ASSAM UNIVERSITY, SILCHAR

Department of Mathematics

Four Year Undergraduate Programme

Implemented under NEP 2020

Effective from the Academic Year 2023-24

Syllabus of MATHEMATICS

Approved in the ____th meeting of the Academic Council on _____vide Resolution No. _____

Programme Specific Outcome

Bachelor in MATHEMATICS with Honours/ Honours and Research

Programme Specific Outcomes:

1. This program fosters critical thinking and scientific temper among the students.

2. It enables the students to appreciate mathematical logic and ideas and to write mathematical statements correctly with quantifiers

3. This program provides a curriculum that trains the students to ask more questions. 4. It enriches the knowledge base and provides a strong foundation for higher studies. 5. It makes the students employable in academia and industry sectors.

6. It motivates the students towards research.

7. This program helps the students to model real-life problems and to go for solving them with the help of various mathematical to

Table 1 :
Semester wise list of DSC (Discipline Specific Core) Courses in Mathematics

Semester	Course Code	Title of Courses	Credits
I	**MAT-DSC-101**	Higher Algebra and Trigonometry	3
	MAT-DSC-102	Differential Calculus	3
II	**MAT-DSC-151**	Analytical Geometry	3
	MAT-DSC-152	Integral Calculus and Vectors	3
III	**MAT-DSC-201**	Real Analysis – I	4
	MAT-DSC-202	Ordinary Differential Equations	4
IV	**MAT-DSC-251**	Abstract Algebra – I	4
	MAT-DSC-252	Mechanics – I	4
	MAT-DSC-253	Linear Algebra	4
V	**MAT-DSC-301**	Partial Differential Equations	4
	MAT-DSC-302	Topology	4
	MAT-DSC-303	Real Analysis – II	4
VI	**MAT-DSC-351**	Complex Analysis	4
	MAT-DSC-352	Hydrodynamics	4
	MAT-DSC-353	Multivariate Calculus	4
	MAT-DSC-354	Linear Programming	4
VII	**MAT-DSC-401 (any one)**	**A** : Abstract Algebra – II	4
		B : Probability and Statistics	
	MAT-DSC-402 (any one)	**A** : Mechanics – II	4
		B : Advanced Analysis	
	MAT-DSC-403 (any one)	**A** : Number Theory and Combinatorics	4
		B : Integral Equations and Calculus of Variations	
	MAT-DSC-404 (any one)	**A** : Optimization Techniques	4
		B : Advanced Numerical Methods	
VIII	**FOR HONOURS DEGREE WITH RESEARCH**		
	MAT-DSC-451	Research Methodology	4
	MAT-DSC-452	Research Project/Dissertation	12
	FOR HONOURS DEGREE		
	MAT-DSC-451	Special Functions	4
	MAT-DSC-452	Graph Theory	4
	MAT-DSC-453 (any one)	**A** : Advanced Topology and Functional Analysis	4
		B : Advanced Differential Equations	
	MAT-DSC-454 (any one)	**A** : Mathematical Modelling	4
		B : Discrete Mathematics	

Table 2 :
Semester wise list of Mathematics DSM (Discipline Specific Minor) Courses

Semester	DSM1/DSM2	Course Code	Title of Courses	Credits
I	DSM1	MAT-DSM-101	Calculus	3
II	DSM2	MAT-DSM-151	Calculus	3
III	DSM1	MAT-DSM-201	Classical Algebra and Trigonometry	4
IV	DSM1	MAT-DSM-251	Differential Equations	3
	DSM2	MAT-DSM-252	Differential Equations	3
V	DSM1	MAT-DSM-301	Geometry and Vectors	3
	DSM2	MAT-DSM-302	Geometry and Vectors	3
VI	DSM2	MAT-DSM-351	Classical Algebra and Trigonometry	4
VII	DSM1	MAT-DSM-401	Linear Programming	4
VIII	DSM2	MAT-DSM-451	Linear Programming	4

Table 3 :
Semester wise list of Mathematics SEC (Skill Enhancement Course)

Semester	Course Code	Title of Courses	Credits
I	MAT-SEC-101	Mathematical Skill Development with Software (Theory with Practical)	3
II	MAT-SEC-151	Mathematical Programming in C (Theory with Practical)	3
III	MAT-SEC-201	Numerical Methods (Theory with Practical)	3

Table 4 :
Semester wise list of Mathematics IDC (Interdisciplinary Course)

Semester	Course Code	Title of Courses	Credits
I	MAT-IDC-101	Foundation Course in Mathematics	3
II	MAT-IDC-151	Geometry	3
III	MAT-IDC-201	Basic Calculus	3

Semester*	: I
Course Type	: DSC
Course Code**	: MAT-DSC-101
Name of the Course	: Higher Algebra and Trigonometry
Learning level***	: 150
Credits	: 3
Contact Hours	: 45
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30
Course Objectives	:

★ To provide a comprehensive understanding of trigonometry, formal logic, polynomial equations, inequalities, and systems of linear equations.
★ To enable the learners to gain the necessary skills and knowledge to apply mathematical concepts in a variety of real-world contexts.

Unit-I

Polar representation of complex numbers. De Moivre's theorem for rational indices and related problems. Expansions of sin nθ, cos nθ, sin θ, cos θ. Expansions for sinn θ, cosn θ for even and odd n.

Unit-II

Exponential and logarithmic functions of complex arguments, Gregory's series, hyperbolic functions, summation of trigonometric series.

Unit-III

Relations: Reflexive, symmetric, transitive, and equivalence. Equivalence classes and partitions. Introduction to Logic: propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions. Converse, contrapositive and inverse propositions and precedence of logical operators. Quantifiers: Universal and Existential quantifiers.

Unit-IV

Relation between roots and coefficients of a polynomial equations of nth degree, symmetric functions of roots. Transformation of equations, reciprocal and binomial equations. Cardan's method of solution of cubic equations. Descartes' rule of signs. Inequalities involving arithmetic and geometric means, Cauchy-Schwarz's inequality, Minkowski inequality.

Unit-V

Elementary transformation of matrices, echelon and canonical forms, rank of a matrix, linear dependence and independence of n-tuples; Inverse of a matrix by elementary operations. Systems of linear equations and their solutions by Gaussian elimination method.

Textbooks:

1. B.C. Das and B.N. Mukherjee, Higher Trigonometry, 34th ed., U.N. Dhur and Sons, 1933 **(Units-I, II)**
2. A. Kumar, S. Kumaresan, and B.K. Sarma, A Foundation Course in Mathematics, 1st ed., Narosa Publishing House, 2018 **(Unit-III)**
3. J.G. Chakraborty and P.R. Ghosh, Higher Algebra: Classical and Modern, 23rd ed., U.N. Dhur and Sons, 1972 **(Unit-IV)**
4. S. Lipschutz and M. Lipson, Schaum's Outlines: Linear Algebra, 3rd ed., McGraw Hill Education, 2017 **(Unit-V)**

Reference books:

1. S.K. Mapa, Higher Algebra: Classical, 9th ed., Sarat Book House, 2021.

2. D.C. Lay, Linear Algebra and its Applications, 3rd ed., Pearson Education India, 2002.

Course Learning Outcome

After completion of the course, learners will be able to

1. Demonstrate understanding of complex numbers in polar form and apply De Moivre's theorem effectively.
2. Analyse and solve problems involving exponential and logarithmic functions with complex arguments and series expansions.
3. Apply formal logic principles to construct logical statements and understand the relationship between roots and coefficients of polynomial equations.
4. Solve polynomial equations and inequalities involving means using appropriate techniques.
5. Solve systems of linear equations using Gaussian elimination and understand concepts related to matrices, rank, and linear dependence/independence.

Semester*	: I
Course Type	: DSC
Course Code**	: MAT-DSC-102
Name of the Course	: Differential Calculus
Learning level***	: 150
Credits	: 3
Contact Hours	: 45
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30
Course Objectives	:

★ To provide the learners with a detailed understanding of differential calculus and its applications.

Unit - I

Limit of a function, Fundamental theorems on limits, Some important limits, Cauchy's criterion, Problems on limits. Continuity of a function, Different classes of discontinuity, Properties of continuous functions, related problems. Differentiability of a function, Fundamental theorems on differentiation, problems involving derivatives of a function of a function, inverse circular functions, hyperbolic functions, logarithmic differentiation, implicit functions and parametric equations.

Unit - II

Significance of derivative and its sign, geometrical interpretation, derivative as a rate measurer and related problems. Successive Differentiation, nth derivatives of some special functions, nth derivatives of rational algebraic functions, related problems. Leibnitz's theorem and related problems. Indeterminate forms, L'Hospital's theorem, and related problems.

Unit - III

Rolle's theorem, Lagrange's Mean Value Theorem, Geometrical interpretation and related problems. Generalized mean value theorem (Taylor's series in finite form), Lagrange's form of remainder, Cauchy's form of remainder, Expansion of functions in infinite power series - Taylor's series and Maclaurin's series. Increasing and decreasing functions, Maxima and minima for functions of single variables and related problems.

Unit - IV

Tangents and normals - equation of tangent, tangent at the origin, equation of normal, angle of intersection of curves, related problems. Cartesian subtangent and subnormal, derivative of arc-length (cartesian form), angle between radius vector and tangent, derivative of arc-length (polar form), polar subtangent and subnormal. Radius of curvature of cartesian and polar curves.

Unit - V

Partial derivatives, related problems, homogeneous functions, Euler's theorem on homogeneous functions. Asymptotes, Concavity, Points of inflection, Tracing graphs of polynomial and rational functions.

Textbook :

1. B.C. Das and B.N. Mukherjee; Differential Calculus, U.N. Dhur and Sons.
   (For Unit - I to Unit - V (upto Euler's theorem))
2. H. Anton, I. Bivens and S. Davis; Calculus; John Wiley & Sons.
   (For Unit-V (Asymptotes, concavity, tracing of graphs))

Reference books :

1. G.B. Thomas and R.L. Finney; Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. Shantinarayan; Differential Calculus.

Semester* : II
Course Type : DSC
Course Code** : MAT-DSC-151
Name of the Course : Analytical Geometry
Learning level*** : 199
Credits : 3
Contact Hours : 45
Total Marks : 100
End Semester Marks : 70
Internal Marks : 30
Course Objective

The main objective of this course is to introduce orthogonal transformation, pair of straight lines, some basic idea of circles, parabola, hyperbola, ellipse, determination of pole and polar *w.r.t.* to them. This course further explains the shortest distance and its equation, definition of sphere, great circle and related problems. It also describes cone and cylinder under various conditions.

Unit – I

Change of origin, invariants in orthogonal transformation, pair of straight lines, bisector of angles between pair of straight lines.

Unit – II

Orthogonal circles, radial axis, radical centre of three circles, circles through intersection of two circles, circles through intersection of a circle and a straight line, condition of tangency of a straight line to a circle, parabola, ellipse and hyperbola.

Unit – III

Definition, equation of polar of a point with respect to a circle, parabola, ellipse and hyperbola, determination of the pole of a straight line with respect to a circle, parabola, ellipse and hyperbola, polar equation of a conic in the form $l/r = 1 + e\cos\theta$, equation of chord and tangent, related problems.

Unit – IV

Shortest distance and equation of shortest distance line, general equation of a sphere, sphere through origin and having intercepts on the axes, section of a sphere by a plane, great circle, sphere through a given circle, the curve of intersection of two spheres, tangent plane to a sphere at a given point on it, condition of tangency of a given plane to be a tangent plane to a sphere.

Unit – V

Cone with vertex at a given point and a given curve as base, equation of a right circular cone with vertex is at a point other than origin, cylinder, equation of a cylinder, equation of a right circular cylinder, related examples.

Textbook:

1. J.G. Chakraborty and P.R. Ghosh, Advanced Analytical Geometry, 14th ed., U.N. Dhur and sons, 1987.

Reference books:

1. S.L. Loney, The Elements of Coordinate Geometry, 17th ed., Arihant Publication (India), 2023. 2. B. Das, Analytical Geometry with Vector Analysis, 1st rev. ed., Orient Book Company, 2018.

Course Learning Outcome

After completion of the course, learners will be able to

1. Know about transformation of co-ordinate axes, pair of straight lines, angle between pair of straight lines, orthogonal circles, radical axis, parabola, hyperbola and ellipse.
2. Know about how to determinate the pole and polar *w.r.t.* circle, parabola, hyperbola, ellipse and polar form of conics.
3. Know about spheres, formula to find shortest distance and great circles, etc. 4. Know about definition of cone, right circular cone, cylinder, right circular cylinder and its related problems.

Semester*	: II
Course Type	: DSC
Course Code**	: MAT-DSC-152
Name of the Course	: Integral Calculus and Vectors
Learning level***	: 199
Credits	: 3
Contact Hours	: 45
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

The aim of this course is to introduce integral calculus and vectors to study indefinite, definite integrals and the properties of definite integrals, reduction formulae, rectification of plane curves, areas of surfaces of revolution and volumes of solids of revolution. This course further explores the scalar and vector triple products, vector equations, vector functions, etc.

Unit – I

Integration of rational functions, definite integral as the limit of a sum. Definite integrals and their properties.

Unit – II

Reduction formulae, derivations and illustrations of reduction formulae of the types $\int \sin^n x\,dx$, $\int \cos^n x\,dx$, $\int \tan^n x\,dx$, $\int \sec^n x\,dx$, $\int (\log x)^n\,dx$, $\int \sin^m x\,\cos^n x\,dx$, $\int \sin^m x\,\cos nx\,dx$.

Unit-III

Cartesian and parametric equations of plane curves, rectification of plane curves, areas of surfaces of revolution and volumes of solids of revolution.

Unit – IV

Scalar and vector triple products, related problems. Vector equations of lines, planes and spheres.

Unit – V

Vector functions, limit, continuity and differentiation of vector functions, and related problems, gradient, divergence and curl, their identities and related problems.

Textbooks:

1. B.C. Das and B.N. Mukherjee, Integral Calculus with Differential Equations, 57th ed., U.N. Dhur
and Sons, 1938 (Unit-I-III)
2. M.R. Spiegel, Schaum's Outlines: Vector Analysis, 2nd ed., McGraw Hill Education, 2017 (Unit-IV, V)

Reference Books:

1. G.B. Thomas and R.L. Finney, Calculus and Analytical Geometry, 9th ed., Pearson Education India, 2010.
2. Shanti Narayan and P.K. Mittal, Integral Calculus, 35th ed., S. Chand, 2005.
3. Shanti Narayan and P.K. Mittal, A Textbook of Vector Analysis, S. Chand, 2020.

Course Learning Outcome

After completion of the course, learners will be able to

1. Solve problems of definite and indefinite Integrations and learn properties of definite integrals.
2. Prove reduction formulae and solved some problems by using these formulae.
3. Explain the importance of integrations and its techniques to solve real life problems.
4. Understand vector calculus and related problems.

Semester*	: III
Course Type	: DSC
Course Code**	: MAT-DSC-201
Name of the Course	: Real Analysis - I
Learning level***	: 250
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

★ To provide a strong foundation of real analysis with a comprehensive study of the properties of real numbers, sequences, continuous and differentiable functions.

Unit - I

Algebraic properties of **R**, Order Properties of **R**, Absolute Value and the Real Line, ε-neighbourhood, boundedness of sets, least upper bound, greatest lower bound, Completeness property of **R**, boundedness of functions. Archimedean Property, Density Theorem, Intervals, Characterization of intervals, Nested Interval Property.

Unit - II

Sequence of real numbers, limit of a sequence, uniqueness of limit, recursive sequence, tails of sequences, bounded sequence, limit theorems, sum, difference, product, quotient of sequences, squeeze theorem, monotone sequences, monotone convergence theorem.

Unit - III

Subsequences, divergence criteria, monotone subsequence theorem, Bolzano-Weierstrass Theorem for sequences, Cauchy sequence, Cauchy convergence criterion, properly divergent sequences.

Unit - IV

Concept of Cluster point (Limit point) of a set in **R**, limit of a function, sequential criterion for limits, Divergence criteria, bounded function, limit theorems, squeeze theorem. Continuous functions, sequential criterion for continuity, Discontinuity criterion, combinations of continuous functions, composition of continuous functions.

Unit - V

Continuous functions on intervals, Boundedness theorem, Maximum-minimum theorem, Location of roots theorem, Intermediate value theorem, Preservation of intervals theorem. Differentiability of functions, Caratheodory's theorem, Interior-extremum

theorem, Rolle's theorem, Mean Value theorem, Intermediate value property of derivatives - Darboux's theorem.

Textbook :

1. R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons.

Reference books :

1. S.C. Malik and S. Arora, Real Analysis, New Age International Publishers.
2. A. Kumar and S. Kumaresan; A basic course in real analysis; CRC Press.

Course Outcome :

After completion of this course, the learner is expected to understand how some fundamental properties of real numbers are essential for the rigorous development of real analysis. A comprehensive treatment of sequences in this course will enable the learner to appreciate and apply the sequential approach to limits and continuity. The course is expected to enhance the learner's understanding of limits, continuity and differentiabilty with a detailed analytical approach.

Semester*	: III
Course Type	: DSC
Course Code**	: MAT-DSC-202
Name of the Course	: Ordinary Differential Equations
Learning level***	: 250
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

★ The objective of the course is to introduce the fundamental concepts of ordinary differential equations and to explain the methods to solve such equations.

Unit-I

Basic Concepts of differential equations; origin, order, degree, formation, Linear and nonlinear. Differential Equations of First order and first degree: Separable equation, Homogeneous Equation and equation reducible to homogeneous form, Exact differential equation.

Unit-II

Integrating factors, Rules for finding the Integrating factors. Linear differential equations, Equations reducible to linear equations. Equations of first order but of higher degrees: Equations solvable for p, Equations solvable for x, Equations solvable for y, Homogeneous equations in x,y. Clairaut's equation, Equations Reducible to Clairaut's form, singular solution.

Unit-III

Idea of homogeneous and nonhomogeneous linear differential equations of order greater than one. Linear dependent, linear independent functions and Wronskian. Basic theory of Linear differential equations. Solution of higher order (upto 4th order) linear differential equation with constant coefficients.

Unit-IV

Method of undetermined coefficients. Method of variation of parameters. The Cauchy - Euler Equation and its solutions. Trajectories: Isogonal and Orthogonal.

Unit-V

Simultaneous differential equations, total differential equations, condition for integrability, condition for exactness and methods of solution.

Textbooks:

1. M.D.Raisinghania; Ordinary Differential Equations; S.Chand.
2. Differential Equations and Their Applications, Third Edition, Zafar Ahsan, PHI Learning

Pvt Ltd.

Reference books:

1. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.

Course Outcome:

After successful completion of the course, students will be able to

1. recognise different types of differential equations.
2. understand the different methods of solving first and higher order differential equations.
3. use appropriate methods to solve differential equations based on their type.
4. understand the linear dependence & independence of solution of differential equation and use of technique to check their dependence or independence.

Semester*	: IV
Course Type	: DSC
Course Code**	: MAT-DSC-251
Name of the Course	: Abstract Algebra - I
Learning level***	: 299
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

★ To provide a comprehensive treatment of group theory and an introductory treatment of ring theory.

Unit - I

Binary operation, definition of group, abelian group, Cayley table, various examples of groups. Uniqueness of identity, cancellation laws, uniqueness of inverse, related problems. Order of a group, order of an element, definition and examples of subgroups, one-step subgroup test, two-step subgroup test, finite subgroup test, related problems.

Unit - II

Subgroup generated by an element, center of a group, centralizer of an element in a group, cyclic group, related problems, generators of cyclic groups, fundamental theorem of cyclic groups, number of elements of each order in a cyclic group, related problems.

Unit - III

Permutation of a finite set, permutation group of a finite set, symmetric group of degree n, cycle notation, product of disjoint cycles, commutativity of disjoint cycles, order of a permutation, product of transpositions, classification of permutations as even and odd, alternating group of degree n. Cosets of a subgroup, properties of cosets.

Unit - IV

Lagrange's theorem and consequences. Normal subgroups - definition and examples, normal subgroup test, factor or quotient groups, related problems.

Unit - V

Ring, examples of rings, properties of rings, subrings, subring test. Zero-divisors, definition, examples and properties of integral domain, field, characteristic of a ring, related problems.

Textbooks :

1. Joseph A. Gallian, Contemporary Abstract Algebra, Narosa Publishing House.

Reference Books :

1. Michael Artin; Algebra; Prentice Hall of India.
2. John. B. Fraleigh; A first course in Abstract Algebra; Pearson Education.
3. V.K.Khanna and S.K. Bhambri; A course of Abstract Algebra; Vikas Publishing House Pvt. Ltd.

Course outcome :

After successful completion of the course, students will be able to

- Define groups, abelian groups, and construct Cayley tables. Apply concepts like uniqueness of identity and inverses.
- Understand subgroups, one-step, two-step, and finite subgroup tests. Determine group and element order. Analyze cyclic groups, center, and centralizer.
- Learn permutations, symmetric groups, and cycle notation. Classify permutations as even and odd. Understand cosets of subgroups.

Semester* : IV
Course Type : DSC
Course Code** : MAT-DSC-252
Name of the Course : Mechanics - I
Learning level*** : 299
Credits : 4
Contact Hours : 60
Total Marks : 100
End Semester Marks : 70
Internal Marks : 30
Course Objective

★ The objective of the course is to make the learners understand the laws of forces, rigid body equilibrium, motion in planes and the principles governing the motion of objects.

Unit I

Parallelogram law of forces, resolving a given force into perpendicular components, Triangle of forces, Converse of the Triangle of forces, Lami's theorem, Converse of Lami's theorem (Only the statements and proofs of the theorems). Moment and Couple (definition only). Coplanar forces and their resultant, Equilibrium of three coplanar forces, related problems involving contact with smooth planes.

Unit II

Friction, laws of friction, angle of friction, cone of friction, related problems. Centre of gravity, CG is unique, CG of a triangle formed by three rods, CG of an arc and a sector of a circle, of a quadrant of an ellipse, of a cardioid, of an astroid, of a lamina bounded by a parabola and a line.

Unit III

Motion in a plane, velocity and acceleration. Radial and Transverse components of velocity and acceleration. Angular velocity and acceleration. Tangential and Normal components of acceleration. Simple Harmonic Motion.

Unit IV

Motion under inverse square law, motion under laws of motion - laws of attraction being μ/x, μ/x^3, $\mu/x^{5/3}$ and $\mu(x + a^4/x^3)$. Projectile, Range of projectile on a horizontal and inclined plane, motion inside and outside a smooth vertical circle, related problems.

Unit V

Impulse of a force, work, power, energy, principle of energy, principle of work, principle of conservation of linear momentum. Direct impact of two elastic bodies, Direct impact of an elastic body on a smooth fixed plane, oblique impact of two perfectly smooth spheres, related problems.

Textbooks :

1. Statics; B.Das and B.N.Mukherjee; U.N.Dhur & Sons Private Limited.
   (Units I and II)
2. Dynamics; M.D.Raisinghania; S Chand & Co.
   (Units III, IV and V)

Reference books :

1. S.L. Loney; The elements of Statics and Dynamics; Cambridge University Press.
2. M.Ray; Dynamics; S.Chand & Co.

Course Outcome :

1. Apply fundamental principles in mechanics to solve engineering problems.
2. Demonstrate mastery of concepts such as forces, motion, and energy conservation.
3. Develop critical thinking skills through problem-solving in real-world scenarios.

Semester*	: IV
Course Type	: DSC
Course Code**	: MAT-DSC-253
Name of the Course	: Linear Algebra
Learning level***	: 299
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

- ★ To develop the idea of basic arithmetic operations on vectors and matrices
- ★ To learn the basic terminology of linear algebra in Euclidean spaces including linear dependence and independence, span, basis, dimension, rank, nullity of a linear transformation.
- ★ To learn how to find the eigenvalues, eigenvectors of a matrix or a linear transformation and using them to diagonalize a matrix.
- ★ To know about inner product space and its related theorems and examples.

Unit I

Vector spaces, definition, properties, examples, geometrical interpretation of vector addition. Vector subspaces, examples and properties. Linear combination of vectors, linear span, subspace generated by a set, sum of subspaces, linear dependence and linear independence of vectors.

Unit II

Basis of a vector space, examples and properties, finite dimensional vector space, dimension of a finite dimensional vector space, related examples and properties. Quotient space, examples and properties, dimension of a quotient space.

Unit III

Linear transformations - definition, examples and properties. Linear functional - definition, examples. Matrix of a linear transformation - definition, examples and properties. Kernel and image of a linear transformation, rank-nullity theorem. Isomorphism - definition, examples and properties.

Unit IV

Eigenvalue, eigenvector and eigen space of a linear operator, characteristic polynomial and characteristic equation of a linear operator, Cayley- Hamilton theorem, related problems. diagonalizable operator, matrix of a diagonalizable operator.

Unit V

Inner product spaces - definition, examples and properties. Norm function, Cauchy-Schwarz's inequality, distance in an inner product space, orthogonality, Pythagoras

Theorem, polarization identity, orthonormal set, orthonormal basis, Bessel's inequality, orthogonal complement and its related theorems.

Textbook :

1. S. Kumaresan; Linear Algebra: A geometric approach; Prentice Hall India

Reference Books:

1. Friedberg, Insel, Spence; Linear Algebra; Pearson Education India.
2. Sheldon Axler; Linear Algebra Done Right; Springer.
3. Kenneth Hoffman, Ray Alden Kunze; Linear algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd.,1971.
4. S. Lipschutz and M. Lipson; Linear Algebra; Schuam's Outlines.
5. A.R Vasistha and J. N. Sharma, Linear Algebra, Krishna Prakashan.

Course Outcome :

After successful completion of this course learners will learn concepts of vector spaces and its related topics, to find the eigen value, eigen vectors and solve the eigen value problems, they can apply the principles of matrix algebra to linear transformation, understand about the inner product space, norms and can apply their knowledge in various disciplines including engineering, physics, computer applications etc.

Semester* : V
Course Type : DSC
Course Code** : MAT-DSC-301
Name of the Course : Partial Differential Equations
Learning level*** : 350
Credits : 4
Contact Hours : 60
Total Marks : 100
End Semester Marks : 70
Internal Marks : 30
Course Objective

The aim of this course is to introduce first and higher order partial differential equations and their classification, and analytic methods for computing the solutions of various partial differential equations. It also explains various applications of partial differential equations in physical situations like one dimensional wave equation, heat equation.

Unit-I

Partial differential equations – Basic concepts and definitions, order and degree of a PDE. Formation of a partial differential equation. First order partial differential equations- Solution of linear partial equations by direct integration method, Lagrange's method of solving first order PDE, examples of linear partial differential equations with three independent variables and integral surface.

Unit-II

Nonlinear first order partial differential equation - Introduction, Various types of integrals (complete integral, particular integral, singular integral and general integral). Solution of standard types of first order PDE- equation containing only p and q, clairaut's form, equation containing only z, p and q, equation of the form $f(x,p) = g(y,q)$ and Charpit's method.

Unit-III

Solution of linear PDE with constant coefficients of second and higher order, solution of PDE with variable coefficients, reducible to equations with constant coefficients, characteristic equations and characteristic curves of second order partial differential equation. Cauchy's problem for second order PDE.

Unit-IV

Classification of linear partial differential of second order in two independent variables. Canonical forms of first-order linear equations, hyperbolic equation, parabolic equation and elliptic equation. Method of solving linear PDE by separation of variables.

Unit-V

Initial-boundary conditions, boundary value problems. Fourier half range sine and cosine series. Assumptions followed in deriving one dimensional heat and wave equation. Solution of one dimensional heat equation under different boundary conditions with some mathematical problems. Solution of one dimensional wave equation with the given boundary and initial conditions.

Textbooks:

1. M.D. Raisinghania, Advanced Differential Equations, S. Chand and Sons.

   (Units I & II)

2. K. Sankara Rao, Introduction to Partial Differential Equation. PHI Learning Private Limited, 2019.

   (Units III, IV, V)

Reference books:

1. Matthew P. Coleman, An introduction to Partial Differential Equations with MATLAB. CRC Press Taylor & Francis Group, 2015

2. Sneddon, I., Elements of partial differential equation, McGraw Hill, NY, 1957; Dover, 2006

Course Outcomes:

After successful completion of this course, the students can understand basic concepts to solve the first order PDEs and Cauchy problems of first order and will be able to determine the integral surfaces passing through a curve, characteristic curves of second order PDE. Also students can understand the solution of some significant PDEs like one dimensional wave equation, heat equation.

Semester*	: V
Course Type	: DSC
Course Code**	: MAT-DSC-302
Name of the Course	: Topology
Learning level***	: 350
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

★ To familiarize learners with the concept of topological properties and other important mathematical concepts, generalize them in the context of topological spaces.

★ To enable learners to pursue advanced courses such as advanced topology and algebraic topology, it is crucial to provide them with a solid foundation in fundamental mathematical concepts, including topological properties. By introducing and exploring these concepts in the context of topological spaces, learners will gain the necessary background knowledge to excel in more advanced mathematical studies.

Unit I

Metric spaces, definition and examples. Distance of a point to a set, Diameter of a set, Open sphere, open set, limit point of a set, closed set, their properties and related problems.

Unit II

Interior of a set, closure of a set, boundary points, boundary of a set, dense set, their properties and related problems. Sequences in metric spaces, convergence of sequence, Cauchy sequence, their properties and related problems.

Unit III

Complete metric spaces, their properties and related problems, Cantor's Intersection theorem. Continuous functions in metric spaces, their properties and related problems.

Unit IV

Topological spaces, open sets, definition and examples, closed sets, closure, interior and boundary of a set, their properties and related problems.

Unit V

Metrizable space, relative topology. Continuous mapping, open mapping, homeomorphism in topological spaces, related theorems and problems.

Textbook :

1. G.F. Simmons, Introduction to topology and modern analysis, McGraw Hill Education (India) Pvt. Ltd.

Reference books :

1. S. Kumaresan, Topology of metric spaces; Narosa Publishing.
2. C. Adams and R. Franzosa, Introduction to Topology-pure and applied; Pearson Prentice Hall.
3. J. Munkres; Topology; Pearson Education.

Course outcomes

On completion of the course, learners will

1. Develop an understanding of the concepts of metric spaces, topological spaces and their role in mathematics.
2. Develop an understanding about the principles of convergence of sequences, continuity of functions in metric spaces and topological spaces.
3. Facilitate the application of principles to tackle a diverse range of mathematical problems at an optimal level of complexity

Semester*	: V
Course Type	: DSC
Course Code**	: MAT-DSC-303
Name of the Course	: Real Analysis - II
Learning level***	: 350
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

★ To impart a higher level of understanding of several aspects of real analysis involving sets, functions, infinite series and integration.

Unit - I

Finite and Infinite Sets, Countable and Uncountable sets, Cantor's theorem, Uncountability of **R**. Uniform Continuity of functions, non-uniform continuity criteria, uniform continuity theorem, Lipschitz function, Continuous extension theorem.

Unit - II

Infinite series, convergent and divergent series, nth term test, comparison test, limit comparison test, absolute convergence, conditional convergence, grouping of series, rearrangement of series, rearrangement theorem. Problems based on Limit Comparison Test II, Cauchy's root test, ratio test, integral test, Raabe's test, alternating series test.

Unit - III

Integration of bounded functions on **R**, upper and lower sums, refinement of partitions, upper and lower integrals, Darboux integral, integrability criterion, integrability of the sum and difference of integrable functions, integrability of the product, quotient and modulus of integrable functions, integrability of continuous functions, monotone functions and functions having finite number of discontinuities.

Unit - IV

Riemann sum of a function for a tagged partition, Riemann integral, uniqueness of Riemann integral, properties of integral - algebraic combinations of integrable functions, boundedness theorem, Cauchy criterion, Squeeze theorem, Riemann integrability of step function, continuous function and monotone function, additivity theorem. Equivalence of Darboux's and Riemann integral.

Unit - V

Two fundamental theorems of integral calculus, Mean value theorems of integral calculus. Improper integrals, integration of unbounded functions with finite limits of integration, integration of bounded functions with infinite range of integration, comparison tests for convergence.

Textbooks :

1. R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons. (Units I to IV)
2. S.C. Malik and S. Arora, Real Analysis, New Age International Publishers. (Units V)

Reference books :

1. S.K.Mapa; Introduction to Real Analysis; Levant.
2. A. Kumar and S. Kumaresan; A basic course in real analysis; CRC Press.
3. S.R. Ghorpade and B.V. Limaye; A course in calculus and real analysis; Springer.

Course Outcome :

After completion of this course, the learner is expected to gain a conceptual understanding of countable and uncountable sets, uniform continuity and infinite series. The learner will be able to distinguish between Darboux's approach and Riemann's approach to integration and appreciate the equivalence between the two. The course will give an insight to convergence of improper integrals. The learner will be able to apply the concepts in allied fields.

Semester* : VI
Course Type : DSC
Course Code** : MAT-DSC-351
Name of the Course : Complex Analysis
Learning level*** : 399
Credits : 4
Contact Hours : 60
Total Marks : 100
End Semester Marks : 70
Internal Marks : 30
Course Objective

The course aims to familiarize the learner with algebra of complex numbers, limits & derivative of complex function, analytic function, the concept of Cauchy's theorems, integral formulas, singularities and Calculus of residues

Unit-I

Algebra of complex numbers, polar representation of complex numbers, geometrical interpretation of $arg\left(\frac{z-\alpha}{z-\beta}\right)$, complex equations of straight lines, circles, locus represented by $\left|\frac{z-\alpha}{z-\beta}\right|$ = Constant. Limits, continuity of functions of complex variables, regions in the complex plane.

Unit-II

Derivatives, Differentiation formulae, Cauchy-Riemann equations, Sufficient conditions for differentiability, Analytic functions, examples of analytic functions, Harmonic functions.

Unit-III

Definite integrals of functions, contours, contour integrals and its examples, upper bounds for moduli of contour integrals, Cauchy's theorem, Cauchy-Goursat theorem, Morera's theorem.

Unit-IV

Cauchy's integral formula, Liouville's theorem, Fundamental theorem of algebra, Taylor's series and related problems.

Unit-V

Laurent's series, types of singularities, Poles, Calculus of residues, Cauchy's residue theorem, related problems.

Textbooks :

1. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishers.

Reference books :

1. M.R. Spiegel, Complex Analysis, McGraw Hill Publications.
2. B. Choudhury, The Elements of Complex Analysis, New Age International Publishers.
3. Dennis G. Zill, Patrick D. Shanahan, Complex Analysis, Jones & Bartlett Learning
4. J. N. Sharma, Functions of a Complex Variable, Krishna Prakashan

Course Outcomes :

After studying this course, the student will be able to

1. Understand limits and derivatives of complex functions.
2. Understand analytic function, harmonic function,
3. Learn Cauchy's theorems and integral formulas.
4. Learn the notion of singularities and their applications.

Semester*	: VI
Course Type	: DSC
Course Code**	: MAT-DSC-352
Name of the Course	: Hydrodynamics
Learning level***	: 399
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

The aim of this course is to introduce the learners to the dynamics of fluids. This course further explains the description of fluid motion, fluid velocity, significance of continuity equation and its various forms. It also explains Euler's motion, Bernoulli's theorem, pressure equation and its applications.

Unit-I

Fluids, forces acting on fluids, viscosity, types of fluids (real and ideal fluids), description of fluid motion (Eulerian and Lagrangian methods), Velocity of a fluid particle, material, local and convective derivatives and their relations, acceleration of a fluid particle (vector form and its equivalence in Cartesian and polar forms), related problems.

Unit-II

Steady and unsteady flows, uniform and non-uniform flows, stream lines, path lines, velocity potential, potential flow, rotational and irrotational motion, vorticity vector and related problems.

Unit-III

Equation of continuity-Lagrangian and Eulerian forms and their equivalence, significance of the equation of continuity, cartesian, polar, and curvilinear forms of equation of continuity and related problems.

Unit –IV

Euler's equation of motion, equation of motion of an inviscid fluid (Eulerian and Lamb's hydrodynamics forms), The basic dynamical principles (the principle of linear momentum, angular momentum), energy equation and related problems.

Unit-V

Pressure at a point in moving fluid of known velocity, Bernoulli's theorem and related problems, Euler's momentum theorem, D'Alembert's paradox, irrotational motion in two dimensions, stream function, physical significance of stream function and related problems, Circulation, Kelvin's circulation theorem.

Textbooks :

1. Shanti Swarup; Fluid Dynamics; Krishna Prakashan.

Reference books :

1. M.D.Raisinghania; Fluid dynamics; S.Chand.
2. J.K Goyal & K.P.Gupta: Fluid Dynamics; Pragati Prakashan

Course outcomes:

After going through this course, the student will be able to

1. Know about types of fluid, and different methods to describe fluid motion.
2. Know about how to obtain equation of continuity in different forms.
3. Derive equation of motion, Pressure equation and Bernoulli's equation and able to solve real life applications.

Semester*	: VI
Course Type	: DSC
Course Code**	: MAT-DSC-353
Name of the Course	: Multivariate Calculus
Learning level***	: 399
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

- ★ To acquaint learners with the principles of multivariable functions and the generalized concept of integration.
- ★ To introduce the vector field and related aspects of the vector field.
- ★ To introduce the double integral, triple integral and the line integral.
- ★ To familiarize learners with the concepts of Green's theorem, the Divergence theorem, Stokes' theorem, and the practical applications of these theorems.

Unit-I

Functions of several variables, limit and continuity of functions of two variables, repeated limits, sequential criteria of limit and continuity for the function of two variables. partial differentiation,

Unit-II

Young's theorem, Schwarz theorem, applications and related problems. Jacobians and related problems. Directional derivatives, gradient, maximal and normal property of the gradient, tangent planes, extrema of functions of two variables.

Unit-III

Differentiation of vector field, divergence and curl, Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar coordinates.

Unit-IV

Triple integrals, Triple integral over a parallelepiped and solid regions, volume by triple integrals, cylindrical and spherical coordinates. Change of variables in double integrals and triple integrals. Line integrals, Applications of line integrals.

Unit-V

Fundamental theorem for line integrals, conservative vector fields, independence of path, Green's theorem, surface integrals, integrals over parametrically defined surfaces, Stoke's theorem, the divergence theorem.

Textbooks:

1. Sudhir R. Ghorpade, Balmohan V. Limaye, A Course in Multivariable Calculus and Analysis (Undergraduate Texts in Mathematics), Springer. (Unit I, II)

2. G. B. Thomas and R. L. Finney, Calculus and Analytics Geometry, 9th Ed., Pearson Education, Delhi, 2005. (Unit III, IV, V)

Reference books:

1. M. D. Raisinghania, Vector Calculus, S. Chand.
2. S. Shirali and H.S. Vasudeva, Multivariable Analysis, Springer India.
3. S. C. Malik and S. Arora, Principles of Mathematical Analysis, New Age International Publishers.

Course outcomes:

In this course, learners will

1. Enhance the ability to examine the fundamental principles such as convergence, limits, continuity, and related concepts through an analytical lens.
2. Strengthen logical reasoning abilities for effective problem-solving through the application of mathematical techniques.
3. Foster the proficiency in mastering line integrals, double integrals, and triple integrals as part of the learning process.
4. Acquaint oneself with the concept of generalization as it pertains to the determination of area, volume, and related aspects.

Semester*	: VI
Course Type	: DSC
Course Code**	: MAT-DSC-354
Name of the Course	: Linear Programming
Learning level***	: 399
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

1. To develop formulation skills in Linear programming problem and finding solutions using Graphical method, Simplex method, Big M method and two-phase method
2. To introduce the concept and construction of Duality
3. To develop solving skills in Transportation and Assignment problems

Unit-I

Formulation of LPP, General LPP, Graphical method of solution of LPP; Convex sets and their properties; Standard form of a LPP.

Unit-II

Simplex method; Artificial variables techniques : Big M method and two-phase method, related problems.

Unit-III

Duality : Concept of duality, Mathematical formulation of duals, Construction of duals, primal-dual relationships, theorems on duality; Dual Simplex method.

Unit-IV

Transportation problems : Mathematical formulation and methods of determining initial basic feasible solution - North West corner, Row minima, Column minima, Matrix minima, Vogel's approximation methods. Unbalanced transportation problems.

Unit-V

Optimality tests for transportation problems and MODI method for obtaining optimal solution, degeneracy in transportation problems; Assignment problems, Hungarian method of solution. Travelling Salesman Problem.

Textbooks :

1. J.G. Chakraborty and P.R.Ghosh; Linear Programming and Game theory; Moulik Library.

Reference books :

1. P.M.Karak; Linear Programming and theory of games; New Central Book Agency.
2. R.K. Gupta, Operations Research, Krishna Prakashan Media, Meerut.

3. Kanti Swarup, P.K.Gupta, M. Mohan; Operations Research; Sultan Chand and sons.
4. D. C. Sanyal, K. Das; Linear Programming and Game Theory; U. N. Dhur & sons

Course Outcomes :

After studying this course, the student will be able to

1. Learn the technique of maximizing the profit and minimizing the cost.
2. Select the place for distribution of products so that total cost of transportation is minimum
3. Appoint the most suitable persons on minimum salary, determine the best age of retirement and to select the number of persons to be appointed

Semester*	: VII
Course Type	: DSC
Course Code**	: MAT-DSC-401
Name of the Course	: **Option A -** Abstract Algebra - II
Learning level***	: 500
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

- ★ To provide the concept of group homomorphism, properties of homomorphisms, group isomorphism and related theorems.
- ★ To impart knowledge on external and internal direct products.
- ★ Understanding the concept of ideals, ideals generated by element and subset.
- ★ To provide concepts of factor rings, ring homomorphism and related properties.
- ★ Understanding certain structures called PID, UFD, ED and their relations and various properties.

Unit - I

Group isomorphism, examples, Cayley's theorem, properties of isomorphism, Automorphism, Inner automorphism. Group homomorphism, examples, kernel of a homomorphism, properties of homomorphisms, properties of subgroups under homomorphisms. First, second and third isomorphism theorems for groups.

Unit - II

External direct product, properties of external direct product. Group of units modulo n as an external direct product. Internal direct products of a finite number of subgroups of a group, relation between internal direct product and external direct product. Ideals of a ring, examples, ideal test, principal ideal generated by an element, ideal generated by a subset.

Unit - III

Factor rings, prime ideal, maximal ideal, related problems. Ring homomorphism, ring isomorphism, properties of ring homomorphism, kernels. First, second and third isomorphism theorems for rings.

Unit - IV

Ring of polynomials over a commutative ring, division algorithm, remainder theorem, factor theorem, related problems. Principal ideal domain. Associates, irreducibles and primes in an integral domain, equivalence of primes and irreducibles in a PID, ascending chain condition in a PID.

Unit - V

Unique factorization domain, Euclidean domain, relations between ED, PID, UFD. Irreducible polynomials, reducible polynomials. Eisenstein's Criterion, Relation between irreducible polynomials, maximal ideals and fields.

Textbooks :

1. Joseph A. Gallian, Contemporary Abstract Algebra, Narosa Publishing House.

Reference Books :

1. Michael Artin; Algebra; Prentice Hall of India.
2. John. B. Fraleigh; A first course in Abstract Algebra; Pearson Education.
3. V.K.Khanna and S.K. Bhambri; A course of Abstract Algebra; Vikas Publishing House Pvt. Ltd.

Course outcomes

On completion of the course, learners will be able to

- ★ Define concepts like homomorphism, isomorphism, and automorphism and check whether a given function defines one of these.
- ★ Develop an understanding about External and Internal direct products.
- ★ Will be able to develop new structures viz., factor ring, ED, PID, UFD based on given structures and related theorems.
- ★ Develop their analytical ability to find the irreducibility of a polynomial using Eisenstein's criterion.

Semester*	: VII
Course Type	: DSC
Course Code**	: MAT-DSC-401
Name of the Course	: **Option B -** Probability and Statistics
Learning level***	: 500
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

- ★ To provide the fundamentals & concept of probability theory.
- ★ To introduce the basic concepts of Random Variables.
- ★ To impart knowledge on Univariate, Bivariate distributions and their applications.
- ★ Understanding different types of discrete and continuous probability distributions and their use.

Unit-I

Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function

Unit-II

Discrete distributions: uniform, binomial, Poisson, geometric, negative binomial. Continuous distributions: uniform, normal, exponential. Related problems.

Unit-III

Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables

Unit-IV

Bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables. Least squares methods and related problems.

Unit-V

Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers, Central Limit theorem for independent and identically distributed random variables with finite variance.

Textbooks :

1. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Sons.

Reference books :

1. Sheldon Ross, Introduction to Probability Models, Academic Press

Course outcomes

On completion of the course, learners will be able to

- ★ Apply basic rules and theorems in probability including random variables, probability distributions, expectations and variances to find probability.
- ★ Develop an understanding about joint distribution function, joint density functions, marginal distribution.
- ★ Understand Bivariate distribution and its use.
- ★ Understand the convergence of sequence of probabilities and central limit theorem.

Semester*	: VII
Course Type	: DSC
Course Code**	: MAT-DSC-402
Name of the Course	: **Option A -** Mechanics - II
Learning level***	: 500
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

The objective of the course is to develope problem solving skills. The course will introduce the learners to the principles of statics and dynamics and help them develope proficiency in applying these principles to formulate and solve problems.

Unit I

Virtual work - virtual displacement and virtual work, principle of virtual work for a system of coplanar forces, forces which can be omitted in the equation of virtual work, simple problems.

Unit II

Stable and unstable equilibrium, conditions of stability and unstability, Energy test for stability, simple problems. Catenary - the common catenary, important relations for the common catenary. Equilibrium of a string under any given force in a plane. Deduction of equations $\frac{d}{ds}(T\frac{dx}{ds}) + mX = 0, \frac{d}{ds}(T\frac{dy}{ds}) + mY = 0.$

Unit III

Central Orbits (polar and pedal forms), Apses and apsidal distances. Kepler's laws of planetary motion (statement and geometric implications). Simple problems.

Unit IV

Motion in a resisting medium under gravity (upward and downward motion only). Motion on a smooth and rough cycloid. Simple problems.

Unit V

Moments and products of inertia, theorems of parallel and perpendicular axes, M.I. about any line in terms of M.I. and P.I. about any three mutually perpendicular lines, equimomental bodies, principal axes, principal moments. D'Alembert's principle and general equations of motion. Simple problems.

Text books :

1. P.N.Chatterjee; Mechanics; Rajhans Publications.
   (Units I & II)
2. M.D.Raisinghania; Dynamics; S.Chand & Co.
   (Units III to V)

Reference books :

1. The elements of Statics and Dynamics - S.L. Loney (Cambridge University Press)
2. Dynamics - M.Ray (S.Chand & Co.)

Course Outcomes :

After completion of the course learners will be able to

1. Know about virtual displacement and virtual work.
2. Know about stability - stable and unstable equilibrium and equilibrium of strings.
3. Know about central orbits, laws that govern the motion of planets.
4. Know in detail the motion in a rough cycloid as well as motion in resisiting mediums.
5. Know in detail the concepts of dynamics of rigid bodies.

Semester*	: VII
Course Type	: DSC
Course Code**	: MAT-DSC-402
Name of the Course	: **Option B -** Advanced Analysis
Learning level***	: 500
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

The objective of this course is to provide learners with an advanced understanding of mathematical analysis. It covers topics like convergence of functions, power series, functions of bounded variations, and elementary measure theory.

Unit-I

Pointwise and uniform convergence of sequence and series of functions: definitions, examples and related problems. Cauchy's criterion for uniform convergence and Weierstrass M-Test.

Unit-II

Limit superior and limit inferior, power series, radius of convergence, Cauchy Hadamard theorem. Applications and related problems.

Unit-III

Functions of bounded variations: definition, examples, and properties; total variation.

Unit-IV

σ-algebra, Borel sets and Borel σ-algebra. Lebesgue outer measure and measurable sets: definition, examples and properties.

Unit-V

Lebesgue measure, its properties, and the Borel-Cantelli lemma. Cantor set: Construction and topological properties.

Recommended Books:

1. R.G. Bartle and D.S. Sherbert, Introduction to Real Analysis, 4th ed., Wiley, 2014 [Units I-II]
2. T.M. Apostol, Mathematical Analysis, 2nd ed., Narosa, 2002 [Unit III]
3. H.L. Royden and P.M. Fitzpatrick, Real Analysis, 4th ed., PHI Learning, 2012 [Units IV-V]

Reference Books:

1. S. Abbott, Understanding Analysis, 2nd ed., Springer, 2015.
2. S.C. Malik and S. Arora, Mathematical Analysis, 4th ed., New Age International, 2010.

Course Outcomes:

On completion of the course, learners will be able to analyse and demonstrate convergence properties of functions, determine the convergence of power series, and apply the idea of functions of bounded variations in various contexts. They will also master essential concepts in measure theory, such as σ-algebras and Lebesgue measure, and apply them to analyse measurable sets.

Semester*	: VII
Course Type	: DSC
Course Code**	: MAT-DSC-403
Name of the Course	: **Option A -** Number Theory and Combinatorics
Learning level***	: 500
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

- ★ To familiarize learners with the key concepts of number theory and combinatorics through a problem based strategy.
- ★ To deepen mathematical knowledge and foster an appreciation for the elegance and beauty of numbers.
- ★ To enable learners to take up more advance courses like algebraic number theory, analytic number theory and application of number theory in cryptology.

Unit-I

Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues, Chinese Remainder theorem, Fermat's Little theorem.

Unit-II

Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula.

Unit-III

Greatest integer function, Euler's function, Euler's theorem, reduced set of residues, some properties of Euler's phi-function.

Unit-IV

Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, Euler's criterion, the Legendre symbol and its properties.

Unit-V

Basic combinatorial numbers, basic counting principle, permutation and combinations, the multinomial theorem, properties of binomial coefficients, partitioning of a set, The Pigeonhole Principle, the inclusion & exclusion principle.

Textbooks :

1. D.M. Burton, Elementary Number Theory, McGraw Hill.(Unit I to Unit IV)
2. Introductory Combinatorics, Richard A. Brualdi, Pearson.(Unit V)

Reference books:

1. S. B. Malik; Basic Number Theory, Vikas Publishing House.
2. Hardy, G.H. and Wright, E. M., An Introduction to the Theory of Numbers, 4^{th} edition (Oxford University Press, 1960).
3. K. H. Rosen, Discrete Mathematics & its Applications, 6^{th} Edition., Tata Mc Graw Hill, 2007.
4. V. K. Balakrishnan, Introductory Discrete Mathematics, Dover Publications, New York, 1996.

Course outcomes:

After completing the course, learners will

- ★ Enhance problem-solving skills through the utilization of various strategies in number theory.
- ★ Acquire a range of combinatorial techniques and develop the capacity to employ these methods to solve problems across various branches of mathematics.
- ★ Strengthen the capacity for mathematical reasoning and attain proficiency in utilizing abstraction for problem-solving in the domain of number theory.

Semester* : VII
Course Type : DSC
Course Code** : MAT-DSC-403
Name of the Course : **Option B -** Integral Equations and Calculus of Variations
Learning level*** : 500
Credits : 4
Contact Hours : 60
Total Marks : 100
End Semester Marks : 70
Internal Marks : 30
Course Objective :

The objective of this course is to give a formal introduction of integral equations and their different types. It also includes application of appropriate integral equations governing the behaviour of several standard problems. Also, the paper introduces the basics of calculus of variation.

Unit-I

Integral Equation, linear and nonlinear integral equations, Special kinds of Kernel, Integral equations of the convolution type (Definition), Volterra integral equations and their kinds, solution of Volterra integral equations, Initial value problem, Converting an IVP into a Volterra integral equations, Converting Volterra integral equations to IVPs.

Unit-II

Fredholm integral equation and their kinds, solution of Fredholm integral equation, Boundary value problem , Converting an BVP into a Fredholm integral equation, Converting Fredholm integral equations to BVPs, Fredholm integral equations of second kind.

Unit-III

Characteristic values and Characteristic functions, solution of homogeneous Fredholm integral equations of second kind with separable kernel, solution of Fredholm integral equations of the second kind with separable kernels.

Unit-IV

Linear functional, variations of functional, continuity and differentiability of functional, extremum of functional, necessary condition for extremum, Fundamental lemma of calculus of variations, Euler's equation and applications.

Unit-V

Generalization of Euler's equations (n-dependent functions, higher order derivatives), Variational problems with subsidiary conditions, Method of variational techniques, Derivation of basic formula, Eigenvalue problems.

Text Books:

1. M.D. Raisinghania, Integral Equations and Boundary value problems, S. Chand & Company Pvt. Ltd, 2007 (Unit I to III)
2. A.S. Gupta, Calculus of variations with Applications, PHI, 2004. (Units IV & V)

References :

1. Krasnov, M. L., Makarenko, G. I. and Kiselev, A. I., Problems and Exercises in the Calculus of Variations, translated from Russian by George Yankovsky, 1975.
2. Shanti Swarup, Integral Equations, Krishna Publishers, 2019.
3. Mikhlin, S. G., Linear Integral Equations, Dover Publications, 2020.
4. Abdul-Majid Wazwaz, Linear and Nonlinear Integral Equations - Methods and Applications, Springer.

Course Outcomes: After successful completion of the course, students will understand how to solve the linear and nonlinear integral equations by different methods with some problems which give rise to Integral Equations. Also understand the applications of linear functional and variations of functional in different problems of applied mathematics.

Semester*	: VII
Course Type	: DSC
Course Code**	: MAT-DSC-404
Name of the Course	: **Option A -** Optimization Techniques
Learning level***	: 500
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

This course will introduce the students to the basic idea of optimization methods that can be used during research works.

UNIT-I

Definition of optimization and its importance; Basic terminologies: Design variables, Constraints,Objective function, and Variable bounds; Different types of Optimization Algorithms – based on number of variables, nature of variables, constraints, approaches used and number of objectives, etc. Formulation of different types of unconstrained and constrained optimization problems.

UNIT-II

Local optimal point; Global optimal point; Inflection point; Optimality criteria; Related examples. Basic idea of Traditional and Non-traditional Optimization Algorithms. Bracketing Methods: Exhaustive search method and Bounding phase method; Algorithms and examples. Region elimination methods: Interval halving method, Fibonacci search method and Golden section search method; Algorithms and examples.

UNIT-III

Gradient based methods: Bisection method, Newton Raphson method and secant method; Algorithms and examples. Optimality criteria for Multi-variable functions; Unidirectional search; Direct search method: Simplex search method; Algorithms and examples.

UNIT - IV

Method of multipliers, Kuhn-Tucker conditions for nonlinear programming. Solution of constrained nonlinear optimization problems through Kuhn-Tucker conditions; Problems.

UNIT-V

Other optimization algorithms: Genetic Algorithms, Particle Swarm Optimization, Ant Colony Optimization and Artificial Bee Colony Optimization; Basic terminologies, working principles and simple problems.

Textbooks :

1. Kalyanmoy Deb, "Optimization for Engineering Design – Algorithms and Examples" Prentice Hall of India Pvt. Ltd.
2. Chander Mohan and Kusum Deep, "Optimization Techniques" New Age International Publishers.

References:

1. S. S. Rao, Engineering Optimization, Theory and Practice, New Age International Publishers.
2. P.k. Gupta, D.S. Hira; Operations Research; S.Chand & Co.

Course Outcomes:

At the end of the course the students will be able to:

Learn efficient computational procedures to solve different types of optimization problems.

Semester*	: VII
Course Type	: DSC
Course Code**	: MAT-DSC-404
Name of the Course	: **Option B -** Advanced Numerical Methods
Learning level***	: 500
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

- ★ To familiarize learners with the concepts of interpolation, eigenvalue problem techniques for mathematical problems arising in various fields.
- ★ To familiarize learners with solutions of initial value and boundary value problems.
- ★ To understand the concept of solving integration and differential equations numerically for various real world problems.

Unit-I

System of Linear Equations and Eigenvalue Problems **:** LU factorization and Cholesky methods; Conjugate gradient method and its convergence; Polynomial, Power and Householder's methods for computing eigenvalues of matrices. Fundamental matrix.

Unit-II

Interpolation: Polynomial interpolation, Newton's interpolation, Lagrange's interpolation, Spline interpolation; Curve-fitting: Least-squares fittings of straight line and polynomial curves.

Unit-III

Numerical methods to IVPs: Taylor's series method, Picard's method, Euler's and Modified Euler's method, Runge-Kutta methods (up to 4th order), Predictor-corrector methods, Adams-Moulton method, Milne's method.

Unit-IV

Numerical methods to BVPs: Finite difference methods, Shooting method, Spline method.

Unit-V

Numerical solutions of PDEs: One-dimensional heat-conduction equation and One-dimensional wave equation by using (explicit) finite difference methods.

Recommended Books:

TextBooks:

1. B. Bradie: A Friendly Introduction to Numerical Analysis, Pearson Prentice Hall, New Delhi.
2. S. S. Sastry: Introductory Methods of Numerical Analysis; Prentice Hall of India, New Delhi.

Reference Books:

1. B. N. Datta: Numerical Linear Algebra; Brooks/Cole Publishing Company, New York.
2. E. Balagurusami: Numerical Methods; Tata McGrow-Hill Publishing Company, New Delhi.
3. M. K. Jain, S. R. K. Iyengar, and R. K. Jain: Numerical Methods for Scientific and Engineering Computation New Age International Publisher, New Delhi.

Course Outcomes :

After completing the course, learners will

- ★ Be able to find the solution of linear systems by using different standard methods.
- ★ Acquire knowledge on numerical methods for finding eigenvalues and eigenvectors of matrices
- ★ Acquire basic knowledge in use of relevant numerical techniques for interpolation with equal and unequal intervals. Estimate the missing terms through interpolation methods.
- ★ Be able to derive Least – Squares curve fitting procedures, fitting a straight line, fitting any polynomial curves.
- ★ Acquire knowledge on finding numerical solutions of ordinary differential equations.
- ★ Be able to use appropriate methods to solve Boundary value problems of ODE and PDE.

Semester* : VII
Course Type : DSC
Course Code** : MAT-DSC-451
Name of the Course : **Option A -** Special Functions
Learning level*** : 600
Credits : 4
Contact Hours : 60
Total Marks : 100
End Semester Marks : 70
Internal Marks : 30
Course Objective :

The aim of this course is to introduce Legendre's differential equation, Bessel's differential equation and analytic methods for computing the solutions of these differential equations. It also explains Laplace transform and their application, Fourier integrals and Fourier transform.

Unit-1

Beta, Gamma functions and their properties, Legendre's equation, Legendre's Polynomial, generating function, Laplace's definite integral for $P_n(x)$, orthogonal properties and recurrence formulae for $P_n(x)$, Rodrigues formula.

Unit-II

Bessel's equation of order 0, 1 and n, Bessel's functions for $J_n(x)$, Recurrence formula for $J_n(x)$, generating function for $J_n(x)$, equations reducible to Bessel's equation, orthogonality of Bessel functions, some fundamental properties.

Unit-III

Laplace transform, the inverse Laplace transform and their properties. Related problems.

Unit-IV

Application of Laplace transform to differential equations: Method of solving linear differential equations with constant coefficients with given initial conditions, Method of solving simultaneous linear equations with constant coefficients with given initial conditions. Fourier Integral Theorem, Fourier sine and cosine Integrals.

Unit-V

Fourier's Complex Integral, Fourier Transforms, Fourier sine and cosine Transforms, Properties of Fourier Transform, Relationship Between Fourier and Laplace Transforms. Inverse Fourier transform.

Textbooks :

1. M.D. Raisinghania; Special Functions.
2. M.D. Raisinghania, Laplace and Fourier Transform, S. Chand and Sons

Reference books :

2. M.R.Spiegel; Laplace Transform; Schuam's Outlines Series; McGraw Hill.
3. M.R.Spiegel; Fourier Analysis; Schuam's Outlines Series; McGraw Hill

Course Outcomes:

After successful completion of this course, the students will be able to understand solution of Legendre's equation, Bessel's equation, their Polynomials and their recurrence formula. Also students will be able to know Laplace transform of functions, Fourier transforms of functions and their application in solving ordinary differential equation.

Semester*	: VIII
Course Type	: DSC
Course Code**	: MAT-DSC-452
Name of the Course	: **Option B -** Graph Theory
Learning level***	: 600
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

This course aims to provide students with a solid foundation in graph theory. It covers graph definitions, properties, and operations, along with concepts like trees, isomorphism, paths, and circuits. Learners will also gain proficiency in analyzing planarity, weighted graphs, and solving optimization problems using algorithms like Dijkstra's and Floyd-Warshall.

Unit-I

Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bipartite graphs, digraphs, operations on graphs (union, intersection, product, composition), subgraph, induced subgraph.

Unit-II

Walks, paths and circuits, Connected graph, disconnected graph, component, Isomorphism of graphs.

Unit-III

Trees and their characterization, Spanning tree, Cut point, bridges and blocks, Eulerian circuits, Hamiltonian cycles.

Unit-IV

Planarity: plane and planar graphs, outerplanar graphs, characterization of planar graphs, Eulerian property of a planar graph, Kuratowski's two graphs and the related problems.

Unit-V

Matrix Representation of a graph: Incidence matrix, the adjacency matrix. Weighted graph, Travelling salesman's problem, shortest path, Dijkstra's algorithm, Floyd-Warshall algorithm.

Textbook :

1. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, 1st ed., Dover Publications Inc., 2016.

Reference Book:

1. Frank Harary, Graph Theory, 1st ed., Narosa Publishing House, 2001.

Course Outcomes:

By the end of the course, students will be able to define and classify various graph types, perform graph operations, identify key graph structures, and determine planarity. They will also develop skills in applying algorithms to solve optimization problems and shortest path calculations in real-world scenarios. Overall, this course equips students with the knowledge and problem-solving skills needed to comprehend and work with graph theory effectively.

Semester*	: VIII
Course Type	: DSC
Course Code**	: MAT-DSC-453
Name of the Course	: **Option A -** Advanced Topology and Functional Analysis
Learning level***	: 600
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

- ★ The aim of this course is to introduce the ideas of some topics on topology and some of the fundamental theorems of functional analysis.
- ★ To provide a working knowledge of compactness, separated sets, connectedness, disconnected sets, the basic properties of Banach space, Hilbert spaces, bounded linear operators, compact linear operator and inner product space.

Unit - I

Compactness for topological spaces, finite intersection property, related theorems and problems, Heine-Borel theorem. Compactness for metric spaces, sequential compactness, related theorems and problems.

Unit - II

T_1 spaces and Hausdorff spaces, related theorems. Connected and disconnected spaces, continuity and connectedness, related theorems.

Unit - III

Normed linear space, metric induced by norm, Banach space, examples and properties, subspace of a Banach space, Schauder basis, completion of a normed space, finite dimensional normed spaces and subspaces, equivalent norms.

Unit - IV

Hilbert space, examples and properties, completion of an inner product space, subspace of a Hilbert space, orthogonal complements, minimizing vector, projection theorem.

Unit - V

Linear operators on finite dimensional spaces : bounded and continuous linear operators, linear functionals, dual spaces.

Textbooks:

1. G.F. Simmons, Introduction to topology and modern analysis, McGraw Hill Education (India) Pvt. Ltd (Units I and II)
2. Erwin Kreyszig; Introductory Functional Analysis with Applications; Wiley Classical Library Edition (Units III, IV and V)

Reference Books:-

1. J. N. Sharma; Topology; Krishna Prakashan Media
2. B.V. Limaye : Functional Analysis; New age international limited publication

Course Outcomes:

On successful completion of this course learners will able to appreciate the use of advanced level of topology and functional analysis, understand about compactness, separated sets, connectedness, contraction mapping, fixed point theorem, the theory of normed space, banach space, role of inner product space, theory of Hilbert space and how to use the ideas in different branches of science and develop the problem solving skills.

Also learners can prepare them to go for higher level studies and pursue research in this topics

Semester*	: VIII
Course Type	: DSC
Course Code**	: MAT-DSC-453
Name of the Course	: **Option B -** Advanced Differential Equations
Learning level***	: 600
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

To acquaint the knowledge of various application techniques of solving First order ordinary differential equations.
To understand the knowledge of techniques to solve the Systems of linear differential equations. To understand how to use series solution and applications of Numerical Methods to ODE
To understand the finite methods for time dependent partial differential equations.

Unit-I

Application of ordinary differential equations of First order: Single species population model, growth and decay, Dynamics of Tumour Growth, Newton's law of cooling, Temperature rate of change, Diffusion, Biological Growth, SI, SIS model in Epidemiology.

Unit-II

Systems of linear differential equations, types of linear systems, differential operators, an operator method for solving linear systems with constant coefficients, basic theory of linear systems in normal form, homogeneous linear systems with constant coefficients: two equations in two unknown functions. Matrix Method for homogeneous linear systems with constant coefficients.

Unit-III

Power series solutions: Ordinary points, Regular singular points, Irregular singular points, ordinary power series methods, Frobenius method. Solutions of Bessel's and Legendre equations.

Unit IV

Numerical Methods for ODE: Explicit Adams-Bashforth Techniques, Implicit Adams-Moulton Techniques, Predictor-Corrector Techniques, Finite difference methods for solving two-point linear boundary value problems.

Unit-V

1-D Parabolic equations: explicit finite difference methods, weighted average approximation, Dirichlet and Neumann conditions. 1-D hyperbolic equations – method of characteristics, different explicit methods.

Recommended Text Books:

1. Zafar Ahsan; Differential Equations and Their Applications, PHI Learning Pvt Ltd.
2. S.L. Ross, Introduction to Ordinary Differential Equations, John Wiley & Sons, New York, 1989
3. M K Jain , S R K Iyengar , R K Jain; Computational Methods for Partial Differential Equations", New Age Publishers, New Delhi , 1994.

References:

1. Nanda kumaran, A.K, Datti, P.S. & Raju K.G., Ordinary Differential Equations: Principles and Applications, Cambridge University Press, 2018.
2. Deo, S.G. & Raghavendra, V., Ordinary Differential Equations, Tata McGraw Hill, New Delhi, 2006.
3. Morton K.W. and Mayers D.F., "Numerical solution of partial differential equations", Cambridge University press, Cambridge, 2002.

Course Outcomes:

After studying this course, the student will be able to

1. Apply various methods of solving differential equation which arise in many application problems.
2. Familiar with Numerical methods to solve ordinary differential equations.
3. Familiar with various methods to solve time dependent partial differential equations.

Semester*	: VIII
Course Type	: DSC
Course Code**	: MAT-DSC-454
Name of the Course	: **Option A -** Mathematical Modelling
Learning level***	: 600
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

This course introduces students to the theory and practice of Mathematical modelling, focusing on Ordinary Differential Equations (ODEs) and their applications in various fields. Students will learn to formulate Mathematical models, analyze them using appropriate techniques, and interpret the results in the context of real-world problems.

Unit I

Introduction to Mathematical Modelling: Definition and scope of Mathematical modelling, Steps involved in Mathematical modelling, classification of Mathematical models, continuous, deterministic models with their illustrations, advantages and limitations of Mathematical modelling, some real-world examples of Mathematical models in different disciplines.

Unit II

Formulation of Mathematical Models: Problem identification and abstraction, Mathematical representations of models using ordinary differential equations, basic formulations of Mathematical models based on ODEs, exponential growth and decay models, logistic growth models.

Unit III

Physical system Models: Formulation of some Mathematical models for harmonic oscillator, damped and force harmonic oscillators, simple and compound pendulums, electric circuits (L-R, R-C, L-R-C)

Unit IV

Two Species Interacting Populations Models: Simple Prey-Predator interaction models, Lotka-Volterra models with intraspecies competition, Lotka-Volterra mutualistic models with or without intraspecies competition.

Unit V

Epidemiological Models: Susceptible, Infective populations, Endemic, Epidemic and Pandemic nature of viral outbreaks with examples, simple Epidemic models-SI models, SIS model, SIS model with constant number of carriers, models with removal.

Textbook:

1. Kapur, J.N., Mathematical modelling, New Age International

Reference books:

1. Giordano, F.R.,and Weir, M.D., A first course in Mathematical Modelling, Brooks Cole
2. Kamalananda, K. and Jawahar, P., Mannar, Mathematical Modelling of systems and analysis, PHI.

Course Outcomes:

By the end of the course, students will be able to:

1. Formulate Mathematical models through Ordinary Differential Equations to represent some of the major real-world problems.
2. Analyze Mathematical models using appropriate Mathematical and computational techniques.
3. Simulate the Mathematical models in the context of the original problem.
4. Apply Mathematical modelling techniques to solve problems in various fields such as engineering, Economics and Bio-Mathematics.

Semester*	: VIII
Course Type	: DSC
Course Code**	: MAT-DSC-454
Name of the Course	: **Option B -** Discrete Mathematics
Learning level***	: 600
Credits	: 4
Contact Hours	: 60
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

The objective of this course is to familiarize a student with the basic mathematical concepts and tools pertinent to application and modeling.

UNIT I

Propositional logic: proposition, connectives, truth table, tautology and contradiction, validity of argument, rules of inference. First order predicate logic (FOL): domain, quantifiers, existential and universal quantifier, bounded and free variables, English to FOL translation.

UNIT II

Partially ordered set, well-ordered set, Principle of well-ordered induction, Lexicographical order, Hasse diagram, Maximal and minimal elements, Lattice, sublattice, distributive lattice, complement of an element, related properties.

UNIT III

Recurrence relation, Fibonacci numbers, properties of Fibonacci numbers, Lucas sequence, modeling with recurrence relation, solution of linear homogeneous and non-homogeneous recurrence relations with constant coefficients, solution of recurrence relation by substitution.

UNIT IV

Boolean algebra: Boolean sum, product and compliment, Boolean expressions and functions, identities of Boolean algebra, duality, abstract definition of Boolean algebra, sum-of-product expansions, functional completeness, logic gates.

UNIT V

Finite state machines: alphabets, strings and languages, Deterministic Finite Automata (DFA), designing DFAs, minimization of DFA, partition algorithm, Non-deterministic Finite Automata (NFA), Conversion of NFA to DFA, regular expression, properties, equivalence of FA and RE, regular languages.

Textbooks:

1. Kenneth H. Rosen (Indian adaptation by Kamala Kritivasan), *Discrete Mathematics and its applications*, Mcgraw Hill.
2. David J. Hunter, *Essentials of discrete mathematics*, Jones and Bartlett publisher.

Reference books:

1. S. Lipschutz, M. Lipson, *Theory and problems of discrete mathematics,* Schaum's outline series.
2. C. L. Liu: *Elements of Discrete Mathematics*, Mcgraw Hill.

COURSE OUTCOMES

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

1. Understand the mathematical reasoning necessary to construct logical arguments which are the building blocks of mathematical proofs.
2. Comprehend the set theoretical concepts which are essential towards developing discrete mathematical structures.
3. Apply the tools of recurrence relation to simulate various practical phenomena arising in numerous branches of science, linguistics etc.
4. Analyze the working principle of digital circuits which are the fundamental blocks of every electronic device and to design them efficiently.
5. Demonstrate the basic knowledge of formal computation and its relationship with various classes of languages arising in computation.

Semester* : I
Course Type : DSM
Course Code** : MAT-DSM-101
Name of the Course : Calculus
Learning level*** : 100
Credits : 3
Contact Hours : 45
Total Marks : 100
End Semester Marks : 70
Internal Marks : 30
Course Objective

The main objective of this course is

1. To introduce the concept of limits, continuity, differentiability of functions and their various applications.
2. To learn the techniques of L'Hospital rule for evaluation of limit.
3. To explain the concept of definite integral and various types of reduction formula for integration of trigonometric function.
4. To explain the applications in finding the area and rectification of plane curves; the volume and surface area of revolution of curve.

Unit – I

Limit (ε - δ definition), Cauchy's criterion for existence of limit (without proof), problems on limits. Continuity (ε - δ definition), related theorems and problems, types of discontinuities. Differentiability of a function, problems on differentiability, relation between continuity and differentiability. Successive differentiation, Leibnitz's theorem and its application.

Unit –II

Rolle's theorems, Lagrange's mean value theorem, Cauchy's mean value theorem. Statement and applications of Taylor's and Maclaurin's theorems, Taylor's and Maclaurin's series, expansions of functions $\sin x$, $\cos x$, e^x, $\log(1 + x)$ (assuming $R_n \to 0$ as $n \to \infty$). Maxima and minima for functions of one variable, necessary and sufficient condition for maxima and minima. Indeterminate forms: $\frac{0}{0}$, $\frac{\infty}{\infty}$, $0 \times \infty$, $\infty - \infty$, 0^0, 1^∞ and ∞^∞.

Unit –III

Partial differentiation. Euler's theorem on homogeneous functions (two variable). Tangents, normals: Equations and properties of tangents and normals, subtangents and subnormals of cartesian and polar curves.

Unit –IV

Definition and properties of definite integrals, Fundamental theorem (without proof), Reduction formulae of the types $\int \sin^n x\, dx$, $\int \cos^n x\, dx$, $\int \tan^n x\, dx$, $\int \sec^n x\, dx$, $\int (\log x)^n$ dx, $\int \sin^m x \cos^n x\, dx$, $\int \sin^m x \cos nx\, dx$.

Unit –V

Area bounded by plane curves (cartesian and polar), rectification of plane curves (cartesian and polar), volumes and surface of solid of revolution about axes: Cartesian curves.

Textbooks:

1. B.C. Das and B.N. Mukherjee, Differential Calculus, 55th ed., U.N. Dhur and Sons, 1949. [Unit – I to Unit – III]

2. B.C. Das and B.N. Mukherjee, Integral Calculus with Differential Equations, 57th ed., U.N. Dhur and Sons, 1938. [Unit – IV to Unit – V]

Reference books:

1. S.C. Malik and S. Arora, Mathematical Analysis, 4th ed., New Age International, 2010.

2. R.K. Ghosh and S.K. Maity, An Introduction to Analysis: Differential Calculus,13th ed., New Central Book Agency, 2011.

3. R.K. Ghosh and S.K. Maity, An Introduction to Analysis: Integral Calculus, 12th ed. New Central Book Agency, 2013.

4. Shanti Narayan and P.K. Mittal, Differential Calculus, 15th ed., S. Chand, 1942.

5. Shanti Narayan and P.K. Mittal, Integral Calculus,35th ed., S. Chand, 2005.

Course Learning Outcome

After completion of this course, the learners will be able to

1. Solve the problems of limits, continuity, derivative and integration.
2. Apply Calculus in real life problems.

Semester* : II
Course Type : DSM
Course Code** : MAT-DSM-151
Name of the Course : Calculus
Learning level*** : 100
Credits : 3
Contact Hours : 45
Total Marks : 100
End Semester Marks : 70
Internal Marks : 30
Course Objective

The main objective of this course is

1. To introduce the concept of limits, continuity, differentiability of functions and their various applications.
2. To learn the techniques of L'Hospital rule for evaluation of limit.
3. To explain the concept of definite integral and various types of reduction formula for integration of trigonometric function.
4. To explain the applications in finding the area and rectification of plane curves; the volume and surface area of revolution of curve.

Unit – I

Limit (ε - δ definition), Cauchy's criterion for existence of limit (without proof), problems on limits. Continuity (ε - δ definition), related theorems and problems, types of discontinuities. Differentiability of a function, problems on differentiability, relation between continuity and differentiability. Successive differentiation, Leibnitz's theorem and its application.

Unit –II

Rolle's theorems, Lagrange's mean value theorem, Cauchy's mean value theorem. Statement and applications of Taylor's and Maclaurin's theorems, Taylor's and Maclaurin's series, expansions of functions $\sin x$, $\cos x$, e^x, $\log(1 + x)$ (assuming $R_n \to 0$ as $n \to \infty$). Maxima and minima for functions of one variable, necessary and sufficient condition for maxima and minima. Indeterminate forms: $\frac{0}{0}$, $\frac{\infty}{\infty}$, $0 \times \infty$, $\infty - \infty$, 0^0, 1^∞ and ∞^∞.

Unit –III

Partial differentiation. Euler's theorem on homogeneous functions (two variable). Tangents, normals: Equations and properties of tangents and normals, subtangents and subnormals of cartesian and polar curves.

Unit –IV

Definition and properties of definite integrals, Fundamental theorem (without proof), Reduction formulae of the types $\int \sin^n x\,dx$, $\int \cos^n x\,dx$, $\int \tan^n x\,dx$, $\int \sec^n x\,dx$, $\int (\log x)^n$ dx, $\int \sin^m x\,\cos^n x\,dx$, $\int \sin^m x\,\cos nx\,dx$.

Unit –V

Area bounded by plane curves (cartesian and polar), rectification of plane curves (cartesian and polar), volumes and surface of solid of revolution about axes: Cartesian curves.

Textbooks:

1. B.C. Das and B.N. Mukherjee, Differential Calculus, 55th ed., U.N. Dhur and Sons, 1949. [Unit – I to Unit – III]

2. B.C. Das and B.N. Mukherjee, Integral Calculus with Differential Equations, 57th ed., U.N. Dhur and Sons, 1938. [Unit – IV to Unit – V]

Reference books:

1. S.C. Malik and S. Arora, Mathematical Analysis, 4th ed., New Age International, 2010.

2. R.K. Ghosh and S.K. Maity, An Introduction to Analysis: Differential Calculus,13th ed., New Central Book Agency, 2011.

3. R.K. Ghosh and S.K. Maity, An Introduction to Analysis: Integral Calculus, 12th ed. New Central Book Agency, 2013.

4. Shanti Narayan and P.K. Mittal, Differential Calculus, 15th ed., S. Chand, 1942.

5. Shanti Narayan and P.K. Mittal, Integral Calculus,35th ed., S. Chand, 2005.

Course Learning Outcome

After completion of this course, the learners will be able to

1. Solve the problems of limits, continuity, derivative and integration.
2. Apply Calculus in real life problems.

Semester* : III
Course Type : DSM
Course Code** : MAT-DSM-201
Name of the Course : Classical Algebra and Trigonometry
Learning level*** : 199
Credits : 4
Contact Hours : 60
Total Marks : 100
End Semester Marks : 70
Internal Marks : 30
Course Objective

The main objective of this course is

1. To provide a first approach to the subject of classical algebra.
2. To introduce the concept of rank of a matrix, solution of a system of linear equations.
3. To familiarize the students with relation between roots and coefficients of a polynomial equation, symmetric function of roots.
4. To introduce the concept of inequalities and its use.
5. To provide basic knowledge of trigonometry, hyperbolic functions.
6. Understanding the summation of trigonometric series, expansions.

Unit-I

Adjoint of Square matrix, Jacobi's Theorem; Inverse of a square matrix, Elementary transformation on matrices, Rank of a matrix, solution of a system of linear equations by matrix inverse and by Gaussian elimination method.

Unit-II

Relation between the roots and coefficients of a polynomial equation of nth degree with special reference to cubic equation, Symmetric function of roots; Transformation of equation; Cardan's Method of solution of cubic equation of the form $ax^3+bx+c=0$ $(a\neq0)$;

Unit- III

Inequalities, properties, inequalities involving arithmetic, geometric and harmonic means, Cauchy-Schwarz's inequality, Minkowski inequality, Holder's inequality.

Unit- IV

De Moivre's theorem, related problems, Expansion of sin nθ and cos nθ, expansion of Sin θ and Cosθ in ascending powers of θ, functions of complex arguments.

Unit- V

Gregory's series; summation of trigonometric series; hyperbolic functions.

Textbooks :

1. J.G. Chakraborty, P.R. Ghosh; Higher Algebra; U.N. Dhur & Sons. (Units I & II)
2. S.K. Mapa; Higher Algebra (Classical); Levant. (Unit III)
3. B.C. Das, B.N.Mukherjee; Higher Trigonometry; U.N.Dhur & Sons. (Units IV & V)

Course Learning Outcome

After completion of this course, the learners will be able to

1. Describe the role of elementary Transformations on matrices.
2. Find the solution of a polynomial equation.
3. Apply the concept of symmetric functions.
4. Understand the importance of De Moivre's theorem.
5. Find expansions of trigonometric functions and related problems.
6. To acquire knowledge of Gregory's series, summation of Trigonometric series and related problems.

Semester* : IV
Course Type : DSM
Course Code** : MAT-DSM-251
Name of the Course : Differential Equations
Learning level*** : 250
Credits : 3
Contact Hours : 45
Total Marks : 100
End Semester Marks : 70
Internal Marks : 30

Course Objective

The objectives of this course are:

1. To introduce the concept of ordinary differential equations.
2. To introduce the concept of first order partial differential equations.
3. To explain solution techniques of ordinary and partial differential equations.

Unit-I

Introduction to differential equations, order and degree, Formation of differential equations, Differential equations in which variables are separable, Homogeneous differential equations, First order exact differential equations, Integrating factors, rules to find an integrating factor, Linear differential equations.

Unit-II

First order higher degree equations solvable for x, y, p, Equations in Clairaut's form. Solving a differential equation by reducing its order, Linear homogenous equations with constant coefficients, linear non-homogenous equations with constant coefficients.

Unit-III

Linear ordinary differential equations with variable coefficients, Cauchy-Euler equation, Equations reducible to homogeneous linear form, Method of variation of parameters.

Unit-IV

Simultaneous differential equations with constant coefficients, Simultaneous differential equations of the form $(dx)/P = (dy)/Q = (dz)/R$, Total differential equations.

Unit-V

Order and degree of partial differential equations, concept of linear and non-linear partial differential equations, Formation of first order partial differential equations, Lagrange's method.

Textbooks :

1. M.D. Raisinghania; Ordinary and Partial Differential Equations; S. Chand.

Reference books :

1. S. L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, 1984.

Course Outcomes:

After studying this course, the students will be able to

(i) Learn ordinary differential equations and describes various methods of solving them.

(ii) Learn partial differential equations of first order and solve first order partial differential equations.

Semester* : IV
Course Type : DSM
Course Code** : MAT-DSM-252
Name of the Course : Differential Equations
Learning level*** : 250
Credits : 3
Contact Hours : 45
Total Marks : 100
End Semester Marks : 70
Internal Marks : 30
Course Objective

The objectives of this course are:

4. To introduce the concept of ordinary differential equations.
5. To introduce the concept of first order partial differential equations.
6. To explain solution techniques of ordinary and partial differential equations.

Unit-I

Introduction to differential equations, order and degree, Formation of differential equations, Differential equations in which variables are separable, Homogeneous differential equations, First order exact differential equations, Integrating factors, rules to find an integrating factor, Linear differential equations.

Unit-II

First order higher degree equations solvable for x, y, p, Equations in Clairaut's form. Solving a differential equation by reducing its order, Linear homogenous equations with constant coefficients, linear non-homogenous equations with constant coefficients.

Unit-III

Linear ordinary differential equations with variable coefficients, Cauchy-Euler equation, Equations reducible to homogeneous linear form, Method of variation of parameters.

Unit-IV

Simultaneous differential equations with constant coefficients, Simultaneous differential equations of the form $(dx)/P = (dy)/Q = (dz)/R$, Total differential equations.

Unit-V

Order and degree of partial differential equations, concept of linear and non-linear partial differential equations, Formation of first order partial differential equations, Lagrange's method.

Textbooks :

1. M.D. Raisinghania; Ordinary and Partial Differential Equations; S. Chand.

Reference books :

1. S. L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, 1984.

Course Outcomes:

After studying this course, the students will be able to

(iii) Learn ordinary differential equations and describes various methods of solving them. Learn partial differential equations of first order and solve first order partial differential equations.

Semester* : V
Course Type : DSM
Course Code** : MAT-DSM-301
Name of the Course : Geometry and Vectors
Learning level*** : 300
Credits : 3
Contact Hours : 45
Total Marks : 100
End Semester Marks : 70
Internal Marks : 30
Course Objective

The objective of this course is to give knowledge on transformation of coordinate axes, pair of straight lines, conic sections, determination of pole and polar with respect to the conic, polar equation in two dimensional Cartesian geometry. Also this course explains vector algebra and vector calculus.

Unit-I

Transform of coordinates: Change of origin without changing the direction of axes, rotation of one pair of rectangular axes to another with same origin, invariants in orthogonal transformation, pair of straight lines, bisector of angles between pair of straight lines, condition that general equation of second degree represents a pair of straight lines.

Unit-II

Tangents and Normals: Condition of tangency of a straight line to a circle, parabola, ellipse and hyperbola, pair of tangents from an external point to a circle, parabola and ellipse.

Unit-III

Definition of poles and polars, equation of polar of a point with respect to a circle, parabola, ellipse and hyperbola, polar equation of the form $\frac{l}{r} = 1 + e\cos\theta$, equation of chord and tangent, related problems.

Unit-IV

Scalar triple product, vector triple product, vector equation of lines, planes and spheres and some problems, vector functions: Differentiation of vector functions, properties and their applications.

Unit-V

Vector differential operator, gradient, divergence and curl,their physical interpretation, their identities and applications in related problems.

Text books :

1. J.G.Chakraborty and P.R.Ghosh; Advanced analytical geometry; U.N.Dhur and sons.

2. M.D. Raisinghania; Vector Calculus; S.Chand

Reference books:

1. S.L.Loney; The elements of coordinate geometry; McMilan and Company, London
2. M.R. Spiegel, Vector Calculus; McGraw Hill
3. K.C. Pal;Vector analysis; New Central Book agency (P) Ltd

Course Outcomes:

After successful completion of the course, students will be able to understand how to solve the problems on transformation of coordinate axes, bisector angle between lines, conic section and poles and polar with respect to conic. Also from this course students will be able to understand vector equations, lines, planes and spheres in three dimensions, vector differentiation, gradient, divergence and curl.

Semester* : V
Course Type : DSM
Course Code** : MAT-DSM-302
Name of the Course : Geometry and Vectors
Learning level*** : 300
Credits : 3
Contact Hours : 45
Total Marks : 100
End Semester Marks : 70
Internal Marks : 30
Course Objective

The objective of this course is to give knowledge on transformation of coordinate axes, pair of straight lines, conic sections, determination of pole and polar with respect to the conic, polar equation in two dimensional Cartesian geometry. Also this course explains vector algebra and vector calculus.

Unit-I

Transform of coordinates: Change of origin without changing the direction of axes, rotation of one pair of rectangular axes to another with same origin, invariants in orthogonal transformation, pair of straight lines, bisector of angles between pair of straight lines, condition that general equation of second degree represents a pair of straight lines.

Unit-II

Tangents and Normals: Condition of tangency of a straight line to a circle, parabola, ellipse and hyperbola, pair of tangents from an external point to a circle, parabola and ellipse.

Unit-III

Definition of poles and polars, equation of polar of a point with respect to a circle, parabola, ellipse and hyperbola, polar equation of the form $\frac{l}{r} = 1 + e\cos\theta$, equation of chord and tangent, related problems.

Unit-IV

Scalar triple product, vector triple product, vector equation of lines, planes and spheres and some problems, vector functions: Differentiation of vector functions, properties and their applications.

Unit-V

Vector differential operator, gradient, divergence and curl,their physical interpretation, their identities and applications in related problems.

Text books :

1. J.G.Chakraborty and P.R.Ghosh; Advanced analytical geometry; U.N.Dhur and sons.

2. M.D. Raisinghania; Vector Calculus; S.Chand

Reference books:

1. S.L.Loney; The elements of coordinate geometry; McMilan and Company, London
2. M.R. Spiegel, Vector Calculus; McGraw Hill
3. K.C. Pal;Vector analysis; New Central Book agency (P) Ltd

Course Outcomes:

After successful completion of the course, students will be able to understand how to solve the problems on transformation of coordinate axes, bisector angle between lines, conic section and poles and polar with respect to conic. Also from this course students will be able to understand vector equations, lines, planes and spheres in three dimensions, vector differentiation, gradient, divergence and curl.

Semester* : VI
Course Type : DSM
Course Code** : MAT-DSM-351
Name of the Course : Classical Algebra and Trigonometry
Learning level*** : 199
Credits : 4
Contact Hours : 60
Total Marks : 100
End Semester Marks : 70
Internal Marks : 30
Course Objective

The main objective of this course is

1. To provide a first approach to the subject of classical algebra.
2. To introduce the concept of rank of a matrix, solution of a system of linear equations.
3. To familiarize the students with relation between roots and coefficients of a polynomial equation, symmetric function of roots.
4. To introduce the concept of inequalities and its use.
5. To provide basic knowledge of trigonometry, hyperbolic functions.
6. Understanding the summation of trigonometric series, expansions.

Unit-I

Adjoint of Square matrix, Jacobi's Theorem; Inverse of a square matrix, Elementary transformation on matrices, Rank of a matrix, solution of a system of linear equations by matrix inverse and by Gaussian elimination method.

Unit-II

Relation between the roots and coefficients of a polynomial equation of nth degree with special reference to cubic equation, Symmetric function of roots; Transformation of equation; Cardan's Method of solution of cubic equation of the form $ax^3+bx+c=0$ $(a\neq0)$;

Unit- III

Inequalities, properties, inequalities involving arithmetic, geometric and harmonic means, Cauchy-Schwarz's inequality, Minkowski inequality, Holder's inequality.

Unit- IV

De Moivre's theorem, related problems, Expansion of sin nθ and cos nθ, expansion of Sin θ and Cosθ in ascending powers of θ, functions of complex arguments.

Unit- V

Gregory's series; summation of trigonometric series; hyperbolic functions.

Textbooks :

4. J.G. Chakraborty, P.R. Ghosh; Higher Algebra; U.N. Dhur & Sons.
(Units I & II)
5. S.K. Mapa; Higher Algebra (Classical); Levant.
(Unit III)
6. B.C. Das, B.N.Mukherjee; Higher Trigonometry; U.N.Dhur & Sons.
(Units IV & V)

Course Learning Outcome

After completion of this course, the learners will be able to

2. Describe the role of elementary Transformations on matrices.
2. Find the solution of a polynomial equation.
3. Apply the concept of symmetric functions.
4. Understand the importance of De Moivre's theorem.
5. Find expansions of trigonometric functions and related problems.
6. To acquire knowledge of Gregory's series, summation of Trigonometric series and related problems.

Semester* : VII
Course Type : DSM
Course Code** : MAT-DSM-401
Name of the Course : Linear Programming
Learning level*** : 399
Credits : 4
Contact Hours : 60
Total Marks : 100
End Semester Marks : 70
Internal Marks : 30
Course Objective

1. To develop formulation skills in Linear programming problem and finding solutions using Graphical method, Simplex method, Big M method and two-phase method
2. To introduce the concept and construction of Duality
3. To develop solving skills in Transportation and Assignment problems

Unit-I

Formulation of LPP, General LPP, Graphical method of solution of LPP; Convex sets and their properties; Standard form of a LPP.

Unit-II

Simplex method; Artificial variables techniques : Big M method and two-phase method, related problems.

Unit-III

Duality : Concept of duality, Mathematical formulation of duals, Construction of duals, primal-dual relationships, theorems on duality; Dual Simplex method.

Unit-IV

Transportation problems : Mathematical formulation and methods of determining initial basic feasible solution - North West corner, Row minima, Column minima, Matrix minima, Vogel's approximation methods. Unbalanced transportation problems.

Unit-V

Optimality tests for transportation problems and MODI method for obtaining optimal solution, degeneracy in transportation problems; Assignment problems, Hungarian method of solution.

Text books :

1. J.G. Chakraborty and P.R.Ghosh; Linear Programming and Game theory; Moulik Library.

Reference books :

1. P.M.Karak; Linear Programming and theory of games; New Central Book Agency.
2. R.K. Gupta, Operations Research, Krishna Prakashan Media, Meerut.
3. Kanti Swarup, P.K.Gupta, M. Mohan; Operations Research; Sultan Chand and sons.
4. D. C. Sanyal, K. Das; Linear Programming and Game Theory; U. N. Dhur & sons

Course Outcomes :

After studying this course, the student will be able to

1. Learn the technique of maximizing the profit and minimizing the cost.
2. Select the place for distribution of products so that total cost of transportation is minimum
3. Appoint the most suitable persons on minimum salary, determine the best age of retirement and to select the number of persons to be appointed

Semester* : VIII
Course Type : DSM
Course Code** : MAT-DSM-451
Name of the Course : Linear Programming
Learning level*** : 399
Credits : 4
Contact Hours : 60
Total Marks : 100
End Semester Marks : 70
Internal Marks : 30

Course Objective

1. To develop formulation skills in Linear programming problem and finding solutions using Graphical method, Simplex method, Big M method and two-phase method
2. To introduce the concept and construction of Duality
3. To develop solving skills in Transportation and Assignment problems

Unit-I

Formulation of LPP, General LPP, Graphical method of solution of LPP; Convex sets and their properties; Standard form of a LPP.

Unit-II

Simplex method; Artificial variables techniques : Big M method and two-phase method, related problems.

Unit-III

Duality : Concept of duality, Mathematical formulation of duals, Construction of duals, primal-dual relationships, theorems on duality; Dual Simplex method.

Unit-IV

Transportation problems : Mathematical formulation and methods of determining initial basic feasible solution - North West corner, Row minima, Column minima, Matrix minima, Vogel's approximation methods. Unbalanced transportation problems.

Unit-V

Optimality tests for transportation problems and MODI method for obtaining optimal solution, degeneracy in transportation problems; Assignment problems, Hungarian method of solution.

Text books :

1. J.G. Chakraborty and P.R.Ghosh; Linear Programming and Game theory; Moulik Library.

Reference books :

1. P.M.Karak; Linear Programming and theory of games; New Central Book Agency.
2. R.K. Gupta, Operations Research, Krishna Prakashan Media, Meerut.
3. Kanti Swarup, P.K.Gupta, M. Mohan; Operations Research; Sultan Chand and sons.
4. D. C. Sanyal, K. Das; Linear Programming and Game Theory; U. N. Dhur & sons

Course Outcomes :

After studying this course, the student will be able to

1. Learn the technique of maximizing the profit and minimizing the cost.
2. Select the place for distribution of products so that total cost of transportation is minimum
3. Appoint the most suitable persons on minimum salary, determine the best age of retirement and to select the number of persons to be appointed

Semester*	: I
Course Type	: SEC
Course Code**	: MAT-SEC-101
Name of the Course	: Mathematical Skill Development with Software
Learning level***	: 200
Credits	: 3
Contact Hours	: 45
Total Marks	: 100
End Semester Marks	: 80 (Theory - 50, Practical - 30)
Internal Marks	: 20

Course Objective

The main objective of this course is

1. To enhance and strengthen one's understanding and proficiency in various mathematical concepts and techniques.
2. To plot the graphs of various functions and analyse them.
3. To enhance learners problem-solving skills by applying mathematical principles in a visual and intuitive manner using software applications.

THEORY

Unit – I

Introduction to problem solving with computer programming. Introduction to algorithms, flowcharts, symbols used in flowcharts. Algorithms and flowcharts for decision making - use of if-then, if-then-else, nested if-then-else. Algorithms and flowcharts for problems involving iterations and looping - use of repeat while. Algorithms and flowcharts involving arrays. Common exercises involving each of the above from the textbook.

Unit – II

Relations, functions, types of functions: exponential, logarithm, trigonometric, polynomial, periodic, greatest integer, injective, surjective, bijective, even and odd. Operation of functions: addition, subtraction, multiplication, division and composition.

Unit– III

Well-ordering property of positive integers, Division algorithm, Divisibility of integers, Euclidean algorithm, Greatest Common Divisor (GCD), Prime number, Fundamental Theorem of Arithmetic, Congruence relation between integers, properties of congruences.

Unit– IV

Idempotent, nilpotent, involutory matrices, transpose of a matrix, conjugate of a matrix, symmetric, skew symmetric, Hermitian, skew Hermitian, orthogonal, unitary matrices, adjoint of a square matrix, Jacobi's theorem, inverse of a square matrix.

Unit– V

Introduction of differential equation, basic concepts, general and particular solutions of a differential equation, formation of a differential equation whose general solutions are given. Methods of solving differential equations: variable separable, homogeneous differential equation, linear differential equation.

Textbooks:

1. A.B. Chaudhuri, Flowchart and Algorithm Basics: The Art of Programming, 1st ed., Mercury Learning and Information, 2020.
2. J.G. Chakraborty and P.R. Ghosh, Higher Algebra: Classical and Modern, 23rd ed., U.N. Dhur and Sons, 1972.
3. D.M. Burton, Elementary Number Theory, 7th ed., McGraw Hill Education, 2017.
4. M.D. Raisinghania, Ordinary and Partial Differential Equations, S.Chand, 2020.

Reference books:

1. S.K. Mapa, Higher Algebra: Classical, 9th ed., Sarat Book House, 2021.
2. S.B. Malik, Basic Number Theory, 2nd ed., Vikas Publishing House, 2018.
3. S.L. Ross, Differential Equations, 3rd ed., Wiley, 2007.
4. S. Lipschutz and M. Lipson, Schaum's Outlines: Linear Algebra, 3rd ed., McGraw Hill Education, 2017.

PRACTICAL

(*Using any software*)

1. Input the values of variables and display them, demonstrate use of if, if-else, nested if statements, demonstrate use of loops, demonstrate the use of arrays
2. Plotting of graphs of various functions
3. Check, obtain, list the prime numbers and check divisibility, obtain divisor, remainder and GCD of two numbers
4. Different operations of matrices (Like addition, multiplication, transpose, inverse, etc.) 5. Solving ordinary differential equation through software and plotting the solution of the family of differential equation

Course Learning Outcome

After completing the course, learners will

1. Build a solid understanding of the core principles that underpin various branches of mathematics, laying the groundwork for their application in science and technology fields.
2. Gain proficiency in utilising mathematical software to solve a wide range of mathematical problems.

Semester*	: II
Course Type	: SEC
Course Code**	: MAT-SEC-151
Name of the Course	: Mathematical Programming in C
Learning level***	: 200
Credits	: 3
Contact Hours	: 45
Total Marks	: 100
End Semester Marks	: 80 (Theory - 50, Practical - 30)
Internal Marks	: 20

Course Objective

The main objective of this course is to introduce the fundamentals of the C programming language and its application in mathematical programming and to develop problem-solving skills by implementing mathematical algorithms.

THEORY

Unit – I

Introduction to C language, C characters, constants and variables. Arithmetic expression and statement. Input-output statements, assignment statement, printf and scanf statements, declaration statement.

Unit – II

Simple computer programs. Logical expression and statements, logical and relational operators.

Unit – III

Decision control structures and loops: if statement, if-else statement, for loop, while loop, do-while loop, switch statement, break statement, continue statement, go to statement.

Unit – IV

Functions: Defining a function, function prototypes, passing arguments to a function.

Unit – V

Return statement, arrays, defining one and multi-dimensional arrays.

Textbook:

1. E. Balagurusamy, Programming in ANSI C, 8th ed., McGraw Hill Education (India), 2019.

Reference books:

1. T. Jeyapoovan, A First Course in Programming with C, 1st ed., Vikas

Publishing House, 2004. 2. Y. Kanetkar, Let Us C, 15th ed., BPB Publications, 2016.
3. B.W. Kernighan, D.M. Ritchie, The C Programming Language, 2nd ed., Pearson Education India, 2015.

PRACTICAL

1. Write a program to find the area of a
    a. circle
    b. rectangle
    c. triangle
2. Write a program to determine whether a given year is a leap year or not
3. Write a program to check whether a given character is a vowel or a consonant
4. Write a program to check whether a given positive integer is prime
5. Write a program to find the factorial of a positive integer using a
    a. loop b. recursive function
6. Write a program to find the sum of the following series for a given positive integer n:
$$1! + 2! + \cdots + n!$$
7. Write a program to find the biggest element in an array of integers
8. Write a program to sort a given array of integers in
    a. ascending order b. descending order
9. Write a program to find
    a. the sum of two matrices b. the product of two matrices
10. Write a program to find the determinant of a
    a. 2×2 matrix b. 3×3 matrix
11. Write a program to find the inverse of a
    a. 2×2 matrix b. 3×3 matrix

Course Outcome

On successful completion of the course, learners will be able to
1. Demonstrate a comprehensive understanding of the syntax, variables, and data types used in the C programming language,
2. Apply C programming concepts effectively to solve mathematical problems, including calculating areas, determining leap years, and checking for prime numbers,
3. Develop efficient C programs to compute factorials, sum of series, and manipulate arrays for mathematical computation,
4. Utilize decision control structures (if-else, switch) and loops (for, while, do-while) proficiently in mathematical programming scenarios,
5. Design and implement modular programs by defining functions, passing arguments, and using return statements to solve mathematical problems.

Semester* : III
Course Type : SEC
Course Code** : MAT-SEC-201
Name of the Course : Numerical Methods
Learning level*** : 299
Credits : 3
Contact Hours : 45
Total Marks : 100
End Semester Marks : 80 (Theory - 50, Practical - 30)
Internal Marks : 20

Course Objective

The objective of this course is to introduce the learners to the various aspects of numerical analysis including error analysis, finite differences, interpolation, numerical differentiation, integration, solutions of transcendental equations and simultaneous linear equations,.

Unit I

Exact and approximate numbers; Significant digits; Round off and truncation errors; Absolute and relative errors; Estimation of round off errors; Error propagation under arithmetic operations. Finite difference operators and their properties.

Unit II

Polynomial interpolation; Newton's forward and backward interpolation formulae; Lagrange's interpolation formula; errors in interpolation formulae and related numerical problems.

Unit III

Bisection method; False position method; Secant method, Fixed point iteration method; Newton-Raphson method; Convergence of the above methods and related problems.

Unit IV

Numerical differentiation using Newton's interpolation formulae; Error in numerical differentiation; General quadrature formula,Trapezoidal and Simpson's one third and three eighth rules for numerical integration.

Unit V

Gaussian elimination and Gauss-Jordan methods with and without pivoting; Jacobi and Gauss Seidel iterative methods and their convergence.

Practicals

List of Experiments (using any software)

1. Newton's forward interpolation

2. Newton's backward interpolation

3. Lagrange's interpolation

4. Bisection method

5. False position method

6. Fixed point iteration method

7. Newton-Raphson method

8. Numerical differentiation

9. Trapezoidal rule

10. Simpson's one third rule

11. Gaussian elimination method

12. Gauss-Jordan method

13. Jacobi method

14. Gauss-Siedel method

Text Books:

1. S. A. Mollah: Numerical Analysis and Computational Procedures; Books and Allied Pvt. Ltd., Kolkata.

2. E. Balagurusamy: Numerical Methods; Tata McGrow-Hill Publishing Company, New Delhi.

Reference Books:

1. G. Shankar Rao: Numerical Analysis; New Age International Publisher, New Delhi.

2. J .B. Scarborough: Numerical Mathematical Analysis; Oxford and IBH Publishing.

3. J. G. Chakraborty and P. R. Ghosh: Numerical Analysis; U. N. Dhur and Sons, Kolkata.

4. M. K. Jain, S. R. K. Iyengar and R. K. Jain: Numerical Methods for Scientific and Engineering Computation New Age International Publisher, New Delhi.

Course Outcomes:

1. Demonstrate proficiency in numerical methods and their applications in solving mathematical problems.
2. Apply appropriate techniques to analyze and estimate errors in numerical

calculations.

3. Develop skills in using numerical software to solve complex engineering problems efficiently.

Semester*	: I
Course Type	: IDC
Course Code**	: MAT-IDC-101
Name of the Course	: Foundation Course in Mathematics
Learning level***	: 100
Credits	: 3
Contact Hours	: 45
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

The main objective of this course is to enable the learners review basic mathematical concepts that are helpful for various competitive examinations.

Unit – I

Place value, face value of digits in decimal number system. Natural numbers, integers, rational numbers. Divisibility of integers. Problems on LCM, GCD, fractions, ratio and proportion, percentage, profit and loss, simple and compound interest.

Unit – II

Unitary method, problems on time and work, speed and distance. Surds, Laws of exponents. Elementary set theory, union, intersection, difference, cartesian product of sets, subsets, number of elements of sets.

Unit – III

Simultaneous Linear equations in two variables and related problems. Quadratic equations and related problems. Arithmetic Progression, Geometric Progression.

Unit – IV

Permutation and Combination, Binomial Theorem for positive integer indices. Introduction to Probability, simple problems.

Unit – V

Matrices: order, transpose, sum, difference, scalar multiple, product, inverse. Symmetric and skew symmetric matrices. Determinant of a square matrix, problems on evaluating determinants. Elementary row and column operations on matrices. Use of matrices and determinants to solve system of linear equations.

Textbooks:

1. J.C. Chakravarti, Arithmetic for the use of schools and colleges, 16th ed., Sanyal and Co., 1920. 2. J.G. Chakraborty and P.R. Ghosh, Higher Algebra: Classical and Modern, 23rd ed., U.N. Dhur and Sons, 1972.

Reference books:

1. V. Krishnamurthy, C.R. Pranesachar, K.N. Ranganathan, and B.J. Venkatachala, Challenge and thrill of Pre-College mathematics, 4th ed., New Age International, 2022.
2. V.K. Sinha, Introduction to Matrix Theory, 1st ed., Narosa Publishing House, 2014.

Course Learning Outcome

After completion of the course, learners will be able to

1. Understand and apply concepts of numbers, fractions, ratios, percentages, and basic financial calculations.
2. Solve problems related to time, work, speed, distance, exponents, surds, sets, and equations.
3. Apply principles of permutation, combination, binomial theorem, and introductory probability.
4. Demonstrate proficiency in working with matrices, including operations, determinants, and solving linear equations.
5. Apply mathematical concepts to real-life scenarios, develop critical thinking and problem solving skills, and communicate mathematical ideas effectively.

Semester*	**: II**
Course Type	**:** IDC
Course Code**	**:** MATIDC151
Name of the Course	**:** Geometry
Learning level***	**:** 100
Credits	**:** 3
Contact Hours	**:** 45
Total Marks	**:** 100
End Semester Marks	**:** 70
Internal Marks	**:** 30

Course Objective

The main objective of this course is to introduce coordinate geometry concepts, including distance between points, section formula, and conversion between Cartesian and polar coordinates and to gain proficiency in working with equations of straight lines, conic sections, etc.

Unit – I

Coordinates, distance between two points, section formula, area of a triangle and quadrilateral with given coordinates of vertices, polar coordinates, change of cartesian to polar coordinates.

Unit – II

Straight lines, various forms of equation of a straight line, angles between two straight lines, conditions for parallel and perpendicular lines, lengths of perpendiculars, intersection of two straight lines.

Unit – III

Pair of straight lines, conditions parallel and perpendicular lines, bisector of angles between pair of straight lines, general equation of 2nd degree. Homogeneous equation of 2nd degree.

Unit – IV

Circles, various forms of equation of a circle, condition that the general equation of 2nd degree may represent a circle, tangent and normal to a circle.

Unit – V

Conic sections, parabola, hyperbola, ellipse, their equations in various forms.

Textbook:

1. S.L. Loney, The Elements of Coordinate Geometry, 17th ed., Arihant Publication (India), 2023.

Reference book:

1. J.G. Chakraborty and P.R. Ghosh, Advanced Analytical Geometry, 14th ed., U.N. Dhur and sons, 1987.

Course Outcome

After completion of the course, learners will be able to

1. Apply coordinate geometry to solve real-world problems, such as distance calculations and area determinations.
2. Solve geometric problems involving straight lines, including determining angles, intersections, and perpendiculars.
3. Demonstrate understanding of conic sections and their equations, and solve problems involving parabolas, hyperbolas, and ellipses.

Semester*	: III
Course Type	: IDC
Course Code**	: MAT-IDC-201
Name of the Course	: Basic Calculus
Learning level***	: 200
Credits	: 3
Contact Hours	: 45
Total Marks	: 100
End Semester Marks	: 70
Internal Marks	: 30

Course Objective

This is an interdisciplinary course on basic Calculus for the students outside the discipline of mathematics. The course is developed in order to introduce the basics and simple applications in both differential and integral calculus with some simple but effective real life examples. The main objective of this course;

1. Course introduces the concept of limit and continuity.
2. It develops the skill of differentiation and integration.
3. To introduce the skill of implementing Calculus to solve various real life problems.

Unit I

Real valued functions, some standard functions (polynomial, trigonometric, exponential and logarithmic) functions. Definition of limit of function, Algebra of limits (Definition only) and related problems on limit. Definition of continuity of real valued functions.

Unit II

Derivatives of standard functions - polynomial, exponential, trigonometric, logarithmic. Product rule, quotient rule for derivatives. Concept of higher order derivatives.

Unit III

Application of derivatives as a rate measurer, simple problems on area, perimeter, volume. To find the maximum and minimum of a function (Using 2^{nd} derivative test only). Definition of monotone function. To find the interval at which function is monotone.

Unit IV

Definition of integration. Integration as anti differentiation of simple functions. Integration by substitution. Integration by partial fractions. Integration by parts.

Unit V

Fundamental Theorem of Integral Calculus (Statement only). Definite Integral and its properties (without proof). Problems on definite integrals using properties. Application of definite integrals to find the area between the simple curves.

Textbooks:

1. B.C. Das and B.N. Mukherjee; Differential Calculus, U.N. Dhur and Sons.(Unit I-III)
2. BC Das and B.N. Mukherjee; Integral Calculus, U.N. Dhuri and Sons.(Unit IV-V).

Reference books:

1. Santinarayan; Differential Calculus
2. Santinarayan; Integral Calculus

Course Outcome:

On developing the concept and skill of basic calculus the following outcomes can be expected from the learner.

1. The learner is able to solve the problems on limits and continuity of different functions: constant function, polynomial function, trigonometric function, rational function, modulus function and step functions.
2. The learners can implement the concept and tool of differentiability and integration to solve real life problems such as: Rate of change of area, Increasing decreasing, Maximum and Minimum, Cost and Revenue problems etc.
3. Interested learners can extend the knowledge of calculus exploring different advanced topics such as: Cauchy's criterion of existence of limit, Sequential continuity, Leibnitz Theorem, Rectification etc.