From Session 2026-27 Onwards

	Proposed Structure UG- Mathematics													
Year	**Sem.**	**Major A (Subject 1)**			**Major B (Subject 2)**		**Minor (Subject 3)**			**CC/VC**			**Total**	**Degree**
		Courses		**Credits**		**Credits**	**Courses**		**Credits**	**Courses**		**Credits**	**Credits**	
1	**Sem. 1**	P-1	Differential Calculus	4	P-1	4	Q-1	Applicable Mathematics- I	2	CC-1	Elementary Number Theory	2	20	**Certificate**
		P-2	Matrices and Algebra	4	P- 2	4								
	Sem. 2	P-3	Integral Calculus	4	P-3	4	Q-2	Applicable Mathematics- II	2	VC-1	Vedic Mathematics	2	20	
		P-4	Geometry	4	P-4	4								
2	**Sem. 3**	P-5	Linear & Abstract Algebra	4	P-5	4	Q-3	Applicable Mathematics- III	2	CC-2	Foundations of Mathematics for Machine Learning and Artificial Intelligence	2	20	**Diploma**
		P-6	Mechanics	4	P-6	4								
	Sem. 4	P-7	Mathematical Methods	4	P-7	4	Q-4	Applicable Mathematics- IV	2	VC-2	Introduction to LaTeX using Overleaf	2	20	
		P-8	Ordinary Differential Equations	4	P-8	4								
3	**Sem. 5**	P-9	Numerical Analysis	4	P-9	4				**Internship/ Term Paper/Minor Project in Major A to be decided by student in Semester 5**		4	20	**Graduation Degree**
		P-10	Complex Analysis	4	P-10	4								
	Sem. 6	P-11	Integral & Partial Differential Equations	4	P-11	4							20	
		P-12	Differential Geometry & Tensor Analysis	4	P-12	4								
		P-13 A	Operations Research	4										
		P-13 B	Number Theory											
		P-13 C	Discrete Mathematics											
4	**Sem. 7**	P-14	Topology	4									20	**Graduation Honours with Research**
		P-15	Advanced Algebra	4										
		P-16	Fluid Mechanics	4										
		P-17	Geometry of Manifolds	4										
		P-18 A	Advanced Differential Equations	4										
		P-18 B	Advanced Complex Analysis											
		P-18 C	Measure Theory & Integration											
	Sem. 8	P-19	Research Methodology	4						**Major Research Project or Dissertation**		12	20	
		P-20	Term paper	4										
Rashtra Gaurav (Compulsory Non-credited)**														
Total Credits													**160**	

UG Semester I

Paper 1: Differential Calculus

Credit: 4 **T: 04**

Course Outcomes:

1. Know the concepts of calculus, namely, limits, continuity, differentiability of functions of one and two variables and their applications in the form of mean value theorem and Taylor's theorem.
2. Sketch curves in a plane using its mathematical properties in the different coordinate systems of reference.
3. Get knowledge of curvature, asymptotes, envelopes and evolutes.

UNIT I

Limit, continuity and differentiability of function of single variable, Cauchy's definition, Heine's definition, Uniform continuity, Borel's theorem, boundedness theorem, Bolzano's theorem, Intermediate value theorem, extreme value theorem, Darboux's intermediate value theorem for derivatives, Chain rule, indeterminate forms.

UNIT II

Rolle's theorem, Lagrange and Cauchy Mean value theorems, mean value theorems ofhigher order, Taylor's theorem with various forms of remainders, Successive differentiation, Leibnitz theorem, Maclaurin's and Taylor's series,

Limit and Continuity of functions of two variables, Differentiation of function of two variables, Necessary and sufficient condition for differentiability of functions two variables.

UNIT III

Partial differentiation, Euler's theorem on homogeneous function, Schwarz's and Young theorem, Taylor's theorem for functions of two variables with examples, Maxima and minima for functions of two variables, Lagrange multiplier method, Jacobians, Inverse function theorem and implicit function theorem.

UNIT IV

Tangents and normals, Asymptotes, Curvature, Envelops and evolutes, Tests forconcavity and convexity, Points of inflexion, Multiple points, Parametric representation of curves and tracing of parametric curves, Tracing of curves in Cartesian and Polar forms.

References:

Text Books:

1. T.M. Apostol, Calculus Vol. I, John Wiley & Sons Inc.
2. S. Balachandra Rao, C. K. Shantha, Differential Calculus, New Age Publication.

Suggested Reading:

1. H. Anton, I. Birens and S. Davis, Calculus, John Wiley and Sons, Inc.,2002.
2. G.B. Thomas and R.L. Finney, Calculus, Pearson Education, 2007.

Web References:

1. Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org
2. https://openlearninglibrary.mit/edu/courses
3. http://heecontent.upsdc.gov.in/SearchContent.aspx
4. https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science

Paper 2: Matrices and Algebra

Credit: 4 **T:04**

Course Outcomes:

1. Find the rank and eigen values of matrices.
2. Study the system of linear homogeneous and non-homogeneous equations.
3. Recognize the mathematical objects that are groups, and classify them as abelian, cyclic and permutation groups, etc.
4. Link the fundamental concepts of Groups and symmetrical figures.
5. Analyze the subgroups of cyclic groups.
6. Explain the significance of the notion of cosets, normal subgroups, and factor group.
7. Understand the concepts of rings, subrings and fields.

UNIT I

Elementary operations on matrices, Rank of a matrix, Echelon and normal form of a matrix, Inverse of a matrix by elementary operations, System of linear homogeneous and non-homogeneous equations, Theorems on consistency of a system of linear equations. Eigen values, Eigen vectors and characteristic equation of a matrix, Cayley-Hamilton theorem and its use in finding inverse of a matrix.

UNIT II

Equivalence relations and partitions, Congruence modulo n, Definition of a group with examples and simple properties, Subgroups, Generators of a group, Cyclic groups, Coset decomposition, Lagrange's theorem and its consequences, Fermat and Euler theorems. Normal subgroups, Quotient groups.

UNIT III

Homomorphism and isomorphism, Fundamental theorem of homomorphism, Theorems on isomorphism, Permutation groups, Even and odd permutations, The alternating group, Cayley's theorem, Direct products.

UNIT IV

Rings, types of rings (commutative rings, rings with unity, division rings, Integral domains and fields) with examples, basic properties, sub-rings, Characteristic of a ring, Ideals and quotient rings, Ring homomorphism, Isomorphism theorems, Field of quotient of an integral domain, polynomial rings.

References:

Text Books:

1. Linear Algebra by K. Hoffman and R. Kunze.
2. V. Sahai and V. Bist, Algebra, Narosa

Suggested Readings:

1. J.B. Fraleigh, A First Course in Abstract Algebra, Pearson
2. I.N. Herstein, Topics in Algebra, John Wiley & Sons

Web References:

1. Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org
2. https://openlearninglibrary.mit/edu/courses
3. http://heecontent.upsdc.gov.in/SearchContent.aspx
4. https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science

(For students with Mathematics as a minor subject)

Paper Q1: Applicable Mathematics– I

Credit: 2 **T:02**

Course Outcomes:

1. To compute the rank of a matrix and its applications in finding solutions of system of equations, computing Eigen values and Eigen vectors and their applications.

2. To Know the concepts of calculus, namely, limits, continuity, differentiability of functions and their applications in the form of mean value theorem and Taylor's theorem.

UNIT I

Types of matrices, elementary operations on matrices, rank of a matrix, echelon and normal forms of a matrix, inverse of a matrix by elementary operations, systems of linear homogeneous and non - homogeneous equations, consistency of linear system of equations.

UNIT II

Eigenvalues, eigenvectors and characteristic equation of a square matrix, Cayley-Hamilton theorem and its application in finding the inverse of a matrix.

UNIT III

Limit, continuity and differentiability of functions of single variable, successivedifferentiation, Leibnitz's theorem, Rolle's theorem, Lagrange's and Cauchy's mean value theorems, Taylor's and Maclaurins's series.

UNIT IV

Limit, continuity and differentiability of functions of two variables, partial derivatives, Euler's theorem for homogeneous functions, Jacobian.

References:

Textbooks

1. Linear Algebra by K. Hoffman and R. Kunze.
2. Calculus, Volumes I & II by T. M. Apostol.
3. Mathematical Analysis by S.C. Malik and S. Arora, New Age International Limited, New Delhi.

Suggested Books

1. R. R. Goldberg : Methods of Real Analysis, Oxford & IBH Pub. Co. Pvt. Ltd.
2. R. G. Bartle, The Elements of Real Analysis, Wiley International Edition.

Co-Curricular Course in Mathematics

Paper CC-1: Elementary Number Theory
(Pre-requisites: Mathematics in Class 12)

Credit: 2 **T:02**

Course Objectives:

1. To introduce the student to basic concepts of number theory.
2. To identify and apply various properties of and relating to the integers.
3. To apply number theoretic algorithms in cryptography.

Course Outcomes:

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

1. Solve problems in elementary number theory.
2. Study certain number theoretic functions and their properties.
3. Understand the concept of congruence and related theorems.
4. Apply linear congruences in cryptography.

UNIT I

GCD, Euclid algorithm for finding GCD, Extended Euclid algorithm, Prime numbers and their properties, Prime number theorem.

UNIT II

Congruence and its properties, Linear Congruence, Chinese Remainder theorem, Fermat's theorem, Euler's theorem, Wilson's theorem,

UNIT III

Primality testing algorithm, Discrete logarithm, Some factorization algorithms.

UNIT IV

Some algebraic structure: Group, Ring and Field, Finite fields and their construction.

Recommended Books:

1. Elementary Number Theory, Burton, Mc Graw Hill.

UG Semester II

Paper 3: Integral Calculus

Credit: 4 **T:04**

Course Outcomes:

1. Some of the families and properties of Riemann integrable functions, and the applications of the fundamental theorems of integration.
2. Beta and Gamma functions and their properties.
3. The valid situations for the inter-changeability of differentiability and integrability with infinite sum, and approximation of transcendental functions in terms of power series.
4. Compute area of surfaces of revolution and the volume of solids by integrating over cross-sectional areas.

UNIT I

Definite integrals as limit of the sum, Riemann integral, Integrability of continuous and monotonic functions, Fundamental theorem of integral calculus, Mean value theorems of integral calculus, Differentiation under the sign of Integration.

UNIT II

Improper integrals, their classification and convergence, Comparison test, μ- test, Abel's test, Dirichlet's test, quotient test, Beta and Gamma functions.

UNIT III

Rectification, Volumes and Surfaces of Solid of revolution, Pappus theorem, Multiple integrals, change of order of double integration, Dirichlet's theorem, Liouville's theorem for multiple integrals.

UNIT IV

Vector Differentiation, Gradient, Divergence and Curl, Normal on a surface, Directional Derivative, Vector Integration, Theorems of Gauss, Green, Stokes and related problems.

References:

Text Books:

1. T.M. Apostol, Calculus Vol. II, John Wiley Publication.
2. Shanti Narayan, P.K. Mittal, Integral Calculus, S. Chand.

Suggested Readings:

1. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.

Web References:

1. Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org
2. https://openlearninglibrary.mit/edu/courses
3. http://heecontent.upsdc.gov.in/SearchContent.aspx
4. https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science

Paper 4: Geometry

Credit: 4 **T: 04**

Course Outcomes:

1. To learn and visualize the fundamental ideas of coordinate geometry.
2. To describe some surfaces by using analytical geometry.
3. To gain knowledge about regular geometrical figures and their properties.

UNIT I

General equation of second degree, System of conics, Tracing of conics, Confocal conics, Polar equation of conics and its properties.

UNIT II

Three-Dimensional Coordinates, Projection and Direction Cosine, Plane (Cartesian and vector form), Straight line in three dimension (Cartesian and vector form).

UNIT III

Sphere, Cone and Cylinder.

UNIT IV

Central conicoids, Paraboloids, Plane section of conicoids, Generating lines, Confocal conicoids, Reduction of second degree equation.

References:
Text Books:
1. P. R. Vittal, Analytical Geometry
2. S. L. Loney, The Elements of Coordinate Geometry, Macmillan Suggested

Suggested Readings:

1. Robert J.T. Bell, Elementary Treatise on Coordinate Geometry of three dimensions, Macmillan India Ltd

Web References:

1. Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org
2. https://openlearninglibrary.mit/edu/courses
3. http://heecontent.upsdc.gov.in/SearchContent.aspx
4. https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science

(For students with Mathematics as a minor subject)

Paper Q2: Applicable Mathematics– II

Credit: 2 **T:02**

Course Outcomes:

1. To understand the concepts of vector calculus
2. To understand application and techniques of solving various types of ordinary differential equations.
3. To learn sequences and various tests to check convergence of an infinite series.

UNIT I

Vector differentiation, gradient, divergence and curl with their physical interpretations, tangent and normal on a surface, directional derivative, line, surface and volume integrals, applications of Green's, Stoke's and Gauss' divergence theorems (without proofs). Application and properties of Beta and Gamma function, Dirichlet and Liouville theorems.

UNIT II

Ordinary differential equations - Bernoulli's equation, exact differential equations and integrating factors, special integrating factors and transformations, differential equations of order one and degree more than one, Clairaut's equation, singular solutions and orthogonal trajectories.

UNIT III

Linear differential equations with constant coefficients, homogeneous Linear differential equations, series solutions of Legendre's, Bessel's and hypergeometric equations and their basic properties.

UNIT IV

Sequences, limit of a sequence, convergence, divergence and oscillation of a sequence, infinite series and its convergence, geometric and harmonic series, tests for convergence and divergence - comparison test, Cauchy integral test, D'Alembert's ratio test, Cauchy's nth root test, Raabe's logarithmic test, DeMorgan and Bertrand's test, alternating series, absolute and conditional convergence, Leibnitz's theorem (without proof).

References:
Textbooks

1. G.F.Simmons: Differential Equations with Applications and HistoricalN, Tata McGraw Hill.
2. R.G. Bartle : Introduction to Real Analysis, Wiley.
3. M.R. Spiegel: Theory and Problems of Vector Analysis, Schaum Outline Series, MgGraw Hill Book Company.

Suggested books:

1. B. Rai, D.P. Choudhary & H.J. Freedman, A Course in Differential Equations.
2. S. L Ross, Differential Equations, 3rd Edition, Wiley

Vocational Course in Mathematics

Paper VC-1: Vedic Mathematics
(Pre-requisites: Mathematics in Class 12)

Credit: 2 **T:02**

Course Outcomes:

1. To understand the concepts of Vedic arithmetic as in Indian knowledge system.
2. To understand application and techniques of Vedic algebra as in Indian knowledge system.

UNIT I

Vedic Arithmetic: Base and complement, addition and subtraction, some important vedic sutras, Multiplication- Ekadhikenpurven method (multiplication of two numbers oftwo digits), Ekununenpurven method (multiplication of two numbers of three digits), Urdhvatiragbhyam method (multiplication of two numbers of three digits), Nikhilam Navtashchramam Dashtaha (multiplication of two numbers of three digits), Combined Operations.

UNIT II

Division- Nikhilam Navtashchramam Dashtaha (two digits divisor), Paravartya Yojyet method (three digits divisor), Divisibility- Ekadhikenpurven Method (two digits divisor), Eknunenpurven method (two digits divisor), LCM and HCF, Power- Square and Cube of two digit numbers, Square root of four digit numbers and Cube root of six digit numbers, calendar.

UNIT III

Vedic Algebra: Multiplication (Quadratic expressions of single variable)- Urdhvatiragbhyam Method, Combined Operations.

UNIT IV

Division (Divisor: Linear expression of single variable), Factorization (Quadratic expression of single variable), Solution of linear simultaneous expressions.

Recommended Books:

1. Vedic Mathematics, Motilal Banarsi Das, New Delhi.
2. Vedic Ganita: Vihangama Drishti-1, Siksha Sanskriti Uthana Nyasa, New Delhi.
3. Vedic Ganita Praneta, Siksha Sanskriti Uthana Nyasa, New Delhi.
4. Vedic Mathematics: Past, Present and Future, Siksha Sanskriti Uthana Nyasa, New Delhi.
5. Leelavati, Chokhambba Vidya Bhavan, Varanasi.
6. Bhartiya Mathematicians, Sharda Sanskrit Sansthan, Varanasi.
7. Beejganitam, Chokhambba Vidya Bhavan, Varanasi.

UG Semester III

Paper 5: Linear & Abstract Algebra

Credit: 4 **T:04**

Course Outcomes:

1. The fundamental concept of Rings, Fields, subrings, integral domains and the corresponding morphisms.
2. The concept of linear independence of vectors over a field, the idea of basis and the dimension of a vector space.
3. Basic concepts of linear transformations, the Rank-Nullity Theorem, matrix of a linear transformation and the change of basis.
4. Automorphisms for constructing new groups from the given group.
5. Group actions, Sylow theorems and their applications to check nonsimplicity.
6. Compute inner products and determine orthogonality on vector spaces.

UNIT I

Automorphism, inner automorphism, automorphism groups and their computations, Conjugacy relations, Normaliser, Counting principle and the class equation of a finite group, Center of group of prime power order, simple groups, Group action, Burnside lemma, Sylow theorems and its applications.

UNIT II

Prime and maximal ideals, Euclidean Rings, Principal ideal rings, Polynomial Rings, Polynomial over the Rational Field, The Eisenstein Criterion, Polynomial Rings over Commutative Rings, unique factorization domain.

UNIT III

Vector spaces, Subspaces, Linear independence and dependence of vectors, Basis and dimension, Quotient space, Linear transformations, Direct sums, The Algebra of linear transformations, rank nullity theorem, their representation as matrices, Linear functionals, Dual space, Characteristic values, Cayley Hamilton Theorem.

UNIT IV

Inner product spaces, Cauchy-Schwarz inequality, Orthogonal vectors, Orthonormal sets and bases, Bessel's inequality for finite dimensional spaces, Gram-Schmidt orthogonalization process, Bilinear and Quadratic forms.

References:

Text books:

1. Topics in Algebra by I. N. Herstein.
2. Algebra by V. Sahai and V. Bist
3. Linear Algebra by V. Sahai and V. Bist

Suggested Readings:

1. Linear Algebra by K. Hoffman and R. Kunze.

Web References:

1. Digital platforms web links : NPTEL/SWAYAM/ MOOCS/Openstax.org
2. https://openlearninglibrary.mit/edu/courses
3. http://heecontent.upsdc.gov.in/SearchContent.aspx
4. https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science

Paper 6: Mechanics

Credit: 4 **T:04**

Course Outcomes:

1. The significance of mathematics involved in physical quantities and their uses.
2. To understanding the various concepts of basic mechanics like simple harmonic motion, motion under other laws and forces.
3. To study and to learn the cause-effect related to these.
4. The applications in observing and relating real situations/structures.

UNIT I

Frame of reference, work energy principle, Forces in three dimensions, Poinsot's central axis, Wrenches, Null lines and planes.

UNIT II

Virtual work, Stable and Unstable equilibrium, Catenary, Catenary of uniform strength.

UNIT III

Velocities and accelerations along radial and transverse directions, and along tangential and normal directions, Simple Harmonic motion, Motion under other law of forces. Elastic strings, Motion in resisting medium, Constrained motion, Motion on smooth and rough plane curves.

UNIT IV

Motion of particles of varying mass, Rocket motion, Central orbit, Kepler's laws of motion, Motion of particle in three dimensions, Rotating frame of reference, Rotating Earth, Acceleration in terms of different coordinates systems.

References Text Books:

1. R.C. Hibbeler, Engineering Mechanics-Statistics
2. Nelson, Engineering Mechanics- Dynamics, Tata McGraw Hill

Suggested Readings:

1. J.L. Synge & B.A. Griffith, Principles of Mechanics, Tata McGraw Hill

Web References:

1. Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org
2. https://openlearninglibrary.mit/edu/courses
3. http://heecontent.upsdc.gov.in/SearchContent.aspx
4. https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science

(For students with Mathematics as a minor subject)

Paper Q3: Applicable Mathematics– III

Credit: 2 **T:02**

Course Outcomes:

1. To understand the concepts of groups, cyclic groups, and homomorphism of groups.
2. To know the concepts of rings, ideals, quotient rings and homomorphism of rings.
3. To know the concept of vector spaces and linear transformations.

UNIT I

Equivalence relations and partitions, congruence modulo n, groups, subgroups, cyclic groups, coset decomposition, Lagrange's theorem, Fermat's & Euler's theorems.

UNIT II

Normal subgroups, quotient groups, homomorphism and homomorphism theorems, permutation group, even and odd permutations.

UNIT III

Rings, types of rings - commutative rings, rings with unity, division rings, integral domains and fields, subrings, ideals and quotient rings, ring homomorphism, characteristic of a ring, Polynomial rings.

UNIT IV

Vector spaces, subspaces, linear independence and dependence, basis and dimension, quotient space, linear transformations.

References:

Textbooks

1. V. Sahai & V. Bist : Algebra, Narosa.
2. J.A. Gallian : Contemporary Abstract Algebra, Narosa.
3. R.G. Bartle : Introduction to Real Analysis, Wiley.

Suggested books:

1. J.B. Fraleigh : A First course in Abstract Algebra, Pearson.
2. D.S. Dummit & R.M. Foote : Abstract Algebra, Wiley International edition.

Co-Curricular Course in Mathematics

Paper CC-2: Foundations of Mathematics for Machine Learning and Artificial Intelligence

Credit: 2 **T:02**

Course Objectives:

1. Introduce students to mathematical concepts used in AI and Machine Learning.
2. Develop understanding of linear algebra and calculus and Statistics for AI models.
3. Connect mathematical ideas with AI applications such as data analysis.

Course Outcomes:

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

1. Represent data using vectors and matrices.
2. Apply linear algebra concepts in machine learning models.
3. Understand the role of derivatives and gradients in optimization.
4. Interpret mathematical structures used in AI algorithms.

UNIT I : Introduction to AI and LLM

What is Artificial Intelligence(AI), machine learning(ML) and deep learning(DL)? What are Large Language Models (LLM)? Applications (ChatGPT, translation, chatbots), Tokens and text representation, Basic idea: next-word prediction Activities: Interacting with ChatGPT, Simple prompt experiments

UNIT II : Linear Algebra for Artificial Intelligence

Vectors and vector spaces, Linear independence and Span, Bases, Matrices, Different types of matrices, Matrix operations, Rank, Determinants, Matrices in system of linear equations, Linear transformations, Eigenvalues and eigenvectors, Singular Value Decomposition, Data representation using Vectors and matrices, use of vectors in regression, Applications in AI: Feature vectors, Dimensionality reduction, Principal Component Analysis (PCA)

UNIT III : Calculus for Machine Learning

Functions of several variables, Partial derivatives, Gradient and Jacobian, Chain rule, Optimization methods, Gradient descent

Applications in AI: Training neural networks, Loss functions and optimization

UNIT IV : Statistics for Machine Learning

Random variables and distributions, Expectation and variance, Conditional probability and Bayes theorem

Recommended Books and Links :

1. Mathematics for Machine Learning — Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong
2. Dive into Deep Learning (Open Source Book) by Aston Zhang, Zachary C. Lipton, Mu Li, and Alexander J. Smola
3. Foundations for Machine Learning (https://youtu.be/C8hEa2qb46k?si=pIYobI15yHjm8jyL)

UG Semester IV
Paper 7: Mathematical Methods

Credit: 4 **T:04**

Course Outcomes:

1. To develop mathematical skills in calculus and analysis.
2. To get knowledge of Laplace Transforms and Fourier series.
3. To get acquainted with the essentials of calculus of variations.

UNIT I

Definition of a sequence, theorems on limits of sequences, bounded and monotonic sequences, Cauchy's convergence criterion, Cauchy sequence, limit superior and limit inferior of a sequence, subsequence, Series of non-negative terms, convergence and divergence, Comparison tests, Cauchy's integral test, Ratio tests, Root test, Raabe's logarithmic test, de Morgan and Bertrand's tests, alternating series, Leibnitz's theorem, absolute and conditional convergence. Sequences and series of functions: point wise and uniform convergence of sequences of functions, consequences of uniform convergence, integration and differentiation of series of functions.

UNIT II

Existence theorems for Laplace transforms, Linearity of Laplace transform and their properties, Laplace transform of the derivatives and integrals of a function, Convolution theorem, inverse Laplace transforms, Solution of the differential equations using Laplace transforms.

UNIT III

Fourier series, Fourier expansion of piecewise monotonic functions, Half and full range expansions, Fourier transforms (finite and infinite), Fourier integral.

UNIT IV

Calculus of variations-Variational problems with fixed boundaries- Euler's equation for functionals containing first order derivative and one independent variable, Extremals, Functionals dependent on higher order derivatives, Functionals dependent on more than one independent variable, Variational problems in parametric form.

References:

Text Books:

1. T.M. Apostol. Mathematical Analysis, Pearson
2. RG Bartle, Introduction to Real Analysis, Wiley India

Suggested Readings:

1. G.F. Simmons, Differential Equations with Applications and Historical Notes, Tata- McGraw Hill
2. A.S. Gupta, Calculus of Variations with Applications Prentice Hall India.

Web References:

1. Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org
2. https://openlearninglibrary.mit/edu/courses
3. http://heecontent.upsdc.gov.in/SearchContent.aspx
4. https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science

Paper 8: Ordinary Differential Equations

Credit: 4 **T:04**

Course Outcomes:

1. Formulate Differential Equations for various Mathematical models.
2. Solve first order non-linear differential equation and linear differential equations of higher order using various techniques.
3. Apply these techniques to solve and analyze various mathematical models.
4. Conceptualize nature of critical points.

UNIT I

Differential Equations of first order and first degree, variable separable equations and equations reducible to this form, linear equations and Bernoulli equations, Exact differential equations and integrating factors, special integrating factors and transformations. Differential Equations of first order and higher degree, Clairaut equation, singular solutions. Orthogonal trajectories.

UNIT II

Linear Differential Equations with constant coefficients, homogeneous linear equation with constant coefficients, Wronskian, its properties and applications. Second order linear differential

equations with variable coefficients: Use of a known solution to find another, normal form, method of undetermined coefficient, variation of parameters.

UNIT III

Systems of first order equations, linear systems, homogeneous linear systems with constant coefficients, Volterra's prey predator equations, The phase plane & its phenomena, types of critical points & Stability, Critical points & stability for linear system, stability by Liapunov's direct method.

UNIT IV

Series solutions of differential equations, Power series method. Bessel, Legendre and Hypergeometric functions and their properties, recurrence and generating relations.

References

Text Books:

3. B. Rai, D.P. Choudhary & H.J. Freedman, A Course in Differential Equations.
4. S. L Ross, Differential Equations, 3rd Edition, Wiley

Suggested Readings:

1. G.F. Simmons, Differential Equations with Applications and Historical Notes, Tata McGraw Hill

(For students with Mathematics as a minor subject)

Paper Q4: Applicable Mathematics– IV

Credit: 2 **T:02**

Course Outcomes:

1. To understand application and techniques of solving various types of ordinary differential equations.
2. To understand the Laplace transforms and its applications in solving differential equations.
3. To understand Fourier series and Fourier transforms.
4. To understand standard techniques for finding numerical solution of ordinary differential equations.
5. To know the basic concepts of complex analysis including Cauchy's integral formula, derivative of analytic functions, Taylor's and Laurent's series.

UNIT I

Functions of complex variables - analytic functions, Cauchy - Riemann equations, harmonic functions, Cauchy's integral theorem.

UNIT II

Cauchy's integral formula, derivatives of analytic functions, formulae for first, second and nth derivatives, Taylor's and Laurent's series, singularities, zeroes and poles of order n.

UNIT III

Laplace transforms - existence theorem, Laplace transforms of derivatives and integrals, inverse Laplace transform, convolution theorem, applications to simple linear differential equations.

UNIT IV

Periodic functions, Fourier series, Fourier expansion of piecewise monotonic functions, half and full range expansions, Fourier transforms (finite and infinite), Fourier integral.

References:

Textbooks:

1. J.W. Brown and R.V. Churchill : Complex Variables and Applications, Mc Graw Hill.
2. Complex Variables, Schaum's Outline Series
3. G. F. Simmons : Differential Equations with Applications and Historical Notes, Tata McGraw Hill.
4. T. M. Apostol : Mathematical Analysis.

Vocational Course in Mathematics

Paper VC-2: Introduction to LaTeX using Overleaf

Credit: 2 **T:02**

Course Objectives:

1. To provide an introduction to technical writing, complex graphics, and computer presentations with LaTeX
2. To create basic types of LaTeX documents (article, report, letter, book)
3. To format words, lines, and paragraphs, design pages, create lists, tables, references, and figures in LaTeX.
4. To typeset the complicated mathematics: basic formulas (inline), centered and numbered equations, aligning multi-line equations.
5. To list the content and references: creating a table of contents, lists of figures and tables, create bibliographies, and generate the index.
6. To create professional presentation slides using LaTeX.

Course Outcomes:

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

1. Having the skill of using high-quality typesetting system.
2. LaTeX for publication of research papers, theses and book chapters.
3. Typesetting of complex mathematical formulae using LaTeX.
4. Create Tables, Graphics and Pictures Lists, Arrays and Bibliography by using LaTeX.
5. Create Slides with Beamer.

UNIT I

Introduction to LaTeX. Online Overleaf access. Structure of LaTeX document. Defining class of the document. Packages and different environments. Writing the first LaTeX content. Creating a Title, chapters and sections and their labeling, basics of LaTeX syntax, page style, fonts, font sizes, font styles.

UNIT II

Labelling Table of Contents, coloured text, boxes, theorems, comments & spacing, special characters, line breaking. Columns, multi-columns and minipages. Page numbering, foot notes, headers and footers. Fancy page styles. Short cuts and definitions.

UNIT III

Introduction to mathematics environment, writing Greek symbols, some basic mathematics type structure: fractions, superscript, subscript, overline, underline etc.Matrix, determinant and other similar structure. Writing Equations and Arrays. Equation references. Introduction to *amsmath* package. Various mathematical operation symbols.Inserting pictures and tables, creating reference database.

UNIT IV

Presentations in LaTeX. Introduction to beamer class. Themes of beamer presentations.

Recommended Books:

1. LaTeX 2e: An Unofficial Reference Manual by Karl Berry, Stephen Gilmore, et al.
2. Latex: A Document Preparation System, 2/E, A Document Preparation System User's Guide and Reference Manual Leslie Lamport
3. https://www.cs.ntua.gr/~sivann/books/LaTeX%20-%20User's%20Guide%20and%20Reference%20Manual-lamport94.pdf
4. https://www.overleaf.com/learn
5. https://www.colorado.edu/aps/sites/default/files/attached-files/latex_primer.pdf

UG Semester V

Paper 9: Numerical Analysis

Credit: 4 **T:04**

Course Outcomes:

1. Some numerical methods to find the zeroes of nonlinear functions of a single variable and solution of a system of linear equations, up to a certain given level of precision.
2. Interpolation techniques to compute the values for a tabulated function at points not in the table.
3. Applications of numerical differentiation and integration to convert differential equations into difference equations for numerical solutions.

UNIT I

Solution of equations: bisection, Secant, Regular Falsi, Newton Raphson's method, Newton's method for multiple roots, Interpolation, Lagrange and Hermite interpolation, Difference schemes, Divided differences, Interpolation formula using differences.

UNIT II

Numerical differentiation, Numerical Quadrature: Newton Cotes Formulas, Gaussian Quadrature Formulas, System of Linear equations: Direct method for solving systems oflinear equations (Gauss elimination, LU Decomposition, Cholesky Decomposition),Iterative methods (Jacobi, Gauss Seidel, Relaxation methods). The algebraic Eigen value problem: Jacobi's method, Givens method, Power method.

UNIT III

Numerical solution of Ordinary differential equations: Euler method, single step methods, Runge-Kutta method, Multi-step methods: Milne-Simpson method, Types of approximation: Last Square polynomial approximation, Uniform approximation, Chebyshev polynomial approximation.

UNIT IV

Difference Equations with constant and variable coefficients and their general and particular solutions.

References

Text Books:

1. S. S. Sastry, Introductory Methods of Numerical Analysis, PHI

2. Numerical Methods for Engineering and scientific computation by M. K. Jain, S.R.K. Iyengar & R.K. Jain.

Suggested Readings:

1. Kandasamy P. et al., Numerical Methods, S. Chand & Co.

Paper 10: Complex Analysis

Credit: 4 **T:04**

Course Outcomes:

1. To understand the topics of Complex Analysis needed in pure Mathematics.
2. Understand the significance of differentiability of complex valued functions leading to the understanding of Cauchy-Riemann equations.
3. Evaluate the contour integrals and understand the role of Cauchy-Goursat theorem and the Cauchy integral formula.
4. Expand some simple functions as their Taylor and Laurent series, classify the nature of singularities, find residues.
5. To understand the properties of Maximum modulus of a complex valued functions.

UNIT I

Stereographic projection, Continuity and Differentiablity of complex functions, Analytic functions, Cauchy Riemann equations, Harmonic functions.

UNIT II

Complex integration, Cauchy-Goursat theorem, Cauchy's integral formula, Formulae for first, second and nth derivatives, Cauchy's Inequality, Liouville's Theorem, Elementary functions, Mapping by elementary functions, conformal mapping, Mobius Transformation.

UNIT III

Taylor and Laurent Series, Convergence of sequence and series of functions, Cauchy's criterion, Weierstrass' M-test, Differentiation and Integration of power series, Radius of convergence, Absolute and uniform convergence of Power series.

UNIT IV

Zeros and poles of order m, Singularities, Residue and residue theorem, Maximum Modulus theorem, Schwarz's Lemma, Hadamards three circle theorem, Minimum Modulus theorem.

Text books:

1. J. W. Brown & R. V. Churchill , Complex variable and applications, Mc Graw Hill.

Internship/Term Paper/Minor Project

Credit: 4

UG Semester VI

Paper 11 : Integral & Partial Differential Equations

Credit: 4 **T:04**

Course Outcomes:

1. Describe different types of Linear types of Linear integral equations and partial differential equations for the impart knowledge of formulation of practical problems of applies mathematics.
2. Understand the theoretical basic behaviour of different types of arising problems such as Fredholm, Volterra, Singular, Hilbert and Cauchy integral equations.
3. Explain the foundations of various problems by various methods.
4. Deal with problems in applied mathematics, theoretical mechanics and mathematical physics and engineering.

UNIT I

Origin of first order partial differential equations. Partial differential equations of the first order and degree one, Lagrange's solution, Partial differential equation of first order and degree greater than one. Cauchy's method of characteristic, Charpit's method of solution, Surfaces orthogonal to the given system of surfaces.

UNIT II

Origin of second order PDE, Solution of partial differential equations of the second and higher order with constant coefficients, Classification of linear partial differential equations of second order, Solution of second order partial differential equations with variable coefficients, Monge's method of solution.

UNIT III

Linear Integral Equations-Definition and Classification of conditions, Special kinds of Kernels, Eigen values and Eigen functions, Convolution integral, Inner product, Integral equations with separable Kernels. Reduction to a system of algebraic equations.

UNIT IV

Fredholm alternative, Fredholm Theorem, Fredholm alternative theorem, Approximate method, Method of successive approximations, Iterative scheme. Solution of Fredholm and Volterra integral equation, Results about resolvent Kernel.

References:

Text Books:

1. I.N. Sneddon: Elements of Partial Differential Equations, Mc -Graw Hill, 1988.
2. Ram P. Kanwal, Linear Integral Equations (2nd ed.), Birkhäuser, Boston.

Suggested Readings:

1. T. Amarnath: An Elementary Course in Partial Differential Equations, Narosa Publishing House, New Delhi, 2005.
2. Tyn Myint U: Partial Differential Equations of Mathematical Physics, Elsevier Publications.

Paper 12: Differential Geometry & Tensor Analysis

Credit: 4 **T:04**

Course Outcomes:

1. Explain the concepts of differential geometry.
2. Understand the concepts of tensors in differential geometry.
3. Apply various concepts of differential calculus in tensors.

UNIT I

Local theory of curves-Space curves, Examples, Plane Curves, tangent and normal and binormal, Osculating Plane, normal plane and rectifying plane, Helices, Serret-Frenet apparatus, contact between curve and surfaces, tangent surfaces, involutes and evolutes of curves, Bertrand curves, Intrinsic equations, fundamental existence theorem for space curves.

UNIT II

Metric-first fundamental form and arc length, Direction coefficients, families of curves, intrinsic properties, geodesics, canonical geodesic equations, normal properties of geodesics, geodesics curvature, Gauss-Bonnet theorem, Gaussian curvature, normal curvature, Meusneir's theorem, mean curvature, Gaussian curvature, umbilic points, lines of curvature, Rodrigue's formula,Euler's theorem.

UNIT III

Tensor algebra: Vector spaces, the dual spaces, tensor product of vector spaces, transformation formulae, contraction, special tensor, inner product, associated tensor.

Tensor Analysis: Contravariant and covariant vectors and tensors, Mixed tensors, Symmetric and skew-symmetric tensors, Algebra of tensors, Contraction and inner product, Quotient theorem, Reciprocal tensors, Christoffel's symbols, Covariant differentiation.

UNIT IV

Gradient of scalars, Divergence of a contra-variant vector, covariant vector and conservative vectors, Laplacian of an invariant, curl of a covariant vector, irrotational vector, Riemannian space, Riemannian curvatures and their properties, Ricci tensor, and scalar curvature, Einstein space and Einstein tensor, Geodesics.

References:

Text books:

1. T.J. Willmore, An introduction to Differential Geometry,Dover Publication 2012.
2. S.Lang., Fundamentals of Differential Geometry; Springer, 1999.
3. B. O'Neil, Elementary Differential Geometry, 2nd Edition, Academic press, 2006.
4. R.S. Mishra, A Course in Tensors with Application to Riemannian Geometry, Pothishala 1988.

Suggested Readings:

1. David C. Kay, Tensor Analysis, Schaum's Outline series McGraw Hill 1988.

Web References:

1. Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org
2. https://openlearninglibrary.mit/edu/courses
3. http://heecontent.upsdc.gov.in/SearchContent.aspx
4. https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science

Paper 13 A: Operations Research

Credit: 4 **T:04**

Course Outcomes:

1. Be able to understand the application of OR and frame a LP Problem with solution
2. Be able to build and solve Transportation and Assignment problems using appropriate method.
3. Be able to design and solve simple models of CPM and queuing to improve decision making and develop critical thinking and objective analysis of decision problems.
4. to take best course of action out of several alternative courses for the purpose of achieving objectives by applying game theory and sequencing models.

UNIT I

Linear programming problems, Slack and surplus variables, Statement of general Linear

programming Problems, Standard and matrix forms of linear programming problem, Basic feasible solution.

UNIT II

Convex sets, Fundamental theorem of linear programming, Simplex method. Artificial variables, Big-M method, Two- phase method, Revised simplex method.

UNIT III

Resolution of degeneracy, Duality in linear programming problems, Dual simplex method, Primal-dual relation analysis, integer programming.

UNIT IV

Transportation problems, assignment problems, Queuing Theory, Markov Chains, PERT and CPM, Optimization and constrained Optimization using Langrange's Multiplier.

References:

Text books:

1. Hamdy A. Taha, Operations Research: An Introduction, 10th Edition, Pearson
2. G. Hadley, Linear Programming.

Suggested Readings:

1. Kanti Swaroop, P. K. Gupta, Manmohan, Operations Research, Sultan Chand.

Web References:

1. Digital platforms web links: NPTEL/SWAYAM/MOOCS/Openstax.org
2. https://openlearninglibrary.mit/edu/courses
3. http://heecontent.upsdc.gov.in/SearchContent.aspx
4. https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science

Paper 13 B: Number Theory

Credit: 4 **T:04**

Course Outcomes:

1. To have knowledge of primes, congruences, quadratic residues and primitive roots.
2. Solving Diophantine equations.
3. Derive generating functions and recurrence relations.

UNIT I

Divisibility; Euclidean algorithm; primes; congruences; Fermat's theorem, Euler's theorem and Wilson's theorem; Fermat's quotients and their elementary consequences; solutions of congruences; Chinese remainder theorem; Euler's phi-function. Congruences

UNIT II

Congruence modulo powers of prime; primitive roots and their existence; quadratic residues; Legendre symbol, Gauss' lemma about Legendre symbol; quadratic reciprocity law; proofs of various formulations; Jacobi symbol.

UNIT III

Diophantine Equations, Solutions of ax + by = c, $xn+ yn= zn$; properties of Pythagorean triples; sums of two, four and five squares; assorted examples of Diophantine equations.

UNIT IV

Generating functions and recurrence relations, generating function models, calculating coefficient of generating functions, partitions, exponential generating functions, a summation method. recurrence relations: recurrence relation models, divide and conquer relations, solution of linear recurrence relations, solution of inhomogeneous recurrence relations, solutions with generating functions.

References:

Text Books:

1. Niven, I., Zuckerman, H. S. and Montgomery, H. L. (2003) An Int. to the Theory of Numbers (6th edition) John Wiley and sons, Inc., New York.
2. Burton, D. M. (2002) Elementary Number Theory (4th edition) Universal Book Stall, New Delhi.

3. Balakrishnan, V. K. (1996) Introductory Discrete Mathematics, Dover Publications.

Suggested Readings:

1. Balakrishnan, V. K. (1994) Schaum's Outline of Theory and Problems of Combinatorics Including Concepts of Graph Theory, Schaum's Outline.

Web References:

1. Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org
2. https://openlearninglibrary.mit/edu/courses
3. http://heecontent.upsdc.gov.in/SearchContent.aspx
4. https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science

Paper 13 C: Discrete Mathematics

Credit: 4 **T: 04**

Course Outcomes:

1. Lattices and their types.
2. Boolean algebra, switching circuits and their applications.
3. Graphs, their types and its applications in study of shortest path algorithms.
4. Display familiarity with the mathematical models which are the integral part of the hardware and software of computer science.
5. Elaborate and expand their understanding of the tools helpful in the implementation of circuit design, AI algorithms and compiler construction.

UNIT I

Propositional Logic- Proposition logic, basic logic, logical connectives, truth tables, tautologies, contradiction, normal forms (conjunctive and disjunctive), modus ponens and modus tollens, validity, predicate logic, universal and existential quantification, proof by implication, converse, inverse contrapositive, contradiction, direct proof by using truth table.

UNIT II

Boolean Algebra- Basic definitions, Sum of products and products of sums, duality principle, Boolean functions, Logic gates and Karnaugh maps. Lattice, Duality, types of lattices, sublattices, bounded lattices, distributive lattices, complemented lattices, modular lattices, join irreducible elements.

UNIT III

Combinatorics- Inclusion- exclusion, recurrence relations (nth order recurrence relation with constant coefficients, Homogeneous recurrence relations, Inhomogeneous recurrence relations), generating function (closed form expression, properties of G.F., solution of recurrence relations using G.F. solution of combinatorial problem using G.F.)

UNIT IV

Finite Automata- Basic concepts of automation theory, Deterministic Finite Automation (DFA), transition function, transition table, Non Deterministic Finite Automata (NDFA), Mealy and Moore machine, Minimization of finite automation.

References:

Text books:

1. Discrete Mathematics by C. L.Liu.
2. Discrete Mathematics with computer application by Trembley and Manohar.
3. Mendelson, Elliott: Introduction to Mathematical Logic, Chapman & Hall, 1997
4. John E. Hoprcroft, Rajeev Motwani, Jeffrey D. Ullman: Introduction to Automata Theory, Languages and Computation, Pearson Education, 2000

Suggested Readings:

1. Arnold B. H.: Logic and Boolean Algebra, Prentice Hall, 1962
2. K. H. Rosen: Discrete Mathematics and its applications, MGH 1999

Web References:

1. Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org
2. https://openlearninglibrary.mit/edu/courses
3. http://heecontent.upsdc.gov.in/SearchContent.aspx
4. https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science