KASHI NARESH UNIVERSITY, BHADOHI

DEPARTMENT OF MATHEMATICS

(National Education Policy-2020)

Syllabus

of

MATHEMATICS

(Effective from Academic Session 2026-2027)

For

B.A./B.Sc.

Approved by

Board of Studies
Department of Mathematics
Faculty of Science
Kashi Naresh University
Bhadohi

Convenor/Head
Department of Mathematics
Kashi Naresh University, Bhadohi

Dean
Faculty of Science
Kashi Naresh University, Bhadohi

(Dr. Rahul Kumar)
Member of Board of Studies

(Dr. Vinod Kumar Bharati)
Member of Board of Studies

(Dr. Iftekhar Ahamad Ansari)
Member of Board of Studies

Programme Objectives

The Undergraduate Programme in Mathematics aims to:

1. Provide in-depth knowledge of Mathematics through a thorough understanding of key mathematical concepts, principles, theories, and their applications.
2. Inculcate a strong interest and appreciation for the learning of Mathematics among students.
3. Develop broad and balanced knowledge and understanding of definitions, fundamental concepts, principles, and theorems in Mathematics.
4. Enable learners to apply the knowledge and skills acquired during the programme to solve theoretical as well as applied problems in Mathematics.
5. Develop the ability among students to use relevant mathematical tools and techniques for addressing issues and problems arising in social sciences, natural sciences, and related interdisciplinary fields.
6. Provide students with sufficient knowledge, analytical ability, and practical skills to pursue higher studies and research in Mathematics and allied disciplines.
7. Prepare students for various national and international competitive examinations such as IIT-JAM, GATE, GRE, UGC-CSIR NET/JRF, and Civil Services Examinations.

SEMESTER WISE TITLES OF THE PAPER IN UG MATHEMATICS COURSE

Year	Semester	Course Code	Paper Title	Theory / Practical	Paper Credit	Total Credit	Marks Distributions
1	I	**B030101T**	Matrices, Differential Equations and Geometry	**Theory**	**6**	**6**	**75+25**
	II	**B030201T**	Differential Calculus and Integral Calculus	**Theory**	**6**	**6**	**75+25**
2	III	**B030301T**	Algebra and Mathematical Methods	**Theory**	**6**	**6**	**75+25**
	IV	**B030401T**	Differential Equations and Mechanics	**Theory**	**6**	**9**	**75+25**
		B030402R	Research Project	**Research Project**	**3**		**100+0**
3	V	**B030501T**	Ring Theory and Linear Algebra	**Theory**	**5**	**10**	**75+25**
		Any One of The Followings					
		B030502T	Number Theory and Game Theory	**Theory**	**5**		**75+25**
		B030503T	Graph Theory and Discrete Mathematics				
	VI	**B030601T**	Metric Spaces and Complex Analysis	**Theory**	**4**	**10**	**75+25**
		B030602T	Numerical Analysis and Operations Research	**Theory**	**4**		**75+25**
		B030603P	Practical	**Practical**	**2**		**75+25**

Programme Outcomes (POs)

PO1. Formulate, analyze, and solve problems through the application of fundamental mathematical concepts, methods, and techniques.
PO2. Develop the ability to examine the validity of mathematical arguments, cultivate logical and analytical thinking, and independently solve mathematical problems as well as construct rigorous mathematical proofs.
PO3. Demonstrate an understanding of the foundations of various branches of Mathematics and apply this knowledge to formulate and present mathematical arguments in a systematic and logical manner.
PO4. Apply mathematical knowledge and skills to translate information into mathematical form, select appropriate formulae, methods, or techniques, process the information effectively, and draw meaningful conclusions.
PO5. Investigate and apply mathematical solutions in diverse contexts related to science, technology, business, and industry, and represent these solutions using symbolic, numerical, analytical, or graphical methods.
PO6. Develop computational, problem-solving, communication, and critical-thinking skills required for interdisciplinary applications and real-world problem analysis.
PO7. Build a strong foundation for higher studies in Mathematics and related disciplines requiring quantitative techniques, and enhance career opportunities through success in competitive examinations and professional placements requiring mathematical and analytical aptitude.

Programme Specific Outcomes (PSOs)

Year	Semester	Programme Specific Outcomes (PSOs)
First	SEM-I	**PSO1.** Students should be able to recall and understand the basic concepts and fundamental ideas of Mathematics and demonstrate them effectively.
	SEM-II	Students should be able to develop conceptual clarity and strengthen their foundation in core areas of Mathematics through problem-solving and analytical thinking
Second	SEM-III	**PSO2.** Students should be able to gain adequate exposure to various branches and aspects of Mathematical Sciences.
	SEM-IV	Students should be able to apply mathematical methods and techniques to solve theoretical and practical problems in different domains.
Third	SEM-V	**PSO3.** Students should be able to acquire mathematical modelling ability, critical mathematical thinking, and problem-solving skills, and apply their knowledge in various fields such as Science, Engineering, Commerce, and Management.
	SEM-VI	Students should be able to develop computational and analytical skills for interdisciplinary applications and advanced mathematical problem solving.

B.A. /B.Sc. I
(MATHEMATICS)
Detailed Syllabus
For
CERTIFICATE COURSE
IN
APPLIED MATHEMATICS

FIRST YEAR (SEMESTER-I)

MATRICES, DIFFERENTIAL EQUATIONS AND GEOMETRY

Class: UG	**Year:** FIRST	**Semester:** FIRST
Subject: MATHEMATICS		
Course Code: B30201T	**Course Title:** MATRICES, DIFFERENTIAL EQUATIONS AND GEOMETRY	
Credits: 6	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 6-0-0		

Course prerequisites:
To study this course, a student must have the subject Mathematics in class 12^{th}.

Course Objectives

The objectives of this course are to:

1. Introduce the concepts of matrices, determinants, and rank of matrices along with their algebraic properties and applications.
2. Develop understanding of the consistency and solution of systems of linear equations using matrix methods and related techniques.
3. Provide knowledge of ordinary differential equations and their applications in various branches of science, engineering, and humanities.
4. Develop understanding of the fundamental concepts of coordinate geometry and enable students to describe curves and surfaces using analytical and geometrical methods.

Unit	Topics
	PART-A **MATRICES AND DIFFERENTIAL EQUATIONS**
I	Types of Matrices, Elementary operations on Matrices, Rank of a Matrix, Echelon form of a Matrix, 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.
II	Eigenvalues, Eigenvectors and characteristic equation of a matrix, Cayley-Hamilton theorem and its use in finding inverse of a matrix, symmetric, skew-symmetric, Hermitian, skew-Hermitian, normal, orthogonal and unitary matrices.
III	Formation of differential equations, Geometrical meaning of a differential equation, Equation of first order and first degree, Equation in which the variables are separable, Homogeneous equations, Exact differential equations and equations reducible to the exact form, Linear equations.
IV	First order higher degree equations solvable for x, y, p, Clairaut's equation and singular solutions, orthogonal trajectories, Linear differential equation of order greater than one with constant coefficients, Cauchy-Euler form.
	PART-B **GEOMETRY**
V	General equation of second degree, System of conics, Confocal conics, Polar equation of conics and its properties.
VI	Three-Dimensional Coordinates, Direction Cosines & Ratios, Projections, Planes (Cartesian and vector form), Straight lines in three dimensions.
VII	Sphere, Cone and Cylinder.
VIII	Central conicoids, Paraboloids, Plane section of conicoids, Generating lines, Confocal conicoids, Reduction of second degree equations.

Course Outcomes (COs)

CO1: The course is designed to develop mathematical skills in Algebra, Calculus, and Analysis, and to provide in-depth knowledge of Geometry, Differential Equations, and related mathematical theories.
CO2: Students will be able to determine the rank and eigenvalues of matrices, analyze linear homogeneous and non-homogeneous systems of equations, and apply appropriate methods for solving various types of differential equations along with their geometrical interpretations.
CO3: Students will learn and visualize the fundamental concepts of Coordinate Geometry and develop the ability to describe curves and surfaces using analytical and geometrical techniques.
CO4: Upon successful completion of the course, students will gain knowledge of standard geometrical figures and their properties, thereby building a strong foundation for advanced studies in Geometry and related mathematical disciplines.

Books Recommended

1. Felix R. Gantmacher, The Theory of Matrices, AMS Chelsea Publishing.
2. Roger A. Horn & Charles R. Johnson, Matrix Analysis, Cambridge University Press.
3. Thomas S. Shores, Applied Linear Algebra and Matrix Analysis, Springer.
4. G.F. Simmons, Differential Equations, Tata McGraw Hill Publishing Company Ltd.
5. M.D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand and Company Ltd., New Delhi.
6. Richard Bronson & Gabriel B. Costa, Schaum's Outline of Differential Equations, McGraw-Hill Education.
7. Zafar Ahsan, Differential Equations and Their Applications, PHI.
8. R.J.T. Bell, An Elementary Treatise on Co-ordinate Geometry of Three Dimensions, Macmillan India Ltd., New Delhi, 1994.
9. Shanti Narayan & P.K. Mittal, Analytical Solid Geometry, S. Chand & Company, New Delhi, 2008.
10. M.M. Tripathi, Coordinate Geometry: Polar Coordinates Approach, Narosa Publishing House, New Delhi.
11. P.R. Vittal, Analytical Geometry 3D, Pearson.

FIRST YEAR (SEMESTER-II)

DIFFERENTIAL CALCULUS AND INTEGRAL CALCULUS

Class: UG	**Year:** FIRST	**Semester:** SECOND
Subject: MATHEMATICS		
Course Code: B03101T	**Course Title:** DIFFERENTIAL CALCULUS AND INTEGRAL CALCULUS	
Credits: 6	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 6-0-0		
Course prerequisites: To study this course, a student must have the subject Mathematics in class 12^{th}.		

Course Objectives

The course aims to develop:

1. A deep and rigorous understanding of the real line, along with the fundamental concepts required to study convergence and divergence of sequences and series of real numbers. These concepts have wide-ranging applications in mathematics, science, engineering, and real-life situations.
2. Proficiency in Differential Calculus, including the concepts of limits, continuity, and differentiability, which form the foundation for several advanced areas of Mathematics and its applications.
3. The ability to apply Integral Calculus in solving geometrical and analytical problems such as finding the area bounded by curves and determining the volume of solids of revolution about coordinate axes.
4. Skills in writing rigorous mathematical proofs for fundamental theorems of single-variable calculus using essential analytical tools such as continuity, differentiability, and convergence.

Unit	Topics
	PART-A **DIFFERENTIAL CALCULUS**
I	**Introduction to Indian ancient Mathematics and Mathematicians should be included under Continuous Internal Evaluation (CIE).** 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 test, Logarithmic test, de Morgan and Bertrand's tests.
II	Limit, continuity and differentiability of function of single variable, Cauchy's definition, Heine's definition, equivalence of definition of Cauchy's and Heine's, 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.
III	Rolle's theorem, Lagrange and Cauchy Mean value theorems, mean value theorems of higher order, Taylor's theorem with various forms of remainders, Successive differentiation, Leibnitz theorem, Maclaurin's and Taylor's series, Partial differentiation, Euler's theorem on homogeneous function.
IV	Tangent and normal, Asymptotes, Curvature, Envelops and evolutes, Tests for concavity and convexity, Points of inflexion, Multiple points.
	PART-B **INTEGRAL CALCULUS**
V	Definite integrals as limit of the sum, Differentiation under the sign of Integration, Improper integrals and their classifications.
VI	Convergence of Improper integrals, Comparison test, μ-test, Abel's test, Dirichlet's test, quotient test, Beta and Gamma functions, Rectifications.
VII	Volumes and Surfaces of Solid of revolution, Multiple integrals, change of order of double integration, Dirichlet's theorem, Liouville's theorem for multiple integrals.
VIII	Vector Differentiation, Gradient, Divergence and Curl, Normal on a surface, Directional Derivative, Vector Integration, Theorems of Gauss, Green, Stokes and related problems.

Course Outcomes (COs)

CO1: Develop foundational knowledge of Mathematics, including its applied aspects, to enhance quantitative and analytical skills and prepare students for higher studies and research in Mathematics and related disciplines.
CO2: Acquire understanding of real-valued functions, sequences, and series, including the concepts of convergence and divergence. Students will also gain knowledge of curvature, envelopes, evolutes, and the Riemann integral along with their applications.
CO3: Develop the necessary analytical and technical skills through the application of Differential and Integral Calculus to solve a variety of theoretical and practical problems arising in science, engineering, and related fields.
CO4: Equip students with standard mathematical concepts, methods, and tools at intermediate to advanced levels, enabling them to pursue higher-level courses and advanced studies in Mathematics successfully.

Books Recommended

Part–A: Differential Calculus

1. R.G. Bartle & D.R. Sherbert, Introduction to Real Analysis, John Wiley & Sons.
2. T.M. Apostol, Calculus Vol. I, John Wiley & Sons Inc.
3. Gorakh Prasad, A Text Book on Differential Calculus, Pothishala Private Ltd., Prayagraj.
4. S. Balachandra Rao & C.K. Shantha, Differential Calculus, New Age Publications.
5. H. Anton, I. Bivens & S. Davis, Calculus, John Wiley & Sons Inc., 2002.
6. G.B. Thomas & R.L. Finney, Calculus, Pearson Education, 2007.

Part–B: Integral Calculus

7. T.M. Apostol, Calculus Vol. II, John Wiley Publications.
8. Gorakh Prasad, A Text Book on Integral Calculus, Pothishala Private Ltd., Prayagraj.
9. Shanti Narayan & Dr. P.K. Mittal, Integral Calculus, S. Chand Publications.
10. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.

B.A. /B.Sc. II (MATHEMATICS)

Detailed Syllabus

For

DIPLOMA IN MATHEMATICS

SECOND YEAR (SEMESTER-III)

ALGEBRA AND MATHEMATICAL METHODS

Class: UG	**Year:** SECOND	**Semester:** THIRD
Subject: MATHEMATICS		
Course Code: B30301T	**Course Title:** ALGEBRA AND MATHEMATICAL METHODS	
Credits: 6	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 6-0-0		

Course prerequisites:
To study this course, a student must have passed Mathematics as Major Subject in UG First Year Programme.

Course Objectives

1. Introduce the fundamental concepts of Algebra, which form one of the basic pillars of modern Mathematics.
2. Develop understanding of algebraic structures such as groups and related concepts along with applications of matrices.
3. Enhance mathematical maturity, logical reasoning, and analytical thinking among students.
4. Provide knowledge of multivariable calculus involving continuity, differentiability, and related analytical tools.
5. Develop understanding of the relationship between Mathematics and physical systems through mathematical modelling and applications.

Unit	Topics
	PART-A **ALGEBRA**
I	Sets, relations and Functions, Binary operations, Equivalence classes, Divisibility in Z, Fundamental theorem of arithmetic, Congruences and residue classes, Chinese Remainder Theorem, Eulers φ '- function, Fermat' s theorem
II	Algebraic Structure, Definition of a group with examples and simple properties, Subgroups, Generators of a group, Cyclic groups, Order of an element of a group, Centre of group
III	Permutation groups, Cyclic permutation, Transposition, Even and odd permutations, The alternating group, Cayley's theorem, Coset decomposition, Lagrange's theorem and its consequences, Fermat's and Euler's theorems
IV	Homomorphism and isomorphism, Kernel of homomorphism, Normal subgroups, Simple group, Quotient groups, Fundamental theorem of homomorphism, Theorems on isomorphism.
	PART-B **MATHEMATICAL METHODS**
V	Limit and Continuity of functions of two variables, Differentiation of function of two variables, Necessary and sufficient condition for differentiability of functions of two variables, Schwarz's and Young's theorem, Taylor's theorem for functions of two variables with examples, Maxima and minima for functions of two variables, Lagrange's multiplier method, Jacobians.
VI	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.
VII	Periodic functions, Fourier series, Fourier expansion of piecewise monotonic functions, Fourier series for even and odd functions, Half - range expansions.
VIII	Fourier transforms (finite and infinite) and properties of Fourier transform Fourier integrals.

Course Outcomes (COs)

CO1: Students will acquire knowledge of Integers, Groups, and their fundamental properties, which will provide a foundation for advanced studies in Algebra and higher Mathematics.
CO2: Students will develop understanding of permutation groups, normal subgroups, and related algebraic structures and their applications.
CO3: Upon successful completion of the course, students will gain analytical and problem-solving skills in Algebra, enabling them to pursue higher studies and research in Mathematics and allied disciplines.
CO4: Students will acquire knowledge of functions of several variables, Laplace Transforms, Fourier Series, and Calculus of Variations, which will help them in advanced studies, research, and applications in science and engineering.

Books Recommended:

1. I. N. Herstein , Topics in Algebra, Wiley Eastern Ltd, New Delhi, 1975.
2. Joseph. A. Gallian, Contemporary Abstract Algebra, Cengage Learning India Private Limited, Delhi., Fourth impression, 2015.
3. P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, First Course in Linear Algebra, Wiley Eastern Ltd., New Delhi, 1983.
4. S. Singh and Q. Zameeruddin, Modern Algebra, Vikas Publication House, India.
5. David M. Burton, Elementary Number Theory, Wm. C. Brown Publishers, Dubuque, Iowa 1989.
6. T.M. Apostal, Mathematical Analysis, Pearson
7. G. F. Simmons, Differential Equations with Application and Historical Notes, Tata -McGrawHill
8. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
9. A.C. Srivastava, Engineering Mathematics, PHI Publication.

SECOND YEAR (SEMESTER-IV)

DIFFERENTIAL EQUATIONS AND MECHANICS

Class: UG	**Year:** SECOND	**Semester:** FOURTH
Subject: MATHEMATICS		
Course Code: B030401T	**Course Title:** DIFFERENTIAL EQUATIONS AND MECHANICS	
Credits: 6	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 6-0-0		

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG First Year Programme.

Course Objectives

1. Introduce the concept of series solutions for solving various types of ordinary differential equations.
2. Develop understanding of partial differential equations and their applications in solving real-life and physical problems.
3. Introduce the notions of virtual work, frame of reference, and applications of Poinsot's Central Axis Theorem in mechanics.
4. Explain the applications of differential equations in modelling and solving problems arising in physics, engineering, and related fields.

Unit	Topics
	PART-A
	DIFFERENTIAL EQUATIONS

I	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, Series solutions of differential equations, Power series method.
II	Bessel, Legendre and Hypergeometric functions and their properties, recurrence and generating relations.
III	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. Charpit's method of solution.
IV	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.
PART-B MECHANICS	
V	Frame of reference, work energy principle, Forces in three dimensions, Poinsot's central axis, Wrenches, Null lines and null planes.
VI	Virtual work, Stable and Unstable equilibrium, Catenary, Catenary of uniform string.
VII	Velocities and accelerations along radial and transverse directions, and along tangential and normal directions, Simple Harmonic motion, Motion under other laws of forces. Elastic strings, Motion in resisting medium, Constrained motion, Motion on smooth and rough plane curves.
VIII	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 coordinate systems.

Course Outcomes (COs)

CO1: Students will be able to solve ordinary differential equations and model real-life problems using differential equations. The course will also prepare them for advanced studies in differential equations and boundary value problems with applications in science, engineering, and industry.
CO2: Students will develop analytical and problem-solving skills required for solving advanced problems in differential equations, which will enhance their employability in technical and industrial sectors.
CO3: Students will be able to model and analyze problems in Statics and Dynamics and gain understanding of concepts such as virtual work, stable and unstable equilibrium, catenary, and catenary of uniform strength, along with their engineering applications.
CO4: Upon successful completion of the course, students will acquire knowledge of advanced concepts in mechanics, including applications in hydrodynamics and related fields, thereby improving their prospects for higher studies and industrial employment.

Books Recommended

1. G.F. Simmons, Differential Equations with Applications and Historical Notes, Tata McGraw-Hill.
2. B. Rai, D.P. Choudhary & H.J. Freedman, A Course of Ordinary Differential Equations, Narosa Publishing House.
3. M.D. Rai Singhania, Ordinary and Partial Differential Equations, S. Chand and Company Ltd., New Delhi.
4. L.E. Elsgolts, Differential Equations and Calculus of Variations, University Press of the Pacific.
5. R.C. Hibbeler, Engineering Mechanics: Statics, Pearson.
6. S.L. Loney, The Elements of Statics and Dynamics Part-I (Statics), Arihant Publications.
7. S.L. Loney, The Elements of Statics and Dynamics Part-II (Dynamics), Arihant Publications.
8. A. Nelson, Engineering Mechanics: Statics and Dynamics, Tata McGraw Hill.
9. J.L. Synge & B.A. Griffith, Principles of Mechanics, Tata McGraw Hill.

SECOND YEAR (SEMESTER-IV)

RESEARCH PROJECT

Class: UG	**Year:** SECOND	**Semester:** FOURTH
Subject: MATHEMATICS		
Course Code: B030402P	**Course Title:** RESEARCH PROJECT	
Credits:3	**The student can opt any one as a project from subject (Major-1/ Major-2) in semester-IV**	
Max. Marks: 100	**Min. Passing Marks:** As per University CBCS Norm	

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG Semester-I, II and III Programme.

Project Objectives

1. Develop research aptitude, analytical thinking, and problem-solving skills through independent study of a mathematical topic.
2. Enable students to apply theoretical concepts learned in Core/Major papers to research-oriented and practical problems under faculty supervision.

PROJECT

Candidates/Students shall prepare a project report on a specific topic based on any one of the Core/Major papers studied during Semester–I, II, III, or IV. Each student shall be allotted a supervisor by the concerned faculty/department to guide and supervise the research work related to the selected topic. The project report should be properly typed and prepared in a standard academic format.

Project Outcomes

CO1: Students will be able to apply mathematical concepts and techniques to analyze and solve research-oriented problems independently.

CO2: Students will develop skills in research methodology, academic writing, data analysis, and presentation of mathematical findings in a systematic manner.

Suggested Evaluation Methods: Max. Marks: 100

The project work shall be evaluated internally by the concerned department/subject teacher on the basis of the quality of research work, presentation, analysis, and understanding of the topic.

B.A. /B.Sc. III (MATHEMATICS)

Detailed Syllabus

For

DEGREE IN MATHEMATICS

THIRD YEAR (SEMESTER-V)

RING THEORY AND LINEAR ALGEBRA

Class: UG	**Year:** THIRD	**Semester:** FIFTH
Subject: MATHEMATICS		
Course Code: B030501T	**Course Title:** RING THEORY AND LINEAR ALGEBRA	
Credits: 5	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0		

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG Second Year Programme.

Course Objectives

1. Develop advanced understanding of Abstract Algebra and its fundamental algebraic structures.
2. Introduce the basic concepts of Abstract Algebra and Linear Algebra along with some of their important applications.
3. Explore the concepts of vector spaces over real and complex fields, linear transformations, and related algebraic operations.
4. Develop understanding of orthogonality and inner product spaces and their applications in higher Mathematics.

Unit	Topics
	PART-A **RING THEORY**
I	Introduction to rings, integral domains and fields, Characteristic of a ring, Ring homomorphism, Ideals and quotient rings.
II	Field of quotients of an integral domain, Euclidean domain, Prime and maximal ideals, principal ideal domain, Principal ideal rings, Polynomial rings over commutative rings.
III	Division algorithm and consequences, Principal ideal domains, Factorization of polynomials, Reducibility tests, Irreducibility tests, Eisenstein criterion, Unique factorization in Z[x].
IV	Divisibility in integral domains, Irreducible, Primes, Unique factorization domains, Euclidean domains.
	PART-B **LINEAR ALGEBRA**
V	Vector spaces, Vector Subspaces, Linear combination, Linear independence and dependence of vectors, same and same spaces, Basis and Dimension, Quotient space.
VI	Linear transformations, The Algebra of linear transformations, Rank Nullity theorem, their representation as matrices.
VII	Linear functionals, Dual space, Dual Basis and Dimension, Bilinear and Quadratic forms.
VIII	Change of basis, diagonal forms, triangular forms, Inner product spaces and norms, Cauchy-Schwarz inequality, Orthogonal vectors, Orthonormal sets and bases, Bilinear form.

Course Outcomes (COs)

CO1: After successful completion of the course, students will acquire knowledge rings, integral domains and fields.

CO2: Students will be able to apply the concepts of Ring Theory in areas such as Computer Science, Financial Mathematics, and Industrial Mathematics..

CO3: After successful completion of the course, students will acquire knowledge of polynomial rings over commutative rings, vector spaces, and related algebraic structures.

CO4: Students will be able to apply the concepts of Abstract Algebra and Linear Algebra in areas such as Computer Science, Financial Mathematics, and Industrial Mathematics, and will appreciate the interdisciplinary nature of Mathematics.

Books Recommended

Part–A : Ring Theory

1. I.N. Herstein, Topics in Algebra, Wiley.
2. Joseph A. Gallian, Contemporary Abstract Algebra, Cengage Learning India Private Limited, Delhi, Fourth Impression, 2015.
3. David S. Dummit & Richard M. Foote, Abstract Algebra, 3rd Edition, Wiley India, 2016.

Part–B : Linear Algebra

1. K. Hoffman & R. Kunze, Linear Algebra, 2nd Edition, Prentice-Hall of India.
2. Gilbert Strang, Linear Algebra and Its Applications, Cengage Learning, 2018.
3. Stephen H. Friedberg, Arnold J. Insel & Lawrence E. Spence, Linear Algebra, 4th Edition, Pearson, 2003.
4. Serge Lang, Linear Algebra, 3rd Edition, Springer, 1987.
5. S. Kumaresan, Linear Algebra: A Geometric Approach, Prentice Hall of India, 1999.

THIRD YEAR (SEMESTER-V)

NUMBER THEORY AND GAME THEORY

Class: UG	**Year:** THIRD	**Semester:** FIFTH
Subject: MATHEMATICS		
Course Code: B30502T	**Course Title:** NUMBER THEORY AND GAME THEORY	
Credits: 5	Core Compulsory /Elective	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0		

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG Second Year Programme.

Course Objectives

1. Study the basic concepts of Number Theory, including divisibility properties and Diophantine equations.
2. Develop understanding of important topics such as the Goldbach Conjecture, primes of the form (4n+1) and (4n+3), and fundamental results including Fermat's Theorem, Euler's Theorem, Wilson's Theorem, arithmetic functions, and Quadratic Reciprocity.
3. Introduce the fundamental concepts of Game Theory and its role in optimal decision-making in strategic situations involving independent and competing participants.
4. Develop understanding of various methods and applications of Game Theory in mathematics, economics, management, and related fields.

Unit	Topics
	PART-A
	NUMBER THEORY
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.

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.
III	Solutions of ax + by = c, $x^n + y^n = z^n$; properties of Pythagorean triples; sums of two, four and five squares; assorted examples of diophantine equations.
IV	Generating Function Models, Calculating coefficient of generating functions, Partitions, Exponential Generating Functions, A Summation Method. Recurrence Relations: Recurrence Relation Models, Solution of Linear, Recurrence Relations, Solution of Inhomogeneous Recurrence Relations, Solutions with Generating Functions.
PART-B GAME THEORY	
V	Introduction, overview, uses of game theory, some applications and examples, and formal definitions of: the normal form, payoffs, strategies, pure strategy Nash equilibrium.
VI	Introduction, characteristic of game theory, Two- person zero-sum game, Pure and Mixed strategies, Saddle point and its existence.
VII	Fundamental Theorem of Rectangular games, Concept of Dominance, Dominance and Graphical method of solving Rectangular games.
VIII	Relationship between rectangular game and Linear Programming Problem, Solving rectangular game by Simplex method, reduction of m×n game and solution of 2×2, 2 × s, and r × 2 cases by graphical method, algebraic and linear programming solution of m×n games.

Course Outcomes (COs)

CO1: Students will acquire knowledge and problem-solving skills in Elementary Number Theory and will be able to apply number theoretic concepts in areas such as cryptography and information security.
CO2: Students will understand the fundamental concepts of Game Theory and its applications in analyzing decision-making processes involving interdependent participants in strategic situations.
CO3: Students will be able to analyze strategic situations in which outcomes depend on the decisions of multiple individuals and apply game theoretic methods to real-life problems.
CO4: Students will develop the ability to interpret and apply theoretical concepts through real-world examples, case studies, and practical problem-solving situations.

Books Recommended

1. Ivan Niven, Herbert S. Zuckerman & Hugh L. Montgomery, An Introduction to the Theory of Numbers, 6th Edition, John Wiley & Sons Inc., New York, 2003.
2. David M. Burton, Elementary Number Theory, 4th Edition, Universal Book Stall, New Delhi, 2002.
3. K. Swarup, P.K. Singh & Man Mohan, Operations Research, Sultan Chand and Sons, New Delhi.

THIRD YEAR (SEMESTER-V)

GRAPH THEORY AND DISCRETE MATHEMATICS

Class: UG	**Year:** THIRD	**Semester:** FIFTH
Subject: MATHEMATICS		
Course Code: B030503T	**Course Title:** GRAPH THEORY AND DISCRETE MATHEMATICS	
Credits: 5	Core Compulsory / Elective	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 5-0-0		
Course prerequisites: To study this course, a student must have passed Mathematics as Major Subject in UG Second Year Programme.		

Course Objectives

1. Introduce the basic principles and fundamental concepts of Graph Theory, including graphs and trees.
2. Develop intuitive understanding of graphs through their applications in solving real-world and network-based problems.
3. Provide knowledge of sets, relations, functions, partially ordered sets, lattices, Boolean algebra, and their mathematical and practical applications.

Unit	Topics
	PART-A **GRAPH THEORY**
I	Introduction to graphs, basic properties of graphs, Simple graph, multi graph, graph terminology, representation of graphs, Bipartite, regular, planar and connected graphs, connected components in a graph, Euler graphs, Directed, Undirected, multi-graph, mixed graph.
II	Walk and unilateral components, unicursal graph, Hamiltonian path and circuits, Graph colouring, chromatics number, isomorphism and homomorphism of graphs, Incidence relation and degree of the graph.
III	Operation of graph circuit, Path and circuits, Eulerian circuits, Hamiltonian path and cycles, Adjacency matrix, Weighted graph, Travelling salesman problem, Shortest path, Dijkstra's algorithm.
IV	Tree, Binary and Spanning trees, Coloring, Color problems, Vertex coloring and important properties.
	PART-B **DISCRETE MATHEMATICS**
V	**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.
VI	**Relation-** Definition, types of relation, domain and range of a relation, pictorial representation of relation, properties of relation, partial ordering relation, Hasse diagram. **Boolean Algebra-** Basic definitions, Sum of products and products of sums, Logic gates and Karnaugh maps.
VII	**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.)
VIII	**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.

Course Outcomes (COs)

CO1: Students will acquire knowledge of various types of graphs, graph terminology, and their applications in mathematics, computer science, and related fields.
CO2: Students will understand concepts such as graph isomorphism, homomorphism, paths, circuits, adjacency matrices, trees, and graph coloring, and will be able to apply these concepts to practical and computational problems.
CO3: Students will gain knowledge of logic gates, truth tables, Karnaugh maps, automata concepts, transition functions, and transition tables, and will develop skills in logical reasoning and simplification techniques.
CO4: Students will develop understanding of discrete mathematical structures including logic, counting principles, relations, Hasse diagrams, Boolean algebra, and combinatorial analysis, along with their applications in computer science and formal reasoning.

Books Recommended

1. C.L. Liu, Discrete Mathematics.
2. J.P. Tremblay & R. Manohar, Discrete Mathematics with Applications to Computer Science.
3. Elliott Mendelson, Introduction to Mathematical Logic, Chapman & Hall, 1997.
4. John E. Hopcroft, Rajeev Motwani & Jeffrey D. Ullman, Introduction to Automata Theory, Languages, and Computation, Pearson Education, 2000.
5. Arnold B. Hein, Logic and Boolean Algebra, Prentice Hall, 1962.
6. Kenneth H. Rosen, Discrete Mathematics and Its Applications, McGraw-Hill, 1999.

THIRD YEAR (SEMESTER-VI)

METRIC SPACE AND COMPLEX ANALYSIS

Class: UG	**Year:** THIRD	**Semester:** SIXTH
Subject: MATHEMATICS		
Course Code: B030601T	**Course Title:** METRIC SPACE AND COMPLEX ANALYSIS	
Credits: 4	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0		

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG Second Year Programme.

Course Objectives

1. Introduce the concept of a metric on a general set and develop understanding of metric spaces.
2. Introduce the concepts of connectedness and compactness and their fundamental properties in analysis.
3. Develop understanding of analyticity and related concepts in complex analysis.
4. Introduce the concepts of residues, singularities, and their applications in evaluating complex integrals.

Unit	Topics
	PART-A **METRIC SPACE**
I	**Elementary Real Analysis** Elementary set theory, finite, countable and uncountable sets, Real number system as a complete ordered field, Archimedean property, supremum, infimum, Open and closed balls, Neighborhoods, Open sets, Interior of a set, limit points of a set, derived sets, closed sets, closure of a set, diameter of a set
II	**Metric Spaces** Metric spaces: Definition and examples, Sequences in metric spaces, Cauchy sequences, Complete metric space, Cantor's intersection theorem, Subspaces, Dense set.
III	**Continuity & Uniform Continuity in Metric Spaces** Continuous mappings, Sequential criterion and other characterizations of continuity, Uniform continuity,

	Homeomorphisms, Contraction mappings, Banach fixed point theorem.
IV	**Connectedness and Compactness Connectedness:** Connected subsets of a metric space, Connectedness and continuous mappings, Compactness, Compactness and boundedness, Continuous functions on compact spaces.
	PART-B **COMPLEX ANALYSIS**
V	Complex numbers as ordered pairs, geometric representation of complex number, Stereographic projection, Continuity and Differentiability of complex functions, Analytic functions, Cauchy Riemann equations, Harmonic functions.
VI	Complex functions and separation into real and imaginary parts, Exponential and Logarithmic functions, trigonometric and Hyperbolic functions, Inverse trigonometric and Hyperbolic functions, C+iS Method, Taylor Series, Laurent Series and its examples.
VII	Complex integration, Cauchy-Goursat theorem, Cauchy's Integral formula, Formulae for first, second and nth derivatives, Cauchy's Inequality, Liouville's Theorem.
VIII	Zeroes and poles of order m, Isolated singular points, Types of isolated singular points , Residues, Residues at poles and its examples, Residue at infinity, Cauchy's residue theorem.

Course Outcomes (COs)

CO1: Students will be exposed to the foundations of mathematical analysis, which will help in understanding various physical phenomena and will provide a strong mathematical base.
CO2: After completion of the course, students will develop a rigorous and deeper understanding of fundamental concepts in Mathematics, which will support further study in pure Mathematics and research.
CO3: Students will be able to formulate and solve problems based on Linear Programming.
CO4: After successful completion of the course, students will be able to apply basic concepts of Operations Research to solve real-life and optimization problems.

Books Recommended

Part–A : Metric Spaces

1. Shanti Narayan, A Course of Mathematical Analysis, S. Chand Publication.
2. Satish Shirali & H.L. Vasudeva, Metric Spaces, Springer, First Indian Print, 2009.
3. S. Kumaresan, Topology of Metric Spaces, Narosa Publishing House, 2014.
4. G.F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw Hill, 2004.
5. P.K. Jain & K. Ahmad, Metric Space, PHI, India.

Part–B : Complex Analysis

1. Shanti Narayan, Theory of Functions of a Complex Variable, S. Chand Publications.
2. J.W. Brown & R.V. Churchill, Complex Variables and Applications, McGraw-Hill Higher Education.
3. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House.
4. T.W. Gamelin, Complex Analysis, Springer.
5. T.M. Apostol, Calculus Vol. I, John Wiley & Sons Inc.

THIRD YEAR (SEMESTER-VI)

NUMERICAL ANALYSIS AND OPERATIONS RESEARCH

Class: UG	**Year:** THIRD	**Semester:** SIXTH
Subject: MATHEMATICS		
Course Code: B030602T	**Course Title:** NUMERICAL ANALYSIS AND OPERATIONS RESEARCH	
Credits: 4	Core Compulsory	

Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0	

Course prerequisites:

To study this course, a student must have passed Mathematics as Major Subject in UG Second Year Programme.

Course Objectives

1. Understand and apply various numerical techniques for solving problems arising in science, engineering, and daily life situations.
2. Develop knowledge of optimization theory along with algorithms used for solving different types of optimization problems.

Unit	Topics
	PART-A **NUMERICAL ANALYSIS**
I	Error in numerical computations, Calculus of finite differences, Difference operators, Fundamental theorem of differential calculus, Interpolation with equal and unequal intervals, Newton's forward and backward interpolation formulae, Divided difference interpolation formula, Lagrange's interpolation formula.
II	Solutions of algebraic and transcendental equations, Direct and iterative methods, Bisection method, Regula-falsi method, Newton- Raphson method, Iteration method. Solution of simultaneous linear equations: Gauss-elimination method, Guass-Jordan method, LU decomposition method, Guass-Seidel method.
III	Numerical differentiation derivatives using forward and backward formula, Numerical Integration, General Quadrature formula, Trapezoidal rule, Simpson's one-third and three-eight formulae and Weddle's rules.
IV	Numerical solution of ordinary differential equation, Picard method, Euler's method, Modified Euler's method, Runge-Kutta method.
	PART-B **OPERATIONS RESEARCH**
V	Introduction, Convex sets, Convex and concave functions, Theorems on convexity, Linear programming problem (LPP), Simple and general LPP, Solutions of simple LPP by graphical method, Analytical solution of general LPP, Canonical and standard forms of LPP, Slack and surplus variables.
VI	Solution of general LPP by Simplex method. Use of artificial variables in simplex method, Big-M method and Two-Phase method, revised simplex method.
VII	Resolution of degeneracy, Concept of duality in linear programming, Theorems on duality, Dual simplex method, Sensitivity analysis
VIII	Transportation problem, Solution of transportation problem, Methods for finding Initial basic feasible solution of transportation problem, Optimal solution of transportation problem by modified distribution (MODI) method, Degeneracy in transportation problem, Maximization transportation problem. Assignment problem, Balanced and unbalanced assignment problems. Solution of assignment Problem, Hungarian Method, Maximization Assignment problem.

Course Outcomes (COs)

CO1: Students will understand the basic concepts of Numerical Analysis and will be able to solve algebraic and differential equations using numerical methods.
CO2: Students will develop the ability to handle computational problems and obtain approximate solutions, which will prepare them for advanced studies in Numerical Analysis.
CO3: Students will be able to solve problems based on Linear Programming and apply basic concepts of Operations Research in practical situations.
CO4: Students will be able to formulate Linear Programming problems and obtain their solutions in real-life applications, thereby improving mathematical skills and enhancing employability in industries and survey-related fields.

Books Recommended

Part–A : Numerical Analysis

1. M.K. Jain, S.R.K. Iyengar & R.K. Jain, Numerical Methods for Engineering and Scientific Computation.
2. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI Learning.
3. B.S. Grewal, Numerical Methods in Engineering and Science, Khanna Publications.

Part–B : Operations Research

1. Hamdy A. Taha, Operations Research: An Introduction, Pearson Education.
2. V.S. Verma, Linear Programming and Game Theory, Neelkamal Prakashan, Gorakhpur, 2011.
3. Kanti Swarup, P.K. Gupta & Man Mohan, Operations Research, Sultan Chand & Sons.
4. Frederick S. Hillier & Gerald J. Lieberman, Introduction to Operations Research, McGraw Hill.
5. Wayne L. Winston, Operations Research: Applications and Algorithms, Cengage Learning.
6. D.S. Hira & Prem Kumar Gupta, Problems in Operations Research: Principles and Solutions, S. Chand & Co. Ltd.
7. S. Kalavathy, Operations Research, S. Chand.

THIRD YEAR (SEMESTER-VI)

PRACTICAL

Class: UG	**Year:** THIRD	**Semester:** SIXTH
Subject: MATHEMATICS		
Course Code: B030603P	**Course Title:** PRACTICAL	
Credits: 2	Core Compulsory	
Max. Marks: 25(Internal) + 75(External)	**Min. Passing Marks:** As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-2		

Course prerequisites:

- To study this course, a student must have passed Mathematics as Major Subject in UG Third Year Programme.
- To study this course, a student should have the course B030602T in UG Third year.

Course Objectives

1. Equip students to plot different types of graphs and solve various equations using computer-based software tools.
2. Enable students to solve transcendental and algebraic equations, systems of linear equations, interpolation problems, numerical integration, ordinary differential equations, and difference equations using software such as Python, MATLAB, Maple, C programming, and R programming.
3. Develop the ability to visualize and understand mathematical concepts through computational tools in the modern era and meet national and global technological needs.

Topics

- **Practical / Lab work to be performed in Computer Lab**
- **List of practical to be done using MATLAB / R programming / Python / C programming etc.**

1.	Plotting the 2D/3D graphs of the various algebraic, trigonometrical, hyperbolic, logarithmic and exponential functions. Solving various algebraic and transcendental equations by using mathematical software.

2.	Solution of transcendental and algebraic equations by i. Bisection method ii. Regula Falsi method iii. Newton Raphson method iv. Iteration method
3.	Solution of system of linear equations by i. LU decomposition method ii. Gaussian elimination method iii. Gauss-Seidel method
4.	Interpolation by i. Newton's forward Interpolation ii. Newton's backward Interpolation iii. Lagrange Interpolation iv. Divided difference interpolation formula
5.	Numerical Integration by i. Trapezoidal Rule ii. Simpson's one third rule
6.	Numerical Integration by i. Simpson's three-eight rule ii. Weddle's Rule
7.	Solution of ordinary differential equations by i. Picard Method ii. Euler method iii. Runge Kutta method

Course Outcomes (COs)

CO1: After completion of this course, students will be able to solve transcendental and algebraic equations using numerical and computational methods.
CO2: Students will be able to obtain solutions of systems of linear equations using appropriate numerical techniques.
CO3: Students will be able to solve problems related to interpolation and numerical integration using computational methods.
CO4: Students will be able to solve ordinary differential equations using numerical and software-based approaches.

Books Recommended

1. Cleve B. Moler, MATLAB: A Practical Introduction to Programming and Problem Solving.
2. Reema Thareja, Python programming using problem solving approach

Suggested Internal Evaluation Methods: Max. Marks: 25

Practical Internal Evaluation shall be based on Practical File/Record, Viva-voce and Overall performance.

Sr. No.	Assessment Type	Max. Marks
01	Practical File / Record	10
02	Regularity / Punctuality	10
03	Viva-voce / Class test	5

Suggested External Evaluation Methods (Max. Marks: 75)

Practical External Evaluation:
The practical external evaluation shall be based on viva-voce, practical exercises, and overall performance of the student. The practical examination will be conducted by an external examiner appointed by the University.

Sr. No.	Assessment Type	Max. Marks
01	Practical Examination (02 Experiments)	40
02	Practical File / Record	15

03	Viva-voce	20