevant sections of Chapter 2 to 4 and 6)
2. Walter Rudin, Chapter 5: § 5.16 to 5.19, Chapter 9: § 9.7, 9.8, 9.10-9.15, 9.22-9.29

Reference Books:

1. S. Lang, Analysis-I, Addison-Weslely Publishing Company, Inc. 1969
2. T.M. Apostal, "Mathematical Analysis- A modern approach to Advanced Calculus, Addison- Wesley Publishing Company, Inc 1957 (Indian Edition by Narosa Publishing House New Delhi also available).
3. R.R. Goldberg, "Methods of Real Analysis", Oxford and IHB Publishing Company, NewDelhi.

M.Sc. (Mathematics) Second Semester

Course Code	M-202 (5 Credits)
Name of the Course	**Field Theory**
Type of the Course	Core Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: On completion of the course, students shall be able to

CO1 Develop the understanding about the reducible and irreducible polynomials and their roots.
CO2 Identify the relations of one field to another (known as the concept of field extension).
CO3 Have the knowledge of field extensions, Algebraic extensions, Normal extensions, algebraically closed fields and Splitting fields.
CO4 Have a broad idea of some special types of fields such as Prime fields, finite fields, roots of unity and cyclotomic polynomials. In particular, the representation of elements of finite fields.
CO5 Understand the Galois Theory which creates a bridge to move from a field to a group, and make some remarkable observations using group theory.
CO6 Have a knowledge of separable extensions, automorphism group and fixed fields fundamental theorems of Galois theory and algebra.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√	√	√	√	√		√	
CO2	√	√	√	√	√	√		√	
CO3	√	√	√	√	√	√		√	
CO4	√	√	√	√	√	√		√	
CO5	√	√	√	√	√	√		√	
CO6	√	√	√	√	√	√		√	

Core Course: Field Theory

Section –I

Field Extensions

Irreducible polynomials and Eisenstein criterion, Adjunction of roots, Algebraic extensions, algebraically closed fields, Splitting fields, Normal extensions, Multiple roots.

Section – II

Finite Fields

Prime Fields, Finite fields, Roots of Irreducible Polynomials, Roots of unity and cyclotomic polynomials, Representation of Elements of Finite Fields, Order of Polynomials and Primitive Polynomials, Irreducible Polynomials.

Section – III

Galois Theory and its Applications

Separable extensions, Automorphism groups and fixed fields, Fundamental theorem of Galois theory, Fundamental theorem of algebra.

Text Books:

1. P.B. Bhattacharya, S.K. Jain & S.R. Nagpaul, 'Basic Abstract Algebra', Second Edition, Cambridge University Press, (Chapter 15 to Chapter 18).
2. Rudolf Lidl & Harald Niederreiter, "Finite Fields", Cambridge University Press, Chapter2 (§ 2.2 to 2.4) Chapter 3 (§ 3.1 & 3.2).

M.Sc. (Mathematics) Second Semester

Course Code	M-203 (5 Credits)
Name of the Course	**Partial Differential Equations**
Type of the Course	Core Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: After the completion of the course, students will be able to

CO1 Understand the Basic concepts related to partial Differential equations of first order and various methods to solve these equations.

CO2 Understand the classification of second order partial differential equations, their canonical forms and concept of adjoint operators.

CO3 Derivation of Laplace equation/Poisson equation/ heat equation/wave equations from basic concepts and their basic properties.

CO4 Solve the Laplace equation (elliptic equation), Heat equation (Parabolic equation) and Wave equation (hyperbolic equation) by variable separable method and solve some boundary value problems by some standard methods.

CO5 Derive the Laplace, heat and Wave equations in various coordinate systems and solve them. Learn the use of theory and solutions/tools in solving the dynamical problems arising in engineering and physical sciences.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	√	√	√		√			√	
CO2	√	√	√		√			√	
CO3	√	√	√		√			√	
CO4	√	√	√		√			√	
CO5	√	√	√	√	√	√		√	√

Core Course: Partial Differential Equations

Section – I

Fundamental Concepts

Classification of Second Order Partial Differential Equations. Canonical Forms:Canonical Form for Hyperbolic Equation, Canonical Form for Parabolic Equation, Canonical form for elliptic equation. Adjoint Operators.

Elliptic Differential Equations

Occurrence of the Laplace and Poisson Equations: Derivation of Laplace Equation,Derivation of Poisson Equation. Boundary Value Problems (BVPs). Some Important Mathematical Tools. Properties of Harmonic Functions. Separation of Variables, Dirichlet problem for a rectangle, the Nuemann problem for rectangle.

Section – II

Parabolic Differential Equations

Occurrence of the Diffusion Equation. Boundary Conditions. Elementary Solutions of theDiffusion Equation. Dirac Delta Function. Separation of Variables Method. Solution of DiffusionEquation in Cylindrical Coordinates. Solution of Diffusion Equation in Spherical Coordinates. Maximum-Minimum Principle and its Consequences.

Section – III

Hyperbolic Differential Equations

Occurrence of the Wave Equation. Derivation of One-dimensional Wave Equation. Solution of One-dimensional Wave Equation by Canonical Reduction. The Initial Value Problem; D'Alemberts Solution. Vibrating String – Variables Separable Solution. Forced Vibrations – Solution of Nonhomogeneous Equation. Boundary and Initial Value Problem for Two-dimensional Wave Equation – Method of Eigenfunction. Periodic Solution of One- dimensional Wave Equation in Cylindrical Coordinates. Periodic Solution of One-dimensional Wave Equation in Spherical Polar Coordinates.

Text Book:

1. K. Sankara Rao, Introduction to Partial Differential Equations, Prentice Hall of India Private Limited, New Delhi, 1997 (Scope as in relevant sections of Chapters 1 to 4).

Reference Books:

1. Ian Sneddon, Elements of Partial Differential Equations, McGraw-Hill Book Company, 1985.
2. K.S. Bharma, Partial Differential Equations, An Introductory Treatment with Applications, PHI, N. Delhi, 2010.
3. Purna Chandra Biswal, Partial Differential Equations, PHI, Pvt. Ltd, New Delhi, 2015.

M.Sc. (Mathematics) Second Semester

Course Code	M-204 (5 Credits)
Name of the Course	**Linear Algebra and Matrix Analysis**
Type of the Course	Core Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: On completion of this course the students shall be able to

CO1 Have the basic idea of operators on finite dimensional vector spaces and the basic properties of Normal operators in the context of spectral theory.
CO2 Characterize the diagonalizable matrices and have the basic properties of these matrices.
CO3 Have the basic concept of matrix norms, their examples and the unitarily invariant norm.
CO4 Characterize the positive definite matrices and have the basic properties of Positive definite matrices.
CO5 Have the working knowledge of inequalities involving positive definite matrices.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√	√				√	√	√
CO2	√	√	√			√	√	√	√
CO3	√	√	√			√	√	√	√
CO4	√	√	√				√	√	√
CO5	√	√	√				√	√	√

Core Course: Linear Algebra and Matrix Analysis

Section-I

Inner product, Inner product spaces, Linear functional and adjoints, orthogonal projections, self-adjoint operators. Unitary operators, Normal operators, Spectral theory, functions of operators. Polar decomposition.

Section-II

Simultaneously Diagonalizable Matrices, Unitary equivalence, some implication of Schur's theorem, the eigenvalues of sum and product of commuting matrices. Normal matrices, spectral theorem for normal matrices, Simultaneously unitarily diagonalizable commuting normal matrices. Matrix norms, Examples, Operator norms, Matrix norms induced by vector norms, The spectral norm, Frobenius norm, Unitary invariant norm, The maximum column sum matrix norms, the maximum row sum matrix norm.

Section-III

Positive definite matrices, Definitions and properties, Characterizations, The positive semi-definite ordering, Loewner partial order, Inequalities for the positive definite matrices, Hadamard's inequality, Fischer's inequality, Minkowski's inequality.

Text Books:

1. Linear Algebra, Kenneth Hoffman and Ray Kunze, Second Edition (2001), Princeton-Hall of India.
   Section I, 8.1-8.5, 9.5 (Theorem 9-Theorem-14).

2. Matrix Analysis, Roger A. Horn and Charles R. Johnson. Second Edition (2013). Cambridge University Press.

Section II, 1.3 Definition 1.3.6, 1.3.11, Theorem 1.3.7., 1.3.9., 1.3.12., Lemma 1.3.8, 1.3.10.2.2 Definition 2.2.1, Theorem 2.2.2, 2.3 Theorem 2.3.1-2.3.4, 2.4 2.4.1-2.4.3, Theorem 2.4.8.1, Corollary 2.4.8.5, 2.5 Definition 2.5.1, Theorem 2.5.3-2.5.6., Lemma 2.5.2, 5.6 Examples, Definitions 5.6.1, 5.6.3, Theorem 5.6.2, 5.6.7, 5.6.9.
Section III, 7.1 Observation 7.1.2, 7.1.3, 7.1.4, 7.1.6, 7.1.8, 7.1.9, 7.1.10, 7.1.12, 7.1.14. Corollary 7.1.5, 7.1.7, 7.1.13. Lemma 7.1.11. **7.2** Theorem 7.2.1, 7.2.5, 7.2.6, 7.2.7, Corollary 7.2.2, 7.2.3, 7.2.4, 7.2.8, 7.2.9. **7.7** Definition 7.7.1, Theorem 7.7.2, 7.7.3, 7.7.4, 7.7.7. Lemma 7.7.6. **7.**8 Theorem 7.8.1, 7.8.5, 7.8.21. Corollary 7.8.3.

Reference Books:

1 Matrix Analysis, Rajendra Bhatia, Springer Verlag, (1997).
2 Positive Definite Matrix, Rajendra Bhatia, Hindustan Book Agency, (2007).

M.Sc. (Mathematics) Second Semester

Course Code	M-205 (5 Credits)
Name of the Course	**Mathematical Statistics**
Type of the Course	Core Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: After the successful completion of this course, it is indented that a student will be able to:

CO1 Use the basic probability rules, including additive and multiplicative law by using the concept of probability set function, random variable, the probability density function, distribution function and use these concept for calculating probabilities and drive the marginal/conditional distribution and their respective mean, variance and standard deviation.

CO2 Use discrete and continuous probabilities distributions and identify the characteristics of different discrete and continuous distributions.

CO3 Define binomial, trinomial, multinomial and normal distribution and solve theoretical problems by using these distributions. Also use of property of normal distribution curve in calculating the probability of standard normal variate.

CO4 Learn t, F , limiting distributions etc and learn basic properties as well as the concept of central limit theorem on limiting distributions and its applications.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√	√	√	√	√			
CO2	√	√	√	√	√	√	√		
CO3	√	√	√	√	√	√	√		
CO4	√	√	√	√	√	√	√		

Core Course: Mathematical Statistics

Section – I

Distributions of Random Variables
The importance of the concept of probability, Theorems of probability (addition and multiplication theorems) The probability set Function, random variables, The probability density Function, the distribution function, Certain probability Models, Mathematical Expectation, Some special Mathematical expectations, Chebyshev's Inequality, conditional probability, Marginal and conditional distributions, the correlation coefficient, Stochastic Independence.

Section – II

Some Special Distributions
The Binomial, trinomial, and Multinomial Distributions, the Poisson Distribution, The Gamma and Chi-square Distributions, the normal distribution, and the bivariate normal distribution.

Sampling theory, Transformations of variables of the Discrete type, Transformations of the variables of the continuous type. The t and F distributions.

Section- III

Extensions of the change-of-variable Technique, Distributions of order statistics, themoment generating function Technique, The distribution of □ and nS^2/σ^2, Expectations of Functions of Random variables, Limiting Distributions, Stochastic Convergence, Limiting Moment Generating Functions, The Central limit Theorem, some theorems on limiting Distributions.

Test Book:

Robert V. Hogg and Allen T. Craig, Introduction to Mathematical Statistics, ForthEdition, Macmillan Publishing Co., Inc., New York, 1989, (Chapter 1 to 5).

Reference Book:

Feller, W.: Introduction to Probability and its Applications, Wiley Eastem Pvt. Ltd. Vol.1, (1972).

M.Sc. (Mathematics) Third Semester

Course Code	M-301 (5 Credits)
Name of the Course	**Complex Analysis**
Type of the Course	Core Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: On completion of this course the students shall be able to

CO1 Have the idea of arithmetical and geometrical properties of complex numbers and linear fractional transformations.
CO2 Have the basic concepts of the limit, continuity and derivative of the complex valued functions of a complex variable.
CO3 Have the knowledge of convergence and divergence of the sequences, series and power series.
CO4 Have the general concept of the complex integration and many important properties of analytic functions which follow from the complex integration.
CO5 View that the calculus of residues provide a very efficient tool for the evaluation of definite integrals.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	√	√	√		√			√	
CO2	√	√	√		√			√	
CO3	√	√	√		√			√	
CO4	√	√	√		√			√	
CO5	√	√	√	√	√	√		√	√

Core Course: Complex Analysis

Section – I

The algebra and the geometric representation of complex numbers. Limits and continuity.Analytic functions. Polynomials and rational functions. The exponential and the trigonometric functions. The periodicity. The logarithm. Sets and elements. Arcs and closed curves, Analytic functions in region. Conformal mapping, length and area. The linear group, the cross ratio, symmetry, oriented circles, family of circles. The use of level curves, a survey of elementary mappings, elementary Riemann surfaces.

Section- II

Line integrals, rectifiable arcs, line integral as function of arcs, Cauchy's theorem for a rectangle, Cauchy's theorem in a disk. The index of a point with respect to a closed curve. The integral formula. Higher derivatives.

Sequences, Series, Uniform convergence, Power series and Abel's limit theorem. Weierstrass's theorem, the Taylor's series and the Laurent series.

Removable singularities. Taylor's theorem, zeros and poles. The local mapping and themaximum principle.

Section – III

Chains and cycles, simple connectivity, Homology, the general statement of Cauchy's theorem. Proof of Cauchy's theorem. Locally exact differentials and multiply connected regions. The residue theorem, the argument principle and evaluation of definite integral.

Text Book:

1. Lars V. Ahlfors, Complex Analysis, McGraw Hill Int. Ed. (1979).
   Section-I: Chapter-1 §§ 1.1 - 1.5 and §§ 2.1 – 2.4. Chapter-2 §§ 1.1 – 1.4, 3.1 – 3.4. Chapter-3 §§ 1.1, 2.1 – 2.4, 3.1 – 3.5 and 4.1 – 4.3.
   Section-II: Chapter-4 §§ 1.1 – 1.5, 2.1 – 2.3, 3.1 – 3.4. Chapter – 2 §§ 2.1 – 2.5. Chapter – 5 §§ 1.1 – 1.3 and
   Section-III: Chapter- 4 §§ 4.1 – 4.7 , 5.1 – 5.3.

Reference Book:

1. John B. Conway, Function of One Complex Variable, (Second Edition), Narosa Publishers.

M.Sc. (Mathematics) Third Semester

Course Code	M-302 (5 Credits)
Name of the Course	**Classical Mechanics**
Type of the Course	Core Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: After the successful completion of this course, it is expected that a student will be able to

CO1 State and derive the conservation principle involving momentum, angular momentum and energy as well as understand that they follow the fundamental equation of motion.
CO2 Learn about the generalized coordinates, Lagrangian, Hamiltonian and Hamilton-Jacobi's formulation of Classical mechanics and develop their understanding about equivalence of these formulation with the Newton's Law of motion.
CO3 Derive and use the Lagrange's, Hamilton's and Hamilton-Jacobi's equation of motion for finding the solution of a dynamical problem.
CO4 Derive the Hamilton's principle and the principle of least action by applying the concept of variational calculus.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	√	√	√	√	√		√	√	
CO2	√	√	√	√	√		√	√	
CO3	√	√	√	√	√		√	√	
CO4	√	√	√	√	√			√	

Core Course: Classical Mechanics

Section-I

Frame of references, Different co-ordinate systems (Cartesian ,plane polar, cylindrical and spherical polar coordinate system) Generalized Coordinates. Constraints. Work and potential energy. Generalized forces.The Principle of virtual work. Introduction to Lagrange's equations. Lagrange's Equations for a particle in a plane. The Classification of Dynamical Systems. Lagrange's equations for any simple Dynamical system. Lagrange's equations for Non-holonomic systems with moving constraints. Lagrange's equations for impulsive motion.

Section-II

The Variational principle/ Hamilton's Principle, Lagrange's equation from Hamilton's principle. Stationary Values of a function. Constrained stationary values. Stationary Value of a definite integral. The Brachistochrone problem. Hamilton's equations. Derivation of Hamilton's equations. Ignorable coordinates. The Routhian function.

Section-III

The form of Hamiltonian function. Modified Hamilton's principle. Principle of least action (different form of Least action principle). The Hamiton-Jacobi equation. Lagrange and Poission Brackets. Calculus of Variation. Invariance of Lagrange and Poission Brackets under canonical transformation.

Text Books:

1. Principle of Mechanics, John L. Synge and Byron A. Griffith, McGraw Hill, International Edition (§§ 10.6, 10.7, 15.1 & 15.2), Third Edition.

2. Classical Dynamics, Donald. T. Green – Wood, Prentice – Hall of India, 1979, (§§ 4.2, 4.3, 5.2 & 6.3).

3. Classical Mechanics, K. Sankara Rao, Prentice-Hall of India, 2005 (§§ 6.7, 6.8, 7.5 & 7.6).

M.Sc. (Mathematics) Third Semester

Course Code	M-303 (5 Credits)
Name of the Course	**Topology**
Type of the Course	Core Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: On completion of the course, students shall be able to

CO1 Develop the understanding about the partial ordered relations and lattices.
CO2 Understand some elementary concepts in metric spaces and topological spaces such as open bases, open subbases, weak topology and the function algebras.
CO3 Identify the open sets, closed sets, convergence and continuity in metric/topological spaces.
CO4 Have a broad idea of compactness and various separation axioms in a topological space using some remarkable theorems such as Tychonoff's theorem, the Urysohn imbedding theorem, Ascoli's theorem, Urysohn's lemma and Tietze's theorem.
CO5 Understand connectedness in topological spaces, connected components, locally connected spaces and totally disconnected spaces.
CO6 Have a knowledge of The Weierstrass approximation theorem used to approximate a real valued continuous function by a real polynomial.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√	√		√			√	
CO2	√	√	√		√			√	
CO3	√	√	√		√			√	
CO4	√	√	√		√			√	
CO5	√	√	√	√	√	√		√	√
CO6	√	√	√		√			√	

Core Course: Topology

Section - I

Elementary Set Theory

Partial ordered sets and lattices.

Metric Spaces

Open sets, closed sets, convergence, completeness, Baire's category theorem, continuity.

Topological Spaces

The definition and some examples, elementary concepts, Open bases and open subbases,weak topologies, the function algebras C (X, R) and C (X, C).

Section - II

Compactness

Compact spaces, products of spaces, Tychonoff's theorem and locally compact spaces, compactness for metric spaces, Ascoli's theorem.

Separation

T_1-spaces and Hausdorff spaces, completely regular spaces and normal spaces, Urysohn'slemma and Tietze's extension theorem, the Urysohn imbedding theorem, the Stone-Cech compactification.

Section - III

Connectedness

Connected spaces, the components of a space, totally disconnected spaces, locallyconnected spaces.

Approximation

The Weierstrass approximation theorem.

Text Book:

1. G.F. Simmons, Introduction to Topology and Modern Analysis, International Student Edition, McGraw Hill Book Company, Inc. 1963.
   Chapter1: §§ 8; Chapter 2: §§ 9-15; Chapter3: §§ 16-20; Chapter 4: §§ 21-25; Chapter 5: §§ 26-30); Chapter 6: §§ 31-34 and Chapter 7: 35

M.Sc. (Mathematics) Third Semester

Course Code	M-304A (5 Credits)
Name of the Course	**Magneto Fluid Dynamics**
Type of the Course	Departmental Elective Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: On successful completion of this course, the student will be able to

CO1 Derive the Fundamental equations, Maxwell's electromagnetic field equation and Magnetic induction equation.

CO2 Acquire knowledge about Magnetic Reynold's number. Alfven's Theorem and its consequences. Magnetic energy equation. Mechanical equations and effects. Magneto hydrostatic, Force Free magnetic fluids.

CO3 Understand about Steady States, Pressure balanced magneto hydrostatic configurations. Toroidal magnetic field. Steady laminar motion. General solution of a vector wave equation.

CO4 Know about Magneto hydrodynamic, Waves Alfven waves, Magneto hydrodynamic waves in compressible fluid. Reflection and refraction of Alfven waves. Dissipative effects.

CO5 Understand the Linear Pinch. Method of small Oscillations. Energy principle.

CO6 Drive and analyse Virial Theorem. Marginal stability – Bénard problem with a magnetic field.

CO7 Understand about turbulence, spectral analysis. Homogeneity and Isotropy. Kolmogorff's principle. Hydro magnetic turbulence. Inhibition of turbulence by a magnetic field.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√		√	√	√	√		
CO2	√	√	√	√	√		√	√	
CO3	√	√	√	√			√		
CO4	√	√	√	√	√	√	√	√	
CO5	√			√	√		√		
CO6	√	√	√	√	√	√	√	√	
CO7	√	√	√				√	√	

Departmental Elective Course: Magneto Fluid Dynamics

Section – I

Fundamental Equations

Maxwell's electromagnetic field equations, Magnetic induction equation and magnetic Reynold's number. Alfven's Theorem and its consequences. Magnetic energy equation. Mechanical equations and effects.

Magneto hydrostatics

Magneto hydrostatics, Force Free magnetic fluids (Basic equations, boundary conditions & magnetic energy, general solution when α is constant).

Section – II

Steady States

Pressure balanced magneto hydrostatic configurations. Toroidal magnetic field. Steadylaminar motion. General solution of a vector wave equation.

Magnetohydrodynamic Waves

Aflven waves, Magnetohydrodynamic waves in compressible fluid. Reflection and refractionof Alfven waves. Dissipative effects.

Section – III

Stability

Introduction. Linear Pinch. Method of small Oscillations. Energy principle. Virial Theorem. Marginal stability – Bénard problem with a magnetic field.

Turbulence

Introduction, spectral analysis. Homogeneity and Isotropy. Kolmogorff's principle. Hydromagnetic turbulence. Inhibition of turbulence by a magnetic field.

Text Book:

1. An Introduction to Magneto Fluid Dynamics by V.C.A. Ferraro & C. Plumpton. Clarendon Press, Oxford 2nd Edition, 1966.
   (Chapter 1: §§ 1.1 to 1.7, Chapter 2: §§ 2.1, 2.1 (1,2,3), 2.3, 2.4; Chapter 4: §§ 5.1 to 5.6, Chapter 6: §§ 6.1, 6.3 to 6.7).

M.Sc. (Mathematics) Third Semester

Course Code	M-304B (5 Credits)
Name of the Course	**Cryptography**
Type of the Course	Departmental Elective Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: On successful completion of this course, the student will be able to

CO1 Understand the concept of Integer Arithmetic, Modular Arithmetic, Matrices and Linear Congruence.
CO2 Investigate the theory and Mathematics of Traditional Symmetric-Key Ciphers.
CO3 Acquire knowledge of Modern Symmetric-Key Ciphers.
CO4 Assimilate the concept of Data Encryption Standard (DES) and Advanced Encryption Standard (AES).
CO5 Attain mastery in use of Modern Block Ciphers and use of Stream Ciphers.
CO6 Study in detail the concept of RSA Cryptosystem, Rabin Cryptosystem, ElGamal Cryptosystem and Elliptic Curve Cryptosystem.
CO7 Understand the Mathematics of Asymmetric-Key Cryptography.

Mapping of Course Outcomes and Programme Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	√	√	√	√	√	√
CO2	√	√	√	√	√	√
CO3	√	√	√	√	√	√
CO4	√	√	√	√	√	√
CO5	√	√	√	√	√	√
CO6	√	√	√	√	√	√
CO7	√	√	√	√	√	√

Departmental Elective Course: Cryptography

Section- I

Mathematics of Cryptography: Integer Arithmetic, Modular Arithmetic, Matrices, Linear Congruence.
Traditional Symmetric-Key Ciphers: Substitution Ciphers, Transposition Ciphers, Stream and BlockCiphers.
Mathematics of Symmetric-Key Cryptography: Algebraic Structures, GF(2^n) Fields.

Introduction to Modern Symmetric-Key Ciphers: Modern Block Ciphers, Modern Stream Ciphers.

Section- II

Data Encryption Standard (DES): DES Structure, DES Analysis, Security of DES, Multiple DES-Conventional Encryption Algorithm.
Advanced Encryption Standard(AES) : Transformations, Key Expansion, The AES Ciphers, Analysis of AES.
Encipherment Using Modern Symmetric-Key Ciphers: Use of Modern Block Ciphers, Use of StreamCiphers.

Section- III

Mathematics of Asymmetric-Key Cryptography: Primes, Primality Testing, Factorization, ChineseRemainder Theorem, Quadratic Congruence, Exponentiation and Logarithm.
Asymmetric-Key Cryptography: RSA Cryptosystem, Rabin Cryptosystem, ElGamal Cryptosystem,Elliptic Curve Cryptosystem.

Text Book:

1. Forouzan, B.A. & Mukhopadhyay, D., Cryptography and Network Security, Tata McGraw Hill Publication. [Chapter 2 – Chapter 10]

Reference Books:

1. William Stallings, Cryptography and Network Security: Principles and Practice, Pearson, 2014.
2. Douglas R. Stinson & M. B. Paterson, Cryptography Theory and Practice, CRC Press, fourth edition, 2019.

M.Sc. (Mathematics) Third Semester

Course Code	M-305A (5 Credits)
Name of the Course	**Analytical Number Theory**
Type of the Course	Departmental Elective Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: On successful completion of this course, the student will be able to

CO1 Understand the divisibility theory in the Integers, the Fundamental Theorem of Arithmetic, the Sieve of Eratosthenes and the Goldbach Conjecture.

CO2 Study the theory of congruences and basic properties of congruences.

CO3 Analyse Fermat's Theorem, Fermat's Factorization Method, the Little Theorem and the Wilson's Theorem.

CO4 Acquire knowledge of the Theoretic Functions: The function τ and σ, the Mobius inversion formula, the Greatest Integer Function and its Application to the Calendar.

CO5 Attain mastery to solve problems using Euler's Phi Function, Euler's Theorem, some properties of Phi Function and their applications to Cryptography.

CO6 Understand the primitive roots, the Quadratic Reciprocity Law and Theory of Indices.

CO7 Study in detail the Quadratic Congruences with composite moduli.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	√	√	√				√	√	
CO2	√	√	√			√	√	√	
CO3	√	√	√			√	√	√	
CO4	√	√	√				√	√	
CO5	√	√	√				√	√	
CO6	√	√	√				√	√	
CO7	√	√	√				√	√	

Departmental Elective Course: Analytical Number Theory

Section – I

Divisibility Theory in the Integers
The Division Algorithm, The Greatest Common Divisor, The Euclidean Algorithm, andThe Diophantine Equation ax + by = c.
Primes and their Distribution
The Fundamental Theorem of Arithmetic. The Sieve of Eratosthenes and The GoldbachConjecture.
The Theory of Congruences
Basic Properties of Congruence, Special Divisibility Tests and Linear Congruences.

Section – II

Fermat's Theorem
Fermat's Factorization Method, The Little Theorem and Wilson's Theorem.
Number – Theoretic Functions
The Functions τ and σ, The Möbius Inversion Formula, The Greatest Integer Functionand An Application to the Calendar.
Euler's Generalization of Fermat's Theorem
Euler's Phi-Function, Euler's Theorem and Some properties of the Phi-Function, An Application to Cryptography.

Section – III

Primitive Roots and Indices
The Order of an Integer Modulo *n*, Primitive Roots for Primes, Composite NumbersHaving Primitive Roots and The Theory of Indices.
The Quadratic Reciprocity Law
Euler's Criterion, The Legendre Symbol and Its Properties, Quadratic Reciprocity and Quadratic Congruences with Composite Moduli.

Text Book:

1. David M. Burton, "Elementary Number Theory", (Fifth Edition) International Edition, McGraw Hill, (Chapter 2^{nd} to 9^{th}).

M.Sc. (Mathematics) Third Semester

Course Code	M-305B (5 Credits)
Name of the Course	**Wavelet Theory**
Type of the Course	Departmental Elective Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: After the completion of the course**, s**tudents would be able to

CO1 Understand the concept of Discrete Fourier Transform.
CO2 Compute Discrete Fourier Transform rapidly via the Fast Fourier Transform.
CO3 Learn the basics of wavelets in finite dimensions and construct wavelets by iteration.
CO4 Learn the basics of wavelets in infinite dimensions and construction of wavelets in first stage.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√	√				√	√	
CO2	√	√	√				√	√	
CO3	√	√	√				√	√	
CO4	√	√	√				√	√	

Departmental Elective Course: Wavelet Theory

Section – I

The Discrete Fourier Transform: Basic properties of discrete Fourier transform, translation-invariant linear transformation, The fast Fourier transform

Section – II

Wavelets on $\mathbb{Z}_N$: Construction of wavelets on $\mathbb{Z}_N$ First stage and by iteration, The Haar system, Shannon wavelets, Daubechies' D6 wavelets on $\mathbb{Z}_N$

Section – III

Wavelets on $\mathbb{Z}$: Description of $l^2(\mathbb{Z})$, complete orthonormal sets in Hilbert spaces, $L^2\big([-\pi,\pi)\big)$ and Fourier series, Fourier transform and convolution on $l^2(\mathbb{Z})$, first stage wavelets on wavelets on $\mathbb{Z}$, iteration step for wavelets on $\mathbb{Z}$, implementation and examples

Text Books:

1. Michael W. Frazier, An Introduction to Wavelets through Linear Algebra, Springer-Verlag, 1999.

Reference Books:

1. C. K. Chui, An Introduction to Wavelets, Academic Press, 1992.
2. Ingrid Daubechies, Ten Lectures on Wavelets, CBS-NFS Regional Conferences.
3. Eugenio Hernández and Guido Weiss, A First Course on Wavelets, CRC Press, 1996.

M.Sc. (Mathematics) Fourth Semester

Course Code	M-401 (5 Credits)
Name of the Course	**Functional Analysis**
Type of the Course	Core Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: On completion of the course, students shall be able to

CO1 Develop the understanding about the Normed linear spaces and Banach spaces.
CO2 Have the knowledge of continuous linear transformations between normed linear spaces and the concept of dual spaces, double dual and reflexive spaces.
CO3 Have a broad idea of some important results such as The Hahn-Banach theorem, the open mapping theorem, the closed graph theorem and the Uniform Boundedness theorem.
CO4 Understand Hilbert spaces, its conjugate space, adjoint of an operator, self-adjoint, normal and unitary operators and projections.
CO5 Describe the spectral theory in normed spaces, spectral properties of Bounded linear operators, Banach algebra and its properties.
CO6 Apply the knowledge of Complex Analysis in Spectral theory

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√	√				√	√	√
CO2	√	√	√			√	√	√	√
CO3	√	√	√			√	√	√	√
CO4	√	√	√				√	√	√
CO5	√	√	√				√	√	√
CO6	√	√	√				√	√	√

Core Course: Functional Analysis

Section – I

Banach paces

The definition and some examples, continuous linear transformations. The Hahn- Banach Theorem, the Open Mapping Theorem, the Closed Graph Theorem, the Uniform Boundedness Theorem, the natural embedding of N in N**, reflexivity.

Section – II

Hilbert Spaces

The definition and some simple properties, orthogonal complements, orthonormal sets, the conjugate space H*, the adjoint of an operator, self-adjoint normal and unitary operators, projections.

Section – III

Spectral Theory of Linear Operators in Normed spaces

Spectral Theory in Finite Dimensional Normed Spaces. Basic Concepts. Spectral Properties of Bounded Linear Operators. Further Properties of Resolvent and Spectrum. Use of Complex Analysis in Spectral Theory. Banach Algebras. Further Properties of Banach Algebras.

Text Books:

1. G.F. Simmons, Introduction to Topology and Modern Analysis, International Student Edition, McGraw Hill Book Company, Inc. 1963, (Chapter 9: §§ 46-51 and Chapter10: §§ 52-59).

2. E. Kreyszig, Introductory Functional Analysis with Applications, John, Wiley and Sons, Wiley Classics Library Edition Published, 1989 (Chapter 7).

M.Sc. (Mathematics) Fourth Semester

Course Code	M-402 (5 Credits)
Name of the Course	**Integral Equations and Calculus of Variations**
Type of the Course	Core Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: Students would be able to

CO1 Understand the methods to reduce Initial value problems associated with linear differential equations to various integral equations.
CO2 Categorize and solve different integral equations using various techniques.
CO3 Solve the singular integral equations and derivation of Hilbert-Schmidt theorem.
CO4 Know the variational problems, extremum of a functional and necessary conditions for the extremum of a functional.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√	√				√	√	√
CO2	√	√	√			√	√	√	√
CO3	√	√	√			√	√	√	√
CO4	√	√	√				√	√	√

Core Course: Integral Equations and Calculus of Variations

Section – I

Integral Equations

Definitions of Integral Equations and their classification, Eigen values and Eigen functions. Reduction to a system of algebraic equations, An Approximate Method. Fredholm Integral equations of the first kind.

Method of Successive Approximations

Iterative Scheme for Volterra and Fredholm Integral equations of the second kind. Conditions of uniform convergence and uniqueness of series

solution. Resolvent kernel and its results. Application of iterative Scheme to Volterra integral equations of the Second kind.

Classical Fredholm Theory

Method of solution of Fredholm equations, Fredholm Theorems

Section – II

Symmetric Kernels

Introduction to Complex Hilbert Space, Orthonormal system of functions, Riesz-Fischer Theorem, Fundamental properties of Eigen values and Eigen functions for symmetric kernels, Expansion in Eigen function and bilinear form, Hilbert Schmidt Theorem and some immediate consequences, Solutions of integral equations with symmetric kernels.

Singular Integral Equations

The Abel integral equation, Cauchy principal value for integrals, Cauchy-type integrals, singular integral equation with logarithmic kernel, Hilbert- kernel, solution of Hilbert-type singular integral equation

Section - III

Calculus of Variations

Variational problems, the variation of a functional and its properties, Extremum of a functional, Necessary condition for an extremum, Euler's equation and its generalization, Variational derivative, General variation of a function and variable end point problem.

Text Book:

1. R.P. Kanwal, Linear Integral Equations, Theory and Techniques, Academic Press, New York.

Reference Books:

1. S. G. Mikhlin, Linear Integral Equations (translated from Russian) Hindustan Book Agency, 1960
2. J.M. Gelfand and S.V. Fomin, Calculus of Variations, Prentice Hall, New Jersy, 1963.
3. M. D. Raisinghania, Integral Equations & Boundary Value Problems, Sultan Chand & Sons.

M.Sc. (Mathematics) Fourth Semester

Course Code	M-403 (5 Credits)
Name of the Course	**Advanced Discrete Mathematics**
Type of the Course	Core Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: On successful completion of this course, the student will be able to

CO1 Understand the Boolean Algebras Logic, Propositional Equivalences, Predicates and Quantifiers and study in detail the Partial Ordered Set, Lattices, Distributive and Complemented Lattices.

CO2 Analyse the Boolean Lattices and Boolean Algebras, Boolean Functions and Boolean Expressions and apply Boolean Algebra to switching theory.

CO3 Acquire knowledge of the Pigeonhole Principle and A Theorem of Ramsey.

CO4 Assimilate the concept of Permutations and Combinations, the Binomial Theorem, the Multinomial Theorem and the Newton's Binomial Theorem.

CO5 Gain knowledge of the Inclusion-Exclusion Principle and Applications.

CO6 Study in detail the Recurrence Relations, Recurrences and Generating Functions and Exponential Generating Functions.

CO7 Understand the Introduction to Graph Theory.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√	√				√	√	
CO2	√	√	√				√	√	
CO3	√	√	√				√	√	
CO4	√	√	√				√	√	
CO5	√	√	√				√	√	
CO6	√	√	√				√	√	
CO7	√	√	√				√	√	

Core Course: Advanced Discrete Mathematics

Section -I

Boolean Algebra

Logic, Propositional Equivalences, Predicates and Quantifiers. Partial Ordered Sets, Lattices and Algebraic Systems, Principle of Duality, Basic Properties of Algebraic Systems defined by Lattices, Distributive and Complemented Lattices, Boolean Lattices and Boolean Algebras, Uniqueness of Finite Boolean Algebras, Boolean Functions and Boolean Expressions, Propositional Calculus, Switching Circuits.

The Pigeonhole Principle

Pigeonhole principle: Simple form, Pigeonhole principle: Strong form, A theorem of Ramsey.

Permutations and Combinations

Two basic counting principles, Permutations of sets, Combinations of Sets, Permutations of multisets, Combinations of multisets.

Section – II

Generating Permutations and Combinations

Generating permutations, Inversions in permutations, Generating combinations, Partial orders and equivalence relations.

The Binomial Coefficients Pascal's formula, The binomial theorem, Identities, Unimodality of binomial coefficients, The multinomial theorem, Newton's binomial theorem.

The Inclusion-Exclusion Principle and Applications

The inclusion-exclusion principle, Combinations with repetition, Derangements, Permutations with forbidden positions.

Recurrence Relations and Generating Functions

Some number sequences, Linear homogeneous recurrence relations, Non-homogeneous recurrence relations, Generating functions, Recurrences and generating functions, Exponential generating functions.

Section – III

Introduction to Graph Theory

Basic properties, Eulerian trails, Hamilton chains and cycles, Bipartite multigraphs, Trees, The Shannon switching game. Digraphs and Networks, Digraphs and Networks, More on Graph Theory, Chromatic number, Plane and planar graphs, A 5-color theorem, Independence number and clique number, Connectivity.

Text Books:

4. C.L. Liu, 'Elements of Discrete Mathematics', Tata McGraw-Hill, Second Edition, (§§ 12.1 to 12.8 & 12.10).
5. Richard A. Brualdi, Introductory Combinatorics, third Edition, (Chapter 2 to 7 and Chapter11 to 13).

Reference Book:

1. Kenneth H. Rosen, "Discrete Mathematics and Its Applications", Tata McGraw-Hill, Fourth Edition.

M.Sc. (Mathematics) Fourth Semester

Course Code	M-404A (5 Credits)
Name of the Course	**Differential Geometry**
Type of the Course	Departmental Elective Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: On successful completion of this course, the student will be able to

CO1 Understand the basic concepts and results related to curves in spaces, tangents, principal normal, curvature , binormal and torsion.
CO2 Derive the Serret- Frenet formulae and its applications in solving various problems.
CO3 Acquire knowledge of locus of center of curvature, spherical curvature , locus of center of spherical curvature and derive the results related to them.
CO4 Identify the curves determined by intrinsic equations, Helices, Involutes and evolutes.
CO5 Understand tangent plane, normal plane, directions on a surface, curvatures, asymptotic lines and then apply their important theorems and results to study various properties of surfaces.
CO6 Derive, analyze and utilize Gauss characteristic equations.
CO7 Comprehend Geodesics, it’s all related terms and attain mastery over its properties and theorems.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√	√		√	√		√	
CO2	√	√	√		√			√	
CO3	√	√	√		√	√		√	
CO4	√	√	√		√			√	
CO5	√	√	√		√	√		√	
CO6	√	√	√		√			√	
CO7	√	√	√		√			√	

Departmental Elective Course: Differential Geometry

Section –I

Tangent, Principal normal, Curvature, Binormal, Torsion, Serret Frenet formulae, Locus of center of curvature, Spherical curvature, Locus of center of spherical curvature. Theorem: Curve determined by its intrinsic equations, Helices, Involutes & Evolutes.

Section – II

Surfaces, Tangent plane, Normal, Curvilinear co-ordinates First order magnitudes, Directions on a surface, The normal, second order magnitudes, Derivatives of n, Curvature of normal section. Meunier's theorem, Principal directions and curvatures, first and second curvatures, Euler's theorem. Surface of revolution.

Section – III

Gauss's formulae for $\rho_{11,}$ $\rho_{12,}$ ρ_{22}, Gauss characteristic equation, Mainardi – Codazzi relations, Derivatives of angle ω, Geodesic property, Equations of geodesics, surface of revolution, Torsion of geodesic, Bonnet's Theorem, vector curvature, Geodesic curvature, κ_g.

Text Book:

1. Differential Geometry of Three Dimension, C.E. Weatherburn, Khosla Publishing House, 2003 (§§ 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 13, 14, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 34, 41, 42, 43, 46, 47, 48, 49, 50, 52, 53).

Reference Book:

1. Introduction to Differential Geometry, T.J. Willmore, Oxford.

M.Sc. (Mathematics) Fourth Semester

Course Code	M-404B (5 Credits)
Name of the Course	**Coding Theory**
Type of the Course	Departmental Elective Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: Students would be able to

CO1 Understand Hamming distance, Nearest neighbour/minimum distance decoding, Distance of a code.
CO2 Learn the linear codes and bases of linear codes.
CO3 Have knowledge about lower bounds, sphere covering bound, Gilbert–Varshamov bound, Hamming bound and perfect codes, Binary Hamming codes.
CO4 Know about cyclic codes, generator polynomials, generator and parity-check matrices, decoding of cyclic codes.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	√	√	√				√	√	√
CO2	√	√	√			√	√	√	√
CO3	√	√	√			√	√	√	√
CO4	√	√	√				√	√	√

Departmental Elective Course: Coding Theory

Section –I

Error detection, correction and decoding

Communication channels, Maximum likelihood decoding, Hamming distance, Nearest neighbour/minimum distance decoding, Distance of a code.

Finite Fields

Fields, Polynomial rings, Structure of finite fields, Minimal polynomials.

Section – II

Linear codes

Vector spaces over finite fields, Linear codes, hamming weight, Bases for linear codes, Generator matrix and parity-check matrix, Equivalence of linear codes, Encoding and decoding of linear codes, Cosets, Nearest neighbor decoding for linear codes.

Bounds in coding theory

The main coding theory problem, Lower bounds, Sphere-covering bound, Gilbert–Varshamov bound, Hamming bound and perfect codes, Binary Hamming codes, q-ary Hamming codes, Golay codes, some remarks on perfect codes, Singleton bound and MDS codes.

Section – III

Construction of linear codes

Propagation rules, Reed–Muller codes, Subfield codes.

Cyclic codes

Definitions, generator polynomials, generator and parity-check matrices, decoding of cyclic codes, Burst-error-correcting codes.

Text Books:

1. S. Ling and C. Xing, Coding Theory: A First Course, Cambridge University Press 2004 (§§ 5 - 153).
2. L. R. Vermani, Elements of Algebraic coding Theory, Champman and Hall, 1996.

M.Sc. (Mathematics) Fourth Semester

Course Code	M-405A (5 Credits)
Name of the Course	**Solid Mechanics**
Type of the Course	Departmental Elective Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: On completion of the above course, the students will be able to

CO1 Understand the concept of the analysis of the strain, infinitesimal affine transformation, general infinitesimal deformation, finite deformation.

CO2 Understand the concept of stress analysis, equations of equilibrium, to calculate maximum normal and shear stresses acting on a body mathematically as well as graphically.

CO3 Understand the concept of generalized Hooke's law and modified Hooke's law derived by using one plane elastic symmetry, three plane symmetry and isotropy of the homogeneous media.

CO4 Examine the deformation of a beam by its own weight, by terminal couples and torsion of a circular shaft.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√	√				√	√	
CO2	√	√	√				√	√	
CO3	√	√	√				√	√	
CO4	√	√	√				√	√	

Departmental Elective Course: Solid Mechanics

Section-I

Analysis of Strain – Affine transformation, Infinitesimal Affine deformations, Geometrical interpretation of the components of Strain. Strain Quadric of Cauchy, Principal Strains. Invariants. General Infinitesimal Deformation. Equation of compatibility. Finite deformation.

Analysis of Stress – Stress Tensor. Equations of Equilibrium. Transformation of coordinates. Stress Quadric of Cauchy. Principal stress and Invariants. Maximum normal and shear stresses, Mohr's circle Diagram.

Section – II

Equations of Elasticity – Generalized Hooke's law. Stress – Strain relations for a mediumhaving one plane elastic symmetry, three orthogonal planes symmetry and for homogeneous isotropic media. Elastic-moduli for isotropic media. Equilibrium and Dynamic equations for an isotropic solids. Strain energy function and its connection with Hooke's law. Unique solution of Boundary value problem. Derivation of Navier's equations and Beltrami-Michal compatibility equations.

Section – III

Statement of problem. Extension of beams by longitudinal forces. Beam stretched by its own weight. Bending of beams by terminal couples. Torsion of a circular shaft. Plane stress. Plane strain.

Text Book:

1. I.S. Sokolnikoff, Mathematical Theory of Elasticity, Tata McGraw-Hill Publishing Company Ltd, 1977, (Chapter I, II, III, IV: §§29 – 33 and Chapter V: §§ 65-67).

Reference Books:

1. S. Timoshenko and N. Goodier, Theory of Elasticity, McGraw-Hill, New York 1970.
2. A.E. Love, A Treatise on the Mathematical Theory of Elasticity, Cambridge University Press, London, 1963.
3. Y.C. Fung, Foundations of Solid Mechanics, Prentice-Hall, New Delhi , 1965.
4. I.H. Shames, Introduction to Solid Mechanics, Prentice-Hall, New Delhi , 1975.
5. S. Valliappan, Continuum Mechanics, Oxford and IBH Publishing Company, New Delhi,1981.

M.Sc. (Mathematics) Fourth Semester

Course Code	M-405B (5 Credits)
Name of the Course	**Non-Linear Programming Problems**
Type of the Course	Departmental Elective Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

On successful completion of this course, the student will be able to

CO1 Apply Kuhn Tucker condition and graphical solution method to solve the Non-linear Programming Problem.

CO2 Identify and formulate Dynamic Programming Problem and its applications in solving various optimization problems.

CO3 Introduce students to practical application of operations research in big mining projects.

CO4 Identify the Quadratic and Separable Programming Problems.

CO5 Have a broad idea of Wolfe's method and Beale's method and implications of these methods**.**

Mapping of Course Outcomes with Programme Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√	√				√	√	
CO2	√	√	√			√	√	√	
CO3	√	√	√			√	√	√	
CO4	√	√	√				√	√	
CO5	√	√	√				√	√	

Departmental Elective Course: Non-Linear Programming Problems

Section – I

Non-Linear Programming Problems (NLPP): Formulation of a NLPP, General non-linear NLPP, Constrained optimization with equality constraint, Necessary and sufficient condition fora general NLPP (with one constraint), with m(<n) constraints, constrained optimization with inequality constraints (Kuhn – Tucker conditions), Saddle point problem, saddle point andNLPP, Graphical solution of NLPP, Verification of Kuhn – Tucker conditions, Kuhn – Tucker conditions with Non-negative constraints.

Section – II

Dynamic Programming

Decision Tree and Bellman's principle of optimality, Concept of dynamic programming, minimum path problem, Mathematical formulation of Multistage Model, Backward & Forward Recursive approach, Application in linear programming.

Network Techniques

Shortest path model, Dijkastra algorithm, Floyd's algorithm, Minimal Spanning tree, Maximal flow problem.

Section – III

Separable Programming

Separable Programming, Piecewise linear approximation, Separable programmingalgorithm.

Quadratic programming

Quadratic programming; Wolfe's Modified Simplex method, Beale's Method.

Text Books:

1. S.D. Sharma, Operations Research, Kedar Nath Ram Nath & Co. 14th Edition 2004 (Scope as in relevant sections of Chapters: 27 to 30 and 33).
2. R. Panneerselvam, Operations Research, Prentice Hall of India Pvt. Ltd., 2004 (Chapters 5: §§ 5.1 to 5.4).
3. Kanti Swarup, P.K. Gupta and Manmohan, Operations Research, Sultan Chand & Sons 12th Edition, 2004 (Scope as in relevant sections of Chapters)

Reference Books:

1. J.K. Sharma, Operations Research, Macmillan India Pvt. Ltd. 2003.
2. M.S. Bazara, H.D. Sherali and C.M. Shetty, Non-Linear Programming, Theory and Algorethms, 2nd Ed., John Wiley & Sons, Inc.

M.Sc. (Mathematics) Fourth Semester

(Only for Regular students)

Course Code	M-406 (5 Credits)
Course	**Project**
Type of the Course	Compulsory
Duration	1 Semester
Evaluation of the Project	70 marks
Viva-voce	30 marks
Total marks of the Project	100

All the Regular students are required to undertake a Project M-406 of 5 credits allotted by the Mentor/Teacher at the end of 3^{rd} Semester and shall require to submit it by the end of 4^{th} Semester before the commencement of End Semester Examinations. Projects shall be on the topics related to the course contents learnt by the student during his M.Sc. Degree.

The Project will be evaluated as per the guidelines given in the scheme of Examination.

M.Sc. (Mathematics) Fourth Semester

(*For ICDEOL and Private students only*)

Course Code	M-407(5 Credits)
Name of the Course	**Topics in Applied Mathematics**
Type of the Course	Additional Course
Number of teaching hours required for this course	50 hrs.
Internal Assessment: Based on Assignment/Class Test/ Mid-Term Examination Attendance (Marks Attendance: 5 marks to be given as per the regulations)	Max. Marks:20
End Semester Examination	Max Marks: 80 Maximum Times: 3 hrs.
Total Lectures to be Delivered	60

Instructions

1. **Instructions for paper setter:** The question paper will consist of **three Sections I, II & III** of 80 marks. Nine questions will be set in all. Each section will contain three questions. Each question will be of 16 marks.
2. **Instructions for Candidates:** The candidates will be required to attempt five questions in all selecting at least one question (but not more than two questions) from each section.

Course Learning Outcomes: On completion of the Course, students shall be able to

CO1 Have the understanding about Step Function, Dirac delta function, Linear Differential Operators, Adjoint Operators, Green's Operator and Green's Function.

CO2 Understand the Fourier series, and evaluate the Fourier transform of a continuous function and familiar with its basic properties.

CO3 Compute the solutions of the partial differential equation and Integral Equations using Fourier Transforms.

CO4 Have knowledge of Laplace transforms and its properties.

CO5 Solve ordinary and partial differential equations using Laplace transforms.

Mapping of Course Outcomes with Programme Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	√	√	√	√	√	√		√	
CO2	√	√	√	√	√	√		√	
CO3	√	√	√	√	√	√		√	
CO4	√	√	√	√	√	√		√	
CO5	√	√	√	√	√	√		√	

Additional Course: Topics in Applied Mathematics

Section-I

Green's Functions

Heaviside Step Function, Dirac Delta Function, Linear Differential Operators, Inner Product and Norm, Green's Operator and Green's Function, Adjoint Operators, Green's Function and Adjoint Green's Function, Sturm-Liouville Operator, Eigen functions and Green's Function.

Section –II

Fourier Transforms

Fourier series, Fourier Transform, Fourier Integral Theorem, Fourier Cosine and Sine Transforms, Properties of Fourier Transforms, Properties of Trigonometric Transforms, transforms of Elementary Functions, Convolution Integral, Solution of Laplace equation, Diffusion equation and Wave equation using Fourier Transform

Section – III

Laplace Transforms

Properties of the Laplace Transform, Transforms of Elementary Functions, Inverse Transform, Convolution Integral, Applications of Laplace Transform: Ordinary Differential Equations, Partial Differential Equations. Solutions of Diffusion equation and Wave equation using Laplace Transform.

Text Books:

1. Nair, S., Advanced topics in applied mathematics: for engineering and the physical sciences. Cambridge University Press, (2011), Scope as in relevant sections of Chapter 1 and 3 to 4.
2. Sankara Rao, K., Introduction to Partial Differential Equations, 3rd Edition, PHI Learning Private limited, (2011). Scope as in relevant sections of Chapter 5 -7.

Reference Books:

1. Dyke, P. P, An introduction to Laplace transforms and Fourier series, London: Springer (2001).
2. Brown J.W. & Churchill, R.V., Fourier series and Boundary Value Problems, McGraw-Hill Education, (2011).