MAA VINDHYAVASINI UNIVERSITY, MIRZAPUR

DEPARTMENT OF MATHEMATICS

National Education Policy-2020 in

Choice Based Credit System (CBCS)

Syllabus

of

MATHEMATICS (3+1 FYUP)

(Effective from Academic Session 2026-2027)

For

UG Four Year Programme

(UG Honors/UG Honors with Research)

Dean
Faculty of Science And Technology
Maa Vindhyavasini University, Mirzapur

MAA VINDHYAVASINI UNIVERSITY, MIRZAPUR

DEPARTMENT OF MATHEMATICS

National Education Policy-2020

Syllabus of Four Year Programme (UG Honors / UG Honors with Research) Mathematics (3+1 FYUP) Designed by

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Dean
Faculty of Science And Technology
Maa Vindhyavasini University, Mirzapur

UG Four Year Programme (UG Honors/UG Honors with Research) For Mathematics (3+1 FYUP) based on National Education Policy-2020 in Choice Based Credit System (CBCS)

The proposed curriculum is designed to provide students with comprehensive knowledge of science by covering various fundamental and advanced aspects of Mathematics and related disciplines. It aims to develop not only conceptual understanding but also the ability to apply commonly used mathematical techniques and methods to interdisciplinary fields and real-life problems. The programme emphasizes analytical thinking, problem-solving skills, research aptitude, and practical applications of mathematics.

The Undergraduate Four-Year Programme (UG Honors / UG Honors with Research) in Mathematics will be spread over four academic years, namely 1st Year, 2nd Year, 3rd Year, and 4th Year. Each academic year will consist of two semesters, and consequently, the programme will include a total of eight semester examinations. The curriculum is structured progressively to ensure systematic learning, skill enhancement, and research orientation among students.

Subject Prerequisites

To study this subject, a student must have studied Mathematics at the 10+2 (Class 12th) level or its equivalent examination from a recognized board or institution.

Eligibility for Admission

For admission to the Undergraduate Programme in Mathematics, candidates must have passed the 10+2 examination or an equivalent examination with Mathematics as one of the main subjects from a recognized board/institution, subject to the rules and regulations of the university.

Programme Duration

The duration of the Undergraduate Four-Year Programme (UG Honors / UG Honors with Research) in Mathematics shall be four academic years consisting of eight semesters. Candidates admitted to Semester-I will undergo the programme over this period. Each academic year shall comprise two regular semesters.

Examination and Assessment

Suggested Internal Continuous Evaluation / Examination Methods (Max. Marks: 25)
(Except Research Project and Practical)

Sr. No.	Assessment Type	Max. Marks
01	Class Test	10
02	Punctuality / Regularity	10
03	Presentation / Research Oriented Assignment	5

External Examination Methods (Max. Marks: 75)

As prescribed by the University (as per common ordinance for examination and assessment).

Programme Objectives

The Undergraduate Four-Year Programme (UG Honors / UG Honors with Research) 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.

Framework of Four Year UG Programme (UG Honors/ UG Honors with Research)

Year	Semester	Major 1 (Subject-1) Mathematics			Major 2 (Subject-2) From Same Faculty	Minor (Subject- 3) From Same / Other Faculty	SEC/ Vocational	AEC/ CoCurricular	Dissertation/ Research Project/ Field Work/ Survey	Semester Credits	Total Credits	Award Degree
		Course Code	Course Title	Credit	Credit	Credit	Credit	Credit	Credit			
1	I	B040101T	Differential Calculus and Integral Calculus	6	6	---	3	2	---	17	40	Certificate in Faculty (40 Credits)
	II	B040201T	Matrices, Differential Equations and Geometry	6	6	6*	3	2	---	23		
2	III	B040301T	Algebra and Mathematical Methods	6	6	---	3	2	---	17	40	Diploma in Faculty (80 Credits)
	IV	B040401T	Differential Equations and Mechanics	6	6	6*	---	2	3**	23		
3	V	B040501T	Ring Theory and Linear Algebra	5	10	---	---	---	---	20	40	UG Degree (120 Credits)
		Any One of The Followings										
		B040502T	Number Theory and Game Theory	5								
		B040503T	Graph Theory and Discrete Mathematics									
		B040504T	Differential Geometry and Tensor Analysis									
	VI	B040601T	Metric Spaces and Complex Analysis	4	10	---	---	---	---	20		
		B040602T	Numerical Analysis and Operations Research	4								
		B040603P	Practical	2								

B.Sc. Honors												
4	VII	B040701T	Algebra-I	4	---	---	---	---	---	20	40	UG Honors (160 Credits)
		B040702T	Real Analysis	4								
		B040703T	Complex Analysis	4								
		B040704T	Integral Equations and Calculus of Variations	4								
		B040705T	Hydrodynamics	4								
	VIII	B040801T	Algebra -II	4	---	---	---	---	---	20		
		B040802T	Topology	4								
		B040803T	Advanced Differential Equations	4								
		Any Two of The Followings										
		B040804T	Operations Research-I	4+4								
		B040805T	Classical Mechanics									
		B040806T	Probability Theory									
		B040807T	Special Theory of Relativity									
OR												
B.Sc. Honors with Research (For the Students who Secure 75% Marks or More in First Six Semesters)												
4	VII	B040701T	Algebra-I	4	---	---	---	---	---	20	40	B.Sc. Honors with Research (160 Credits)
		B040702T	Real Analysis	4								
		B040703T	Complex Analysis	4								
		B040704T	Integral Equations and Calculus of Variations	4								
		B040705R	Dissertation/ Research Project	4								
	VIII	Any Four of The Followings								20		
		B040801T	Hydrodynamics	4+4+4+4								
		B040802T	Algebra –II									
		B040803T	Topology									
		B040804T	Advanced Differential Equations									
		B040805T	Operations Research-I									
		B040806T	Classical Mechanics									
		B040807T	Probability Theory									
		B040808T	Special Theory of Relativity									
		B040809R	Dissertation/ Research Project	4								

Note: 1. .SEC (Skill Enhancement Course/ Vocational Course).

2. AEC (Ability Enhancement Course/ CoCurricular Course).

3. *Minor multidisciplinary only in even semester of 1st year and 2nd year.

4.** The student has to opt one project from subject-1/ subject-2/ subject-3.

Course Structure of Mathematics as Major Subject in UG Honors / UG Honors with Research Programme

Year	Semester	Course Code	Paper Title	Theory / Practical	Paper Credit	Total Credit	Marks Distributions
1	I	B040101T	Differential Calculus and Integral Calculus	Theory	6	6	75+25
	II	B040201T	Matrices, Differential Equations and Geometry	Theory	6	6+6*	75+25
		B040202M	Basic Arithmetic (Minor Multidisplinary)	Theory	6*		75+25
	III	B040301T	Algebra and Mathematical Methods	Theory	6	6	75+25
	IV	B040401T	Differential Equations and Mechanics	Theory	6		75+25

2	IV	B040402R	Research Project	Project	3**	6+3**+6*	100+0
		~~B040403M~~	Basic Reasoning and Logic (MINOR)	Theory	6*		75+25
3	V	B040501T	Ring Theory and Linear Algebra	Theory	5	10	75+25
		Any One of The Followings					
		B040502T	Number Theory and Game Theory	Theory	5		75+25
		B040503T	Graph Theory and Discrete Mathematics				
		B040504T	Differential Geometry and Tensor Analysis				
	VI	B040601T	Metric Spaces and Complex Analysis	Theory	4	10	75+25
		B040602T	Numerical Analysis and Operations Research	Theory	4		75+25
		B040603P	Practical	Practical	2		75+25
B.Sc. Honors							
4	VII	B040701T	Algebra-I	Theory	4	20	75+25
		B040702T	Real Analysis	Theory	4		75+25
		B040703T	Complex Analysis	Theory	4		75+25
		B040704T	Integral Equations and Calculus of Variations	Theory	4		75+25
		B040705T	Hydrodynamics	Theory	4		75+25
	VIII	B040801T	Algebra –II	Theory	4	20	75+25
		B040802T	Topology	Theory	4		75+25
		B040803T	Advanced Differential Equations	Theory	4		75+25
		Any Two of The Followings					
		B040804T	Operations Research-I	Theory	4+4		75+25 & 75+25
		B040805T	Classical Mechanics				
		B040806T	Probability Theory				
		B040807T	Special Theory of Relativity				
OR							
B.Sc. Honors with Research (For the Students who Secure 75% Marks or More in First Six Semesters)							
4	VII	B040701T	Algebra-I	Theory	4	20	75+25
		B040702T	Real Analysis	Theory	4		75+25
		B040703T	Complex Analysis	Theory	4		75+25
		B040704T	Integral Equations and Calculus of Variations	Theory	4		75+25
		B040705R	Dissertation/ Research Project	Project	4		100+0
	VIII	Any Four of The Followings					
		B040801T	Hydrodynamics	Theory	4+4+4+4	20	75+25 & 75+25 & 75+25 & 75+25
		B040802T	Algebra –II				
		B040803T	Topology				
		B040804T	Advanced Differential Equations				
		B040805T	Operations Research-I				
		B040806T	Classical Mechanics				
		B040807T	Probability Theory				
		B040808T	Special Theory of Relativity				
		B040809R	Dissertation/ Research Project	Project	4		100+0

Note: 1. * Minor multidisciplinary only in even semester of 1st year and 2nd year.

2. ** The student has to opt one project from subject-1/ subject-2/ subject-3.

Programme Exit Options

The mandatory number of credits to be secured for the award of Certificate in Faculty, Diploma in Faculty, UG Degree, UG Honors, and UG Honors with Research under the Undergraduate Four-Year Programme in Mathematics are listed in the following table.

Sr. No.	Type of Award	Stage of Exit	Mandatory Credits to be Secured for the Award	Exit Options
1	Certificate in Faculty	After Successful Completion of Semester II	**40**	Exit option-**1**
2	Diploma in Faculty	After Successful Completion of Semester IV	**80**	Exit option-**2**
3	UG Degree	After Successful Completion of Semester VI	**120**	Exit option-**3**
4	UG Honors	After Successful Completion of Semester VIII	**160**	----
		OR		
4	UG Honors with Research	After Successful Completion of Semester VIII	**160**	----

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 SEM-II	**PSO1.** Students should be able to recall and understand the basic concepts and fundamental ideas of Mathematics and demonstrate them effectively. Students should develop conceptual clarity and strengthen their foundation in core areas of Mathematics through problem-solving and analytical thinking
Second	SEM-III SEM-IV	**PSO2.** Students should gain adequate exposure to various branches and aspects of Mathematical Sciences. Students should be able to apply mathematical methods and techniques to solve theoretical and practical problems in different domains.
Third	SEM-V SEM-VI	**PSO3.** Students should 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. Students should develop computational and analytical skills for interdisciplinary applications and advanced mathematical problem solving.
Fourth	SEM-VII SEM-VIII	**PSO4.** Students should be able to comprehend, analyze, and apply acquired knowledge to formulate research objectives, adopt appropriate methodologies in identified research areas, and provide plausible mathematical solutions through research projects. **PSO5.** Students should build a strong foundation for pursuing higher studies such as a Master's degree in Mathematics with research orientation as a prerequisite for doctoral research (Ph.D.) in Mathematics and allied disciplines.

FIRST YEAR (SEMESTER-I)

DIFFERENTIAL CALCULUS AND INTEGRAL CALCULUS

Class: UG	**Year:** FIRST	**Semester:** FIRST
Subject: MATHEMATICS		
Course Code: B040101T	**Course Title:** DIFFERENTIAL CALCULUS AND INTEGRAL CALCULUS	
Credits: 6+0	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 12th.

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, Alternating series.
II	Limit, continuity and differentiability of function of single variable, Cauchy's definition, Uniform continuity, Boundedness theorem, Intermediate value theorem, Bolzano's 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, Parametric representation of curves and tracing of parametric curves, Tracing of curves in Cartesian and Polar forms.
	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, Pappu's theorem, 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.

FIRST YEAR (SEMESTER-II)

MATRICES, DIFFERENTIAL EQUATIONS AND GEOMETRY

Class: UG	**Year:** FIRST	**Semester:** SECOND
Subject: MATHEMATICS		
Course Code: B040201T	**Course Title:** MATRICES, DIFFERENTIAL EQUATIONS AND GEOMETRY	
Credits: 6+0	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 12th.

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, Tracing 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)

BASIC ARITHMATIC (MINOR MULTIDISCIPLINARY)

Class: UG	**Year:** FIRST	**Semester:** SECOND
Subject: MATHEMATICS		
Course Code: B040202M	**Course Title:** BASIC ARITHMATICS	
Credits: 6+0		
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 class10th		
Course Objectives The course aims to develop fundamental understanding of basic mathematical concepts and quantitative techniques required for solving academic and real-life problems. It enhances computational, analytical, and problem-solving skills through topics related to arithmetic, geometry, mensuration, and financial mathematics. The course also introduces basic data interpretation techniques and builds a strong foundation for higher studies and competitive examinations.		

Unit	Topics
	BASIC ARITHMATICS
I	Number System, H.C.F. and L.C.M., Decimal Fractions, Simplification, Square Roots and Cube Roots, Average, Problems on Numbers.
II	Surds and Indices, Percentage, Profit and Loss, Ratio and Proportion, Partnership, Time and Work, Time and Distance, Problems on Trains.
III	Angles and Triangles, Polygons, Area and Perimeter, Volume and Surface Area, Problems on Ages, Calendar Problems, Clock Problems.
IV	Simple Interest, Compound Interest, True Discount, Banker's Discount, Pie Charts, Line Charts, Bar Diagrams, Basic Data Interpretation.

Course Outcomes (COs)

CO1: Students will acquire foundational knowledge of basic mathematical concepts and their applications, leading to the development of quantitative and analytical skills required for higher studies and competitive examinations.
CO2: Students will develop understanding of Arithmetic, Reasoning, and Logical thinking, and will be able to apply these concepts in solving practical and problem-based situations.

Books Recommended

1. R.S. Aggarwal, Arithmetic, S. Chand and Company Limited.
2. R.S. Aggarwal, A Modern Approach to Verbal and Non-Verbal Reasoning, S. Chand and Company Limited.

SECOND YEAR (SEMESTER-III)

ALGEBRA AND MATHEMATICAL METHODS

Class: UG	**Year:** SECOND	**Semester:** THIRD
Subject: MATHEMATICS		
Course Code: B040301T	**Course Title:** ALGEBRA AND MATHEMATICAL METHODS	
Credits: 6+0	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 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 and partition, Divisibility in Z, Fundamental theorem of arithmetic, Congruences and residue classes, Eulers φ- function, Fermat's and Euler's theorems(Statement and application only).
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.
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.

SECOND YEAR (SEMESTER-IV)

DIFFERENTIAL EQUATIONS AND MECHANICS

Class: UG	**Year:** SECOND	**Semester:** FOURTH
Subject: MATHEMATICS		
Course Code: B040401T	**Course Title:** DIFFERENTIAL EQUATIONS AND MECHANICS	
Credits: 6+0	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 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 modeling 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, Surfaces Orthogonal to the given system of surfaces.
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. Raisinghania, 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: B040402R	**Course Title:** RESEARCH PROJECT	
Credits:0+3	**The student can opt any one as a project from subject-1/ subject-2/ subject-3 (Major-1/ Major-2/ Minor-3) in semester-IV**	
Max. Marks: 100	**Min. Passing Marks:** As per University CBCS Norm	

Course prerequisites:

To study this course, a student must have Mathematics as Major / Minor 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.

RESEARCH PROJECT

Candidates/Students shall prepare a project report on a specific topic based on any one of the Core/Major/Minor 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.

SECOND YEAR (SEMESTER-IV)

BASIC REASONING AND LOGIC (MINOR MULTIDISCIPLINARY)

Class: UG	**Year:** SECOND	**Semester:** FOURTH
Subject: MATHEMATICS		
Course Code: B040403M	**Course Title:** BASIC REASONING AND LOGIC	
Credits: 6+0		
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 has the subject Mathematics in class 10^{th}

Course Objectives

The course aims to develop logical, analytical, and critical thinking abilities among students through various concepts of verbal, non-verbal, and analytical reasoning. It enhances problem-solving skills, decision-making ability, and quantitative aptitude required for competitive examinations and real-life situations. The course also helps students improve their reasoning power, accuracy, and systematic approach towards logical analysis and interpretation.

Unit	Topics
	BASIC REASONING AND LOGIC
I	**Verbal Reasoning-** Series Completion, Analogy, Classification, Coding–Decoding, Blood Relations, Puzzle Test, Sequential Output Tracing, Direction Sense Test, Alphabet Test, Alpha-Numeric Sequence Puzzle.
II	**Analytical and Logical Reasoning-** Mathematical Operations, Logical Sequence of Words, Arithmetical Reasoning, Eligibility Test, Logical Deduction, Syllogism, Statement and Assumptions, Statement and Conclusions, Cause and Effect, Assertion and Reason.
III	**Non-Verbal Reasoning-** Non-Verbal Series, Non-Verbal Analogy, Classification, Mirror Images, Water Images, Embedded Figures, Figure Matrix, Rule Detection, Grouping of Identical Figures, Dot Situation.
IV	**Logic and Critical Thinking-** Symbols and Notations, Identifying Arguments, Detecting Fallacies, Logical Venn Diagrams, Logical Reasoning, Critical Thinking and Decision Making.

Course Outcomes (COs)

CO1: Students will develop logical, analytical, and critical thinking skills required for solving verbal, non-verbal, and analytical reasoning problems.

CO2: Students will be able to apply reasoning and logical techniques in problem-solving, decision-making, and competitive examinations with improved accuracy and efficiency.

Books Recommended

1. R.S. Aggarwal, Arithmetic, S. Chand and Company Limited.
2. R.S. Aggarwal, A Modern Approach to Verbal and Non-Verbal Reasoning, S. Chand and Company Limited.
3. Edgar Thorpe, Test of Reasoning, Pearson Education.
4. B.S. Sijwali & Indu Sijwali, A New Approach to Reasoning Verbal and Non-Verbal, Arihant Publications.
5. M.K. Pandey, Analytical Reasoning, BSC Publishing Co. Pvt. Ltd.
6. Peeyush Bhardwaj, Logical and Analytical Reasoning, Arihant Publications.

THIRD YEAR (SEMESTER-V)

RING THEORY AND LINEAR ALGEBRA

Class: UG	**Year:** THIRD	**Semester:** FIFTH
Subject: MATHEMATICS		
Course Code: B040501T	**Course Title:** RING THEORY AND LINEAR ALGEBRA	
Credits: 5+0	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 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, Orthogonal vectors, Orthonormal sets and bases.

Course Outcomes (COs)

CO1: After successful completion of the course, students will acquire knowledge of polynomial rings over commutative rings, vector spaces, and related algebraic structures.

CO2: 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: B040502T	**Course Title:** NUMBER THEORY AND GAME THEORY	
Credits: 5+0	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 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; Jacobi symbol.
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, Divide and conquer Relations, 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: B040503T	**Course Title:** GRAPH THEORY AND DISCRETE MATHEMATICS	
Credits: 5+0	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 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-V)

DIFFERENTIAL GEOMETRY AND TENSOR ANALYSIS

Class: UG	**Year:** THIRD	**Semester:** FIFTTH
Subject: MATHEMATICS		
Course Code: B040504T	**Course Title:** RING THEORY AND LINEAR ALGEBRA	
Credits: 4+0	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: 4-0-0		

Course prerequisites:

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

Course Objectives

1. Provide knowledge of the geometry of curves and surfaces and their mathematical properties.
2. Introduce the concepts of curvature and torsion and their geometrical significance.
3. Develop understanding of the methods and applications of vector and tensor analysis.
4. Introduce the concepts of Riemannian spaces, Riemannian curvature, and their fundamental properties.

Unit	Topics
	PART-A **DIFFERENTIAL GEOMETRY**
I	Local theory of curves -space curves, Regular curve and Plane curve, twisted curve, equation of a plane and straight line, equation of curves in space, length of a curve, tangent to curve, Order of contact between curves and surfaces, osculating plane , equation of osculating plane, equation osculating plane at a point of curve of intersection of two surfaces. Tangent, principal normal and binormal, normal plane and rectifying plane.
II	Curvature and torsion, Serret-Frenet formulae, Direction cosines of the principal normal and binormal, Osculating sphere. Involutes and evolutes of curves, curve on surface, Regular point and Singularities of surface, transformation of parameters, Parametric curves, tangent plane and normal line, First fundamental form and arc length. Angle between two curves on surface.
III	Special tensors and its properties, orthogonal trajectories, Differential equation of orthogonal trajectories. Second fundamental form of surface, Geometric interpretation of the second fundamental form, Gauss and Weingarten equation, Identities based on Weingarten equation.
IV	Normal curvature and its equation, Meusnier's theorem. Principal directions and curvatures. Mean curvature, Gaussian Curvature, Minimal surface. Definition of Geodesics and differential equation of geodesics on a surface.
	PART-B **TENSOR ANALYSIS**
V	Tensor : Transformation of coordinates, Contravariant and covariant vectors and tensors, Scalar invariants, Mixed tensors, Symmetric and skew –symmetric tensor, Algebra of tensors, Contraction and inner product, Quotient law, Reciprocal tensors.
VI	Associated tensors, Length of a vector, Unit Vector, Null vector and orthogonal vector, Riemannian Metric and Space and Christoffel symbols.
VII	Covariant differentiation of vector and tensor, Ricci's theorem, Gradient of scalar, Divergence of a contravariant vector, covariant vector and conservative vector, Divergence of a contravariant tensor of order two, Divergence of a mixed tensor of type (1,1), Laplacian of an invariant, curl of a covariant vector
VIII	Riemannian curvature tensor and their properties, Flat space, Ricci tensor and scalar curvature, Einstein space and Einstein tensor.

Course Outcomes (COs)

CO1: After successful completion of the course, students will be able to compute and analyze the curvature of curves in different coordinate systems.

CO2: Students will gain knowledge of the local theory of curves and surfaces, including geodesics, geodesic curvature, geodesic polars, curvature of curves on surfaces, Gaussian curvature, and normal curvature.

CO3: Students will acquire understanding of tensor algebra, types of tensors, and advanced concepts such as Riemannian spaces, Ricci tensor, Einstein space, and Einstein tensor.

Books Recommended

Part–A : Differential Geometry

1. Somasundaram, Differential Geometry, Narosa Publishing House.
2. Andrew Pressley, Elementary Differential Geometry, Springer Verlag, 2014.
3. M.P. do Carmo, Differential Geometry of Curves and Surfaces, Prentice Hall, 1976.
4. Alfred Gray, Differential Geometry of Curves and Surfaces, CRC Press, 1998.
5. S. Montiel & A. Ros, Curves and Surfaces, American Mathematical Society, 2005.
6. Barrett O'Neill, Elementary Differential Geometry, Elsevier, 2006.

Part–B : Tensor Analysis

7. David C. Kay, Tensor Analysis, Schaum's Outline Series, McGraw Hill, 1988.
8. R.S. Mishra, A Course in Tensors with Applications to Riemannian Geometry, Pothishala Pvt. Ltd., Allahabad.
9. P.K. Nayak, Tensor Calculus and Differential Geometry, PHI Learning Private Limited, Delhi.
10. D.C. Kay, Tensor Calculus, Schaum's Outlines.

THIRD YEAR (SEMESTER-VI)

METRIC SPACE AND COMPLEX ANALYSIS

Class: UG	**Year:** THIRD	**Semester:** SIXTH
Subject: MATHEMATICS		
Course Code: B040601T	**Course Title:** METRIC SPACE AND COMPLEX ANALYSIS	
Credits: 4+0	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 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, Topology of metric spaces, 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, 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.
VII	Complex integration, Cauchy-Goursat theorem, Cauchy's Integral formula, Formulae for first, second and nth derivatives, Cauchy's Inequality, Liouville's Theorem, Taylor Series, Laurent Series and its examples.
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, Evaluation of improper real integrals, Definite integrals involving sines and cosines.

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: B040602T	**Course Title:** NUMERICAL ANALYSIS AND OPERATIONS RESEARCH	
Credits: 4+0	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 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. Numerical solution of ordinary differential equation, Picard method, Euler's method, Modified Euler's method, Runge-Kutta method.
IV	Difference Equations and their solutions, Shooting method and Difference equation method for solving second linear order differential equation with boundary conditions of first, second and third type.
	PART-B **OPERATIONS RESEARCH**
V	Introduction, Convex sets, Convex and concave functions, 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, Basic feasible solution.
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, 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: B040603P	**Course Title:** PRACTICAL	
Credits: 2+0	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: 2-0-0		

Course prerequisites:

- To study this course, a student must have Mathematics as Major Subject in UG Third Year Programme.
- To study this course, a student should have the course B040602T 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 SageMath, Mathematica, MATLAB, Maple, Scilab, 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 the practical to be done using SageMath / Mathematica /MATLAB / Maple / SciLab / 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. Varun Kumar, Basics of SageMath, Amazon, 2021.
2. Cleve B. Moler, MATLAB: A Practical Introduction to Programming and Problem Solving.

Suggested Internal Continuous 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

FOURTH YEAR (SEMESTER-VII)

ALGEBRA-I

Class: UG	**Year:** FOURTH	**Semester:** SEVENTH
Subject: MATHEMATICS		
Course Code: B040701T	**Course Title:** ALGEBRA-I	
Credits: 4+0	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 Mathematics as Major Subject in UG Third Year Programme.

Course Objectives

1. Introduce the concepts of automorphisms of groups, group actions, and their applications.
2. Develop understanding of Sylow subgroups and their applications in group theory.
3. Study solvable and nilpotent groups and explore their interrelationships and properties.

Unit	Topics
	PART-A
	ALGEBRA-I
I	Automorphisms, inner automorphisms, Automorphism groups, Automorphism groups of finite and infinite cyclic groups, Characteristic subgroups, Commutator subgroup and its properties; Applications of factor groups to automorphism groups.
II	Conjugacy relation. Normalizer of an element, Class equation of a finite group, Center of a group, Fundamental theorems on isomorphism of groups. Group action, Stabilizer subgroups and orbit decomposition, Orbit-Stabilizer theorem.
III	Maximal subgroups, Normal series, Composition series, Examples of normal series and Composition series. Jordan-Holder theorem, Solvable groups, Solvable subgroups, Nilpotent groups, Zassenhaus Lemma(without proof), Schreier's refinement theorem.
IV	External and internal direct product of groups, Cauchy's theorem for finite group, Cauchy's theorem for abelian group, Groups of order p^2 and pq, Sylow's p subgroups, Sylow's first, second and third theorems. Application of Sylow's theorems to find the number of Sylow's p subgroups of a finite groups.

Course Outcomes (COs)

CO1: Students will be able to compute automorphisms of groups, understand group actions, and apply Cauchy's theorem for finite groups. They will also gain knowledge of the structure of groups of orders (pq), (p^2q), and (pqr).

CO2: Students will be able to understand and prove Schreier's refinement theorem and the Jordan–Hölder theorem, and compute commutator subgroups of groups.

CO3: Students will understand the concepts of solvable and nilpotent groups, their interrelationships, and equivalent characterizations of nilpotent groups. The course will also enhance their logical and computational skills and improve employability in teaching and research.

Books Recommended

1. I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi.
2. P.B. Bhattacharya, S.K. Jain & S.R. Nagpaul, Basic Abstract Algebra, 2nd Edition, Cambridge University Press (Indian Edition).
3. Surjeet Singh & Qazi Zameeruddin, Modern Algebra, Vikas Publishing House Pvt. Ltd.
4. K.B. Datta, Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi.
5. S. Kumaresan, Linear Algebra: A Geometric Approach, Prentice Hall of India.
6. A.R. Vasishtha & A.K. Vasishtha, Modern Algebra, Krishna Prakashan Media (P) Ltd., Meerut.
7. H.K. Pathak, Abstract Algebra, Shiksha Sahitya Prakashan.
8. Ramji Lal, Algebra I: Groups, Rings, Fields and Arithmetic, Springer Nature, 2018.
9. David S. Dummit & Richard M. Foote, Abstract Algebra.

FOURTH YEAR (SEMESTER-VII)

REAL ANALYSIS

Class: UG	**Year:** FOURTH	**Semester:** SEVENTH
Subject: MATHEMATICS		
Course Code: B040702T	**Course Title:** REAL ANALYSIS	
Credits: 4+0	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 Mathematics as Major Subject in UG Third Year Programme.

Course Objectives

1. Introduce the concepts of series of arbitrary terms and multiplication of series.
2. Develop understanding of the Riemann–Stieltjes integral and its properties.
3. Study pointwise and uniform convergence of sequences and series of functions.

Unit	Topics
	REAL ANALYSIS
I	Functions of several variables: continuity, partial derivatives, differentiability, derivatives of functions in an open set of R_n into R_m as a linear transformation, chain rule, Taylor's theorem, Riemann integral, Properties of the R- integral, Fundamental theorem of Calculus.
II	Definition and existence of Riemann-Stieltjes integral, Conditions for R-S integrability, Properties of integral, Riemann Stieltjes integral as a limit of sums, Mean value theorem for RS-Integrals, Integration and differentiation.
III	Countable and uncountable sets, Cardinal numbers, Schroeder-Bernstein theorem, Series of arbitrary terms, Convergence, divergence and oscillation, Absolute Convergence, Abel's and Dirichilet's tests, Multiplication of series, Rearrangements of terms of a series, Riemann's theorem and sum of series.
IV	Point-wise and uniform convergence, Uniform convergence of sequences and series of functions, Cauchy's criterion for uniform convergence, Abel's and Dirichilet's tests, uniform convergence and continuity, Mn-test, Weierstrass M-test, uniform convergence and differentiation.

Course Outcomes (COs)

CO1: Students will understand the summation of positive and negative terms of real numbers and the application of Riemann's theorem.
CO2: Students will understand higher-order derivatives and will be able to apply Taylor's theorem with remainder.
CO3: Students will learn the concepts of integration, existence of the Riemann–Stieltjes integral, and the Fundamental Theorem of Integral Calculus.
CO4: Students will understand the integration of a bounded function over a monotonic function.
CO5: Students will learn the concepts of convergence of sequences of functions of real numbers and the role of the Weierstrass Approximation Theorem.
CO6: Students will improve their logical and computational skills and enhance employability in teaching and research.

Books Recommended

1. T.M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1996.
2. Walter Rudin, Principles of Mathematical Analysis, 3rd Edition, McGraw-Hill, 2017 (International Student Edition).
3. S.C. Malik, Mathematical Analysis, Wiley Eastern, New Delhi, 5th Edition, 2017.
4. R.G. Bartle, The Elements of Real Analysis, John Wiley & Sons, 2nd Edition, 1975.
5. Walter Rudin, Principles of Mathematical Analysis, McGraw-Hill.
6. H.L. Royden, Real Analysis, Macmillan Publishing Co. Inc., New York, 4th Edition, 1993.
7. Richard Johnsonbaugh, Foundations of Mathematical Analysis.
8. H.K. Pathak, Real Analysis, Shiksha Sahitya Prakashan.

FOURTH YEAR (SEMESTER-VII)

COMPLEX ANALYSIS

Class: UG	**Year:** FOURTH	**Semester:** SEVENTH
Subject: MATHEMATICS		
Course Code: B040703T	**Course Title:** COMPLEX ANALYSIS	
Credits: 4+0	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 Mathematics as Major Subject in UG Third Year Programme.

Course Objectives

1. Expose students to the foundations of tensor analysis, which will help in understanding various physical phenomena and provide a strong mathematical base.
2. Develop understanding of tensors and basic concepts of differential geometry, preparing students for advanced applications in related fields.

Unit	Topics
	COMPLEX ANALYSIS
I	Review of analytic functions, Branch of logarithm, Conformal mappings, Mobius transformations, Group structure of mobius transforations, Fixed points and mobius map, Cross ratios and its invariance property, Conformal mappings of half planes onto disk, automorphism of unit disk and upper half plane.
II	Zeros of analytic functions, Maximum modulus principle and theorem, Minimum modulus theorem, Phragmen–Lindelöf theorem, Hadamard's three lines theorem, Hadamard's three circles theorem, Schwarz' lemma and its applications, Borel-Caratheodary theorem, Schwarz's pick lemma, Fundamental theorem of Algebra.
III	Classification of Singularities, Riemann removable singuarities theorem, Laurent's series and its further illustraions for singularies, isolated singularities at infinity, meromorphic functions, Argument principle, Rouche's theorem, Essential singularties, Casoriti-Weierstrass theorem, Picard's little theorem.
IV	Schwarz' Reflection principle, Mittage-Leffler's theorem, Infinite product of complex numbers and its convergence, Infinite product of analytic functions, Weierstrass factorization theorem, Hadamard's factorization theorem.

Course Outcomes (COs)

CO1: After completion of this course, students will develop a rigorous and deeper understanding of fundamental concepts in Mathematics, which will support further studies in pure Mathematics and research.

CO2: The course enables students to understand the basics of tensor analysis and differential geometry, which will be useful for advanced studies and applications in higher Mathematics.

Books Recommended

1. J.W. Brown & R.V. Churchill, Complex Variables and Applications, 8th Edition, 2013.
2. L.V. Ahlfors, Complex Analysis, McGraw Hill Co., Indian Edition, 2017.
3. J. Bak & D.J. Newman, Complex Analysis, Springer, 2010.
4. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 2013.
5. D.C. Ullrich, Complex Made Simple, American Mathematical Society, 2008.

FOURTH YEAR (SEMESTER-VII)

INTEGRAL EQUATIONS AND CALCULUS OF VARIATIONS

Class: UG	**Year:** FOURTH	**Semester:** SEVENTH
Subject: MATHEMATICS		
Course Code: B040704T	**Course Title:** INTEGRAL EQUATIONS AND CALCULUS OF VARIATIONS	
Credits: 4+0	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 Third Year Programme.

Course Objectives

1. Understand the concepts of initial value problems and boundary value problems in differential equations.
2. Develop understanding of the relationship between differential equations and integral equations, along with applications of calculus of variations.

Unit	Topics
	INTEGRAL EQUATIONS AND CALCULUS OF VARIATIONS
I	Introduction of integral equations, linear integral equations, types of linear integral equations, conversion of differential equations to integral equations, types of Kernels, L_2-kernels and L_2-functions, eigen values and eigen functions, Solution of Homogeneous and Non-homogeneous Fredholm integral equations of first and second kinds.
II	Solution of Fredholm integral equations by Successive approximations and successive substitution methods, Solution of Volterra integral equations by successive approximations and successive substitution methods, Resolvent Kernel and reciprocal functions, Neumann Series, Volterra solution of Fredholm integral equation of second kind, reduction of Volterra integral equation into differential equation.
III	Variational problems with fixed boundaries- Extremals, Euler's equation for functionals containing first order derivative and one independent variable, Functionals dependent on higher order derivatives, Functional dependent on more than one independent variables, variational problems in parametric form, Invariance of Euler's equation.
IV	Functional dependent on several dependent variables, Isoperimetric problems, Lagrange equation, Variational problems with moving boundaries, one sided variations, Jacobian and Legendre conditions, second variation, Applications of the Calculus of Variations.

Course Outcomes (COs)

CO1: Students will be able to understand and formulate initial value and boundary value problems and apply them in solving differential equations.

CO2: Students will develop understanding of integral equations, their types, and methods of solution, including Volterra and Fredholm integral equations using successive approximations and substitution methods.

CO3: Students will be able to analyze the relationship between differential equations and integral equations and apply numerical and analytical techniques in solving them.

CO4: Students will gain knowledge of calculus of variations, including Euler's equation and variational principles, and will be able to apply these concepts to solve optimization problems in science and engineering.

Books Recommended

1. V.S. Verma, Fundamentals of Integral Equations, Neel Kamal Prakashan, Gorakhpur, 2018.
2. M.D. Raisinghania, Integral Equations and Boundary Value Problems, S. Chand Publications.
3. J.N. Sharma & R.K. Gupta, Special Functions, Krishna Prakashan Media (P) Ltd, 2020.
4. Mukesh Kumar Singh, Calculus of Variations, Krishna Prakashan Media (P) Ltd, 2020.

FOURTH YEAR (SEMESTER-VII)

DISSERTATION/ RESEARCH PROJECT

Class: PG	**Year:** FOURTH	**Semester:** SEVENTH
Subject: MATHEMATICS		
Course Code: B040705R	**Course Title:** DISSERTATION/ RESEARCH PROJECT	
Credits: 0+4	Core Compulsory	
Max. Marks: 100	**Min. Passing Marks:** As per University CBCS Norm	

Course Objectives

1. To develop basic research skills such as literature review, problem understanding, analysis, and structured presentation under the guidance of a supervisor.
2. To improve academic writing and communication skills through preparation of a typed dissertation and PowerPoint presentation.

DISSERTATION/ RESEARCH PROJECT

Candidate/Students should write a dissertation/research project on the specific topic based on Mathematical sciences. The students have been allotted a supervisor in this dissertation/research project on their topic, given by the concern faculty. The dissertation/research project should be typed in LATEX/ MS-WORD and its presentation on Power Point / Beamer.

Course Learning Outcomes

CO1: Students will be able to conduct literature review and identify research problems in Mathematical Sciences.

CO2: Students will be able to analyze mathematical problems and present their findings in a systematic and scientific manner.

CO3: Students will be able to prepare a dissertation/research report using LaTeX/MS-Word with proper academic formatting.

CO4: Students will be able to effectively communicate research work through PowerPoint/Beamer presentations and technical discussions.

Suggested Evaluation Methods (Max. Marks: 100)

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

Note: A soft copy of the dissertation/research project must be submitted to the concerned department/subject teacher. There is no requirement to submit a hard copy of the dissertation/research project during this semester.

FOURTH YEAR (SEMESTER-VIII)

HYDRODYNAMICS

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: MATHEMATICS		
Course Code: B040801T	**Course Title:** HYDRODYNAMICS	
Credits: 4+0	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 Mathematics as Major Subject in UG Third Year Programme.

Course Objectives

1. Develop understanding of fundamental concepts of fluid dynamics including Lagrangian and Eulerian descriptions of fluid motion, continuity equation, and kinematic properties of fluid flow.
2. Introduce the concepts of velocity potential, stream function, circulation, and irrotational motion along with important theorems such as Bernoulli's theorem and Kelvin's circulation theorem.
3. Study the motion of fluids in relation to solid bodies such as cylinders and spheres, and understand the mathematical modeling of flow past these objects.
4. Develop analytical skills to understand advanced topics such as sources, sinks, doublets, image methods, and their applications in fluid flow problems.

Unit	Topics
	HYDRODYNAMICS
I	Lagrangian and Eulerian method, Equation of continuity, Boundary surface, Stream lines, Path lines and streak lines, Velocity potential, Vortex line, Rotational and irrotational motion, Euler's and Lagrange's equation of motion, Bernoulli's equations, Equation of impulsive action.
II	Sources and Sinks, stream or current function, Complex potential and velocity, Doublets, Image of a source w.r.t. line, circle and sphere, Images Theorem of Blasius, Flow and circulation, Kelvin's circulation theorem, Performance of irrotational motion, Kinetic energy of infinite liquid, Euler's momentum theorem, D'Alembert Paradox.
III	General equation of cylinder, Kinetic energy, Motion of circular and elliptic cylinders, Liquid streaming past a fixed circular/elliptic cylinder, Kinetic energy of elliptic cylinder, Milne-Thomson circle theorem, Initial motion between two Coaxial circular cylinder.
IV	Irrotational motion in three dimensions, Motion of a sphere through liquid at rest of infinity, liquid streaming past a fixed sphere, Equation of motion of a sphere, Motion of sphere under gravity, concentric spheres, Stoke's stream function.

Course Outcomes (COs)

CO1: Students will be able to understand and distinguish between Lagrangian and Eulerian descriptions of fluid motion and apply the continuity equation in fluid flow analysis.

CO2: Students will develop knowledge of velocity potential, stream function, circulation, and irrotational flow, and will be able to apply important theorems such as Bernoulli's theorem and Kelvin's circulation theorem.

CO3: Students will be able to analyze fluid motion using concepts such as sources, sinks, doublets, and image methods, and apply them to solve problems in fluid flow.

CO4: Students will gain understanding of the motion of fluids past cylinders and spheres and will be able to model and solve related physical problems using mathematical techniques.

Books Recommended

1. M.D. Raisinghania, Fluid Dynamics, S. Chand, New Delhi, 2013 (11th Edition).
2. B.D. Sharma & A.K. Sachdeva, Elementary Hydrodynamics, Kedarnath Ramnath, Meerut, 2020.
3. W.H. Besant & A.S. Ramsey, A Treatise on Hydrodynamics, CBS Publishers, Delhi, 2006.
4. S.W. Yuan, Foundations of Fluid Dynamics, Prentice-Hall of India, 1988.
5. N. Curle & H.J. Davis, Modern Fluid Dynamics, D. Van Nostrand Company Ltd., London, 1968.
6. B.G. Verma & Gupta, Hydrodynamics, Pragati Prakashan, Meerut, 1995.

FOURTH YEAR (SEMESTER-VIII)

ALGEBRA-II

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: MATHEMATICS		
Course Code: B040802T	**Course Title:** ALGEBRA-II	
Credits: 4+0	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 Mathematics as Major Subject in UG Third Year Programme.

Course Objectives

1. Study polynomial rings and important algebraic structures such as Euclidean domains, principal ideal domains, unique factorization domains, and related factorization results.
2. Introduce the concepts of field theory, including field extensions, finite fields, splitting fields, and algebraic and transcendental extensions.
3. Develop foundational knowledge of Galois theory, including Galois groups and their applications in solving polynomial equations and understanding field structures.

Unit	Topics
	ALGEBRA-II
I	Elementary Ring theory: Homomorphisms and isomorphisms of a ring, Embedding of rings, Quotient fields, Subrings, ideals and isomorphism theorems, quotient rings, second isomorphism theorems of rings, Maximal ideals and prime ideals.
II	**Polynomial rings:** Polynomial rings over Integral domains, Division Algorithm, remainder and factor theorem, **Arithmetic in Rings:** Division in rings, Prime and irreducible elements, G.C.D and L.C.M., Principal ideal domains, Euclidean domains, Chinese remainder theorem in rings, Unique factorization domains (U.F.D).
III	**Arithmetic in Rings (continued):** Gauss lemma, irreducibility criterion over U.F.D., Eisenstein's irreducibility criterion. **Field Theory:** Finite fields, Extension fields, Perfect fields, Finite extension, Simple, algebraic and transcendental extensions, Primitive elements, Simple extensions, Factorization of polynomial in extension fields, Splitting fields, Algebraically closed fields and algebraic closure (definition only).
IV	**Galois Theory:** Galois Group, Fixed field, Galois extensions, Computation of Galois Groups, Dedekind theorem, Properties of Galois groups, Fundamental theorem of Galois theory, Geometric constructions.

Course Outcomes (COs)

CO1: Students will be able to understand and apply concepts of ring theory including homomorphisms, ideals, quotient rings, and isomorphism theorems.
CO2: Students will develop the ability to work with polynomial rings and analyze algebraic structures such as Euclidean domains, principal ideal domains, and unique factorization domains.
CO3: Students will gain knowledge of field theory, including field extensions, finite fields, splitting fields, and algebraic properties of extensions.
CO4: Students will understand the basics of Galois theory, including Galois groups and their applications in solving polynomial equations and studying field extensions.

Books Recommended

1. David S. Dummit & Richard M. Foote, Abstract Algebra, John Wiley & Sons, New York, 2003.
2. N.S. Gopalakrishnan, University Algebra, Wiley Eastern, New Delhi, 1986.
3. Ramji Lal, Algebra II, Springer Verlag, 2018.
4. J.B. Fraleigh, A First Course in Abstract Algebra, Pearson Education Inc., 2002.

FOURTH YEAR (SEMESTER-VIII)

TOPOLOGY

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: MATHEMATICS		
Course Code: B040803T	**Course Title:** TOPOLOGY	
Credits: 4+0	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 Mathematics as Major Subject in UG Third Year Programme.

Course Objectives

1. Develop a strong foundation in general topology by introducing basic concepts such as open and closed sets, closure, interior, boundary, and neighborhood systems.
2. Introduce separation axioms and important theorems including Urysohn lemma and Tietze extension theorem.
3. Develop knowledge of compactness and connectedness along with their properties and applications in topological spaces.

Unit	Topics
	TOPOLOGY
I	Definition and examples of topological spaces. Closed sets. Closure. Dense subsets. Neighbourhoods. Interior, exterior and boundary. Accumulation points and derived sets. Bases andsub-bases. Subspaces and relative topology. Neighbourhood Systems.
II	Continuous functions and homeomorphism, The Pasting lemma. First and second countable spaces. Lindelof's theorems. Separable spaces. Second Countability and Separability.
III	Separation axioms T_0, T_1, T_2, T_3, T_4; their characterizations and basic properties. Urysohn Lemma.Tietze extention theorem.
IV	Compact sets and their properties. Finite intersection property, Bolzano Weierstrass property. Continuous functions and compactness, Sequential compactness, countable compactness and their comparison. One point compactification. Connected spaces. Connectedness on the real line. Components. Locally connected Spaces, Continuous functions and connectedness.

Course Outcomes (COs)

CO1: Students will be able to understand and analyze fundamental concepts of topology such as open sets, closed sets, closure, interior, boundary, and accumulation points.
CO2: Students will develop understanding of continuous functions, homeomorphisms, countability axioms, and important results like the Lindelöf theorem and pasting lemma.
CO3: Students will gain knowledge of separation axioms and important theorems such as Urysohn lemma and Tietze extension theorem.
CO4: Students will be able to understand compactness and connectedness, their properties, and applications in general topology.

Books Recommended

1. George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company.
2. J.L. Kelley, General Topology, Van Nostrand Reinhold Co., New York.
3. K.D. Joshi, Introduction to General Topology, Wiley Eastern Ltd.
4. James R. Munkres, Topology, Prentice Hall of India Pvt. Ltd., New Delhi.
5. Willard, General Topology, Addison-Wesley, Reading.
6. J. Dugundji, Topology, Prentice-Hall of India, 1966.
7. G.E. Bredon, Topology and Geometry, Springer, 2014.
8. T.B. Singh, Elements of Topology, CRC Press, Taylor & Francis, 2013.

FOURTH YEAR (SEMESTER-VIII)

ADVANCED DIFFERENTIAL EQUATIONS

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: MATHEMATICS		
Course Code: B040804T	**Course Title:** ADVANCED DIFFERENTIAL EQUATIONS	
Credits: 4+0	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 Mathematics as Major Subject in UG Third Year Programme.

Course Objectives

1. Introduce Picard's method of successive approximation and develop understanding of existence and uniqueness of solutions for initial value problems in ordinary differential equations.
2. Provide knowledge of classification of second-order partial differential equations and their reduction to canonical forms.
3. Develop understanding of analytical techniques such as separation of variables and Green's function for solving classical partial differential equations.
4. Introduce stability theory of dynamical systems, including linear systems, linearized stability, and Lyapunov functions.

Unit	Topics
	ADVANCED DIFFERENTIAL EQUATIONS
I	Picard's method of successive approximation for intial value problems, Problems of Existence and uniqueness of initial value problems $dy/dx = f(x,y)$, $y(x_0)=y_0$, Lipschitz condition, Picard's theorem, Wronskian.
II	Classification of partial differential equation of second order, Reduction to canonical forms, Cauchy's problem for Homogenous wave equation, Methods of separation of variable for solving Laplace, wave and diffusion equations, Green's function, Planar autonomous systems of ordinary differential equations: Stability of stationary points for linear systems with constant coefficients, Linearized stability, Lyapunov functions.
III	Homogeneous linear partial differential equations with constant coefficients, Complementary functions and particular integrals, Non-homogeneous linear partial differential equations with constant coefficients, Reducible and irreducible linear operators, Partial differential equations reducible to equations with constant coefficients.
IV	Orthogonality, Orthogonal and orthonormal set of functions, Orthogonal and orthonormal set of functions w.r.t. Weight function, Gram-Schmidth process of orthogonalization, Sturm-Liouville (S-L) problems: eigenvalues and eigenfunctions, reality of eigenvalues, orthogonality of Legendre polynomials and Bessel's functions.

Course Outcomes (COs)

CO1: Students will be able to apply Picard's method and understand the existence and uniqueness of solutions of initial value problems for ordinary differential equations.
CO2: Students will be able to classify second-order partial differential equations and reduce them to canonical forms for further analysis.
CO3: Students will develop the ability to solve partial differential equations using separation of variables, Green's function, and related analytical techniques.
CO4: Students will gain knowledge of stability theory in dynamical systems, including linearized stability and Lyapunov functions.

Books Recommended

1. E.A. Coddington, An Introduction to Ordinary Differential Equations, Dover Publications, 2012.
2. T. Myint-U, Ordinary Differential Equations, Elsevier, North-Holland, 1978.
3. S.L. Ross, Differential Equations, 2nd Edition, John Wiley & Sons, India, 2007.
4. I.N. Sneddon, Elements of Partial Differential Equations, Dover Publications, 2006.
5. M.D. Raisinghania, Advanced Differential Equations, S. Chand, New Delhi, 2019.

FOURTH YEAR (SEMESTER-VIII)

OPERATIONS RESEARCH-I

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: MATHEMATICS		
Course Code: B040805T	**Course Title:** OPERATIONS RESEARCH-I	
Credits: 4+0	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: 4-0-0		

Course prerequisites:

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

Course Objectives

1. Introduce the fundamental concepts of Operations Research, including convex sets, convex functions, and the formulation of Linear Programming Problems (LPP).
2. Develop understanding of solution techniques for LPP such as graphical method, simplex method, Big-M method, two-phase method, and revised simplex method.
3. Provide knowledge of duality theory, sensitivity analysis, and related optimization concepts in linear programming.
4. Introduce transportation and assignment problems along with methods for finding optimal solutions such as MODI and Hungarian methods.

Unit	Topics
	OPERATIONS RESEARCH-I
I	Operations Research and its Scope, 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, Basic feasible solutions, Solution of general LPP by Simplex method.
II	Use of artificial variables in simplex method, Big-M method and Two-Phase method, revised simplex method, Resolution of degeneracy, Concept of duality in linear programming, Theorems on duality, Dual simplex method, Sensitivity analysis.
III	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.
IV	Integer programming, Dynamic Programming, Inventory Control: Introduction, Classification of Inventory, Economic parameter associated withinventory problems, Deterministic and Probabilistic models with without lead time.

Course Outcomes (COs)

CO1: Students will be able to understand the basic concepts of Operations Research, including convex sets, convex and concave functions, and formulation of Linear Programming Problems.
CO2: Students will be able to solve Linear Programming Problems using graphical method, simplex method, Big-M method, two-phase method, and revised simplex method.
CO3: Students will gain knowledge of duality theory, sensitivity analysis, and apply these concepts in optimization problems.
CO4: Students will be able to solve transportation and assignment problems using methods such as MODI and Hungarian method.

Books Recommended

1. S.D. Sharma, Operations Research, Kedar Nath Ram Nath & Company.
2. S.S. Rao, Optimization Theory and Applications, Wiley Eastern Ltd., New Delhi.
3. J.K. Sharma, Operations Research: Theory and Applications, Macmillan India Ltd.
4. H.A. Taha, Operations Research: An Introduction, Macmillan Publishing Co., New York.
5. Kanti Swarup, P.K. Gupta & Man Mohan, Operations Research, Sultan Chand & Sons, New Delhi.
6. B.S. Goel & S.K. Mittal, Operations Research, Pragati Prakashan, Meerut.
7. P.K. Gupta & D.S. Hira, Operations Research: An Introduction, S. Chand & Company Ltd., New Delhi.

FOURTH YEAR (SEMESTER-VIII)

CLASSICAL MECHANICS

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: MATHEMATICS		
Course Code: B040806T	**Course Title:** CLASSICAL MECHANICS	
Credits: 4+0	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: 4-0-0		

Course prerequisites:

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

Course Objectives

1. Introduce the fundamentals of rigid body rotation, including angular momentum, kinetic energy, and Euler's equations of motion.
2. Develop understanding of Lagrangian formulation of mechanics and its application to a wide range of physical systems.
3. Study constrained motion, small oscillations, and impulsive forces using analytical mechanics approaches.
4. Introduce Hamiltonian mechanics including Hamilton's principle, Hamilton–Jacobi theory, and conservation principles.

Unit	Topics
	CLASSICAL MECHANICS
I	Rotation of a vector in two and three-dimensional fixed frame of references. Kinetic energy and angular momentum of rigid body rotating about its fixed point, Euler dynamical and geometrical equations of motion, Generalized coordinates, momentum and force components, Lagrange equations of motion under finite forces, cyclic coordinates and conservation of energy.
II	Lagrangian approach to some known problems-motions of simple, double, spherical and cycloidal pendulums, motion of a particle in polar system, motion of a particle in a rotating plane, motion of a particle inside a paraboloid, motion of an insect crawling on a rod rotating about its one end, motion of masses hung by light strings passing over pulleys, motion of a sphere on the top of a fixed sphere and Euler dynamic equations.
III	Lagrange equations for constrained motion under finite forces. Lagrange equations of motion under impulses, motion of parallelogram about its centre and some of its particular cases, Small oscillations for longitudinal and transverse vibrations, Equations of motion in Hamiltonian approach and its applications on known problems as given above, Conservation of energy, Legendre dual transformations
IV	Hamilton principle and principle of least action, Hamilton-Jacobi equation of motion, Hamilton-Jacobi theorem and its verification on the motions of a projectile under gravity in two dimensions and motion of a particle describing a central orbit, Phase space, canonical transformations, conditions of canonicality, cyclic relations, generating functions, invariance of elementary phase space, canonical transformations form a group and Liouville theorem. Poisson brackets, Poisson first and second theorems, Poisson, Jacobi identity and invariance of Poisson bracket.

Course Outcomes (COs)

CO1: Students will be able to analyze rotational motion of rigid bodies and apply Euler's equations to physical systems.
CO2: Students will be able to formulate and solve problems using Lagrangian mechanics for various dynamical systems.
CO3: Students will develop skills to analyze constrained motion, oscillations, and impulsive forces using analytical methods.
CO4: Students will understand Hamiltonian mechanics, including Hamilton's principle and Hamilton–Jacobi theory, and apply them to physical problems.
CO5: Students will gain knowledge of advanced concepts such as canonical transformations, phase space, and Poisson brackets, and their applications in theoretical mechanics.

Books Recommended

1. A.S. Ramsey, Dynamics – Part II, CBS, 2nd Edition, 2002.
2. N.C. Rana & P.S. Joag, Classical Mechanics, Tata McGraw-Hill, 1991.
3. Herbert Goldstein, Classical Mechanics, Narosa Publishing House, New Delhi, 1990.
4. Naveen Kumar, Generalized Motion of Rigid Body, Narosa Publishing House, New Delhi, 2004.

FOURTH YEAR (SEMESTER-VIII)

PROBABILITY THEORY

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: MATHEMATICS		
Course Code: B040807T	**Course Title:** PROBABILITY THEORY	
Credits: 4+0	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: 4-0-0		

Course prerequisites:

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

Course Objectives: The aim of this course is to

1. Introduce the fundamental concepts of probability theory.
2. develop analytical and problem-solving skills related to random phenomena.
3. familiarize students with probability distributions and random variables.
4. apply probability concepts to real-life situations and statistical modeling.
5. prepare students for advanced studies in statistics, stochastic processes, and data science.

Unit	Topics
	PROBABILITY THEORY
I	Random experiments and sample spaces, Events and algebra of events, Classical, empirical, and axiomatic definitions of probability, Addition and multiplication laws of probability, Conditional probability, Independent events, Theorem of total probability, Bayes' theorem and applications.
II	Definition of random variables, Discrete and continuous random variables, Probability mass function (PMF), Probability density function (PDF), Cumulative distribution function (CDF), Joint probability distributions, Marginal and conditional distributions, Degenerate, Bernoulli, Binomial, Geometric, Poisson, Uniform, Normal, and Exponential distributions, Gamma, Beta, and Normaldistributions, their properties.
III	Expectation of a random variable, Properties of expectation, Moments and central moments, Variance and standard deviation, Covariance and correlation, Moment generating functions (MGF), Chebyshev's inequality.
IV	Joint distributions of two random variables, Independence of random variables, Conditional expectation and variance, Functions of random variables, Distribution of functions of random vectors using transformation of variables and Jacobian method. Mathematical expectation of functions of random vectors, Law of Large Numbers (statement and applications), Central Limit Theorem (statement and applications).

Course Learning Outcomes: After studying this course the student will be able to

CO1. Understand axiomatic foundations of probability.
CO2: Solve problems involving conditional probability and Bayes' theorem.
CO3: Work with discrete and continuous random variables.
CO4: Compute expectation, variance, and moments.
CO5: Apply standard probability distributions in practical problems.

Books Recommended:

1. Ross, S. M. (2020). *A first course in probability*. Harlow, UK: Pearson.
2. Gupta, S. C., & Kapoor, V. K. (2020). *Fundamentals of mathematical statistics*. Sultan Chand & Sons.
3. Bhat, B. R. (2014). *Modern probability theory*, New Age international publishers.
4. Hoel P.G. (1971). *Introduction to Mathematical Statistics*, Asia Publishing House.
5. Rohtagi, V.K. (1967).*An Introduction to Probability Theory and Mathematical Statistics*, John Wiley.
6. Hoges J.L. and Lehmann E.L. (1964). *Basic Concepts of Probability and Statistics*, Holden Day.

THIRD YEAR (SEMESTER-VIII)

SPECIAL THEORY OF RELATIVITY

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: MATHEMATICS		
Course Code: B040808T	**Course Title:** SPECIAL THEORY OF RELATIVITY	
Credits: 4+0	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: 4-0-0		

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

Course Objectives

1. Introduce the foundational concepts of special relativity including inertial frames, Galilean relativity, and the experimental basis leading to Einstein's theory.
2. Develop understanding of Lorentz transformations and their physical and geometrical interpretations in space-time.
3. Study relativistic kinematics including time dilation, length contraction, and transformation of velocity and acceleration.

Unit	Topics
	SPECIAL THEORY OF RELATIVITY
I	Review of Newtonian Mechanics, Inertial frame, Speed of light and Galilean relativity, Michelson- Morley experiment, Lorentz-Fitzerold contraction hypothesis, relative character of space and time, postulates of special theory of relativity, Lorentz transformation equations and geometrical interpretation, Group properties of Lorentz transformations.
II	Relativistic kinematics, composition of parallel velocities, length contraction, time dilation, transformation equations, equations for components of velocity and acceleration of a particle and contraction factor.
III	Geometrical representation of space time, four dimensional Minkowskian space of special relativity, time-like intervals, light-like and space- like intervals, Null cone, proper time, world line of a particle, four vectors and tensors in Minkowskian space time.
IV	Relativistic mechanics- Variations of mass with velocity, equivalence of mass energy, transformation equation for mass, momentum and energy, Energy momentum for light vector, relativistic force and transformation equation for its components, relativistic Lagrangian and Hamiltonian, relativistic equations of motion of a particle, energy momentum tensor of a continuous material distribution.

Course Outcomes (COs)

CO1: Students will be able to understand the fundamental concepts of special relativity including inertial frames, Galilean relativity, and the experimental foundations of Einstein's theory.
CO2: Students will be able to derive and apply Lorentz transformation equations and interpret their physical and geometrical significance.
CO3: Students will understand relativistic kinematics, including time dilation, length contraction, and transformation of velocity and acceleration.
CO4: Students will gain knowledge of relativistic mechanics, including mass–energy equivalence, relativistic momentum, energy transformations, and equations of motion.

Books Recommended

1. Satya Prakash, Theory of Relativity, Pragati Prakashan, 2019.
2. C. Møller, The Theory of Relativity, Clarendon Press, 1952.
3. Robert Resnick, Introduction to Special Relativity, Wiley Eastern Pvt. Ltd., 1972.
4. Goyal & Gupta, Theory of Relativity, Krishna Publication, Meerut.

FOURTH YEAR (SEMESTER-VIII)

DISSERTATION/ RESEARCH PROJECT

Class: UG	**Year:** FOURTH	**Semester:** EIGHTH
Subject: MATHEMATICS		
Course Code: B040809R	**Course Title:** DISSERTATION/ RESEARCH PROJECT	
Credits:0 +12	Core Compulsory	
Max. Marks: 100	**Min. Passing Marks:** As per University CBCS Norm	

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

Course Objectives

3. To enable students to select and work on a specific topic based on any core/major paper studied in any semester.
4. To develop basic research skills such as literature review, problem understanding, analysis, and structured presentation under the guidance of a supervisor.
5. To improve academic writing and communication skills through preparation of a typed dissertation and PowerPoint presentation.

DISSERTATION/ RESEARCH PROJECT

Candidate/Students should write a dissertation/research project on the specific topic based on any one core/major papers opted by the student in any semester. The students have been allotted a supervisor in this dissertation/research project on their topic, given by the concern faculty. The dissertation/research project should be typed and its presentation on Power Point.

Suggested Evaluation Methods (Max. Marks: 100)

The Dissertation/Research Project shall be evaluated by an external examiner appointed by the University. The Dissertation/Research Project may either be a continuation of the previous semester's Dissertation/Research Project or an independent study.

A soft copy as well as a hard copy of the Dissertation/Research Project must be submitted to the concerned department.

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