ST JOSEPH'S UNIVERSITY
BENGALURU-27

DEPARTMENT OF MATHEMATICS

Syllabus for the Bachelor of Science

Under State Education Policy

For Batch 2025 onwards

Name of the Degree Programme : B.Sc.
Discipline Core : Mathematics
Starting year of implementation : 2025-26

ST JOSEPH'S UNIVERSITY, BENGALURU

Syllabus for B.Sc. Mathematics

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Discipline Course : Mathematics Starting Year of
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Programme Outcomes (PO)

By the end of the programme the students will be able to:

PO1	Disciplinary Knowledge: Bachelor's degree in mathematics is the culmination of in-depth knowledge of Algebra, Calculus, Geometry, Differential Equations and several other branches of pure and applied Mathematics. This also leads to a study in related areas.
PO2	Communication Skills: Ability to communicate various Mathematical concepts effectively using examples and their geometric visualization. The skills and knowledge gained in this programme will lead to the proficiency in analytical reasoning which can be used for modeling and solving real-life problems.
PO3	Critical thinking and analytical reasoning: The students undergoing this programme acquire the ability of critical thinking and logical reasoning and the capability of recognizing and distinguishing various aspects of real-life problems.
PO4	Problem Solving: The Mathematical knowledge gained by the students through this programme gives them an ability to analyze the problems and identify or define appropriate computing techniques for their solutions. This programme enhances student's overall development.
PO5	Research related skills: Upon completing this programme the students will develop the capability of asking appropriate questions related to the Mathematical concepts in different areas of Mathematics.
PO6	Information / Digital Literacy: The completion of this programme will enable the learner to find, evaluate and effectively communicate knowledge related to certain mathematical topics using appropriate software.
PO7	Self–directed learning: The student completing this programme will develop an ability to work independently and to make an in-depth study of various notions of Mathematics.
PO8	Moral and ethical awareness / reasoning: The student, on completing this programme, will develop an ability to identify unethical behavior such as fabrication, falsification or misinterpretation of data and adopt objectives that are unbiased and truthful in all aspects of life in general and Mathematical Studies in particular.
PO9	Lifelong learning: This programme provides self-directed and lifelong learning skills. This programme helps the learner to think independently, develop algorithms and computational skills for solving real world problems.
PO10	Ability to pursue advanced studies and research in Pure and Applied Mathematical Sciences.

Syllabus for B.Sc. with Mathematics as Major Subject
SEMESTER– I

MT 125: Mathematics I - Foundations of Mathematics	
Teaching Hours: 3 Hours / Week	Credits: 3
Total Teaching Hours: 42 Hours	Max. Marks: 100

Course Learning Outcomes: This course will enable the students to
- Familiarize themselves with the basics of sets and functions.
- Compute bounds of subsets of real numbers.
- Apply various properties of real numbers.
- Understand systems of linear equations and their solutions through matrix techniques.
- Apply the methods of solving these systems to problems in chemistry, engineering etc.

Unit 1: Basic of Set Theory an function:

Basics of set theory: Sets, Subsets, Union and Intersection of Sets, Complement of a set, Set Difference, Properties of set involving union, intersection, set-difference, De-Morgan's law, Family of sets, Cartesian product of sets.

(5 hours)

Basics of Function: Definition of a function, Domain, Codomian, Range of function with examples, Equality of functions with examples, One-one, Onto functions and bijective functions, understanding one-one, onto and bijective functions graphically, Composition of functions, Inverse of a function, Graph of inverse of inverse of functions, Image and inverse image of subsets under the function and its properties

(8 hours)

Cardinality of sets: Definition for sets with same cardinality with examples, Schroeder-Bernstein Theorem, Application of Schroder-Bernstein, Definition of Countable sets with examples.

(7 hours)

Unit 2: Real Numbers:

Real numbers and their properties, Law of Trichotomy, Upper bound and lower bound and its properties, Achimedean property and its application, Density of Q in R, Nested Interval Property, Modulus function and its properties.

(8 hours)

Unit 3: Linear algebra

Linear models in economics and engineering. System of linear equations. Row reduction and Echelon form. Vector equations. The matrix equation Ax=b. Solution sets of linear systems. Applications of linear systems. Matrix operations. The inverse of a matrix. Characterizations of invertible matrices.

(14 hours)

Text Books:

1. S K Mapa. Higher Algebra. Levant Publication (1.1-1.6). 2014.
2. John M Howie. Real Analysis. Springer Undergraduate Mathematics Series. 2001.
3. David C Lay. Linear Algebra and its Applications. Third edition. Pearson. 2006.

Reference Books:

1. Ajit Kumar, S Kumaresan. A Basic Course in Real Analysis. CRC press. 2014.
2. Ajit Kumar, S Kumaresan, Bhaba Kumar Sharma. A foundation course in Mathematics. Narosa Publishing House. 2018.

PRACTICAL

MT 1P125: Mathematics Practical - I	
Practical Hours: 3 Hours/Week	Credits: 2
Total Practical Hours: 33 Hours	Max. Marks: 50

Course Learning Outcomes: This course will enable the students to

- Learn Free and Open-Source Software (FOSS) tools for computer programming
- Apply proof techniques
- Acquire knowledge of applications of matrices and systems of linear equations through FOSS.

Practical/Lab Work to be performed in Computer Lab.
Suggested Software: Python.

1. Mathematical Statements: And, OR, Implication and its negation, converse and contrapositive of an implication. Predicates and quantifiers, Negation of quantified, importance of the order of quantifiers.
2. Basics of python programming - operations and lists.
3. Working with loops and conditionals
4. Basic matrices in Python
5. Rank of a matrix through row reduction
6. Solving a system of linear equations
7. Proof technique I: Direct Proof with examples. How to prove a statement of the form P implies Q or R. Proof by contradiction.
8. Proof technique II: Proof using contrapositive and exhaustion.
9. Proof technique III: By Induction: The induction principle, strong induction principle and well ordering principle. Example of False statement and counter example.

SEMESTER – II

MT 225: Mathematics II - Real Analysis and Linear Algebra I	
Teaching Hours: 3 Hours/Week	Credits: 3
Total Teaching Hours: 42 Hours	Max. Marks: 100

Course Learning Outcomes: This course will enable the students to

- Understand concepts of sequences and series of real numbers.
- Compute the limit of a function.
- Understand the concept of continuity and differentiability.

Unit 1: Sequences and series

Sequences. Convergence of sequences. Sums, products and quotients of sequences. Bounded sequences. Sandwich principle. Monotonic sequences. Cauchy sequences. Series. The comparison test. Ratio test. Series of positive and negative terms. Problems.

(20 hours)

Unit 2: Limits and Continuity

Limit of a function. Increasing and decreasing functions. General principle of convergence. Algebra of limits. Left and right limits. Problems.Continuity. Uniform continuity.

(12 hours)

Unit 3: Differentiability of Functions

The derivative. Mean value theorems. Higher derivatives. Taylor's Theorem. Related Problems.

(10 hours)

Text books:

1. John M Howie. Real Analysis. Springer Undergraduate Mathematics Series. 2001.

Reference Books:

1. Ajit Kumar, S Kumaresan. A Basic Course in Real Analysis. CRC press. 2014.
2. S K Mapa. Introduction to Real Analysis. 8th edition. Levant books India. 2014.

PRACTICAL II

MT 2P125: Mathematics Practical - II	
Practical Hours: 3 Hours/Week	Credits: 2
Total Practical Hours: 33 Hours	Max. Marks: 50

Course Learning Outcomes: This course will enable the students to

- Learn Free and Open-Source Software (FOSS) tools for computer programming
- Solve problems on sequences, series, limits and linear algebra by using FOSS.
- Acquire knowledge of applications of real analysis and linear algebra through FOSS.
- Understand concepts of limit, continuity, differentiability and integrability of functions.

Practical/Lab Work to be performed in Computer Lab.
Suggested Software: Python.

1. Convergence of sequences I
2. Convergence of sequences II
3. Convergence of series of positive terms
4. Convergence of alternating series
5. Summation of series.
6. Limits and continuity
7. Differentiability
8. Computing nth derivative.
9. Integration

SEMESTER – III

MT 326: Mathematics III - Calculus and Differential Equations I	
Teaching Hours: 3 Hours/Week	Credits: 3
Total Teaching Hours: 45 Hours	Max. Marks: 100

Course Learning Outcomes: This course will enable the students to

- Understand concepts of continuity, differentiability and integrability of functions..
- Compute the limit of a function.
- Understand the methods of solving linear ODEs..

Unit 1:Integrability of Functions

Partitions of closed bounded intervals. Upper and Lower sums and integrals. Definition of integrability. Checking for integrability of functions. Inequalities for integrals. Refining a partition. Criteria for integrability (without proof). Algebra of integrable functions (showing sum, difference, product etc of integrable functions are integrable). Continuous and Monotonic functions are integrable. Definition of primitive. Fundamental Theorem of Calculus. Related Problems. **(15 hours)**

Unit 2: Improper integration and beta gamma functions.

Definition of improper integrals. Types of improper integrals. Comparison tests and their behaviour. Cauchy's test. Infinite range of integration. Absolutely convergent integral. Definition of Beta and Gamma functions (without proof of convergence of integral). Properties of beta and gamma functions. Relation between beta and gamma functions. **(15 hours)**

Unit 3: Ordinary Differential Equations I

Definition of differential equations and formation. General remarks on solutions. Picard's theorem (only statement with standard examples). Families of curves, orthogonal trajectories. Growth, decay, mixing. Homogeneous equations. Exact equations. Integrating factors. Linear equations. Reduction of order. **(15 hours)**

Text books:

1. S C Malik and Savita Arora, Mathematical Analysis, second edition, New Age International pvt limited, 2005.
2. John M Howie. Real Analysis. Springer Undergraduate Mathematics Series. 2001.
3. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Edition, Wiley and Sons, 2010.
4. George F. Simmons, Differential Equations and its applications with historical notes, Third Edition, McGraw-Hill Inc, 1991.

Reference Books:

1. Ajit Kumar, S Kumaresan. A Basic Course in Real Analysis. CRC press. 2014.
2. S K Mapa. Introduction to Real Analysis. 8th edition. Levant books India. 2014.
3. G. Das and S. Pattanayak, Fundamentals of Mathematical Analysis. McGraw-Hill. 1987.
4. S. Narayanaswamy and Manickavasagam T. K. Pillai, Differential Equations and its applications, 2009.
5. V. Sundarapandian , Ordinary and Partial differential equations, McGraw-Hill Education, 2012.

Blueprint (2 hours exam):

	Unit I	Unit II	Unit III	Answering	Total
2 Marks (Part A)	2*	3**	1*+2**	6/8	12
6 Marks (Part B)	2*	4**		4/6	24
6 Marks (Part C)			1*+2**	2/3	12
4 Marks (Part D) (Thought provoking)	1	1	1	Compulsory questions 3/3	12

***Pre-midterm **Post-midterm**

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Note:

1. Compulsory questions can be taken from both pre or post midterm.

2. The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 65% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

PRACTICAL

MT 3P126: Mathematics Practical - III	
Practical Hours: 3 Hours/Week	Credits: 2
Total Practical Hours: 33 Hours	Max. Marks: 50

Course Learning Outcomes: This course will enable the students to

- Learn Free and Open-Source Software (FOSS) tools for computer programming
- Solve problems on calculus and linear differential equations by using FOSS.
- Acquire knowledge of applications of calculus and linear differential equations through FOSS.

Practical/Lab Work to be performed in Computer Lab.
Suggested Software: Python.

1. Computing upper and lower Riemann sums
2. Computing arc length using integrals
3. Computing surface area and volume using integrals
4. Homogeneous and exact differential equations
5. Solution to linear differential equations and Cauchy Euler Equation
6. Introduction to Fourier Series and Fourier series expansion of function f(x) over the interval (0,2*pi) and (0,2l).
7. Fourier Series of odd and even functions.
8. Half Range Fourier series.
9. Fourier series of functions having points of discontinuity and Parseval's Identity in Fourier Series.

SEMESTER – IV

MT 426: Mathematics IV - Multivariable Calculus	
Teaching Hours: 3 Hours/Week	Credits: 3
Total Teaching Hours: 45 Hours	Max. Marks: 100

Course Learning Outcomes: This course will enable the students to

- Understand concepts of continuity, differentiability and integrability of functions..
- Compute the limit of a function.
- Understand the methods of solving linear ODEs.

Unit 1: PARTIAL DERIVATIVES

Functions of several variables. Limit and continuity in higher dimensions. Partial derivatives. Chain rule. Directional derivatives and gradient vectors. Extreme values and saddle points. Lagrange multipliers (with one constraint). **(15 hours)**

Unit 2: INTEGRABILITY OF FUNCTIONS

Double and Iterated Integrals over Rectangles, Double and Iterated Integrals over General Regions, Area by double integration, double integrals in polar form, Triple Integrals in rectangular coordinates, Triple Integral in Spherical and cylindrical coordinates. **(15 hours)**

Unit 3: LINE INTEGRALS AND INTEGRAL THEOREMS

Line integrals, Surface integrals, Greens' theorem on a plane, Stokes theorem, Gauss Divergence theorem. Related problems. **(15 hours)**

Text books:

1. George B Thomas Jr, Maurice Weir and Joel Hass, Thomas' Calculus, 12th edition, Pearson, 2014.

Reference Books:

1. S. C. Malik and Savita Arora, “Mathematical Analysis”, New Academic Science Ltd 5th edition, 2005.
2. K. A. Ross, Elementary Analysis: The Theory of Calculus, Springer (for single variable calculus)

Blueprint (2 hours exam):

	Unit I	Unit II	Unit III	Answering	Total
2 Marks (Part A)	2*	1*+2**	3**	6/8	12
6 Marks (Part B)	2*	1*+3**		4/6	24
6 Marks (Part C)			3**	2/3	12
4 Marks (Part D) (Thought provoking)	1	1	1	Compulsory questions 3/3	12

***Pre-midterm **Post-midterm**

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Note:

1. Compulsory questions can be taken from both pre or post midterm.

2. The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 65% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

PRACTICAL

MT 4P126: Mathematics Practical - IV	
Practical Hours: 3 Hours/Week	Credits: 2
Total Practical Hours: 33 Hours	Max. Marks: 50

Course Learning Outcomes: This course will enable the students to

- Learn Free and Open-Source Software (FOSS) tools for computer programming
- Solve problems on multivariable calculus by using FOSS.
- Acquire knowledge of applications of multivariable calculus through FOSS.

Practical/Lab Work to be performed in Computer Lab.
Suggested Software: Python.

1. Introduction to Laplace and Inverse Laplace transforms
2. Special functions and applications of laplace and its inverse.
3. Verification of Laplace Transform of a Periodic Functions.
4. Laplace transforms of Derivatives and Integrals.
5. Introduction to Cylindrical and Spherical coordinate systems.
6. a) Partial derivatives.
   b) Maxima and minima of functions of two variables.
7. a) Double and triple integrals.
   b) Line integrals.
8. Computing area and volume using multiple integrals.
9. Computing surface area using multiple integrals.

SEMESTER – V

MT5126 : Linear Algebra II and Ordinary Differential Equations II	
Teaching Hours: 3 Hours/Week	Credits: 3
Total Teaching Hours: 45 Hours	Max. Marks: 100

Course Learning Outcomes: This course will enable the students to:

- Understand and construct vector spaces, subspaces, bases, dimensions, and linear transformations using both algebraic and geometric approaches.
- Apply the Rank-Nullity Theorem and perform change of basis to analyze linear mappings and coordinate systems.
- Determine eigenvalues and eigenvectors, and perform diagonalization, spectral decomposition, and singular value decomposition of matrices.
- Solve second and higher order linear differential equations with constant and variable coefficients using standard analytical techniques.
- Apply methods such as variation of parameters and exactness conditions to solve complex differential equations.

Unit 1: VECTOR SPACES AND APPLICATIONS, EIGENVALUES, DIAGONALIZATION, SPECTRAL DECOMPOSITION AND SINGULAR VALUE DECOMPOSITION

Motivation towards vector spaces through Space flight and control systems, vector spaces and subspaces, span of a subset, null space and column space of a matrix, linear transformations, kernel and range of a linear transformation, linearly independent sets, bases, coordinate systems, dimension of a vector space, rank, The rank-nullity theorem, change of basis. Eigenvectors and eigenvalues, Eigenvectors corresponding to different eigenvalues are linearly independent, Characteristic equation, Diagonalization, Orthogonal Vectors, orthogonally diagonalizing a symmetric matrix, Spectral Decomposition of a symmetric matrix **(30 hours)**

Unit 2: SECOND AND HIGHER ORDER LINEAR DIFFERENTIAL EQUATIONS

Second and higher order linear differential equations with constant coefficients, complementary function, particular integrals (standard types), simultaneous linear differential equations (two variables) with constant coefficients, Cauchy–Euler differential equations, methods when a part of the complementary function is given, changing the independent variable, changing the dependent variable, variation of parameters, conditions for exactness, solution when the equation is exact.

(15 hours)

Textbooks:

1. David C. Lay, *Linear Algebra and Its Applications*, 6th ed., Pearson Education (Global Edition), 2021.
2. George F. Simmons, *Differential Equations with Applications and Historical Notes*, 3rd ed., Chapman & Hall/CRC, 2016.
3. Ram Krishna Ghosh & Kantish Chandra Maity, *An Introduction to Differential Equations*, 9th ed., New Central Book Agency (P) Ltd., 2011.

Reference Books:

1. Stephen H. Friedberg, Arnold J. Insel & Lawrence E. Spence, *Linear Algebra*, 4th ed., Pearson Education India, 2015.
2. S. Kumaresan, *Linear Algebra*, (Geometric Approach also authored by same), 2022 ed., PHI Learning Pvt. Ltd., 2022.
3. Gilbert Strang, *Introduction to Linear Algebra*, 6th ed., Wellesley-Cambridge Press, 2023.
4. S. Kumaresan, *Linear Algebra: A Geometric Approach*, 2022 ed., PHI Learning Pvt. Ltd., 2022.
5. Shepley L. Ross, *Differential Equations*, 3rd ed., Wiley India, 2007.
6. Dennis G. Zill, *A First Course in Differential Equations with Modeling Applications*, 12th ed., Cengage Learning, 2023.

Blueprint (2 hours exam):

	Unit I	Unit II	Answering	Total
2 Marks (Part A)	2*+3**	1*+2**	6/8	12
6 Marks (Part B)	2*+4**		4/6	24
6 Marks (Part C)		1*+2**	2/3	12
4 Marks (Part D) (Thought provoking)	2	1	Compulsory questions 3/3	12

***Pre-midterm **Post-midterm**

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Note:

1. Compulsory questions can be taken from both pre or post midterm.

2. The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 65% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

PRACTICAL

MT5P126: Linear Algebra II and Ordinary Differential Equations II	
Practical Hours: 3 Hours/Week	Credits: 2
Total Practical Hours: 33 Hours	Max. Marks: 50

Course Learning Outcomes: This course will enable the students to:

- Implement algorithms to solve second and higher order linear differential equations using Python.
- Compute the basis, dimension, and matrix representations of vector spaces and linear transformations.
- Analyze and verify the rank-nullity theorem through programming-based applications.
- Diagonalize matrices and perform spectral and singular value decomposition computationally.
- Translate theoretical concepts in linear algebra and differential equations into practical, programmatic solutions.

Practical/Lab Work to be performed in Computer Lab.
Suggested Software: Python.

1. Finding complementary function and particular integral of constant coefficient second and higher order ordinary differential equations I
2. Finding complementary function and particular integral of constant coefficient second and higher order ordinary differential equations II
3. Finding the solution of second and higher order ordinary differential equations with variable coefficients
4. Computing the basis and dimension of a vector space.
5. Finding the matrix representation of a linear transformation.
6. Determining the linear transformation from a given matrix and a pair of bases.
7. Computing the rank and nullity of a linear transformation and verify rank nullity theorem
8. Diagonalization of a matrix
9. Singular value decomposition

MT5226 : Group Theory	
Teaching Hours: 3 Hours/Week	Credits: 3
Total Teaching Hours: 45 Hours	Max. Marks: 100

Course Learning Outcomes: This course will enable the students to

- Understand the fundamental concepts and properties of groups and subgroups.
- Apply group-theoretic concepts to solve problems involving cosets, normal subgroups, and quotient groups.
- Demonstrate understanding of homomorphisms, isomorphisms, and structure-preserving maps between groups.
- Interpret and apply the Fundamental Theorem of Homomorphisms
- Work with permutation groups and apply Cayley's Theorem in concrete situations.

Unit 1: BASIC CONCEPTS AND SUBGROUPS

Definition of a group, examples of groups, properties of groups, congruence and related problems, subgroups, centre of a group, order of an element, theorems related to order, cyclic groups, properties of cyclic groups, problems on the number of generators of a cyclic group, problems on subsets of a cyclic group. **(15 hours)**

Unit 2: COSETS, NORMAL SUBGROUPS AND QUOTIENT GROUPS

Coset decomposition of a group, index of a subgroup, Lagrange's Theorem, consequences of Lagrange's Theorem, normal subgroups, examples and problems on normal subgroups, quotient groups, illustrative examples of quotient groups. **(15 hours)**

Unit 3: HOMOMORPHISMS, ISOMORPHISMS AND PERMUTATION GROUPS

Group homomorphisms, group isomorphisms, kernel of a homomorphism, image of a homomorphism, normality of the kernel, Fundamental Theorem of Homomorphisms, properties related to isomorphisms, permutation groups, Cayley's Theorem. **(15 hours)**

Textbooks:

1. J. A. Gallian, Contemporary Abstract Algebra, 4th Edition, Narosa Publishing, 2011.
2. J. B. Fraleigh, A First Course in Abstract Algebra, 7th Edition, Pearson Education India, 2002.

Reference Books:

1. Vivek Sahai and Vikas Bist, *Algebra*, 4th Edition, Narosa Publishing House, 2018
2. I. N. Herstein, Topics in Algebra, 2nd Edition, Wiley, 1975.
3. David S. Dummit and Richard M. Foote, *Abstract Algebra*, 3rd Edition, Wiley, 2004

Blueprint (2-hour exam):

	Unit I	Unit II	Unit III	Answering	Total
2 Marks (Part A)	2*	1*+2**	3**	6/8	12
6 Marks (Part B)	2*	1*+3**		4/6	24
6 Marks (Part C)			3**	2/3	12
4 Marks (Part D) (Thought provoking)	1	1	1	Compulsory questions 3/3	12

***Pre-midterm **Post-midterm**

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Note:

1. Compulsory questions can be taken from both pre or post midterm.

2. The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 65% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

PRACTICAL

MT5P226 : Group Theory and Numerical Analysis	
Practical Hours: 3 Hours/Week	Credits: 2
Total Practical Hours: 33 Hours	Max. Marks: 50

Course Learning Outcomes: This course will enable the students to

- Implement group-theoretic concepts such as subgroups, cosets, and homomorphisms using Python.
- Construct and analyze Cayley tables for finite groups.
- Verify algebraic properties and theorems computationally, including Lagrange's Theorem.
- Apply numerical methods to solve equations and evaluate definite integrals.
- Solve ordinary differential equations using methods like Euler's and Runge-Kutta in a programming environment.

Practical/Lab Work to be performed in the Computer Lab.
Suggested Software: Python.

1. a) Interpolations with equal intervals.
   b) Interpolations with unequal intervals.
2. Evaluate the integrals using
   a) Trapezoidal rule.
   b) Simpson's 1/3rd rule.
   c) Simpson's 3/8th rule.
3. a) Solving ordinary differential equations by modified Euler's method.
   b) Solving ordinary differential equations by the Runge-Kutta method of 4th order.
4. Solving algebraic equations (Bisection method and Newton-Raphson method).
5. Understanding of symmetric groups and dihedral groups.
6. a) Constructing Cayley's table and checking whether a given subset is a subgroup or not
   b) Finding the generator of a group.
7. a) Examples for finding left and right cosets and finding the index of a group.
   b) Verification of Normality of a given subgroup.
8. Verification of Lagrange's theorem.
9. Illustrating homomorphism and isomorphism of groups.

MTDE5326: Foundation of Discrete Mathematics and Number Theory	
Teaching Hours: 3 Hours/Week	Credits: 3
Total Teaching Hours: 45 Hours	Max. Marks: 100 (S.A: 60+I.A: 40)

Course Learning Outcomes: This course will enable the students to

- Solve and analyze recurrence relations using iterative methods and generating functions.
- Represent and examine discrete structures such as relations, partial orders, and lattices using matrices and digraphs.
- Understand key developments in the history of mathematics across ancient civilizations, including the Indian and Kerala schools.
- Apply foundational number theory concepts such as divisibility, congruences, and Euler's theorem to solve problems.
- Demonstrate the use of number-theoretic algorithms in cryptographic systems like RSA.

Unit 1: DISCRETE STRUCTURES AND RELATIONS

Recurrence relations and modelling (e.g., Fibonacci numbers), solving linear and non-linear recurrence relations, generating functions and their applications in counting, representing relations using matrices and digraphs, closures of relations, Warshall's Algorithm, partial orderings, Hasse diagrams, maximal and minimal elements, lattices, Latin squares.

History of Mathematics: Introduction to the History of Mathematics, Mathematics in Early Civilizations, Egyptian and Mesopotamian Mathematics, Mathematics in Ancient China, Indian Mathematics: Vedic to Classical Period, Kerala School and Early Calculus. **(30 hours)**

Unit 2: ELEMENTARY NUMBER THEORY

Divisibility of integers, prime numbers, greatest common divisors, Euclidean algorithm, fundamental theorem of arithmetic, linear Diophantine equations, introduction to congruences, linear congruences, Chinese Remainder Theorem, Fermat's Little Theorem, Euler's Theorem, pseudoprimes, Euler's phi-function, applications of phi-function, character ciphers, RSA public-key cryptography. **(15 hours)**

Textbooks:

1. Kenneth H. Rosen, Discrete Mathematics and Its Applications, McGraw-Hill.
2. G. G. Joseph – The Crest of the Peacock.
3. Kenneth H. Rosen – Elementary Number Theory and Its Applications

Reference Books:

1. Carl B. Boyer – A History of Mathematics Fibonacci Sequence Generator – Generate the first n terms using iteration.
2. Victor Katz – A History of Mathematics.
3. Ralph P. Grimaldi, Discrete and Combinatorial Mathematics, Pearson.
4. Tremblay and Manohar, Discrete Mathematical Structures.
5. David M. Burton – Elementary Number Theory

Blueprint (2 hours exam):

	Unit I	Unit II	Answering	Total
2 Marks (Part A)	2*+3**	1*+2**	6/8	12
6 Marks (Part B)	2*+4**		4/6	24
6 Marks (Part C)		1*+2**	2/3	12
4 Marks (Part D) (Thought provoking)	2	1	Compulsory questions 3/3	12

***Pre-midterm **Post-midterm**

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Note:

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2. The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 65% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

PRACTICAL

MTDE5P326: Foundation of Discrete Mathematics and Number Theory Practical	
Practical Hours: Hours/Week	Credits:2
Total Practical Hours: Hours	Max. Marks: 50

Course Learning Outcomes: This course will enable the students to

- Implement recurrence relations and generate numerical sequences programmatically.
- Represent and analyze binary relations and partial orders using matrices and graphs.
- Apply algorithms such as Warshall's algorithm to compute transitive closures of relations.
- Solve number-theoretic problems such as modular inverses, congruences, and Diophantine equations using Python.
- Simulate RSA public-key cryptography to understand its foundation in number theory.

Practical/Lab Work to be performed in the Computer Lab.
Suggested Software: Python.

1. Fibonacci Sequence Generator – Generate the first n terms using iteration.
2. General Linear Recurrence Solver – Solve a recurrence relation like $a_n = 3a_{n-1} - 2$.
3. Relation Matrix from a Set – Represent a binary relation as a matrix.
4. Warshall's Algorithm – Find the transitive closure of a relation matrix.
5. Equivalence Relation – Test if a relation is reflexive, symmetric, or transitive.
6. Hasse Diagram Structure – List covering pairs from a given partial order.
7. Modular Inverse Finder – Compute the inverse of a modulo m if it exists.
8. Chinese Remainder Theorem – Solve two congruences with coprime moduli.
9. RSA Key Simulation – Simulate RSA key generation using small primes.

MTDE5426: Operation Research	
Teaching Hours: 3 Hours/Week	Credits: 3
Total Teaching Hours: 45 Hours	Max. Marks: 100 (S.A: 60+I.A: 40)

Course Learning Outcomes: This course will enable the students to

- To acquaint students with concept of operations research and its applications
- To apply linear programming problem in decision making
- To recognise the use of transportation problems to make decisions.
- Determine the best strategy and apply appropriate methods to find the value of the given game model.

Unit 1: Linear Programming Problem (LPP)

Evolution of Operations Research: Quantitative approach to Decision making, History, Definitions, Scope and Applications of Operations Research. Phases in Operations Research. Characteristics and limitations of Operations Research, Models used in Operations Research. Linear Programming Problem (LPP), Generalized LPP- Formulation of problems as L.P.P. Canonical and Standard form of LPP, slack, surplus and artificial variables, Solutions to LPP by graphical method, Simplex method for unique solutions.

(15 hours)

Unit 2: Transportation Problem

Transportation problem: Structure of Transportation problem, Mathematical Model of Transportation Problem. Methods for Finding Initial Solution: North West Corner rule, Row minimum method, Column minimum method, Least Cost Method, Vogel's approximation. Optimal Solution using Stepping stone method. **(15 hours)**

Unit 3: Theory of Games

Introduction, Two-Person Zero-Sum Games, Pure Strategies (Minimax and Maximin Principles): Games with Saddle Point, Mixed Strategies: Games without Saddle Point. The Rules (Principles) of Dominance. Solution for Games without Saddle Point: Algebraic method and Graphical method. Formulation of games. **(15 hours)**

Text books:

1. Sharma J.K, Operations Research Theory and applications, 6th Edition, Trinity Press, 2017.

Reference:

1. Hamdy A. Taha, Operations Research - An Introduction, 10th Edition, Prentice Hall of India Private Ltd, 2017.
2. G. Srinivasan, Operations Research – Principles and Applications, 2nd Edition, PHI pvt Lmt, 2010.
3. Michael W. Carter, Camille C. Price, Ghaith Rabadi, Operations Research - A Practical Introduction, 2nd Edition, CRC Press, 2019.

Blueprint (2 hours exam):

	Unit I	Unit II	Unit III	Answering	Total
2 Marks (Part A)	2*	1*+2**	3**	6/8	12
6 Marks (Part B)	2*	1*+3**		4/6	24
6 Marks (Part C)			3**	2/3	12
4 Marks (Part D) (Thought provoking)	1	1	1	Compulsory questions 3/3	12

***Pre-midterm **Post-midterm**

Caution: The blue print is only suggestive of the probable marks distribution and it is not binding on the examiner.

Note:

1. Compulsory questions can be taken from both pre or post midterm.

2. The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 65% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

PRACTICAL

MTDE5P426: – Operation Research Practical	
Practical Hours: Hours/Week	Credits:2
Total Practical Hours: Hours	Max. Marks: 50

Course Learning Outcomes: This course will enable the students to

- Apply appropriate methods and solve problems on LPP, Transportation problems and Game theory manually.
- Write a Python program to obtain solutions for the problems solved manually.

Practical/Lab Work to be performed in Computer Lab.
Suggested Software: Python.

1. Solution of LPP by Graphical method.
2. Solution of LPP by Simplex method.
3. Transportation problem – North west Corner method
4. Transportation problem – Row Minima method & Column method
5. Transportation problem – Least cost method
6. Transportation problem – VAM method
7. Zero sum game – pure and mixed strategy.
8. Solution using Algebraic method.
9. Solution using Graphical method.

Semester – VI

MT6126: Ring Theory and Calculus of Variation	
Teaching Hours: 3 Hours/Week	Credits: 3
Total Teaching Hours: 45 Hours	Max. Marks: 100 (S.A: 60+I.A: 40)

Course Learning Outcomes: This course will enable the students to:

- Define fundamental concepts like rings, integral domains, fields, quotient rings and its properties.
- Understand the fundamental theorem of homomorphism of rings.
- Solve optimization problems that naturally arise in various real-life situations.

Unit I: RING THEORY

Motivation and definition of rings. Examples of rings. Properties of rings. Rules of multiplication. Uniqueness of unity and inverses. Subrings. Subring test. Examples of subrings. Center of a ring. Zero divisors. Definition and examples of integral domains. Definition and examples of fields. Properties of integral domains and fields. Characteristics of a Ring. Characteristics of an Integral Domain. Subfields.

(15 hours)

Definition and examples of ideals. Ideal test. Factor Rings (also called quotient rings). Definition and examples of prime ideals and maximal ideals. Necessary and sufficient conditions for an ideal to be prime or maximal. Definition and examples of ring homomorphisms and isomorphisms. Properties of ring homomorphisms. Kernels are ideals. First Isomorphism theorem for rings. Ideals are kernels. Homomorphisms involving Z, Z_n and rings with unity. **(15 hours)**

Unit II: CALCULUS OF VARIATION

Variation of a function $f = f(x, y, y')$ variation of the corresponding functional. Extremal of a functional. Variational problem. Euler's equation and its particular forms. Examples. Standard problems like geodesics, Minimal surface of revolution. Hanging chain. Brachistochrone problem. Isoperimetric problems.

(15 hours)

Textbooks

1. Joseph Gallian, Contemporary Abstract Algebra, 8th ed. Cengage, 2018.
2. R Weinstock, Calculus of Variation with Application to Physics and Engineering, Dover, 1974.

Reference Books

1. S K Mapa, Higher Algebra: Abstract and Linear, 14th ed. Levant Books, India.
2. Vashista, A First Course in Modern Algebra, 11th ed.: Krishna Prakasan Mandir, 1980.
3. John B Fraleigh, A First Course in Abstract Algebra, 3rd ed.: Narosa Publishing House, 1990.
4. F B Hildebrand, Methods in Applied Mathematics, 1st ed. Prentice-Hall., 1952.

Blueprint (2 hours exam):

	Unit I	Unit II	Answering	Total
2 Marks (Part A)	2*+3**	1*+2**	6/8	12
6 Marks (Part B)	2*+4**		4/6	24
6 Marks (Part C)		1*+2**	2/3	12
4 Marks (Part D) (Thought provoking)	2	1	Compulsory questions 3/3	12

***Pre-midterm **Post-midterm**

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Note:

1. Compulsory questions can be taken from both pre or post midterm.

2. The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 65% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

PRACTICAL

MT6P126: Ring Theory and Calculus of Variation Practical	
Practical Hours: 4 Hours/Week	Credits: 2
Total Practical Hours: 44Hours	Max. Marks: 50 (S.A: 25+I.A:25)

Course Learning Outcomes: This course will enable the students to
- Learn Free and Open-Source Software (FOSS) tools for computer programming
- Solve problems on algebra and calculus by using FOSS.
- Acquire knowledge of applications of algebra and calculus through FOSS

Practical/Lab Work to be performed in Computer Lab.
Suggested Software: **Python.**

1. To check if a given ring is a commutative ring with unity.
2. To check if a given ring is an integral domain or field.
3. To check if a given subset is a subring or an ideal.
4. To check if a given ideal is a prime ideal.
5. To check if a function is a ring homomorphism and to find its kernel and image.
6. To check if a ring homomorphism is an isomorphism.
7. Euler's equation and its particular forms.
8. Geodesics on a sphere and right circular cone
9. Isoperimetric problem.

MT6226: Complex Analysis and Partial Differential Equation	
Teaching Hours: 3 Hours/Week	Credits: 3
Total Teaching Hours:45 Hours	Max. Marks: 100 (S.A: 60+I.A: 40)

Course Learning Outcomes: This course will enable the students to:

- View complex numbers algebraically and geometrically.
- Understand the concepts of complex differentiation and analyticity of complex functions.
- Evaluate complex contour integrals using the Cauchy's integral theorem and the various versions of Cauchy's integral formula.
- Understand the origin and classification of partial differential equations and distinguish between linear and nonlinear PDEs.
- Formulate and derive first-order PDEs using physical laws and solve them using appropriate methods such as Lagrange's and Charpit's methods.

Unit I: COMPLEX ANALYSIS

a) **Complex Functions and Mappings, Analytic Functions :**

Basics of complex numbers, complex plane, polar form of complex numbers, Complex functions, complex functions as mappings, Linear mappings, Special Power functions, Limits and Continuity, Differentiability and Analyticity, Cauchy-Riemann equations, Harmonic functions, Applications. Conformal Mapping, Linear Fractional Transformations (Mobius or bilinear transformations).

b) **Complex Integration :**

Complex Integrals, Cauchy- Goursat Theorem, Independence of path, Cauchy's Integral Formula, Cauchy's Integral formula for derivatives, Consequences of Cauchy's Formula. Cauchy's Inequality, Liouville's Theorem, Fundamental Theorem of Algebra. **(30 hours)**

Unit II: PARTIAL DIFFERENTIAL EQUATIONS

Formation of Partial Differential Equations. Lagrange's Linear Equation. First order Non-linear Partial Differential Equations and their solution by Charpit's Method. Solution of second order Homogeneous Linear Partial Differential Equations in two variables with constant coefficients by finding complementary function and particular integral. Solution of heat, wave, and Laplace equations using separation of variables. **(15 hours)**

Textbooks

1. Dennis Zill and Patrick Shanahan, A first course in Complex Analysis, with applications, Jones and Bartlett Publishers.
2. M. D. Raisinghania, Ordinary and Partial Differential Equations, S Chand Co. Pvt. Ltd., 2013 .

Reference Books

1. R V Churchill and J W Brown, Complex Variables and Applications, 5th ed. McGraw Hill Companies., 1989.
2. A R Vashista, Complex Analysis, Krishna PrakashanaMandir, 2012.
5. John Mathews and Russell Howell, Complex Analysis for Mathematics and Engineering, 6th ed., Jones and Bartlett Learning.

Blueprint (2 hours exam):

	Unit I	Unit II	Answering	Total
2 Marks (Part A)	2*+3**	1*+2**	6/8	12
6 Marks (Part B)	2*+4**		4/6	24
6 Marks (Part C)		1*+2**	2/3	12
4 Marks (Part D) (Thought provoking)	2	1	Compulsory questions 3/3	12

***Pre-midterm **Post-midterm**

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Note:

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2. The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 65% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

PRACTICAL

MT6P226: Complex Analysis and Partial Differential Equation	
Practical Hours: 4Hours/Week	Credits: 2
Total Practical Hours: 44 Hours	Max.Marks:50 (S.A: 25+I.A: 25)

Course Learning Outcomes: This course will enable the students to
1. Learn Free and Open-Source Software (FOSS) tools for computer programming.
2. Use Cauchy's integral theorem and formula to compute line integrals.
3. Construct analytic functions when either the real or imaginary part is given.
4. Analyse the solutions of basic PDE's like Heat and Wave equations.
5. Develop Python programs to solve real-world PDE-based problems in engineering, physics, and data science.

Suggested Software:
Python. Introduction to the software and commands related to the topic.

1. Total Differential Equation, Simultaneous Differential Equation.
2. Solution of PDE: Type I, II, III, IV.
3. Solution of heat equation.
4. Solution of wave equation.
5. Problems on Cauchy-Riemann equations in cartesian and polar form.
6. Constructing analytic functions using the Milne-Thomson method.

7A. Orthogonality of the surfaces obtained from the real and imaginary parts of an analytic function.

B. Verifying real and imaginary parts of an analytic function being harmonic in cartesian and polar coordinates.

8. Cauchy's Integral theorem and Cauchy's Integral Formula.
9. Mobius Transformation.

MTDE6326 : Mathematics for Machine Learning	
Teaching Hours: 3 Hours/Week	Credits: 3
Total Teaching Hours: 45 Hours	Max. Marks: 100

Course Learning Outcomes: This course will enable the students to

- Apply concepts of vectors, matrices, and linear transformations to understand and implement core machine learning algorithms such as Principal Component Analysis (PCA) and linear regression.
- Use probability theory, statistical inference, and distributions to model uncertainty, evaluate predictions, and interpret the behavior of machine learning models.
- Analyze and explain the mathematical underpinnings of algorithms such as support vector machines using relevant mathematical tools.

Unit 1: Matrix Decompositions

Recap of basics of Matrix Algebra, Vector Space, Subspace, Basis and Dimension and Linear Transformations, Norms and Spaces, Orthogonal Complement and Projection Mapping, Eigenvalues and Eigenvectors, Special Matrices and Properties. Applications of Spectral Decomposition and Singular Value Decomposition, Low Rank Approximations, Principal Component Analysis, Linear Discriminant Analysis. **(15 hours)**

Unit 2: Matrices and Calculus in Machine Learning

Least Square Approximation and Minimum Normed Solution, Linear and Multiple Regression, Logistic Regression. Classification Metrics, Gram Schmidt Process, Polar Decomposition, Minimal Polynomial and Jordan Canonical Form, Basics concepts of Calculus, gradient, Jacobian, Chain rule, Change of variables. Convex sets and convex functions, properties of convex functions, Introduction to Optimization. **(15 hours)**

Unit 3: Optimization

Numerical Optimization in Machine Learning, Gradient Descent and other optimization algorithms in machine learning, Review of Probability, Bayes theorem and random variable, Expectation and variance. Discrete and continuous distribution functions, joint probability and covariance, Introduction to SVM, Error minimizing LPP, Lagrangian Multiplier method, concepts of duality, hard and soft margin classifier.

(15 hours)

Text books:

1. Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong, Mathematics for Machine Learning, Cambridge University Press (2020).

Reference Books:

1. Gilbert Strang, Linear Algebra and Learning from Data, Wellesley-Cambridge Press (2019).
2. W. Cheney, Analysis for Applied Mathematics. New York: Springer Science+Business Medias, 2001.
3. S. Axler, Linear Algebra Done Right (Third Edition). Springer International Publishing, 2015.
4. J. Nocedal and S. J. Wright, Numerical Optimization. New York: Springer Science+Business Media, 2006.
5. J. S. Rosenthal, A First Look at Rigorous Probability Theory (Second Edition). Singapore: World Scientific Publishing, 2006.

Blueprint (2 hours exam):

	Unit I	Unit II	Unit III	Answering	Total
2 Marks (Part A)	2*	1*+2**	3**	6/8	12
6 Marks (Part B)	2*	1*+3**		4/6	24
6 Marks (Part C)			3**	2/3	12
4 Marks (Part D) (Thought provoking)	1	1	1	Compulsory questions 3/3	12

***Pre-midterm **Post-midterm**

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Note:

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2. The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 65% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

PRACTICAL

MTDE6P326 : Mathematics for Machine Learning Practicals	
Practical Hours: 3 Hours/Week	Credits: 2
Total Practical Hours: 33 Hours	Max. Marks: 50

Course Learning Outcomes: This course will enable the students to

- Learn Free and Open-Source Software (FOSS) tools for computer programming
- Solve problems on Machine Learning by using FOSS.
- Acquire knowledge of applications of Machine Learning through FOSS.

Practical/Lab Work to be performed in Computer Lab.

Suggested Software: Python.

1. Eigen decomposition and Diagonalization.
2. Gradient descent.
3. Projection of vectors and orthogonality.
4. PCA (Principal Component Analysis) implementation.
5. Implementation of SVD and Low-rank Approximation.
6. SVM in Python.
7. Convex Optimization Problems using Python.

MTDE6426 : Coding Theory	
Teaching Hours: 3 Hours/Week	Credits: 3
Total Teaching Hours: 45 Hours	Max. Marks: 100 (S.A: 60+I.A: 40)

Course Learning Outcomes: This course will enable the students to:

- Explain fundamental concepts of information theory and coding theory.
- Analyse and apply linear codes for error detection and correction.
- Demonstrate understanding of finite fields and their algebraic structure.
- Implement and analyse cyclic codes for error detection and correction.

Unit 1: INTRODUCTION TO CODING THEORY, LINEAR CODES, BOUNDS IN CODING THEORY

Introduction to information theory-Communication system, channel, general information transmission diagram. Motivation and applications of coding theory. Basic concepts: Encoding, Decoding, Error detection and correction, binary symmetric channel, information rate, Maximum likelihood decoding, error detecting and error correcting codes, weight, hamming distance.

- **Linear Codes**
  Definition of Linear codes, examples, distance of a linear code. Dual of a code, bases for linear and its dual code, generating matrix and encoding, parity-check matrices, cosets, maximum likelihood decoding for linear codes, Syndrome decoding.
- **Bounds in Coding Theory**
  Main Coding Theory Problem-Lower Bounds-Sphere Covering Bound, Hamming Bound, Singleton Bound and MDS Codes, Gilbert Varshamov Bound, Perfect Codes, Hamming Codes, Extended Golay codes, Golay codes, Reed- Muller Codes. **(30 hours)**

Unit 2: FINITE FIELDS AND CYCLIC CODES

Overview of Fields and Polynomial Rings-Structure of finite fields-Minimal Polynomials. Definition and properties of cyclic codes, Polynomial representation of codewords, Generator and parity-check polynomials, Encoding and decoding of cyclic codes. Introduction to BCH codes. **(15 hours)**

Text books

1. D.G. Hoffmann, D.A. Leonard, C.C. Lindner, K.T. Phelps, C.A. Roger and J. R. Wall, Coding Theory the Essentials, Marcel Dekker Inc, 1991.
2. San Ling and Chaoping Xing, Coding Theory, a first course, Cambridge University Press, (2004).

Reference books

1. W. C. Huffman and V. Pless, Fundamentals of error-correcting codes, Cambridge University Press, 2003.

2. F. J. MacWilliams and N. J.A. Sloane, The Theory of error-correcting codes, North-Holland Publishing company, 1977.

Blueprint (2 hours exam):

	Unit I	Unit II	Unit III	Answering	Total
2 Marks (Part A)	2*	1*+2**	3**	6/8	12
6 Marks (Part B)	2*	1*+3**		4/6	24
6 Marks (Part C)			3**	2/3	12
4 Marks (Part D) (Thought provoking)	1	1	1	Compulsory questions 3/3	12

***Pre-midterm **Post-midterm**

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Note:

1. Compulsory questions can be taken from both pre or post midterm.

2. The end semester question paper will have a weightage of 35% of the questions from the first half of the syllabus (the portions covered for the mid-semester examination) and a weightage of 65% of the questions from the second half of the syllabus (the portions not covered for the mid-semester examination).

PRACTICAL

MTDE6P426: Coding Theory Practical	
Practical Hours: 3 Hours/Week	Credits: 2
Total Practical Hours: 33 Hours	Max. Marks: 50

Course Learning Outcomes: This course will enable the students to

- Understand and compute Hamming distance and perform error detection using parity checks.
- Construct and analyse linear block codes for given message lengths and error-correcting requirements.
- Apply syndrome decoding techniques to detect and correct errors in received messages.
- Implement Hamming codes and perfect codes for reliable data transmission.
- Explore and verify the properties of special codes such as Golay codes, extended Golay codes, and Reed–Muller codes.
- Perform arithmetic operations in finite fields and apply them to coding problems.
- Design and implement cyclic codes using polynomial representation.

Suggested Software:
Python. Introduction to the software and commands related to the topic.

1. Hamming Distance, Parity Check & Error Detection
2. Linear block codes
3. Syndrome decoding
4. Hamming codes, Perfect codes
5. Golay codes, extended Golay codes, Reed -muller codes
6. Finite fields
7. Cyclic codes

Mathematical Modelling Syllabus

Programme: B.SC.
Course Code: MT_SEC_01
Course Type: Skill Enhancement Course (SEC)

Max. Hours: 28
Hours per week: 2
Max. Marks: 35
No. of credits: 2

Course Description: This course introduces the fundamental principles and techniques of mathematical modeling. Students will learn how to translate real-world problems into mathematical formulations, analyze these models using various mathematical tools, and interpret the results to gain insights and make predictions. The course emphasizes a balance between theoretical understanding and practical applications.

Course Objectives: Upon successful completion of this course, students will be able to:

- Formulate mathematical models for real-world problems.
- Apply appropriate mathematical techniques to analyze models.
- Interpret model results and draw meaningful conclusions.
- Communicate model findings effectively.
- Critically evaluate the assumptions and limitations of models.

Course Outcomes (COs): Upon successful completion of this course, students will be able to:

- **CO1:** Translate real-world problems into appropriate mathematical models using various techniques.
- **CO2:** Solve and analyze mathematical models using analytical and numerical methods.
- **CO3:** Interpret model results and assess their validity in the context of the original problem.
- **CO4:** Critically evaluate the assumptions and limitations of different modeling approaches.
- **CO5:** Communicate effectively the process and results of mathematical modeling.

Units:

Unit 1: Introduction to Mathematical Modeling and ODEs (18 Hours)

- **1.1 Introduction to Mathematical Modeling (4 Hours)**
  - Need and Techniques of mathematical modeling.
  - Classifications and characteristics of mathematical models.
  - Limitations of mathematical modeling.

- **1.2 Modeling Through Ordinary Differential Equations (14 Hours)**
    - ODE of First Order: Linear and Decay models, Compartment models.
    - Systems of ODEs of First Order: Population dynamics (e.g., predator-prey), Epidemics (e.g., SI, SIS model), Modeling in Economics, Models in medicine, Arms race battles and international trade.

Unit 2: Modeling Through Difference Equations (10 Hours)

- **2.1 Modeling Through Difference Equations (10 Hours)**
    - Need for modeling through difference equations.
    - Modeling in: Economics, Finance, Population dynamics, Genetics, Probability theory.

Blueprint (35 Marks Total, Each Question Carries 7 Marks):

Blue Print (1 hour exam):

Each question carries 7 Marks	Pre-midterm	Post-midterm	Number of Questions to be answered	Total
	3 questions	4 questions	5 / 7	35

Textbook References:

1. Mathematical Modeling by Mark H. Holmes
2. Difference Equations by Kenneth S. Miller and Francis Murray
3. Mathematical Models by Richard Haberman.
4. F R. Giordano, A First Course in Mathematical Modeling, 5th Edition, Brooks/Cole Cengage learning, 2014.
5. M. Braun, C.S. Coleman and D. A. Drew, Differential equation Models, 1994

Mathematical Transforms

Programme: B.SC. **Max. Hours: 28**

Course Code: MT_SEC_02 **Hours per week: 2**

Course Type: Skill Enhancement Course(SEC)

Max. Marks: 35

No. of credits: 2

Course Objectives:

CO1 : Understand the fundamental concepts of Fourier transforms and their applications in solving Mathematical and Physical sciences problems.

CO2 : Learn the properties and operational rules of Fourier transforms, including shifting, modulation, and convolution.

CO3 : Develop the ability to compute Fourier sine and cosine transforms and their inversions.

CO4 : Explore the concept of Z-transforms, their properties, and their role in solving difference equations.

CO5 : Apply inverse Z-transforms to obtain solutions to difference equations encountered in various scientific and Engineering contexts.

Unit:1

Fourier Transforms**:** Infinite Fourier transforms, Definition, linear properties, change of scale, Shifting and Modulation properties, Inverse Fourier transforms, Fourier sine and cosine transforms. inversion formula for sine and cosine transforms - problems. Fourier transform of the derivative of a function. Convolution theorem (without proof) - problems. **(14 hours)**

Unit :2

Difference equations and Z-transforms: Difference equations, Z-transform-basic definitions, standard Z-transforms, properties, damping and shifting rules, initial value and final value theorems (without proof) and problems, Inverse Z-transforms -problems and applications to solve difference equations. **(14 hours)**

Text Books:

1. Erwin Kreyszig, **Advanced Engineering Mathematics**, 10th edition, Wiley Dreamtech India, 2010.
2. B.S. Grewal, **Higher Engineering Mathematics**, 45th edition, Khanna publishers, 1965.

Reference Books:

1. Baidyanath Patra, **An Introduction to Integral Transforms**, CPC Press, Taylor & Francis Group.

2. J.K. Goyal, K.P.Gupta, **Integral Transforms**, published by K.K. Mittal for Prakashan, 16th edition, 2013.

3. Larry C. Andrews **, Transform Methods for Engineers, 2nd edition,** SPIE Press, 2003.

4. Lokenath Debnath **, Transform Methods in Applied Mathematics,** Dover Publications, Reprint (2016).

5. Nita H. Shah and Monika K. Naik **, Integral Transforms and Applications,** De Gruyter publications, 1st edition, (2022).

Blue Print (1 hour exam):

Each question carries 7 Marks	**Pre-midterm**	**Post-midterm**	**Number of Questions to be answered**	**Total**
	3 questions	**4 questions**	**5 / 7**	**35**