

CURRICULUM & SYLLABUS



CHOICE BASED CREDIT SYSTEM (CBCS)

FOR

MASTER OF SCIENCE (M.Sc.)

(1 Year / 2 Years Postgraduate Degree Programme)

IN

MATHEMATICS

[w. e. f. 2025-26]

**DEPARTMENT OF MATHEMATICS
FACULTY OF SCIENCE & HUMANITIES
SRM UNIVERSITY DELHI-NCR, SONEPAT
39, Rajiv Gandhi Education City, Delhi-
NCR, Sonapat, Haryana-131029**

SRM UNIVERSITY DELHI-NCR, SONEPAT (HARYANA)

VISION

SRM University Delhi – NCR, Sonapat, Haryana aims to emerge as a leading world - class university that creates and disseminates knowledge upholding the highest standards of instruction in Medicines & Health Sciences, Engineering & Technology, Management, Law, Science and Humanities. Along with academic excellence and skills, our curriculum imparts integrity and social sensitivity to mould our graduates who may be best suited to serve the nation and the world.

MISSION

- To create a diverse community campus that inspires freedom and innovation.
- Promote excellence in educational & skill development processes.
- Continue to build productive international alliances.
- Explore optimal development opportunities available to students and faculty.
- Cultivate an exciting and rigorous research environment.

DEPARTMENT OF MATHEMATICS

VISION

The broad vision of the Department is to carry out high quality research in the different areas of Mathematics, Statistics and Computing so that we can produce proficient graduates, engineers and scientists to contribute significantly in the development of the society. Excellence, integrity, innovation, entrepreneurship and leadership are priorities of the Department. The vision is to become a leading department of global excellence in research and education in all discipline of Mathematics.

MISSION

The Department supports the University's mission by empowering students to:

- Provide excellent knowledge of Mathematical Sciences as well as Statistics for suitable career and groom them for institutional, state, national and international recognition.
- Discover, mentor, and nurture mathematically inclined students, and provide them a supportive environment that fosters intellectual growth.
- Train the students for interdisciplinary applications and research.
- Train the students with Mathematical and Statistical tools for industries as well as research organizations.
- Provide professional services based on our diverse mathematical and statistical expertise.
- The scientific, technical, and educational community.
- Achieve excellence in the subject as well as overall development of the student to strive in a competitive society.

M.Sc. MATHEMATICS GRADUATE EMPLOYABILITY ATTRIBUTES

- Sound knowledge and understanding of the domain area.
- Analytical & critical thinking and problem solving skills.
- Scientific Temperament towards Research & Innovation for the Betterment of Society.
- Efficient Communication & Presentation Skills.
- Dependability, reliability, responsibility, and independent leadership abilities.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

The objectives of the M.Sc. Mathematics program are to develop students with the following capabilities:

- To provide knowledge of a wide range of mathematical techniques and application of mathematical methods/tools in other scientific and engineering domains.
- To provide students with advanced mathematical and computational skills that prepares them to pursue higher studies and conduct research.
- To motivate the students for research studies in mathematics and related fields.
- To provide students with a knowledge, abilities and insight in Mathematics and computational techniques so that they are able to work as mathematical professional.
- To provide students with knowledge and capability in formulating and analysis of mathematical models of real-life applications.

PROGRAM LEARNING OUTCOMES (PLOs)

After successful completion of this program, the students will be able to:

1. Apply knowledge of Mathematics, in all the fields of learning, including higher research and its extensions.
2. Carry out development work as well as take up challenges in the emerging areas of the industry.
3. Demonstrate competence in using mathematical and computational skills to model, formulate and solve real life applications.
4. Crack lectureship and fellowship exams approved by UGC like CSIR – NET and SET/ ISRO/DRDO.
5. Enhance the ability to establish advanced independent critical enquiry and analysis.

Mapping matrix of Program Educational Objectives (PEOs) and Program Learning Outcomes (PLOs)

PEO \ PLO	PLO1	PLO2	PLO3	PLO4	PLO5
PEO1	✓	✓			
PEO2		✓			
PEO3		✓	✓		
PEO4				✓	✓
PEO5					✓

SEMESTER-I

Code	Category	Course	L	T	P	C
Theory						
25MAMS101	Core	Abstract Algebra	3	1	0	4
25MAMS102	Core	Complex Analysis	3	1	0	4
25MAMS103	Core	Number Theory	3	1	0	4
25MAMS104	Core	Classical Mechanics	3	1	0	4
25MAMS105	Departmental Specific Elective – I	Data Structure using C	3	0	2	4
25MAMS106		Discrete Mathematics	3	1	0	4
25MAMS107		Computer Programming using MATLAB	3	0	2	4
Total			15	5/4	0/2	20
Total Contact Hours			20/21			

SEMESTER-II

Code	Category	Course	L	T	P	C
Theory						
25MAMS201	Core	Mathematical Analysis	3	1	0	4
25MAMS202	Core	Solid Mechanics	3	1	0	4
25MAMS203	Core	Special Functions	3	1	0	4
25MAMS204	Core	Functional Analysis	3	1	0	4
25MAMS205	Departmental Specific Elective – II	Python Programming	3	0	2	4
25MAMS206		Fluid Dynamics	3	1	0	4
25MAMS207		Computing with R	3	0	2	4
Total			15	5/4	0/2	20
Total Contact Hours			20/21			

SEMESTER-III

Code	Category	Course	L	T	P	C
Theory						
25MAMS301	Core	Advanced Ordinary Differential Equations	3	1	0	4
25MAMS302	Core	Topology	3	1	0	4
25MAMS303	Core	Integral Equations	3	1	0	4
25MAMS304	Core	Linear Algebra	3	1	0	4
25MAMS305	Departmental Specific Elective - II	Coding Theory and Cryptography	3	1	0	4
25MAMS306		Operational Research	3	1	0	4
25MAMS307		Mathematical Statistics – I	3	1	0	4
Total			15	5	0	20
Total Contact Hours			20			

SEMESTER-IV

Code	Category	Course	L	T	P	C
Theory						
25MAMS401	Core	Partial Differential Equations	3	1	0	4
25MAMS402	Core	Measure Theory and Integration	3	1	0	4
25MAMS441	Core	Project	4	0	0	4
25MAMS403	Departmental Specific Elective – III	Modelling and Simulation	3	1	0	4
25MAMS404		Algebraic Topology	3	1	0	4
25MAMS405		Theory of Elasticity	3	1	0	4
25MAMS406	Departmental Specific Elective – IV	Differential Geometry	3	1	0	4
25MAMS407		Mathematical Programming	3	1	0	4
25MAMS408		Mathematical Statistics – II	3	1	0	4
Total			15	4	0	20
Total Contact Hours			19			

SUMMARY OF CREDITS

Category	I Sem	II Sem	III Sem	IV Sem	Total	%
Core Course	16	16	16	8	56	70.00
Department specific Elective	4	4	4	8	20	25.00
Project	-	-	-	4	4	5.00
Total	20	20	20	20	80	100

SEMESTER-I

Abstract Algebra

Course Code: 25MAMS101	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: Core Course
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To introduces the concepts of groups and ring
- To acquire rigorous understanding of class equation and Sylows theorems to solve different problems
- To understand the axiomatic foundation of rings, sub-rings, ideals including integral domain, principle ideal domain
- To provide a deep knowledge of Euclidean ring and Euclidean domain
- To introduce the concepts of field theory

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Learn to construct and describe groups.
- To describe the properties of groups and get familiar with important classes of groups.
- Apply Sylow's theorems to describe the structure of some finite groups.
- Become familiar with rings, integral domain and their arithmetic.
- Understand the concept of fields.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO \ CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓			✓	
CEO 2		✓	✓		
CEO 3				✓	
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

Permutation Group, Group Action, Equivalent formulation of action as a homomorphism of G to Symmetric group, Stabilizer (Isotropy) subgroups and Orbit decomposition, Class equation of an action, Conjugacy class equation, Transitive actions. Sylow's subgroups, Sylow's Theorem I, II and III.

Unit-II

p -groups and applications, Direct and inverse images of Sylow subgroups, Commutator subgroup, Normal and subnormal series, composition series, Jordan-Holder theorem Solvable groups, Simple groups, simplicity of A_n . Rings and its properties, Left and right ideal, prime ideals, maximal ideals.

Unit-III

Prime and irreducible elements, Greatest Common divisor, Least Common Multiple, Euclidean domains, Maximal and prime ideals, Principal ideal domains, Divisor chain condition. Unique factorization domains, Examples and counterexamples.

Unit-IV

Polynomial rings over domains, Unique factorization in polynomial rings over UFD's. Fields: Field of fractions, Gauss lemma, Fields, field extension.

TEXT BOOKS/ REFERENCE BOOKS

1. R. Lal, Algebra Vol 1 & 2, Springer, New York, 2017.
1. I. N. Herstein, Topics in Algebra, John Wiley & Sons. 2nd edition 2006.
2. W. J. Gilbert, W. K. Nicholson, Modern Algebra with Applications, Wiley, 2nd edition 2003
3. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, Basic Abstract Algebra, Cambridge University Press, 2nd Edition 1994, Indian Edition, Online publication 2012.
4. J.A. Gallian, Contemporary Abstract Algebra, Narosa Publishing House, 4th edition 2008.

Complex Analysis	
Course Code: 25MAMS102	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: Core Course
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To explore the geometrical, algebraic, and topological structure of the complex numbers
- To develop a clear understanding of the fundamental concepts of complex analysis such as analytic functions, Cauchy-Riemann relations and harmonic functions
- To make students equipped with the understanding of the fundamental concepts of complex variable theory
- To enable students to acquire knowledge of contour integration to evaluate complicated real integrals via residue calculus
- To determine the singularities of simple functions by using the Taylor and Laurent expansions

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Define continuity and differentiability of complex functions.
- Prove the Cauchy-Riemann equations and apply them to complex functions in order to determine whether a given continuous function is complex differentiable.
- Compute the radius of convergence for complex power series.
- Evaluate integrals along a path - directly from the definition and also via the Fundamental Theorem of Contour Integration and Cauchy's Theorem.
- Compute the Taylor and Laurent expansions of simple functions, determining the nature of the singularities and calculating residues.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓	✓	
CEO 4				✓	✓
CEO 5			✓		✓

COURSE CONTENTS

Unit-I

Topology of the Complex plane, limits, continuity, Complex functions – Introduction to the complex exponential, the complex logarithm and trigonometric functions, Differentiability, Cauchy Riemann equations, Polar form of Cauchy Riemann equations, Analytic functions Necessary and sufficient conditions for a function to be analytic, , Harmonic function, harmonic conjugates, branches of the logarithm.

Unit-II

Complex Integration, Anti-derivatives, Cauchy-Goursat Theorem, Simply and Multiply connected domains, Cauchy Integral formula, Cauchy Integral formula for higher Order derivatives, Morera theorem, Liouville theorem, fundamental theorem of Algebra.

Unit-III

Power series, Radius of convergence, differentiation of power series, absolute and uniform convergence of a power series; Transformation: Mappings by elementary functions, Conformal Mapping, Mobius Transformations.

Unit-IV

Taylor's theorem and analytic continuation, zeros of analytic functions, open mapping theorem; Singularities, Laurent's theorem, Calculus of residues, Cauchy residue theorem, Evaluation of Integrals (all cases), Zeros, Poles, Maximum Modulus Principle, Minimum Modulus Principle, Schwarz Lemma, Argument principle, Rouche theorem.

TEXT BOOKS/ REFERENCE BOOKS

1. J.W. Brown and R.V. Churchill, Complex Variables and Applications, MC Graw Hill, 9th Edition, 2013.
2. S. Ponnusamy, Foundations of Complex Analysis, Narosa Book Distributors, 2011.
3. H.A. Priestley, Introduction to Complex Analysis, OUP Oxford, 2nd Edition, 2003.
4. J.B. Conway, Functions of one Complex variable, Springer, 2nd Edition, 1995.
5. L.V. Ahlfors, Complex Analysis, McGraw Hill Education, 3rd Edition, 2017.

Number Theory	
Course Code: 25MAMS103	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: Core Course
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To introduce the basic ideas of number theory, through examples, conjectures theorems, proofs and application
- To use these concepts for further context in the development of mathematics
- To acquire knowledge on basic concepts of arithmetical functions, Dirichlet multiplication, arithmetical functions and congruence's
- To develop problem solving skills in the language and notation of number theory
- To provide an opportunity to develop an appreciation of pure mathematics while engaged in the study of basic number theoretic results

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Define and interpret the concepts of divisibility, congruence, greatest common divisor, prime, and prime-factorization.
- Understand the concepts of arithmetical functions, prove and apply properties of number theoretic functions such as the Euler's phi function and of residues modulo n.
- Solve congruence's of various types and use the theory of congruence's in applications.
- Apply the Law of Quadratic Reciprocity and other methods to classify numbers as primitive roots, quadratic residues, and quadratic non-residues.
- Understand the concepts of factorization of polynomials.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓	✓			
CEO 2		✓	✓		
CEO 3			✓		
CEO 4				✓	✓
CEO 5					✓

COURSE CONTENTS

Unit-I

Divisibility, greatest common divisor, Euclidean Algorithm, The Fundamental theorem of arithmetic, congruence's, Special divisibility tests, Chinese remainder theorem, residue classes and reduced residue classes, Fermat's little theorem, Wilson's theorem, Euler's theorem.

Unit-II

Arithmetic functions (n) , $d(n)$, $\sigma(n)$, $\mu(n)$, Mobius inversion Formula, the greatest integer function, perfect numbers, Mersenne primes and Fermat numbers.

Unit-III

Primitive roots and indices, Quadratic residues, Legendre symbol, Gauss's Lemma, Quadratic reciprocity law, Jacobi symbol, Diophantine equations: $ax + by = c$, $x^2 + y^2 = z^2$, $x^4 + y^4 = z^2$
Sums of two and four squares.

Unit-IV

Finite fields, construction and examples, factorizations of polynomials over finite fields, algorithm to determine irreducible polynomials of degree n over Z_m

TEXT BOOKS/ REFERENCE BOOKS

1. Davis M. Burton, Elementary Number Theory, McGraw Hill Education, 7th edition, 2017.
2. I. Niven, H.S. Zuckerman and H.L. Montgomery, An Introduction to the Theory of Numbers, John Wiley & Sons (5th Ed.) 1991.
3. G. H. Hardy, E. M. Wright, An Introduction to the Theory of Numbers, Oxford University Press, 6th Ed., 2008.
4. G. E. Andrews, Number Theory, Dover Publications, 1995.
5. N. Koblitz, A Course in Number Theory and Cryptography, Springer, 2nd Ed., 2012.

CLASSICAL MECHANICS

Course Code: 25MAMS104	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: Core Course
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To examine derivation of Hamilton's principle from D. Alembert's principle.
- To classify and compile classical mechanics approach to solve a mechanical problem.
- To illustrate canonical transformation.

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Apply the concept of D. Alembert's principle in solving problem related to Lagrangian of system.
- Represent the equation of motion for mechanical systems using Hamiltonian formulations.
- Apply the concept of transformation in changing the configuration space.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

Generalized coordinates, Holonomic and non-holonomic systems, Scleronomic and rheonomic systems, Constraints, Generalized potential, Lagrange's equations of motion of the second kind, Energy equation for conservative field, Derivation of Lagrange's equations from D'Alembert's principle, Simple applications of the Lagrangian formulation.

Unit-II

Hamilton's variables, Hamiltonian, Hamilton canonical equations, Derivation of Hamilton's equations of motion by variational principle, Simple applications of Hamilton's equations of motion,

Unit-III

Cyclic coordinates and conservation theorems, Routh's equations of motion, The principle of least action, Derivation of Lagrange's equations from Hamilton's principle, Derivation of Hamilton's principle from D. Alembert's principle.

Unit-IV

TEXT BOOKS/ REFERENCE BOOKS

6. H. Goldstein, Classical Mechanics, 2nd Edition, Narosa Publishing House, New-Delhi, 2018.
7. A. S. Ramsey, Dynamics Part-II, The English Language Book Society and Cambridge University Press, 1972.
8. F. Gantmacher, Lectures in Analytic Mechanics, MIR Publishers, 1st edition Moscow, 1975
9. I. M. Gelfand and S.V. Fomin, Calculus of Variations, Dover Publications, 2012.
10. N. C. Rana and P. S. Chandra Joag, Classical Mechanics, Tata McGraw Hill, 1991.

DATA STRUCTURES

Course Code: 25MAMS105	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 0 2	Course Category: DSE
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To impart the basic concepts of data structures and algorithms.
- To understand concepts about searching and sorting techniques
- To understand basic concepts about linear data structures stacks, queues, lists and their applications.
- To understand the basic concepts of non-linear data structures that is trees and graphs and their applications.
- To enable them to write algorithms for solving problems with the help of fundamental data structures.

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Analyse the algorithms to determine the time and computation complexity and justify the correctness.
- Implement the given search problem, i.e., Linear and Binary Search.
- Write and analyse an algorithm for different sorting techniques and compare their performance in term of Space complexity, Time complexity and application.
- Implement any given problem of Stacks, Queues and linked list and analyze the same to determine the time and computation complexity.
- Identify the best data structure to be used for any particular application and design and analyses the application in terms of time and space complexity.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓				
CEO 2		✓	✓		
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

Algorithm definition and properties, Algorithm Analysis methods, Time and space complexity trade-Off. Data structures- Introduction, Basic terminology, Data structure operations, ADT, 1D-Arrays, 2D-Arrays, Operations on Arrays, their algorithms and analysis. Linear and Binary search, Classification of Sorting Algorithms, Bubble sort, Insertion sort, Selection Sort, Quick Sort and Merge Sort.

Unit-II

Array implementation of List, Traversing, Insertion, Deletion, Application of List, Polynomial Arithmetic, Linked list, Implementation, Insertion, Deletion and Search, Sparse Matrix, Circular Linked List.

Unit-III

STACK: Array implementation, Linked list implementation, Applications of stack: Infix to Postfix, Evaluation of Postfix, Balancing symbols, Nested function calls, Recursion.
QUEUE: Array implementation, Linked List implementation, Circular Queue, Applications of queue: Priority queue, Double ended queue.

Unit-IV

General trees, Terminology, Representation of trees, Tree traversal- Binary tree, Representation, Expression tree, Binary tree traversal, Threaded Binary Tree, Binary Search Tree: Construction, Searching, Insertion, Deletion, Rotation, Insertion, Deletion, B-Trees, Red-Black Trees.

TEXT BOOKS/ REFERENCE BOOKS

1. Seymour Lipschutz, "Data Structures with C", McGraw Hill Education, Special Indian Edition, 2014.
2. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", 2nd Edition, Pearson Education, 2011.
3. Cormen, T. H. (2009). Introduction to Algorithms, 3rd Edition (The MIT Press) (3rd ed.). MIT Press.
4. Kruse et al., Data Structures and Program Design in C – R., Pearson Education
5. Yedidyah Langsam and Moshe J. Augenstein, Data Structures Using C and C++ – Aaron M. Tenenbaum, PHI Publications.
6. Byron C Gottfried, Theory and problem of programming with C, TMH.
7. Narasimha Karumanchi, Data structures and Algorithms Made Easy, 5th edition, Career monk publications.

Discrete Mathematics

Discrete Mathematics	
Course Code: 25MAMS106	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: Core Course
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To extend student's Logical, Mathematical maturity and ability to deal with abstraction
- To introduce most of the basic terminologies of ideas to solve practical problems
- To make students familiar with recurrence relations and the method of generating functions
- To illustrate POSET, lattices and their properties
- To impart the basics of Boolean algebra, Graphs and trees

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Formulate and interpret statements presented in Boolean logic.
- Apply truth tables.
- Know Tautologies, Contradictions and recurrence relations
- Describe POSET, lattices and their properties.
- Develop graphs and their types and find Minimal Spanning Tree

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

Recurrence Relations: Explicit Formula for a Sequence, Homogeneous and Non-homogeneous Recurrence Relations with Constant Coefficients. Solution of Linear Recurrence Relations: Iterative method, characteristic root method (general and particular solution), Generating Functions. Recursive Functions, Convolution of Numeric Functions.

Unit-II

Logics: Connectives, Laws of proposition, Logical Equivalence Involving Tautologies, Contradictions and Contingency, Conditional and Biconditional Propositions, Quantifiers. Laws of Inference of a proposition and quantifiers.

Lattices: Partially Ordered Sets, Hasse Diagram, Properties of Lattices, Lattices as an Algebraic System, Lattice Isomorphism, Bounded, Complemented and Distributive Lattices.

Unit-III

Definitions and Basic Properties of Boolean Algebra, Representation Theorem, Boolean Expressions, Logic Gates and Circuits, Boolean Function, Method to find Truth Table of a Boolean Function, Karnaugh Map, Expressing Boolean Functions as Boolean Polynomials, Dual canonical form.

Unit-IV

Graphs: Basic terminologies, Special types of graphs with their characteristics (cycle, complete, null, wheel, bipartite and complete bipartite), Paths and Circuits, Eulerian Circuits, Hamiltonian Circuits, Matrix Representation of Graphs (adjacency and incidence matrices), Planar Graphs, Graph colouring, chromatic number, Graph Isomorphism.

Trees: Definition, and Characterisation of Trees, Representation of Algebraic Expressions by Binary Trees, Spanning Tree of a Graph, Shortest Path Problem, Minimal Spanning Tree, Rooted Tree.

TEXT BOOKS/ REFERENCE BOOKS

1. B. Kolman, R. Busby, and S. C. Ross., Discrete Mathematical Structure, 6th Ed., Pearson's Publication, 2018.
2. N. Deo, Graph Theory with Application to Engg & Computer Sci., PHI, New Delhi-2017.
3. C.L. Liu, Elements of Discrete Mathematics, Tata McGraw Hill, 4th edition, 2017.
4. Kenneth H. Rosen, Discrete Mathematics and its application, McGraw-Hill Education; 8th edition, 2018.
5. Swapan Kumar Sarkar, A Text book of Discrete Mathematics. S. Chand, 2017.

Computer Programming using MATLAB	
Course Code: 25MAMS107	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: DSE
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To introduce the software MATLAB for numerical simulation and scientific computation
- To enable students to make use of symbol tools of this computer algebra system
- To introduce MATLAB programming
- To familiarize students with the MATLAB Desktop, basic commands through the Command window and output through the Graph window
- To develop programming skills for solving real world problems more efficiently

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand the basics of MATLAB.
- Apply MATLAB software for basic matrix computation problems through loops.
- Demonstrate MATLAB software to solve various Linear algebra problems numerically.
- Find the solutions of linear and nonlinear equations, and numerical integration using MATLAB.
- Solve different types of mathematical problems and draw various types of graphs using MATLAB.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓				
CEO 2	✓	✓			
CEO 3			✓	✓	
CEO 4					✓
CEO 5			✓	✓	✓

COURSE CONTENTS

Unit-I

MATLAB basics, The MATLAB environment, Basic computer programming, Variables and constants, operators and simple calculations, Formulas and functions, MATLAB toolboxes.

Unit-II

Matrices and vectors: Matrix and linear algebra review, Vectors and matrices in MATLAB, Matrix operations and functions in MATLAB.

Unit-III

Computer programming: Algorithms and structures, MATLAB scripts and functions (m-files), Simple sequential algorithms - Control structures (if...then, loops).

Unit-IV

MATLAB programming: Reading and writing data, file handling, personalized functions, Toolbox structure, MATLAB graphic functions, Numerical methods: Solution of nonlinear equations, system of linear equations. Numerical integration. Numerical simulations.

TEXT BOOKS/ REFERENCE BOOKS

1. Amos Gilat, MATLAB: An Introduction with Applications, 4th edition, Wiley, 2012.
2. Holly Moore, MATLAB for Engineers Pearson; 5th edition, December 2017.
3. Stormy Attaway, Matlab: A Practical Introduction to Programming and Problem Solving; Butterworth-Heinemann; 5th edition, 2018
4. Peter I. Kattan, Matlab for Beginners: A gentle Approach, Create space Independent Publishing Platform; Revised edition 2010.

SEMESTER II

Mathematical Analysis	
Course Code: 25MAMS201	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: Core Course
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To acquire basic knowledge of the countable and uncountable set
- To provide a deeper knowledge of sequence, series of real numbers, and their convergence
- To study the Weierstrass theorem
- To develop the notion Riemann integral
- To introduce the concept Riemann Stieltjes

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe fundamental properties of the real numbers that lead to the formal development of real analysis.
- Demonstrate an understanding of limits and how that is used in sequences, series of functions and their convergence.
- Construct rigorous mathematical proofs of basic results in real analysis.
- Apply Cauchy Criterion, Weierstrass M-test, Abel's and Dirichlets tests.
- Extend their knowledge of real variable theory for further exploration of the subject for going into research.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓	✓	
CEO 4		✓	✓		
CEO 5					✓

COURSE CONTENTS

Unit-I

Countable and uncountable sets, Real number system as a complete ordered field, Archimedean property, limit point of a set, supremum, infimum, Bolzano Weierstrass theorem, Heine Borel theorem, Continuity, uniform continuity, differentiability, mean value theorems, Monotonic functions, types of discontinuity.

Unit-II

Sequences and series of functions: Pointwise and uniform convergence of sequences and series of functions, uniform convergence and its consequences, space of continuous functions on a closed interval, Weierstrass approximation theorem, Power series.

Unit-III

Riemann integral: Existence and properties of the integrals, Fundamental theorem of calculus, first and second mean value theorems, Riemann integrals, Definition and properties of Riemann integral. Functions of bounded variation.

Unit-IV

Riemann-Stieltjes integral: Existence and properties of the integrals, Fundamental theorem of calculus, first and second mean value theorems, Definition and properties of Riemann-Stieltjes integral, differentiation of the integral, Fubini's theorem, Improper integrals.

TEXT BOOKS/ REFERENCE BOOKS

1. S. C. Malik and Savita Arora, Mathematical Analysis, New Age International Publishers, 2017.
2. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Ltd, 2017.
3. W. Rudin, Principles of Mathematical Analysis McGraw-Hill, 4th edition, 2017.
4. P.K. Jain and V.P. Gupta, Lebesgue Measure and Integration, Published by Anshan Ltd, 2nd Edition, 2012.
5. H.L. Royden, Real Analysis, Macmillan Pub. Cop. Inc, New York, 4th Edition, 2010.

Solid Mechanics	
Course Code: 25MAMS202	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: Core Course
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To understand the theoretical concepts of Cartesian Tensor with particular emphasis on their elastic properties
- To describe components of strain
- To enhance the knowledge of strain quadric of Cauchy and stress quadric of Cauchy
- To be familiar with various stress function
- To illustrate Waves in various forms

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Define state of stress and strains, equilibrium and compatibility
- Derive the governing equations and their solutions in plane stress state, plane strain state.
- Explain strain quadric of Cauchy and stress quadric of Cauchy
- Analyse various stress function
- Identify and apply various Waves

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

Cartesian Tensor: Coordinate transformation, Cartesian Tensor of different order, Sum or difference and product of two tensors. Contraction theorem, Quotient law, Symmetric & Skew symmetric tensors, Kronecker tensor, alternate tensor and relation between them, Scalar invariant of second order tensor, Eigen values & vectors of a symmetric second order tensor, Gradient, divergence & curl of a tensor field.

Unit-II

Analysis of Strain: Affine transformations. Infinitesimal affine deformation. Geometrical interpretation of the components of strain. Strain quadric of Cauchy. Principal strains and invariants. General infinitesimal deformation. Saint Venant's equations of Compatibility, Analysis of stress: Stress tensor. Equation of equilibrium. Transformation of co-ordinates. Stress quadric of Cauchy.

Unit-III

Equations of elasticity: Generalized Hooke's law. Homogeneous isotropic media. Elastic moduli for isotropic media. Equilibrium and dynamic equations for an isotropic elastic solid. Strain energy function and its connection with Hooke's law. Beltrami-Michell compatibility equations.

Unit-IV

Two-dimensional problems. Plane stress. Generalized plane stress. Airy stress function. General solution of Biharmonic equation. Stresses and displacements in terms of complex potentials.

Waves: Propagation of waves in an isotropic elastic solid medium. Waves of dilation and distortion. Plane waves. Elastic surface waves such as Rayleigh and Love waves.

TEXT BOOKS/ REFERENCE BOOKS

1. Shanti Narayan, A Text Book of Cartesian Tensors, S. Chand & Co., 1950.
2. I.S. Sokolnikoff, Mathematical Theory of Elasticity, Tata McGraw-Hill Private Ltd, 2nd Edition, 1956.
3. A.E.H. Love, A Treatise on Mathematical Theory of Elasticity, Dover Publications, New York, 4th Edition, 1944.
4. S. Timoshenko and J. N. Goodier, Theory of Elasticity, McGraw-Hill, New York, 3rd Edition, 1970.
5. W. Nowacki, Thermoelasticity, Pergamon Press, Warsaw, Poland, 1986.

Special Functions	
Course Code: 25MAMS203	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: Core Course
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To explain the properties of special functions
- To investigate and derive the properties of Beta-Gamma functions, inter-relations between such functions.
- To illustrate special functions in differential equations.
- To compile certain concepts of Bessel's function with its properties.
- To summarize general concepts of Hermite polynomials and their properties.

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Describe the applications and the usefulness of these special functions.
- Demonstrate the Beta and Gamma functions and their properties.
- Solve the Legendre equation and Legendre Polynomials.
- Evaluate and compile the Bessel equations and Bessel functions.
- Describe and integrate the Hermite equation and Hermite polynomial.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

Hypergeometric Functions: Definition and special cases, convergence, analyticity, integral representation, differentiation, transformations, and summation theorems.

Unit-II

Chebyshev polynomials, orthogonal properties of Chebyshev polynomials, recurrence relations, generating functions for Chebyshev polynomials.

Unit-III

Definition, Solution of Bessel's equation, Bessel's function of the first kind of order n , Bessel's function of the second kind of order n , integration of Bessel's equation in series form, definition of $J_n(x)$, recurrence formulae for $J_n(x)$, generating function for $J_n(x)$, orthogonality of Bessel functions.

Unit-IV

Definition, Solution of Legendre's equation. Legendre polynomial of degree n , generating function of Legendre polynomials, definition of $P_n(x)$ and $Q_n(x)$, general solution of Legendre's Equation (derivations not required), Orthogonal properties of Legendre's polynomials, Recurrence formulas for Legendre's Polynomials.

Unit-V

Hermite Differential Equations, Solution of Hermite equation, Hermite polynomials, generating function for Hermite polynomials, other forms for Hermite Polynomials, Rodrigues formula for Hermite Polynomials, Orthogonal properties of Hermite Polynomials, Recurrence formulae for Hermite Polynomials.

TEXT BOOKS/ REFERENCE BOOKS

1. E. D. Rainville: Special Functions, Chelsea Publishing Co., Bronx, New York, Reprint, 1971.
2. M. D. Raisinghania, Ordinary and Partial Differential Equations, 20th Edition, S. Chand & Company Pvt. Ltd. New Delhi, 2020.
3. J. N. Sharma and R. K. Gupta, Differential equations with special functions, Krishna Prakashan, 20th Edition, 1992.
4. George F. Simmons, Differential Equations with Applications and Historical Notes, Tata McGraw-Hill 3rd Edition, 2023.
5. Shepley L. Ross, Differential equations, 3rd Edition, John Willy & sons. New york, 2007.

Functional Analysis	
Course Code: 25MAMS204	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: Core Course
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- Knowledge of Metric on normed linear spaces
- Use of topological structures in studying spaces of function
- Knowledge of linear mappings defined on Banach spaces and Hilbert spaces, especially linear functional and some sequence spaces
- Familiar with Hahn-Banach theorem, uniform boundedness theorem, open mapping theorem
- Knowledge of bound linear operator.

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

- Able to understand the use of duality in various contexts and theoretical results from the course in concrete situations.
- Fluent with families of applications appearing in the course, particularly specific calculations of norm of a function.
- Produce examples and counter examples illustrating the mathematical concepts presented in the course.
- Able to understand the statements and proofs of important theorems and explain the key steps in proofs, sometimes with variation.
- Knowledge of open mapping and closed graph theorem.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓	✓			
CEO 2		✓			
CEO 3			✓	✓	
CEO 4				✓	✓
CEO 5					✓

COURSE CONTENTS

Unit-I

Normed linear spaces, Banach spaces, properties of normed spaces, finite dimensional normed spaces and subspaces, linear operators, bounded and continuous linear operators, linear functionals, normed spaces of operators.

Unit-II

Bounded linear transformations (X) as a normed linear space, Open mapping and closed graph theorems.

Unit-III

Uniform boundedness principle and its consequences, Hahn-Banach theorem and its application, Compact operators.

Unit-IV

Inner product spaces, Hilbert spaces, properties of inner product spaces, orthogonal complements, orthonormal sets, Hilbert – adjoint operator, self-adjoint, unitary and normal operators, projections on Hilbert spaces.

TEXT BOOKS/ REFERENCE BOOKS

1. H.L. Royden, Real Analysis, Pearson publishing, 4th Edition, 2015
2. E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons, 2006.
3. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 2004.
4. A. H. Siddiqi, Khalil Ahmad and R. Manchanda, Introduction to Functional Analysis with Applications, Anshan Ltd; 1 edition, 2007.
5. D.H. Griffel Applied Functional Analysis Mathematics Dover 2nd edition, 2003.

PYTHON PROGRAMMING

Course Code: 25MAMS205	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 0 2	Course Category: DSE
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To study the basic taxonomy, terminology and components of the python programming.
- To study about the control flow and different type of functions in python programming language.
- To study the different data types and their usage in python programming language.
- To study different modules and libraries associated with python programming.
- To study the visualization and plotting functions provided by python programming language.

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Demonstrate the usage of basic programs of python programming.
- Demonstrate the usage of loops, control flow and different functions.
- Classify the different data types and their application in different scenarios.
- Develop advanced programs in python programming using the libraries. .
- Use various visualization tools to develop graphs for data analysis.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

Introduction to programming languages – Machine language, Assembly language, High level language, Software development, History of Python, Thrust areas of Python, Parts of Python programming language – Identifiers, Keywords, Statements and Expressions, Variables, Operators, Precedence and associativity, Data types, Indentation, Comments, Reading Input, Print Output.

Unit-II

Type of Control Flow statements; loops; exception handling; Functions – Built-In Functions, Commonly Used Modules, Function Definition and Calling the Function, The return Statement and void Function, Scope and Lifetime of Variables, Default Parameters, Keyword Arguments, *args and **kwargs, Command Line Arguments; Type conversion functions - int(), float(), str(), chr(), complex(), ord(), hex(), oct(); Functional Programming – lambda, iterators and generators; Strings.

Unit-III

Lists – Creating Lists, Basic List Operations, Indexing and Slicing in Lists, Built-In Functions Used on Lists, List Methods, The del Statement; Dictionaries –

Creating Dictionary, Accessing and Modifying key, Built-In Functions, Dictionary Methods; Tuples and Sets – Creating Tuples, Tuple Operations, Indexing and Slicing in Tuples, Built-In Functions, Tuple Methods, Sets, Set Methods, Set Traversal, Frozen Set, Relation between Tuples and Dictionary, Relation between Tuples and Lists.

Unit-IV

Files – Types of Files, Creating and Reading Text Data, File Methods to Read and Write Data, Reading and Writing Binary Files, The Pickle Module, Reading and Writing CSV Files, Python os and os.path Modules; Regular Expression – RE Operations, Using Special Characters, Regular Expression Methods, Named Groups in Python Regular Expressions, Regular Expression with glob Module.

TEXT BOOKS / REFERENCE BOOKS

- 1 S, G., & A, V. (2018). Introduction to Python Programming (1st ed.). Chapman and Hall/CRC.
2. Boschetti, A., & Massaron, L. (2018). Python Data Science Essentials: A practitioner's guide covering essential data science principles, tools, and techniques, 3rd Edition. Packt Publishing.
3. Shovic, J. C., & Simpson, A. (2019). Python All-In-One For Dummies (1st ed.). For Dummies.

Fluid Dynamics	
Course Code: 25MAMS206	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: DSE
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To develop students understanding about the fluids and their characteristics
- To make students familiar with Bernoulli's equation and potential theorems
- To develop student's understanding about two- dimensional flow in cylindrical polar coordinates
- Familiar with two- dimensional motion, use of cylindrical polar co-ordinates
- Familiar with Complex velocity potential

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

- Fluent with the basic principles of fluid dynamics.
- Able to use Euler and Bernoulli's equations and the conservation of mass to determine velocity and acceleration for incompressible and inviscid fluid.
- Get an understanding the concept of rotational and irrotational flow, stream functions, velocity potential, sink, source, vortex, etc.
- Able to analyse simple fluid flow problems (flow between parallel plates, flow through pipe, etc.) with Navier - Stoke's equation of motion.
- Fluent with Complex velocity potential.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓	✓			
CEO 2		✓			
CEO 3			✓	✓	
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

Kinematics, Velocity at a point of a fluid, Eulerian and Lagrangian methods, Streamlines, path lines and streak lines, Velocity potential, Irrotational and rotational motions, Vorticity and circulation, Equation of continuity, Boundary surfaces, Acceleration at a point of a fluid, Components of acceleration in cylindrical and spherical polar co-ordinates.

Unit-II

Pressure at a point of a moving fluid, Euler equation of motion, Equations of motion in cylindrical and spherical polar co-ordinates, Bernoulli equation, Impulsive motion, Kelvin circulation theorem, Vorticity equation, Energy equation for incompressible flow, Kinetic energy of irrotational flow, Kelvin minimum energy theorem, Kinetic energy of infinite fluid, Uniqueness theorems.

Unit-III

Axially symmetric flows, Liquid streaming past a fixed sphere, Motion of a sphere through a liquid at rest at infinity, Equation of motion of a sphere, Kinetic energy generated by impulsive motion, Motion of two concentric spheres, Three-dimensional sources, sinks and doublets, Images of sources, sinks and doublets in rigid impermeable infinite plane and in impermeable spherical surface

Unit-IV

Two-dimensional motion, Use of cylindrical polar coordinates, Stream function, Axisymmetric flow, Stoke stream function, Stoke stream function of basic flows, Irrotational motion in two-dimensions, Complex velocity potential, Milne-Thomson circle theorem, Two-dimensional sources, sinks, doublets and their images, Blasius theorem.

TEXT BOOKS/ REFERENCE BOOKS

1. W. H. Besaint and A. S. Ramasey, A Treatise on Hydromechanics, Part II, CBS Publishers, Delhi, 1st January 2006
2. F. Chorlton, Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi, 18 April 2018.
3. O. Neill, M.E. and Chorlton, F., Ideal and Incompressible Fluid Dynamics, Ellis Horwood Limited, 1986.
4. R. K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company, 1976.
5. G.K. Batchelor, An Introduction to Fluid Mechanics, Cambridge University Press, Feb 2000.

Computing with R

Course Code: 25MAMS207	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 0 2	Course Category: DSE
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To introduce programming with the eventual aim of developing skills required to write statistical software
- To illustrate programming with examples related to numerical analysis
- To highlight programming with examples related to random number generation, matrix computations
- To describe and explain topics related to graphics
- To be familiar with R computations

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Write the programs for statistical software.
- Apply programming skills in methods and algorithms useful in probability, statistics and data analysis.
- Get equipped with examples related to random number generation, matrix computations
- Apply graphics to represent multivariate data and descriptive statistics.
- Execute the skill regarding R computations.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓	✓			
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

Syntax of R expressions: Vectors and assignment, vector arithmetic, generating regular sequence, logical vector, character vectors, Index vectors; selecting and modifying subsets of data set Data objects: Basic data objects, matrices, partition of matrices, arrays, lists, factors and ordered factors, creating and using these objects; Functions- Elementary functions and summary functions, applying functions to subsets of data

Unit-II

Data frames: The benefits of data frames, creating data frames, combining data frames, Adding new classes of variables to data frames; Data frame attributes. Importing data files: import, data function, read, table function; Exporting data: export. Data function, cat, write, and write. Table functions; Outputting results - sink function, formatting output - options, and format functions; Exporting graphs - export. graph function.

Unit-III

Random numbers from various distributions like uniform, Normal, gamma, exponential etc, Graphics in R: creating graphs using plot function, box plot, histogram, line plot, steam and leaf plot, pie chart, bar chart multiple plot layout, plot titles, formatting plot axes.

Unit-IV

Loops and conditional statements: Control Statements; if statement, if else Statement. Looping statement; for loop, repeat, while loop Developing simple programs in R for data analysis tasks, saving programs, executing stored programs, defining a new binary operator, assignment within function, more advanced examples, object-oriented programme. Creating function libraries- library function, attaching and detaching the libraries

TEXT BOOKS/ REFERENCE BOOKS

1. Purohit, G.S., Gore, S.D. and Deshmukh, S.R., Statistics Using R. Narosa Publishing House, 2008
2. Maindonald J. and Braum, J., Data Analysis and Graphics Using R: An example-based approach Second Edition, Cambridge Series in Statistical and Probabilistic Mathematics, 2007
3. R.A. Thisted, Elements of Statistical Computing, Chapman and Hall, 1st Edition 1988
4. Peter Dalgaard, Statistics and computing: Introductory Statistics with R Springer, 2002.
5. Maria L. Rizzo, Statistical Computing with R, CRC Press, 2007

SEMESTER III

Advanced Ordinary Differential Equations	
Course Code: 25MAMS301	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: Core Course
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To introduce various methods to find the general solution of the ordinary differential equations
- To introduce fundamental theorems for existence and uniqueness of solution of IVP
- To develop a clear understanding of the special functions and its properties
- To provide deeper knowledge of system of linear of differential equations
- To learn the basics of phase plane, critical points, and stability of autonomous systems

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Find the solutions of first and higher order ODEs.
- Discuss the existence and uniqueness of solutions of given IVP.
- Solve ordinary differential equations by Power series solution and special functions.
- Model some physical problem and give physical interpretation of the solution.
- Do stability analysis of the systems which arise in different areas of science and engineering.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓			✓	
CEO 2		✓			
CEO 3			✓	✓	
CEO 4					
CEO 5				✓	✓

COURSE CONTENTS

Unit-I

Initial value problem, Boundary value problem, Linear dependence equations with constant as well as variable coefficient, Wronskian, Variation of parameter, Method of undetermined coefficients, Reduction of the order of equation

Unit-II

Lipchilz's condition and Gron Wall's inequality, Picards theorems, Dependence of solution on initial conditions and on function, Continuation of solutions, Nonlocal existence of solutions Systems as vector equations, Existence and uniqueness of solution for linear systems.

Unit-III

Sturm-Liouville Boundary Value Problem. Sturm-Liouville's system, Green's function and its applications to boundary value problems, Some oscillation theorems such as Sturm theorem, Sturm comparison theorem and related results.

Unit-IV

System of first order equation, fundamental matrix, Nonhomogeneous linear system, Linear system's with constant as well as periodic coefficients.

TEXT BOOKS/ REFERENCE BOOKS

1. William E. Boyce, Richard C. Dippima, Elementary Differential Equations and Boundary Value Problems, John Wiley and Sons; 9th edition, 2009.
2. Shepley L. Ross, Differential Equations, John Wiley and Sons; 3rd edition, 2007.
3. George Simmons, Differential equations with applications and Historical Notes, McGraw Hill Education; 2nd edition, 2017.
4. Martin Brown, Differential Equations and Their Applications, Springer, 1992.
5. A. K. Nandakumaran, Ordinary Differential Equations: Principal and Applications, Cambridge University Press; 1st edition, 2017.

Topology	
Course Code: 25MAMS102	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: Core Course
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To discuss topological spaces, types of topologies, open and closed sets
- To make students familiar with fundamentals of point set topology and constitute an awareness of the need for the topology in Mathematics
- To discuss about continuity, product and metric topologies
- To make students familiar with connected, compact spaces and locally connected spaces
- To highlight separation axioms

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

- Able to construct topological spaces from metric spaces and using general properties of neighbourhood, open sets, close sets, basis and sub-basis.
- Fluent with the properties of open sets, close sets, interior points, accumulation points and derived sets in deriving the proofs of various theorems.
- To discuss the concepts of countable spaces and separable spaces.
- Able to understand the concepts and properties of the compact and connected topological spaces.
- Get an understanding of the concepts – T_0 , T_1 , T_2 , T_3 , $T_{3\frac{1}{2}}$, T_4 .

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓	✓			
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	✓
CEO 5					✓

COURSE CONTENTS

Unit-I

Definition and examples of topological space, Closed sets, Closure, Dense subset, Neighbourhoods, interior, exterior, boundary and accumulation points, Derived sets, Bases and sub-bases, Subspaces, product spaces and relative topology.

Unit-II

Continuous functions, homomorphism, the pasting lemma, Connected and disconnected sets, connectedness on the real line, components, locally connected spaces.

Unit-III

Countability axioms– First and second countable spaces, Lindelofs theorem, Separable spaces, second countability and separability, Separation axioms– T_0 , T_1 , T_2 , T_3 , $T_{3\frac{1}{2}}$, T_4 , their characterizations and basic properties, Urysohns lemma and Teitze extension theorem, Statement of Urysohns Metrization theorem.

Unit-IV

Compactness–Continuous functions and compact sets, basic properties of compactness, compactness and finite intersection property, sequentially and countably compact sets, local compactness and one point compactification, Statements of Tychonoffs Product theorem and Stone-cech compactification theorem.

TEXT BOOKS/ REFERENCE BOOKS

1. J. R. Munkres, Topology, A First Course, PHI Pvt. Ltd., N. Delhi, Second Edition 2015.
2. S. Willard, General Topology, Addison-Wesley, Dover Publications, 12 July 2012
3. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1st edition, 1st July 2017.
4. K.D Joshi, Introduction to General Topology, New Age International Publisher Second Edition, 2014.
5. S. Kumaresan, Topology with Metric Space, Alpha Science International, 2005

Integral Equations	
Course Code: 25MAMS303	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: Core Course
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To develop analytical ability in solving variational problems
- To make students familiar with analytical ability in solving Integral equation
- To develop students' understanding about the properties of geometrical problems
- To illustrate different types of integral equations
- To highlight the decomposition method

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand the properties of geometrical problems.
- Describe variational problems and their solutions.
- Well-versed with isoperimetric problems and their solutions.
- Get an understanding of different types of integral equations.
- Expose to the decomposition method.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓				
CEO 2		✓		✓	
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

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

Unit-II

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

Unit-III

Green function, use of method of variation of parameters to construct the Greens function for a no homogeneous linear second order boundary value problem, Basic four properties of the Greens function, Orthogonal series representation of Green function,

Unit-IV

Alternate procedure for construction of the Greens function by using its basic four properties, Reduction of a boundary value problem to a Fredholm integral equation with kernel as Greens function. Hilbert-Schmidt theory for symmetric kernels.

TEXT BOOKS/ REFERENCE BOOKS

1. A. Jerri, Introduction to Integral Equations with Applications, John Wiley & Sons, 1999.
2. R. P. Kanwal, Linear Integral Equations: Theory and Technique, Birkhauser, Boston Inc; 2nd edition 2013.
3. I. M. Gelfand and S. V. Fomin, Calculus of Variations, Dover Publications Inc., 2000.
4. R. Weinstock, Calculus of Variations, Dover Publications; Revised ed. edition, 2012.
5. Abdul-Majid Wazwaz, A first course in Integral Equations, World Scientific Publishing Company; 2nd edition, 2015.

Linear Algebra

Course Code: 25MAMS304	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: Core Course
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To make students familiar with vector spaces
- To develop students' understanding about linear transformations
- To make students familiar with relationship of linear algebra and Matrices
- To highlight minimal polynomial and annihilators
- To impart basic mathematical theory of inner product space structure

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand the notion of a vector space and linear transformation.
- Determine basis and dual basis.
- Find the characteristic polynomial and characteristic roots of a square matrix.
- get an understanding of minimal polynomial and annihilators
- Compute an orthogonal basis using the Gram-Schmidt process.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1		✓			
CEO 2	✓				
CEO 3		✓	✓	✓	
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

Introduction-vector space, basis, dimension and related properties, Algebra of Linear transformations, Dimension of space of linear transformations, Change of basis and transition matrices, Linear functional, Dual basis, Computing of a dual basis, Dual vector spaces, Annihilator, Second dual space, Dual transformations.

Unit-II

Inner-product spaces, Normed space, Cauchy-Schwartz inequality, Projections, Orthogonal Projections, Orthogonal complements, Orthonormality, Matrix Representation of Inner-products, Gram-Schmidt Orthonormalization Process, Bessel's Inequality, Riesz Representation theorem and orthogonal Transformation, Inner product space isomorphism.

Unit-III

Operators on Inner-product spaces, Adjoint operator, self-adjoint operator, normal operator and their properties, Matrix of adjoint operator, Algebra of $\text{Hom}(V, V)$, Minimal Polynomial, Invertible Linear transformation, Characteristic Roots, Characteristic Polynomial and related results.

Unit-IV

Diagonalization of Matrices, Invariant Subspaces, Cayley-Hamilton Theorem, Canonical form, Jordan Form. Forms on vector spaces, Bilinear Functionals, Symmetric Bilinear Forms, Skew Symmetric Bilinear Forms, Rank of Bilinear Forms, Quadratic Forms, Classification of Real Quadratic forms and related theorems

TEXT BOOKS/ REFERENCE BOOKS

1. Stephen H. Friedberg et al, Linear Algebra, Prentice Hall of India Pvt. Ltd. 4th Edition, 2010
2. Shanti Narayana and P K Mittal, A text book of Matrices, S. Chand & Company Pvt. Ltd., New Delhi, year 1953.
3. Gilbert Strang, Linear Algebra, Wellesley-Cambridge Press, 5th Edition, 2016.
4. A.R. Vasishtha, J.N. Sharma and A.K. Vasishtha, Linear Algebra, Krishna Prakashan Mandir, Meerut, 42nd Edition, 2010.
5. Hoffman and Kunze, Linear Algebra, Prentice-Hall of India, 1978, 2nd Ed.

Coding theory and Cryptography	
Course Code: 25MAMS305	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: DSE
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To introduce the basic ideas of number theory, through examples, conjectures theorems, proofs and application
- To use these concept in linear and nonlinear code
- To acquire knowledge on basic error correcting codes.
- To develop problem solving skills in cryptography.
- To provide an opportunity to develop an appreciation of pure mathematics while engaged in the study of basic number theoretic results

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Define and interpret the concepts code.
- Understand the concepts of arithmetical functions, prove and apply properties of number theoretic functions such as the Euler's phi function and of residues modulo n.
- Solve various types a problems of code.
- Apply the Weight distribution of codes.
- Understand the concepts of DES-security and RSA.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓				✓
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

Polynomial rings over fields, Extension of fields, Computation in $GF(q)$, n -th roots of unity, Vector space over finite fields.

Unit-II

Error correcting codes: Binary group codes, Hamming codes, Linear block codes, The structure of cyclic codes, Quadratic residue codes, Reed Mueller codes, Simplex code

Unit-III

Nonlinear codes, Golay, Hadamard, Justeen, Kerdock, Nordstorm-Robinson codes, First and Second order Reed-Mueller codes, t -designs, steiner systems, Weight distribution of codes.

Unit-IV

Classical cryptosystems, DES-security and generalizations, Prime number generation, Public Key Cryptosystems of RSA, Rabin, etc. their security and cryptanalysis Primality, factorization and quadratic sieve, efficiency of other factoring algorithms.

TEXT BOOKS/ REFERENCE BOOKS

2. Davis M. Burton, Elementary Number Theory, McGraw Hill Education, 7th edition, 2017.
3. Ron Roth, Introduction to Coding Theory, Cambridge University Press, 2006
4. I.Niven, H.S. Zuckerman and H.L.Montgomery, An Introduction to the Theory of Numbers, John Wiley & Sons (5th Ed.) 1991.
5. G. E. Andrews, Number Theory, Dover Publications, 1995.
6. N. Koblitz, A Course in Number Theory and Cryptography, Springer, 2nd Ed., 2012.

Operational Research	
Course Code: 25MAMS306	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: DSE
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To develop students understanding in solving problems in different environments that needs decisions
- To make student familiar with quantitative methods and techniques for effective decisions – making
- To discuss and formulate to apply the models that is used in solving business decision problems as well as in various real-life problems
- To develop students understanding in simplex method
- To make student familiar with nonlinear programming problems

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Get an understanding of real-life problems into Linear programming problems.
- Able to use the simplex method to find an optimal vector for the standard linear programming problem and the corresponding dual problem.
- Able to find the optimal solution of transportation problem.
- Get an understanding of the constructions of the networks of a project and optimal scheduling using CPM and PERT.
- Able to solve Game theory problems.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓	✓			
CEO 2		✓	✓		
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

Introduction to Linear Programming. Problem formulations. Linear independence and dependence of vectors. Convex sets. Extreme points. Hyperplanes and Halfspaces. Directions of a convex set. Convex cones. Polyhedral sets and cones. Theory of Simplex Method. Simplex Algorithm. Degeneracy. Bounded variable problem

Unit-II

Revised Simplex method. Duality theory. Dual-simplex method, Unconstrained and constrained optimization problems. Types of extrema and their necessary and sufficient conditions. Convex functions and their properties.

Unit-III

Transportation and Assignment problems of linear programming, sequencing theory and travelling salesperson's problem. Game theory: Two-person zero-sum games, Games with mixed strategies, Graphical solutions, Solutions by linear programming

Unit-IV

Network analysis: Shortest-path problem, Minimum cost flow problem, Project planning and control with PERT/CPM.

TEXT BOOKS/ REFERENCE BOOKS

2. S. D. Sharma, Operations Research Theory Methods & Applications, Kedar Nath Ram Nath Publishers, 2017.
3. J. K. Sharma, Operations Research – Theory and Applications, Assorted Editorial, 2017.
4. Hillier and Lieberman, Introduction to Operations Research, Mcgraw Higher Ed., 10th edition (5 July 2017).
5. H. A. Taha, Operations Research, Pearson Education, 10th edition, 2017.
6. Kanti Swarup , P. K Gupta Man Mohan, , Operations Research, Sultan chand & Sons , 2019.

Mathematical Statistics-I	
Course Code: 25MAMS307	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: DSE
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To demonstrate the knowledge of probability and the standard statistical distributions
- To understand the concept of two dimensional random variable
- To derive suitable point estimators of the parameters of the distribution of random variable
- To develop a deeper understanding of the testing of hypothesis for large sample
- Perform hypothesis for large samples testing problems in real life examples small samples

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- To know about probability and probability distributions
- Understand the transformation of random variables, central limit theorem, and its application.
- Construct and interpret properties of estimator
- Perform hypothesis for large samples testing problems in real life examples
- Perform hypothesis for small samples testing problems in real life examples

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓	✓			
CEO 2	✓				
CEO 3		✓			
CEO 4			✓	✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

Introduction to probability, random variables, probability distributions, moments, moment generating function, Markov and Chebyshev inequalities, special discrete and continuous distributions.

Unit-II

Function of a random variable, joint distributions, bivariate normal distribution, transformation of random variables, central limit theorem.

Unit-III

Sampling distributions, point estimation, unbiasedness, consistency, method of moments and maximum likelihood estimation, confidence intervals for parameters in one sample and two sample problems from normal populations

Unit-IV

Testing of hypothesis - Null and alternate hypothesis -Neyman Pearson fundamental lemma - Tests for one sample and two sample problems for normal populations - Tests for proportions - Test for small samples – t - test, chi - square test and F-test.

TEXTBOOKS/REFERENCEBOOKS

- 1 V.K. Rohatgi and A.K. Md. E.Saleh, An Introduction to Probability and Statistics. John Willey and Sons, Third Edition 2015.
2. J.S. Milton & J. C. Arnold, Introduction to Probability and Statistics, Tata McGraw Hill Fourth Edition, 2007
3. H. J. Larson, Introduction to Probability Theory and Statistical Inference, Wiley Pub, Third Edition, 1982.
4. S. M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Academic Press, Fifth Edition, 2014.
5. W.W. Hines, D. C. Montgomery, D. M. Goldsman and C. .Borror, Probability and Statistics in Engineering, John Wiley and sons, 2008.

SEMESTER IV

Partial Differential Equations	
Course Code: 25MAMS401	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: Core Course
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To discuss the formulation and solution of PDE
- To make student familiar with the applications of PDE including physical problems.
- To make student familiar with analytical methods and their implementation to solve real life problems
- To develop students understanding of linear transformations
- To discuss heat equation

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

- Able to understand the partial differential equation problem.
- Fluent with linear and non-linear systems.
- Able to solve the first-order linear and non-linear PDEs by using transform methods and other methods.
- Able to determine the solutions of linear PDEs of second and higher order with constant coefficients.
- Able to know Hop-Lax formula, Weak solutions.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓	✓	
CEO 4			✓		
CEO 5					✓

COURSE CONTENTS

Unit-I

First-Order Partial Differential Equations(PDEs)– Formation and classification of first-order PDEs, Linear and Quasi-linear first-order PDEs, Cauchy’s problem for first order PDEs, The Cauchy Kowalevski Theorem, Integral surfaces passing through a given curve, Nonlinear first-order PDEs, The method of characteristics, Compatible systems.

Unit-II

Solution of Partial Differential Equation, Transport equation-initial value problem, non-homogeneous equation, Laplace equation-fundamental solution, Mean value formulas, Properties of harmonic functions, Estimation on derivative, Harnack’s inequality

Unit-III

Green function, Energy methods, Boundary value problem and applications of PDE: Heat equation-fundamental solution, Mean value formula, Properties of solution, Energy methods, Wave Equation-solution by spherical means, Application of D-Alembert’s principle, Energy methods.

Unit-IV

Nonlinear first order PDE-complete integrals, Envelopes, Characteristics, Hamilton-Jacobi equations, Hamilton’s ODE, Hop-Lax formula, Weak solutions, Uniqueness, Representation of solutions

TEXT BOOKS/ REFERENCE BOOKS

- 1 L.C. Evans, Partial Differential Equations (Graduate studies in mathematics), Orient Blackswan, second edition 2014.
- 2 I.N. Sneddon, Elements of Partial Differential Equations, Dover Publications Inc., 2006.
- 3 K.S.Rao, Introduction to Partial Differential Equations, Prentice Hall India Learning Private Limited; third edition, 2011.
- 4 J David Logan, Applied Partial Differential Equations, Springer International Publishing, 2015.
- 5 Walter A. Strauss , An Introduction Partial Differential Equations, Wiley, 2008

Measure Theory and Integration	
Course Code: 25MAMS402	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: Core Course
Prerequisite: Set Theory	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To highlight Measure theory that provides a foundation for many branches of mathematics such as harmonic analysis, theory of partial differential equations and probability theory
- To make students familiar with the basic uses of measure theory
- To make students familiar with measures, Lebesgue integration, differentiation and convergence
- To discuss convergence in measure and dominated Convergence theorems
- To discuss Riemann integrable simple functions

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

- Able to describe the short comings of Riemann integral and benefits of Lebesgue integral.
- Fluent with the fundamental concept of measure and Lebesgue measure.
- Get an understanding of the uses of fundamental theorem of calculus.
- Get an understanding of the basic concepts of measure and integration theory.
- Get an understanding of convergence in measure and dominated Convergence theorems.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓				
CEO 2		✓			
CEO 3		✓	✓	✓	
CEO 4	✓				✓
CEO 5				✓	

COURSE CONTENTS

Unit-I

Length of an open set, concept of measure, Lebesgue outer measure and measurable sets, example of non-measurable set, sigma algebra, Borel sets, $G\delta$ and $F\sigma$ -sets, outer and inner regularity of Lebesgue measure

Unit-II

Set function, abstract measure spaces, properties of measures, some examples of measures, measurable spaces, measurable functions, combinations of measurable functions, limits of measurable functions

Unit-III

Review of Riemann integral, integrable simple functions, the Lebesgue integration of a measurable function, and integration with respect to a measure

Unit-IV

Almost everywhere convergence, convergence in measure, Fatou's Lemma, Monotone and Dominated Convergence Theorems

TEXT BOOKS/ REFERENCE BOOKS

2. G. de Barra, Measure and Integration. New Age International (P) Ltd., New Delhi, 2006.
3. S. K. Berberian, Measure and Integration, Amer. Math. Soc. (reprint), 2011.
4. H. L. Royden, Real Analysis, Macmillan Pub. Co., Inc. 4th Edition, New York, 1993.
5. P. R. Halmos, Measure Theory, Springer-Verlag New York, 1974.
6. P.K Jain and V.P Gupta Lebesgue measure and Integration, New Age International (P) Limited Published, New Delhi, 1986.

Modelling and Simulation	
Course Code: 25MAMS403	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: DSE
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To determine the relationship between theoretical, mathematical and computational aspects
- To make students familiar with Modelling to solve mathematical and engineering problems
- To create competency with mathematical modelling of real- world situations
- To develop students' understanding about Development, prediction and evaluation of outcomes against design criteria
- To learn Markov Chain Monte-Carlo simulation and Metropolis-Hastings algorithm

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Apply Simulation and Monte Carlo integration.
- Discuss and get equipped with different models to population dynamics
- Illustrate inverse transform method and convolution method.
- Illustrate outcomes against design criteria
- Know Markov Chain Monte-Carlo simulation and Metropolis-Hastings algorithm

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓				
CEO 2		✓	✓		
CEO 3		✓	✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

Introduction to mathematical modelling, Discrete Time linear models in population Dynamics, Discrete time linear Age Structured model, Discrete Time Nonlinear model in population dynamics

Unit-II

Introduction to Continuous Time models in population dynamics, Continuous Time Single Species models

Unit-II

Simulation and Monte Carlo integration, Computers as inference machines, Issues in simulation simulating from standard univariate and multivariate distributions, congruential method for uniform generators, transforming uniforms, and inverse transform method, convolution method, and acceptance-rejection method.

Unit-IV

Markov Chain Monte-Carlo simulation, Markov chains with continuous state-space, Markov chain Monte-Carlo integration, The Gibbs-sampler, Metropolis-Hastings algorithm, Random walk proposal, Hybrid strategies.

TEXT BOOKS/ REFERENCE BOOKS

1. G.J. McLachlan and T. Krishnan, The EM Algorithm and Extensions, Wiley, 2nd Edition 2008
2. J.S. Simonoff, Smoothing Methods in Statistics, Springer, 1st Edition 2011.
3. R. Gnanadesikan, Methods for Statistical Data Analysis of Multivariate Observations, Second edition, Wiley, 2011.
4. J. N. Kapur, Mathematical Modeling, New Age Publishers, 2nd Edition 2015.

Algebraic Topology

Course Code: 25MAMS404	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: DSE
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To introduce the notion of homotopy, groups with pointed spaces and covering spaces which is closely associated with the fundamental groups
- To highlight the concept of presentation of a group
- To compute the fundamental group of the wedge of circles
- To define the topology of E_n
- To Classify the Surfaces

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Grasp the basics of Algebraic Topology.
- Determine fundamental groups of some standard spaces like Euclidean spaces and spheres.
- Understand proofs of some beautiful results such as Fundamental theorem of Algebra, Hurwicz uniformization theorem, Borsuk's separation theorem.
- Describe the topology of E_n
- Classify the Surfaces and Covering Spaces

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CLO CEO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓	✓	
CEO 4			✓		
CEO 5					✓

COURSE CONTENTS

Unit-I

Homotopy of paths, the Fundamental group, covering spaces, the fundamental group of the circle, Retractions and fixed points, the fundamental group of the punctured plane.

Unit-II

Deformation retracts and homotopy type, the fundamental group of S_n , Essential and inessential maps, the fundamental theorem of Algebra.

Unit-III

Topology of E_n , Borsuk's separation theorem, deformation of subsets of E_{n+1} , the Jordan Curve Theorem, fiber spaces, Hurwicz uniformization theorem.

Unit-IV

Classification of Surfaces: Fundamental groups of surfaces, Homology of Surfaces, Cutting and Pasting, the Classification theorem. Classification of Covering Spaces: Equivalence of Covering Spaces, Universal Covering Space, Covering Transformations.

TEXT BOOKS/ REFERENCE BOOKS

1. James R Munkres, Topology - A Modern Introduction, Prentice Hall of India, 2nd Edition 2002.
2. James Dugundji, Topology, Allyn and Bacon, New York, 1975.
3. Marvin J. Greenberg & J R Harper, Algebraic Topology –A First Course, Westview Press, 1981.
4. W. S. Massey, Algebraic Topology- An Introduction, Springer Pub 1st Edition, 1990.
5. Satya Deo, Algebraic Topology-A Primer, Hindustan Book Agency, 1st Edition, 2003

Theory of Elasticity

Course Code: 25MAMS405	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: DSE
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To understand the theoretical concepts of Cartesian Tensor with particular emphasis on their elastic properties
- To describe components of strain
- To enhance the knowledge of strain quadric of Cauchy and stress quadric of Cauchy
- To be familiar with various stress function
- To illustrate Waves in various forms

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Define state of stress and strains, equilibrium and compatibility
- Derive the governing equations and their solutions in plane stress state, plane strain state.
- Explain strain quadric of Cauchy and stress quadric of Cauchy
- Analyse various stress function
- Identify and apply various Waves

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓				
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

Cartesian Tensor: Coordinate transformation, Cartesian Tensor of different order, Sum or difference and product of two tensors. Contraction theorem, Quotient law, Symmetric & Skew symmetric tensors, Kronecker tensor, alternate tensor and relation between them, Scalar invariant of second order tensor, Eigen values & vectors of a symmetric second order tensor, Gradient, divergence & curl of a tensor field. Analysis of Strain: Affine transformations. Infinitesimal affine deformation. Geometrical interpretation of the components of strain.

Unit-II

Strain quadric of Cauchy. Principal strains and invariants. General infinitesimal deformation. Saint Venant's equations of Compatibility, Analysis of stress: Stress tensor. Equation of equilibrium. Transformation of co-ordinates. Stress quadric of Cauchy.

Unit-III

Equations of elasticity: Generalized Hooke's law. Homogeneous isotropic media. Elastic moduli for isotropic media. Equilibrium and dynamic equations for an isotropic elastic solid. Strain energy function and its connection with Hooke's law. Beltrami-Michell compatibility equations.

Unit-IV

Two-dimensional problems. Plane stress. Generalized plane stress. Airy stress function. General solution of Biharmonic equation. Stresses and displacements in terms of complex potentials. Waves: Propagation of waves in an isotropic elastic solid medium. Waves of dilation and distortion. Plane waves. Elastic surface waves such as Rayleigh and Love waves.

TEXT BOOKS/ REFERENCE BOOKS

1. Shanti Narayan, A Text Book of Cartesian Tensors, S. Chand & Co., 1950.
2. I.S. Sokolnikoff, Mathematical Theory of Elasticity, Tata McGraw-Hill Private Ltd, 2nd Edition, 1956.
3. A.E.H. Love, A Treatise on Mathematical Theory of Elasticity, Dover Publications, New York, 4th Edition, 1944.
4. S. Timoshenko and J. N. Goodier, Theory of Elasticity, McGraw-Hill, New York, 3rd Edition, 1970.

Differential Geometry	
Course Code: 25MAMS406	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: DSE
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To develop students' understanding about the notion of level sets
- To describe surfaces as solutions of equations
- To be familiar with vector fields, Weingarten equation, line integrals and parameterization of surfaces
- To illustrate and apply theory of space curves
- To understand and apply equations of surface theory, Bonnet theorem and Geodesic mappings

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Compute quantities of geometric interest such as curvature and torsion.
- Introduce the method of the moving frame and over determined systems of differential equations as they arise in surface theory.
- Calculate the involute and evolute of a curve.
- Calculate the first and the second fundamental forms of a surface.
- Calculate the Gaussian curvature, the mean curvature, the curvature lines, the asymptotic lines, the geodesics of a surface.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓		✓		
CEO 2		✓			
CEO 3			✓		
CEO 4				✓	✓
CEO 5					✓

COURSE CONTENTS

Unit-I

Theory of space curves, arc length, tangent and normals, Curvature and torsion of curve given as the intersection of two surfaces, Involutives and Evolutes.

Unit-II

Metric: The first and second fundamental form, Weingarten equation, orthogonal trajectories, Mensuier theorem, Gaussian curvature, Eulers theorem, Dupin's theorem, Rodrigues theorem, Dupin's indicatrix.

Unit-III

Envelopes, Edge of regression, Ruled surface, Developable surface, Monges theorem, Conjugate directions.

Unit-IV

Asymptotic lines, the fundamental equations of surface theory, Gauss formulae, Gauss characteristic equations, Mainardi - Codazzi equations, Weingarten equations, Bonnet's theorem on parallel surface, Geodesics, Clairaut's theorem, Gauss Bonnet theorem, conformal mapping and Geodesic mappings, Tissot's theorem, Dini's theorem.

TEXT BOOKS/ REFERENCE BOOKS

1. J.A. Thorpe, Introduction to Differential Geometry, Springer-verlag, 1st Edition 1994.
2. O'Neill, Elementary Differential Geometry, Academic Press, 2nd Edition, 2006.
3. S. Sternberg, Lectures on Differential Geometry, Prentice-Hall, 1964.
4. M. P. do Carmo, Differential Geometry of Curves and Surfaces, Dover Pub, 2nd Edition, 2016.
5. D. Laugwitz, Differential and Riemannian Geometry, Academic Press, 2014.

Mathematical Programming	
Course Code: 25MAMS407	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: DSE
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- α. To make students familiar with convex sets and convex functions
- β. To discuss Kuhn-Tucker conditions of optimality
- χ. To develop students understanding about theory of the revised simplex method and parametric linear programming
- δ. To discuss basic concepts in integer programming
- ε. To make students familiar with quadratic programming with duality theory of quadratic and convex programming

φ.

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

- γ. Get an understanding of convex sets and functions and application of Kuhn-Tucker conditions of optimality.
- η. Fluent with mathematical programming model of a real-life situation.
- ι. Able to apply a branch and bound algorithm to solve integer programming problems.
- φ. Able to apply Wolfe's algorithm and Beale's algorithm for quadratic programming.
- κ. Get an understanding of the basic theory of separable programming.

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO	CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1		✓				
CEO 2		✓	✓			
CEO 3				✓	✓	
CEO 4						✓
CEO 5					✓	

COURSE CONTENTS

Unit-I

Convex sets, convex functions, pseudo-convex functions, quasi-convex, explicit quasi-convex, quasi-monotonic functions and their properties from the point of view of mathematical programming. Kuhn-Tucker conditions of optimality.

Unit-II

Theory of revised simplex algorithm, Duality theory of linear programming, Sensitivity analysis.

Unit-III

Parametric linear programming, Integer programming and linear goal programming, dynamic programming

Unit-IV

Quadratic programming: Wolfe's algorithm, Beale's algorithm, Theil and Vande-Panne algorithm. Duality theory of quadratic and convex programming, separable programming, sequential unconstrained minimization

TEXT BOOKS/ REFERENCE BOOKS

- 1 G. Hardy, Linear Programming, Narosa Publishing house, 2002
2. G. Hardy, Nonlinear and Dynamic Programming, Addison-Wesley, Reading Mass, 1st Edition 1964.
3. H. A.Taha, Operations Research- An introduction, Pearson Publications 10th Edition, 2017
4. N. S. Kambo, Mathematical Programming Techniques, Affiliated East-West Press, Revised Edition, 2008.
5. O. L. Mangasarian, Nonlinear Programming, Academic Press, 2014

Mathematical Statistics-II	
Course Code: 25MAMS408	Continuous Evaluation: 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	Course Category: DSE
Prerequisite: NIL	

COURSE EDUCATIONAL OBJECTIVES (CEOs)

- To develop students understanding about sampling theory
- To highlight non parametric statistical test
- Understanding about multivariate statistics
- To discuss about design of experiment's models
- To discuss about factorial experiments

COURSE LEARNING OUTCOMES (CLOs)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be:

- Able to know the concept of sampling theory
- Able to apply non parametric test in real life situations
- Get an understanding of multivariate analysis
- Get an understanding of different designs of experiments
- Get an understanding of different factorial experiments

MAPPING BETWEEN COURSE EDUCATIONAL OBJECTIVES (CEOs) AND COURSE LEARNING OUTCOMES (CLOs)

CEO \ CLO	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
CEO 1	✓	✓			
CEO 2	✓				
CEO 3			✓		
CEO 4				✓	
CEO 5					✓

COURSE CONTENTS

Unit-I

Simple random sampling, stratified sampling and systematic sampling. Probability proportional to size sampling. Ratio and regression methods.

Unit-II

Definition of order statistics and their distributions, non-parametric tests, Sign test for univariate and bivariate distribution, Run test, Median test and Mann Whitney-U-test, correlation and rank correlation and test for independence.

Unit-III

Multivariate normal distribution, Wishart distribution and their properties. Distribution of quadratic forms. Inference for parameters, partial and multiple correlation coefficients, and related tests. Data reduction techniques: Principal component analysis, Discriminant analysis, Cluster analysis, Canonical correlation

Unit-IV

Completely randomized designs, randomized block designs and Latin-square designs. Connectedness and orthogonality of block designs, BIBD. 2K factorial experiments: confounding and construction.

TEXTBOOKS/REFERENCEBOOKS

1. A.M. Mood, F.A. Graybill and D. Boes, Introduction to the theory of Statistics, McGraw Hill, Third Edition 1July2017.
2. A.M.Gun,M.K.Gupta,andB.DasGupta,FundamentalsofStatistics,Vol-II,The world press private Ltd1January2016
3. Robert Hogg, Joseph Mckeanand Allen Craig, Introduction to Mathematical Statistics, Pearson Pub Seventh Edition, 2012.
4. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, third edition, 2014.