

MAA VINDHYAVASINI UNIVERSITY, MIRZAPUR

DEPARTMENT OF MATHEMATICS



National Education Policy-2020

Syllabus

of

MATHEMATICS

For

Two Year PG Programme

(Effective from Academic Session 2026-2027)

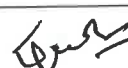
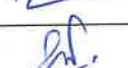
Dean
Faculty of Science And Technology
Maa Vindhyavasini University

MAA VINDHYAVASINI UNIVERSITY, MIRZAPUR

DEPARTMENT OF MATHEMATICS

National Education Policy-2020

Syllabus of Two Year PG (Mathematics) Programme Designed by

Sr. No.	Name	Designation	University/College	Signature
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02	Dr. Neelam Yadav	Assistant Professor	N.S.P.S. Government P.G. College, Magaraha, Mirzapur	
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Two Year PG (Mathematics) Programme

Based on

National Education Policy-2020

The proposed curriculum is designed to provide students with a comprehensive understanding of Mathematics and its diverse applications. It aims to develop not only a strong foundation in important mathematical concepts and techniques but also the ability to apply commonly used mathematical methods to various fields and real-life problems. Through this curriculum, students will enhance their analytical, logical, and problem-solving skills, enabling them to use mathematical tools effectively in interdisciplinary contexts.

Subject Prerequisites

To study this subject, a student must have B.A. / B.Sc. in Mathematics or its equivalent examination from a recognized board or institution.

Eligibility for Admission

For admission to the Two Year Postgraduate Programme in Mathematics, candidates must have passed B.A. / B.Sc. in Mathematics 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 Postgraduate Programme in Mathematics shall be two academic year consisting of four semesters. Candidates admitted to Semester-I will undergo the programme over this period. The session shall comprise four regular semesters.

Examination and Assessment

Suggested Internal Continuous Evaluation / Examination Methods (Max. Marks: 25)			
(Except Research Project)			
		Max. Marks	
Sr. No.	Assessment Type	Regular	Private
01	Class Test	10	15
02	Punctuality / Regularity	10	---
03	Presentation / Research Oriented Assignment	5	10
External Examination Methods (Max. Marks: 75)			
As prescribed by the University (as per common ordinance for examination and assessment).			

Programme Specific Outcomes (PSOs)

PSO1: To develop a deep understanding of the fundamental axioms of Mathematics and the ability to build mathematical ideas and logical reasoning based on them.

PSO2: To provide advanced knowledge in areas of Pure Mathematics, particularly Analysis and Geometry, thereby enabling students to pursue higher studies and research in these fields.

PSO3: To develop an understanding of Applied Mathematics and motivate students to use mathematical techniques as effective tools in the study of other scientific disciplines.

PSO4: To encourage students to undertake research studies in Mathematics and related interdisciplinary areas.

PSO5: To provide students with diverse career opportunities, including research, teaching, banking, and other professional fields where mathematical and analytical skills are highly valued.

PSO6: To inculcate problem-solving ability, critical thinking, and creativity through presentations, assignments, seminars, and project work.

PSO7: To support students in preparing for competitive examinations such as CSIR-NET, GATE, and other related examinations through guidance, counselling, and academic resources.

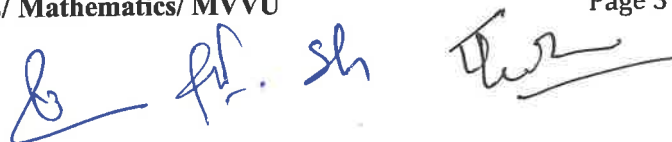
PSO8: To nurture lifelong learners who can independently enhance and expand their mathematical knowledge and expertise whenever required.

Program Structure

The Two-Year Postgraduate Programme in Mathematics is designed with a minimum requirement of 80 credits distributed over four semesters. The programme comprises a total of 27 courses, systematically spread across the four semesters to ensure balanced academic progression.

The courses are categorized into three components:

1. **Core/Major Courses** – These courses provide fundamental and advanced knowledge in Mathematics, with each course carrying 4 credits.
2. **Discipline Specific Elective (DSE)/Elective Courses** – These courses offer specialized and interdisciplinary learning opportunities according to students' interests, with each course carrying 4 credits.
3. **Dissertation/Research Project/Project Work** – This component is intended to promote research aptitude, analytical thinking, and practical application of mathematical concepts, carrying 4 credits.



NUMBER OF COURSES AND CREDITS

S. No.	Types of course	Credit per course	Total Number of course type	Total credit for the particular type
1	Core	4+0	11	44
2	Discipline Specific Elective	4+0	7	28
3	Dissertation/Research Project/ Project	0+4	2	8
Total				80

SEMESTER WISE BREAK-UP OF COURSES

S. No	Types of course	Semester-I	Semester-II	Semester-III	Semester-IV	Total
1	Core	5(20)	3(12)	2(8)	1(4)	10(40)
2	Discipline Specific Elective	---	2(8)	2(8)	3(12)	7(28)
3	Dissertation / Research Project/ Project	---	---	1(4)	1(4)	2(8)
Total		5+0+0(20)	3+2+0(20)	2+2+1(20)	1+3+1(20)	20(80)

COURSE STRUCTURE: I-SEMESTER

Course Code	Course Title	Credits	Marks
Core/Major Courses			
MC0101T	Algebra-I	4+0	75+25
MC0102T	Real Analysis	4+0	75+25
MC0103T	Complex Analysis	4+0	75+25
MC0104T	Integral Equations and Calculus of Variations	4+0	75+25
MC0105T	Hydrodynamics	4+0	75+25
Total Credits		20	

COURSE STRUCTURE: II-SEMESTER

Course Code	Course Title	Credits	Marks
Core/Major Courses			
MC0201T	Algebra -II	4+0	75+25
MC0202T	Topology	4+0	75+25
MC0203T	Advanced Differential Equations	4+0	75+25

Open Elective Courses (Any Two of the Following)			
ME0204T	Operations Research-I	4+0 & 4+0	75+25 & 75+25
ME0205T	Classical Mechanics		
ME0206T	Probability Theory		
ME0207T	Special Theory of Relativity		
Total Credits		20	

COURSE STRUCTURE: III-SEMESTER

Course Code	Course Title	Credits	Marks
Core/Major Courses			
MC0301T	Measure and Integration	4+0	75+25
MC0302T	Advanced Linear Algebra	4+0	75+25
Open Elective Courses (Any Two of the Following)			
ME0303T	Operations Research-II	4+0 & 4+0	75+25 & 75+25
ME0304T	Non-linear Analysis		
ME0305T	Number Theory and Cryptography		
ME0306T	Differential Geometry		
Project			
MP0307R	Research Project	0+4	100
Total Credits		20	

COURSE STRUCTURE: IV-SEMESTER

Course Code	Course Title	Credits	Marks
Core/Major Courses			
MC0401T	Functional Analysis	4+0	75+25
Open Elective Courses (Any Three of the Following)			
ME0402T	Normed Linear Space and Theory of Integration	4+0 & 4+0 & 4+0	75+25 & 75+25 & 75+25
ME0403T	Module Theory		
ME0404T	Discrete Mathematics		
ME0405T	Differential Geometry of Manifolds		
ME0406T	Mathematical Modeling		
ME0407T	Operator Theory		
Project			
MP0408R	Research Project	0+4	100
Total Credits		20	
Total Credits (I+II+III-Semester)		60	
Total Credits (I+II+III+IV)		80	

PG MATHEMATICS (SEMESTER-I)

ALGEBRA-I

Class: PG		Year: FIRST	Semester: FIRST
Subject: MATHEMATICS			
Course Code: MC0101T		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		
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.			

PG MATHEMATICS (SEMESTER-I)

REAL ANALYSIS

Class: PG		Year: FIRST	Semester: FIRST
Subject: MATHEMATICS			
Course Code: MC0102T		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.			

PG MATHEMATICS (SEMESTER-I)

COMPLEX ANALYSIS

Class: PG		Year: FIRST	Semester: FIRST
Subject: MATHEMATICS			
Course Code: MC0103T		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 - Expose students to the foundations of tensor analysis, which will help in understanding various physical phenomena and provide a strong mathematical base. - 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 singularities theorem, Laurent's series and its further illustraions for singulararies, isolated singularities at infinity, meromorphic functions, Argument principle, Rouche’s theorem, Essential singulararties, 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 - J.W. Brown & R.V. Churchill, Complex Variables and Applications, 8th Edition, 2013. - L.V. Ahlfors, Complex Analysis, McGraw Hill Co., Indian Edition, 2017. J. Bak & D.J. Newman, Complex Analysis, Springer, 2010. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 2013. - D.C. Ullrich, Complex Made Simple, American Mathematical Society, 2008.			

PG MATHEMATICS (SEMESTER-I)
INTEGRAL EQUATIONS AND CALCULUS OF VARIATIONS

Class: PG		Year: FIRST	Semester: FIRST
Subject: MATHEMATICS			
Course Code: MC0104T		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.			



PG MATHEMATICS (SEMESTER-I)
HYDRODYNAMICS

Class: PG		Year: FIRST	Semester: FIRST
Subject: MATHEMATICS			
Course Code: MC0105T		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.			

PG MATHEMATICS (SEMESTER-II)

ALGEBRA-II

Class: PG		Year: FIRST	Semester: SECOND
Subject: MATHEMATICS			
Course Code: MC0201T		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.			

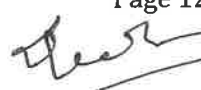


PG MATHEMATICS (SEMESTER-II)

TOPOLOGY

Class: PG		Year: FIRST	Semester: SECOND
Subject: MATHEMATICS			
Course Code: MC0202T		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 and sub-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 extension 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.			





PG MATHEMATICS (SEMESTER-II)**ADVANCED DIFFERENTIAL EQUATIONS**

Class: PG		Year: FIRST	Semester: SECOND
Subject: MATHEMATICS			
Course Code: MC0203T		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. 5. Develop understanding of orthogonality, Sturm–Liouville theory, and special functions such as Legendre polynomials and Bessel 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.			
CO5: Students will understand orthogonality, Sturm–Liouville problems, and properties of special functions such as Legendre polynomials and Bessel 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.			

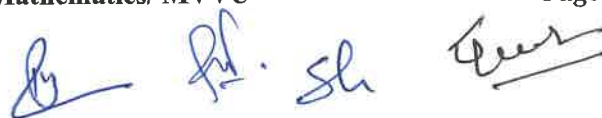
PG MATHEMATICS (SEMESTER-II)

OPERATIONS RESEARCH-I

Class: PG		Year: FIRST	Semester: SECOND
Subject: MATHEMATICS			
Course Code: ME0204T		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. 5. Develop understanding of advanced optimization techniques including integer programming, dynamic programming, and inventory control models.			
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 with inventory problems, Deterministic and Probabilistic models 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.			
CO5: Students will develop understanding of advanced optimization techniques including integer programming, dynamic programming, and inventory control models.			
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.			

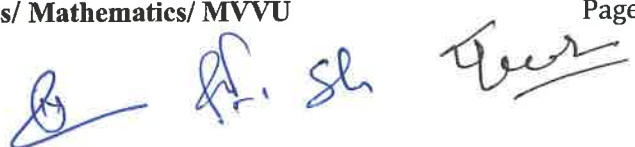
PG MATHEMATICS (SEMESTER-II)
CLASSICAL MECHANICS

Class: PG		Year: FIRST	Semester: SECOND
Subject: MATHEMATICS			
Course Code: ME0205T		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. 5. Develop knowledge of advanced analytical mechanics concepts such as canonical transformations, phase space, and Poisson brackets.			
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 canonicity, 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.			



PG MATHEMATICS (SEMESTER-II)
PROBABILITY THEORY

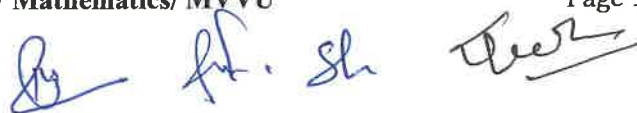
Class: PG		Year: FIRST	Semester: SECOND
Subject: MATHEMATICS			
Course Code: ME0206T		Course Title: PROBABILITY THEORY	
Credits: 4+0		Core Compulsory / Elective	
Max. Marks: 25(Internal) + 75(External)		Min. Passing Marks: As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours 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 Normal distributions, 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.			
CO6: Understand limit theorems and their applications.			
Books Recommended:			
1. Ross, S. M. (2020). <i>A first course in probability</i> . Harlow, UK: Pearson.			
2. Gupta, S. C., & Kapoor, V. K. (2020). <i>Fundamentals of mathematical statistics</i> . Sultan Chand & Sons.			
3. Bhat, B. R. (2014). <i>Modern probability theory</i> , New Age international publishers.			
4. Hoel P.G. (1971). <i>Introduction to Mathematical Statistics</i> , Asia Publishing House.			
5. Rohtagi, V.K. (1967). <i>An Introduction to Probability Theory and Mathematical Statistics</i> , John Wiley.			
6. Hogg J.L. and Lehmann E.L. (1964). <i>Basic Concepts of Probability and Statistics</i> , Holden Day.			



PG MATHEMATICS (SEMESTER-II)

SPECIAL THEORY OF RELATIVITY

Class: PG		Year: FIRST	Semester: SECOND
Subject: MATHEMATICS			
Course Code: ME0207T		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.			



PG MATHEMATICS (SEMESTER-III)

MEASURE AND INTEGRATION

Class: PG		Year: SECOND	Semester: THIRD
Subject: MATHEMATICS			
Course Code: MC0301T		Course Title: MEASURE AND INTEGRATION	
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 Objectives: The main objectives of this course is to			
1. introduce the fundamental concepts of semi-algebras, algebras, monotone classes, σ -algebras, measures, and outer measures.			
2. study Lebesgue measure, measurable sets, Borel sets, Cantor set, and non-measurable sets on R .			
3. develop understanding of measurable functions, simple functions, and Lebesgue integration theory.			
4. study important convergence theorems and compare Riemann and Lebesgue integrals.			
Unit	Topics		
MEASURE AND INTEGRATION			
I	Semi-algebras, algebras, monotone class, σ -algebras, measure and outer measures, Caratheödory extension process of extending a measure on a semi-algebra to generated σ -algebra, completion of a measure space.		
II	Borel sets, Lebesgue outer measure and Lebesgue measure on R , translation invariance of Lebesgue measure, existence of a non-measurable set, characterizations of Lebesgue measurable sets, the Cantor's set, Non-measurable sets.		
III	Measurable functions on a measure space and their properties, Borel and Lebesgue measurable functions, simple functions and their integrals, Lebesgue integral on R and its properties, Riemann and Lebesgue integrals.		
IV	Bounded convergence theorem, Fatou’s lemma, Lebesgue monotone convergence theorem, Lebesgue dominated convergence theorem.		
Course Learning Outcomes: After studying this course the student will be able to			
CO1: verify whether a given subset of real valued function is measurable.			
CO2: understand the requirement and the concept of the Lebesgue integral (a generalization of the Reimann integration) along its properties and relationship between Lebesgue and Riemann integral.			
CO3: know about the concepts of functions of bounded variations and the absolute continuity of functions with their relations. Extend the concept of outer measure in an abstract space and integration with respect to a measure.			
CO4: learn and apply Holder and Minkowski inequalities in L^p -spaces and understand completeness of spaces and convergence in measures.			
Books Recommended:			
1. G. de Barra, Measure Theory and Integration, New Age International Ltd., New Delhi, 2014.			
2. M. Capinski and P.E. Kopp, Measure, Integral and Probability, Springer, 2005.			
3. E. Hewitt and K. Stromberg, Real and Abstract Analysis: A Modern Treatment of the Theory of Functions of a Real Variable, Springer, Berlin, 1975.			
4. H.L. Royden and P.M. Fitzpatrick, Real Analysis, Fourth Edition, Pearson, 2015.			
5. Walter Rudin, Principle of Mathematical Analysis (3rd edition) McGraw-Hill Kogakusha, International Student Edition, 1976.			
6. P. R. Halmos, Measure Theory, Van Nostrand, 1950.			
7. P. K. Jain and V. P. Gupta, Lebesgue Measure and Integration, New Age International, New Delhi, 2000.			
8. R. G. Bartle, The Elements of Integration, John Wiley, 1966			





PG MATHEMATICS (SEMESTER-III)

ADVANCED LINEAR ALGEBRA

Class: PG	Year: SECOND	Semester: THIRD
Subject: MATHEMATICS		
Course Code: MC0302T	Course Title: ADVANCED LINEAR ALGEBRA	
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 Objectives

1. To introduce the concepts of inner product spaces, orthogonality, orthonormal basis, and fundamental inequalities such as Cauchy-Schwarz and Bessel's inequality.
2. To develop understanding of linear transformations through eigenvalues, eigenvectors, eigenspaces, and their role in matrix diagonalization.
3. To study advanced theoretical tools such as Cayley-Hamilton theorem, minimal polynomials, invariant subspaces, and diagonalizability criteria.
4. To provide knowledge of advanced matrix structures including Jordan canonical form, rational canonical form, projections, invariant decompositions, and quadratic forms.

Unit	Topics
ADVANCED LINEAR ALGEBRA	
I	Inner product spaces, Cauchy-Schwarz inequality, orthogonal vectors, Orthonormal basis, Bessel's inequality, Gram-Schmidt orthogonalization process, Eigenvalues, eigenvectors, and eigenspaces, Algebraic and geometric multiplicities of eigenvalues.
II	Diagonalization, Cayley-Hamilton theorem, Invariant subspaces, T-conductors and T-annihilators, Minimal polynomials of linear operators and matrices, Characterization of diagonalizability in terms of multiplicities and also in terms of the minimal polynomial, Triangulability.
III	Projections, Invariant direct sums, Characterization of diagonalizability in terms of projections, Primary decomposition theorem.
IV	Diagonalizable and nilpotent parts of a linear operator, Rational canonical form of matrices, Elementary Jordan matrices, Reduction to Jordan canonical form, Quadratic form.

Course Learning Outcomes (COs)

CO1: Understand and apply the concepts of inner product spaces, including Cauchy-Schwarz inequality, orthogonality, orthonormal basis, Gram-Schmidt process, and Bessel's inequality.

CO2: Analyze eigenvalues, eigenvectors, eigenspaces, and study algebraic and geometric multiplicities along with diagonalization of matrices.

CO3: Apply key results such as Cayley-Hamilton theorem, minimal polynomial, invariant subspaces, T-conductors, and T-annihilators in matrix and linear operator problems.

CO4: Determine and characterize diagonalizability and triangulability using minimal polynomials, multiplicities, and projections.

CO5: Understand advanced matrix structures including Jordan canonical form, rational canonical form, nilpotent operators, invariant direct sums, and quadratic forms.

Books Recommended

1. Vivek Sahai and Vikas Bist, *Linear Algebra*, alpha Science, 2001.
2. T. S. Blyth and Robertson, *Further Linear Algebra*, Springer, 2013.
3. K. Hofmann and R. Kunze, *Linear Algebra*, Prentice Hall of India, New Delhi, 1972.
4. D. S. Dummit and R. M. Foote, *Abstract Algebra*, John Wiley & Sons, N.Y., 2003.
5. N. Jacobson, *Basic Algebra*, Vol. 1, Hindustan Publishing Co., New Delhi, 1984.



PG MATHEMATICS (SEMESTER-III)

OPERATIONS RESEARCH-II

Class: PG		Year: SECOND	Semester: THIRD
Subject: MATHEMATICS			
Course Code: ME0303T		Course Title: OPERATIONS RESEARCH-II	
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 Objectives: The aim of this course is to teach the student the application of various numerical technique for variety of problems occurring in daily life.			
Unit	Topics		
OPERATIONS RESEARCH-II			
I	Game Theory- Two-Person zero-sum games, Games with mixed strategies, Graphical solution, solution by linear programming.		
II	Sequencing problem- Basic terms used in sequencing, Processing n jobs through to machine, Processing n jobs through k machine, Processing 2 jobs through k machine, Problem of Replacement, Individuals and Group replacement policies.		
III	Network analysis- Construction of a network diagram, PERT and CPM, Time estimates in PERT, Project Crashing.		
IV	Non-Linear Programming- One and multi variable unconstrained optimization, Kuhn Tucker, Condition for constrained optimization, Quadratic Programming, Separable Programming, convex optimization, gradient descent, stochastic gradient descent.		
Course Learning Outcomes: After successful completion of this course student will be able			
CO1: to know the concept of game theory and methods of finding suitable solution.			
CO2: to know the method for solving extremal problems whose objective functions/constraints are non-linear.			
CO3: to take multistage problems.			
CO4: to know the methodology for solving networking problems.			
Books Recommended:			
1. S.D. Sharma, <i>Operations Research</i> , Kedar Nath Ram Nath & Company.			
2. S.S. Rao, <i>Optimization Theory and Applications</i> , Wiley Eastern Ltd., New Delhi.			
3. J.K. Sharma, <i>Operations Research: Theory and Applications</i> , Macmillan India Ltd.			
4. H.A. Taha, <i>Operations Research: An Introduction</i> , Macmillan Publishing Co., Inc., New York.			
5. Kanti Swarup, P.K. Gupta, Man Mohan, <i>Operations Research</i> , Sultan Chand & Sons, New Delhi.			
6. B.S. Goel, S.K. Mittal, <i>Operations Research</i> , Pragati Prakashan, Meerut.			
7. P.K. Gupta, D.S. Hira, <i>Operations Research: An Introduction</i> , S. Chand & Company Ltd., New Delhi.			



PG MATHEMATICS (SEMESTER-III)

NON-LINEAR ANALYSIS

Class: PG		Year: SECOND	Semester: THIRD
Subject: MATHEMATICS			
Course Code: ME0304T		Course Title: NON LINEAR ANALYSIS	
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 Objectives			
1. To introduce the fundamentals of metric fixed point theory, including Banach spaces, convexity properties, Lipschitz and contraction mappings, and Banach's contraction principle. 2. To study fixed point results for nonexpansive, asymptotically nonexpansive, and quasi-nonexpansive mappings in Banach and Hilbert spaces. 3. To develop understanding of classical fixed point theorems such as Brouwer's and Schauder's, along with concepts like measure of non-compactness, condensing maps, and Sadovskii's theorem. 4. To provide knowledge of iterative methods and convergence techniques including Mann and Ishikawa iterations and their stability for nonlinear operator equations.			
Unit	Topics		
NONLINEAR ANALYSIS			
I	Background of Metrical fixed point theory, Fixed Points, Uniformly convex, strictly convex and reflexive Banach spaces, Lipschitzian and contraction mapping, Banach's contraction principle, Application to Volterra and Fredholm integral equations.		
II	Nonexpansive, asymptotically nonexpansive and quasi-nonexpansive mappings and Fixed Points, Fixed point theorems for nonexpansive mappings, Nonexpansive operators in Banach spaces satisfying Opial's conditions, The demiclosedness principle.		
III	Brouwer's fixed point theorem, Schauder's fixed point theorem, Measure of Non- Compactness, Condensing map, Fixed points for condensing maps, Strict convexity, Uniform convexity, The modulus of convexity and normal structure, Smoothness, retraction map, Sadovskii's fixed point theorem, Introduction of Set-valued mappings, Set-valued contraction map.		
IV	Fixed point iteration procedures, The Mann Iteration, Lipschitzian and Pseudo contractive operators in Hilbert spaces, Strongly pseudo contractive operators in Banach spaces, The Ishikawa iteration, Stability of fixed point iteration procedures. Iterative solution of Nonlinear operator equations in arbitrary and smooth Banach spaces, Nonlinear m-accretive operator, Equations in reflexive Banach spaces.		
Course Learning Outcomes (COs)			
CO1: Understand the basic concepts of metric fixed point theory, including Banach spaces, convexity properties, Lipschitz and contraction mappings, and Banach's contraction principle.			
CO2: Analyze fixed point results for nonexpansive, asymptotically nonexpansive, and quasi-nonexpansive mappings in Banach and Hilbert spaces.			
CO3: Apply classical fixed point theorems such as Brouwer's, Schauder's, and Sadovskii's theorem along with concepts like measure of non-compactness and condensing maps.			
CO4: Use iterative methods such as Mann and Ishikawa iterations to study convergence and stability of fixed point procedures in nonlinear operator equations.			
CO5: Gain knowledge of advanced topics including set-valued mappings, accretive operators, and applications of fixed point theory in integral and operator equations.			
Books Recommended			
1. V. Berinde, <i>Iterative Approximation of Fixed Points</i>, Lecture Notes in Mathematics, No. 1912, Springer, 2007. 2. M. A. Khamsi and W. A. Kirk, <i>An Introduction to Metric Spaces and Fixed Point Theory</i>, John Wiley & Sons, New York, 2001. 3. Sankatha P. Singh, B. Watson and P. Srivastava, <i>Fixed Point Theory and Best Approximation: The KKM-map Principle</i>, Kluwer Academic Publishers, Dordrecht, The Netherlands, 1997. 4. V. I. Istratescu, <i>Fixed Point Theory: An Introduction</i>, D. Reidel Publishing Co., 1981. 5. K. Goebel and W. A. Kirk, <i>Topics in Metric Fixed Point Theory</i>, Cambridge University Press, 1990. 6. Ravi P. Agarwal, Donal O'Regan, and D. R. Sahu, <i>Fixed Point Theory for Lipschitzian-type Mappings with Applications</i>, Springer, 2009.			



PG MATHEMATICS (SEMESTER-III)

NUMBER THEORY AND CRYPTOGRAPHY

Class: PG		Year: SECOND	Semester: THIRD
Subject: MATHEMATICS			
Course Code: ME0305T		Course Title: NUMBER THEORY AND CRYPTOGRAPHY	
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 Objectives			
1. To introduce the basic concepts of divisibility theory, including gcd, lcm, Euclidean algorithm, and fundamental properties of integers. 2. To develop understanding of congruences, residue systems, and classical results such as Fermat's and Wilson's theorems along with their applications. 3. To provide knowledge of cryptography and classical encryption techniques, including substitution and transposition ciphers. 4. To study important number theoretic functions and advanced topics such as Euler's phi function, Möbius function, quadratic residues, and special number sequences.			
Unit	Topics		
NUMBER THEORY AND CRYPTOGRAPHY			
I	Divisibility: Some basic terms and properties, Division algorithm, Common divisor, Greatest common divisor (gcd), Theorems on gcd, Euclid's lemma, relatively prime, Euclidian Algorithm, least common multiple (lcm), Theorems on lcm, Fundamental theorem of arithmetic, Euclid's theorem, Linear Diophantine Equation $ax + by = c$ and its solutions.		
II	Congruences: Basic properties and theorems of congruences, Residue and complete residue system, Reduced residue system, Fermat's theorem, Wilson theorem, Converse of Wilson theorem, Linear Congruences, Chinese remainder theorem, Method of solution of congruences, Binary and Decimal Representation of Integers.		
III	Cryptography: Introduction of cryptography, Block Diagram of cryptography, some simple cryptosystems, additive cipher, shift cipher, caesar cipher, affine cipher, auto key cipher, play fair cipher, hill cipher or enciphering matrices, vigenere cipher, vernam cipher, rail fence cipher, simple columnar cipher, simple columnar with multiple rounds cipher.		
IV	Arithmetic functions or Number-theoretic functions: The function τ and σ , Multiplicative function, Euler's phi-function, Euler's theorem, Moebius μ -function, Moebius inversion formula, Greatest integer function. Quadratic congruence: Quadratic congruence, Quadratic residues, Euler's criterion. Perfect number, Fermat number, Fibonacci sequence and numbers.		
Course Learning Outcomes (COs)			
CO1: Apply the concepts of divisibility, including gcd, lcm, Euclidean algorithm, and linear Diophantine equations to solve mathematical problems.			
CO2: Analyze and solve problems based on congruences, residue systems, Fermat's theorem, Wilson's theorem, and the Chinese Remainder Theorem.			
CO3: Demonstrate understanding of classical cryptographic techniques such as Caesar, affine, Vigenère, Hill, Playfair, and transposition ciphers.			
CO4: Evaluate and apply arithmetic functions and advanced number theory concepts including Euler's phi function, Möbius function, quadratic residues, and related theorems.			
Books Recommended			
1. Niven and Zuckerman, <i>An Introduction to the Theory of Numbers</i>, Wiley Eastern Ltd. 2. Ireland & Rosen, <i>A Classical Introduction to Modern Number Theory</i>, Springer. 3. Tom Apostol, <i>Introduction to Analytic Number Theory</i>, Narosa Publications, New Delhi. 4. Delfs, H., Knebl, H., <i>Introduction to Cryptography</i>, Springer. 5. Koblitz, N., <i>Algebraic Aspects of Cryptography</i>, Springer. 6. Serre, J.P., <i>A Course in Arithmetic</i>, Springer. 7. Cassels, J.W.S., Frolich, A., <i>Algebraic Number Theory</i>, Cambridge.			

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PG MATHEMATICS (SEMESTER-III)

DIFFERENTIAL GEOMETRY

Class: PG		Year: SECOND	Semester: THIRD
Subject: MATHEMATICS			
Course Code: ME0306T		Course Title: DIFFERENTIAL GEOMETRY	
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 Objectives: The aim of this course is to introduce			
1. introduce the concepts of binormal, osculating plane and Serrete-Frenet formula,			
2. study of local theory of surfaces,			
3. study of global theory of surfaces and fundamental equations of surface theory.			
Unit	Topics		
DIFFERENTIAL GEOMETRY			
I	Tensor Algebra: Contravariant and covariant vector. Tensor product of vector spaces, tensor, contravariant, covariant and mixed tensor of second order. Tensor of type (r, s), tensor product of tensors. Symmetric and skew symmetric tensors, contraction. Definition and examples of differentiable manifold, Differentiable functions, Differentiable curves.		
II	Curves in R^2 and R^3 : Basic Definitions and Examples. Arc Length. Tangent and osculating plane, Principal normal and binormal, Curvature and torsion, The Frenet-Serret Apparatus. The Fundamental Existence and Uniqueness Theorem for Curves.		
III	Local theory of Surfaces: Definition of a surface, Nature of points on a surface, Representation of a surface, Curves on surfaces, Tangent plane and surface normal, The general surfaces of revolution, Helicoids, Metric on a surface— The first fundamental form, Direction coefficients on a surface, Families of curves , Orthogonal trajectories.		
IV	Global Theory of Surfaces: Normal Curvature, The second fundamental Form, Meusnier Theory, classification of points on a surface, Principal curvatures, Mean Curvature and Gaussian Curvature, Umbilic points, Lines of Curvature and Dupin's Theorem. Minimal Surfaces, Fundamental Equation of Surface Theory, Gauss's Equations, weingarten equations, Mainardi-Codazzi equations, Parallel surfaces.		
Course Learning Outcomes: After studying this course the student will be able to			
CO1: to determine and calculate curvature of curves in different coordinate systems and existence, uniqueness of curves.			
CO2: Know the Local theory of surfaces.			
CO3: know global theory of surfaces			
CO4: know some fundamental equations of surface theory.			
Books Recommended:			
1. Christian Bär, <i>Elementary Differential Geometry</i> , Cambridge University Press, 2010.			
2. D. Somasundaram, <i>Differential Geometry: A First Course</i> , Alpha Science International Ltd., 2005.			
3. Pressley, <i>Elementary Differential Geometry</i> , Springer, 2010.			
4. O'Neill, <i>Elementary Differential Geometry</i> , Elsevier, 2006.			
5. R. S. Mishra, <i>A Course in Tensors with Applications to Riemannian Geometry</i> , Pothishala, Allahabad, 1965.			
6. Y. Matsushima, <i>Differentiable Manifolds</i> , Marcel Dekker, 1972.			
7. B. B. Sinha, <i>An Introduction to Modern Differential Geometry</i> , Kalyani Prakashan, New Delhi, 1982.			
8. Y. Talpiert, <i>Differential Geometry with Applications to Mechanics and Physics</i> , Marcel Dekker Inc., 2001.			
9. N. J. Hicks, <i>Notes on Differential Geometry</i> , D. Van Nostrand Inc., 1965.			
10. U. C. De, A. A. Shaaikh, <i>Differential Geometry of Manifolds</i> , Narosa Publishing House, New Delhi, 2007.			
11. K. S. Amur, D. J. Shetty, C. S. Bagewadi, <i>An Introduction to Differential Geometry</i> , Narosa Publishing House, New Delhi, 2010.			
12. S. Shahshahani, <i>An Introductory Course on Differentiable Manifolds</i> , Dover Publication Inc., New York, 2016.			



PG MATHEMATICS (SEMESTER-III)
DISSERTATION/ RESEARCH PROJECT

Class: PG	Year: SECOND	Semester: THIRD
Subject: MATHEMATICS		
Course Code: MP0307R	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.		



PG MATHEMATICS (SEMESTER-IV)

FUNCTIONAL ANALYSIS

Class: PG		Year: SECOND	Semester: FOURTH
Subject: MATHEMATICS			
Course Code: MC0401T		Course Title: FUNCTIONAL 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 Objectives: The main objectives of this course is to			
1. introduce normed linear spaces, Banach spaces, and their basic properties along with important examples. 2. study fundamental inequalities such as Cauchy–Schwarz, Hölder, and Minkowski inequalities and convergence concepts in normed spaces. 3. develop understanding of bounded linear operators, dual spaces, Hahn–Banach theorem, and its applications. 4. study major results in functional analysis including open mapping theorem, closed graph theorem, Baire category theorem, and Hilbert space theory.			
Unit	Topics		
FUNCTIONAL ANALYSIS			
I	Normed linear spaces, Examples of normed linear spaces and its topological properties, Cauchy’s inequality, Hölder’s and Minkowski’s inequality, Convergence in normed linear spaces, Cauchy sequence, Banach space, Examples of Banach space, Quotient space of normed linear space, Equivalent norms, Riesz lemma.		
II	Continuous linear transformation Bounded linear transformations, Norm of bounded linear transformation, Space of bounded linear transformations. Conjugate space (dual space), Functional, Hahn-Banach theorem for real and complex normed linear spaces, Applications of Hahn- Banach theorem, The natural embedding.		
III	Open mapping theorem, Projection of Banach space, Closed graph theorem, Baire category theorem, Uniform boundedness principle. Inner product spaces, Hilbert spaces with examples, Cauchy-Schwarz’s inequality.		
IV	Orthogonal complement, Orthonormal set and its existence, Bessel’s inequality, Complete orthonormal sets and its characterization. Continuous linear functional on Hilbert space, Riesz representation theorem, Reflexivity of Hilbert space. Weak and strong convergence.		
Course Learning Outcomes: After the completion of the course, the student shall be able to			
CO1: Know basics of Banach space as a part of functional analysis.			
CO2: Determine the significance of functional analysis modern applied and computational mathematics.			
CO3: Understand the application of Hilbert spaces in Mathematics and Physics typically as infinite dimensional function space.			
CO4: Apply Hilbert spaces in solving partial differential equations and in studying Fourier analysis, etc.			
Books Recommended:			
1. G. F. Simmons, <i>Introduction to Topology and Modern Analysis</i>, McGraw Hill, 1963. 2. S. Ponnusamy, <i>Foundations of Functional Analysis</i>, Narosa Publishing House, New Delhi, 2002. 3. G. Bachman, L. Narici, <i>Functional Analysis</i>, Academic Press, 1966. 4. A. E. Taylor, <i>Introduction to Functional Analysis</i>, John Wiley, 1958. 5. N. Dunford, J. T. Schwartz, <i>Linear Operators, Part-I</i>, Interscience, 1958. 6. R. E. Edwards, <i>Functional Analysis</i>, Holt Rinehart and Winston, 1965. 7. C. Gofman, G. Pedrick, <i>First Course in Functional Analysis</i>, Prentice-Hall of India, 1987. 8. R. Bhatia, <i>Notes on Functional Analysis</i>, Hindustan Book Agency, India, 2009. 9. E. Kreyszig, <i>Introductory Functional Analysis with Applications</i>, John Wiley & Sons, India, 2006. 10. M. Schechter, <i>Principles of Functional Analysis</i>, Second Edition, AMS, 2001.			



PG MATHEMATICS (SEMESTER-IV)

NORMED LINEAR SPACE AND THEORY OF INTEGRATION

Class: PG		Year: SECOND	Semester: FOURTH
Subject: MATHEMATICS			
Course Code: ME0402T		Course Title: NORMED LINEAR SPACE AND THEORY OF INTEGRATION	
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 Objectives: The purpose of this course is to			
1. introduce L^p -spaces, convex functions, and key inequalities such as Hölder's, Minkowski's, and Jensen's inequalities.			
2. study modes of convergence including convergence in measure and almost uniform convergence, and their completeness properties.			
3. understand signed measures, Hahn and Jordan decomposition, Radon–Nikodym theorem, and Lebesgue decomposition.			
4. study product measures, Tonelli's and Fubini's theorems, and representation theorems including Riesz–Markov theorem and integration on locally compact spaces.			
Unit	Topics		
NORMED LINEAR SPACE AND THEORY OF INTEGRATION			
I	The L^p -space, Convex functions, Jensen's inequality, Holder's and Minkowski's inequalities, Completeness of Convergence in measure, Almost uniform convergence.		
II	Signed measure, Hahn and Jordan decomposition theorems, Absolutely continuous and singular measures, Radon Nikodym theorem, Labesgue decomposition, Riesz representation theorem, Extension theorem (carathedory).		
III	Product measures, Tonelli's theorem, Fubini's theorem, Baire sets, Baire measure, Continuous functions with compact support, Lebesgue-Stieltjes Integral.		
IV	Regularity of measures on locally compact spaces, Integration of continuous functions with compact support, Reisz-Markoff theorem.		
Course Learning Outcomes: After studying this course the student will be able to			
CO1: understand signed measures and complex measures, ability to use Hahn decomposition, Jordan decomposition, Radon-Nikodym theorem and recognize singularity of measures.			
CO2: verify conditions under which a measure defined on a semi-algebra or algebra is extendable to a sigma-algebra and to get the extended measure, and to prove the uniqueness up to P multiplication by a scalar of Lebesgue measure in n as a translation invariant Borel measure.			
CO3: learn and apply Riesz representation theorem for a bounded linear functional on spaces, understand product measure and the results of Fubini and Tonelli.			
CO4: to understand the concepts of Baire sets, Baire measures, regularity of measures on locally compact spaces, Riesz-Markov representation theorem related to the representation of a bounded linear functional on the space of continuous functions.			
Books Recommended:			
1. C. D. Aliprantis, O. Burkinshaw, <i>Principles of Real Analysis</i> , Academic Press, Indian Reprint, 2011.			
2. A. K. Berberian, <i>Measure and Integration</i> , AMS Chelsea Publications, 2011.			
3. P. R. Halmos, <i>Measure Theory</i> , Springer, 2014.			
4. M. E. Taylor, <i>Measure Theory and Integration</i> , American Mathematical Society, 2006.			
5. H. L. Royden, P. M. Fitzpatrick, <i>Real Analysis</i> , Fourth Edition, Pearson, 2015.			



PG MATHEMATICS (SEMESTER-IV)

MODULE THEORY

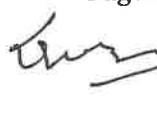
Class: PG		Year: SECOND	Semester: FOURTH
Subject: MATHEMATICS			
Course Code: ME0403T		Course Title: MODULE THEORY	
Credits: 4+0		Core Compulsory / Elective	
Max. Marks: 25(Internal) + 75(External)		Min. Passing Marks: As per University CBCS Norm	
Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 4-0-0			
Course Objectives: The main objectives of this course is to 1. introduce modules over rings, module homomorphisms, submodules, quotient modules, and fundamental isomorphism theorems. 2. study exact sequences, direct sums, products, free modules, and homological properties of modules. 3. develop understanding of projective modules, injective modules, divisible groups, and Baer's characterization. 4. study Artinian and Noetherian modules and rings, Hilbert basis theorem, modules over PID's, and semi-simple modules.			
Unit	Topics		
MODULE THEORY			
I	Modules over a ring, Endomorphism ring of an abelian group, R-Module structure on an abelian group M as a ring homomorphism from R to $\text{End}_Z(M)$, submodules, Direct summands, Annihilators, Homomorphism, Correspondence theorem, Isomorphism theorems.		
II	$\text{Hom}_R(M, N)$ as an abelian group and $\text{Hom}_R(M, M)$ as a ring, Exact sequences, Five lemma, Products, coproducts and their universal property, External and internal direct sums. Free modules, Homomorphism extension property, Equivalent characterization as a direct sum of copies of the underlying ring.		
III	Split exact sequences and their characterizations, Left exactness of Hom sequences and counter-examples for non-right exactness, Projective modules, Injective modules, Baer's characterization, Divisible groups, Examples of injective modules, Existence of enough injectives.		
IV	Artinian and Noetherian modules and rings, Equivalent characterizations, Submodules and factors of artinian and noetherian modules, Hilbert basis theorem, Modules over PID's, Semi-simple modules.		
Course Learning Outcomes: After studying this course the student will be able to			
CO1: identify and construct example of modules, and apply homomorphism theorems on the same.			
CO2: distinguish between projective, injective, free, and semi simple modules.			
CO3: to understand the chain conditions on modules.			
CO4: to characterize finitely generated modules over PID.			
Books Recommended:			
1. M. F. Atiyah, I. G. MacDonald, <i>Introduction to Commutative Algebra</i>, CRC Press, Taylor & Francis, 2018. 2. P. M. Cohn, <i>Basic Algebra: Groups, Rings and Fields</i>, Springer, 2005. 3. D. S. Dummit, R. M. Foote, <i>Abstract Algebra</i>, Third Edition, Wiley India Pvt. Ltd., 2011. 4. N. Jacobson, <i>Basic Algebra, Volumes I & II</i>, Second Edition, Dover Publications, 2009. 5. F. W. Anderson, K. R. Fuller, <i>Rings and Categories of Modules</i>, Springer-Verlag. 6. J. S. Golan, <i>Modules and Structures of Rings</i>, Marcel Dekker Inc. 7. N. S. Gopalakrishnan, <i>University Algebra</i>, Wiley Eastern, New Delhi, 1986. 8. I. A. Adamson, <i>An Introduction to Field Theory</i>, Oliver and Boyd, Edinburgh, 1964. 9. S. Lang, <i>Algebra</i>, Addison Wesley. 10. V. Sahai, V. Bist, <i>Algebra</i>, Fourth Edition, Narosa. 11. I. B. S. Passi, I. S. Luther, <i>Algebra, Volume 3: Modules</i>, Narosa. 12. H. K. Pathak, <i>Abstract Algebra</i>, Shiksha Sahitya Prakashan.			

PG MATHEMATICS (SEMESTER-IV)

DISCRETE MATHEMATICS

Class: PG		Year: SECOND	Semester: FOURTH
Subject: MATHEMATICS			
Course Code: ME0404T		Course Title: DISCRETE MATHEMATICS	
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 Objectives: The course objective is to			
1. introduce the fundamental concepts of lattices, distributive lattices, complemented lattices, and Boolean algebras.			
2. study Boolean identities, canonical forms, minimization of Boolean functions, and applications of Boolean algebra in switching theory.			
3. develop understanding of graph theoretic concepts including paths, cycles, trees, planar graphs, and graph connectivity.			
4. study spanning trees, matrix representation of graphs, Eulerian graphs, directed graphs, weighted graphs, and tree traversals.			
Unit	Topics		
DISCRETE MATHEMATICS			
I	Lattices- Lattices as partially ordered sets, their properties, Lattices as Algebraic system, Sub-lattices, direct product and Homomorphisms, complete, complemented and Distributive Lattices.		
II	Boolean Algebras- Boolean Algebras as Lattices, Various Boolean Identities, switching algebra example, Sub-algebras, Direct products and Homomorphisms, Join-irreducible elements, Atoms and Minterms, Boolean forms and their equivalence, Minterm Boolean forms, sum of products, Canonical Forms, Minimization of Boolean Functions, Applications of Boolean Algebra to switching theory, the Karnaugh Map Method.		
III	Graph Theory- Definition of Graphs, Paths, Circuits, Cycles and Subgraphs, Induced Subgraphs, Degree of a vertex, Connectivity, Planar Graphs, trees, Euler's formula for connected planar graphs, complete and complete Bipartite Graphs, Kuratowski's theorem and its use.		
IV	Spanning trees, matrix representation of graphs, Euler's theorem on the existence of Eulerian Paths and circuits, directed graphs, Indegree and Outdegree of vertex, Weighted undirected Graphs, directed trees, search Trees, Tree Traversals.		
Course Learning Outcomes: After successful completion of this course, student will be able			
CO1: to have the knowledge of lattices and behaviour as an algebraic system.			
CO2: to know new algebraic structure, Boolean algebra, its behaviour as Lattices and its application in circuit theory.			
CO3: to know the notion of graph, some special graph and coloring.			
CO4: to understand searching algorithms for a tree and some other algorithms, kruskal and warshall's algorithm.			
Books Recommended:			
1. John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman, <i>Introduction to Automata Theory, Languages and Computation</i> , Pearson Education, 2000.			
2. Elliott Mendelson, <i>Introduction to Mathematical Logic</i> , Chapman & Hall, 1997.			
3. Arnold B. H., <i>Logic and Boolean Algebra</i> , Prentice Hall, 1962.			
4. K. H. Rosen, <i>Discrete Mathematics and Its Applications</i> , MGH, 1999.			
5. D. B. West, <i>Graph Theory</i> , Pearson Publications, 2002.			
6. F. Harary, <i>Graph Theory</i> , Narosa Publishing House, New Delhi.			
7. R. Garnier, J. Taylor, <i>Discrete Mathematics for New Technology</i> , IOP Publishing, 2002.			
8. A. C. Yadav, <i>Elements of Graph Theory</i> , Golden Valley Publication.			





PG MATHEMATICS (SEMESTER-IV)

DIFFERENTIAL GEOMETRY OF MANIFOLDS

Class: PG		Year: SECOND	Semester: FOURTH
Subject: MATHEMATICS			
Course Code: ME0405T		Course Title: DIFFERENTIAL GEOMETRY OF MANIFOLDS	
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 Objectives: The aim of this course is to introduce			
1. introduce the concepts of Nijenhuis tensor,			
2. study of Contravariant and covariant almost analytic vector field,			
3. study of Affine Connection and Holomorphic Sectional Curvature,			
4. study of different type manifolds.			
Unit	Topics		
DIFFERENTIAL GEOMETRY OF MANIFOLD			
I	Almost Complex manifold, Nijenhuis tensor, Contravariant and covariant almost analytic vector field, Affine Connection, F-connection.		
II	Almost Hermite manifolds, Curvature tensor, Linear Connections, Kahler manifolds, Holomorphic Sectional Curvature, Nearly Kahler Manifolds.		
III	Curvature Identities, Constant Holomorphic sectional Curvature, Almost Kahler Manifolds.		
IV	Almost contact metric Manifolds, Almost Grayan Manifolds, K-contact Riemannian Manifolds, Sasakian Manifolds, Cosymplectic Manifolds.		
Course Learning Outcomes: After successful completion of this course student will be able			
CO1: to determine concepts of Nijenhuis tensor in different manifolds.			
CO2: Know the Holomorphic Sectional Curvature			
CO3: know K-contact Riemannian manifold.			
CO4: know Curvature tensor.			
CO5. improve their skills in different manifold and also give Employability in teaching and research.			
Books Recommended:			
1. R. S. Mishra, Structures on a Differentiable Manifold and Their Applications, Chandrama Prakashan, Allahabad.			
2. Y. Matsushima, Differentiable Manifolds, Marcel Dekker, 1972.			
3. B. B. Sinha, An Introduction to Modern Differential Geometry, Kalyani Prakashan, New Delhi, 1982.			
4. N. J. Hicks, Notes on Differential Geometry, D. Van Nostrand, 1965.			
5. U. C. De, A. A. Shaikh, Differential Geometry of Manifolds, Narosa Publishing House.			


 Dean
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PG MATHEMATICS (SEMESTER-IV)

MATHEMATICAL MODELING

Class: PG		Year: SECOND	Semester: FOURTH
Subject: MATHEMATICS			
Course Code: ME0406T		Course Title: MATHEMATICAL MODELING	
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 Objectives: The objective of this course is to			
1. introduce the basic concepts, techniques, classifications, characteristics, and limitations of mathematical modeling.			
2. develop mathematical models using ordinary differential equations for growth, decay, and dynamic systems.			
3. study mathematical modeling through difference equations and their applications in economics, finance, and population dynamics.			
4. understand linear programming models, transportation and assignment problems, and logistic models used in applied sciences.			
Unit	Topics		
MATHEMATICAL MODELING			
I	Simple situations requiring mathematical modeling, techniques of mathematical modeling, Classifications, Characteristics and limitations of mathematical models, Some simple illustrations.		
II	Mathematical modeling through differential equations, linear growth and decay models, Non linear growth and decay models, Mathematical modeling in dynamics through ordinary differential equations of first order.		
III	Mathematical models through difference equations, some simple models, Basic theory of linear difference equations with constant coefficients, Mathematical modeling through difference equations in economic and finance, Mathematical modeling through difference equations in population dynamic.		
IV	Mathematical modeling through linear programming, Linear programming models in Transportation and assignment, non age and age structured models, simple logistic models, physical basis of logistic model, Smith's model.		
Course Learning Outcomes: After the completion of the course, the student shall be able to			
CO1: assess and articulate what type of modeling techniques is appropriate for a system.			
CO2: construct mathematical models in real-world biological phenomenon.			
CO3: predict the behavior of a system based on the analysis of its mathematical model.			
Books Recommended:			
1. J. N. Kapur, <i>Mathematical Modelling</i> , New Age International (P) Limited, New Delhi, 2007.			
2. J. N. Kapur, <i>Mathematical Models in Biology and Medicine</i> , Affiliated East-West Press Pvt. Ltd., New Delhi, 1985.			
3. J. Mazumdar, <i>An Introduction to Mathematical Physiology and Biology</i> , Cambridge University Press, 1999.			
4. D. N. Burghes, <i>Mathematical Modeling in the Social, Management and Life Science</i> , Ellie Horwood and John Wiley.			
5. F. Charlton, <i>Ordinary Differential and Difference Equations</i> , Van Nostrand.			



PG MATHEMATICS (SEMESTER-IV)

OPERATOR THEORY

Class: PG		Year: SECOND	Semester: FOURTH
Subject: MATHEMATICS			
Course Code: ME0407T		Course Title: OPERATOR 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 Objectives: The aim of this course is to			
1. introduce the fundamental concepts of real Banach spaces, real Hilbert spaces, and bounded linear operators.			
2. study important classes of operators such as adjoint, self-adjoint, normal, unitary, projection, and compact operators on Hilbert spaces.			
3. develop understanding of spectral theory, including spectrum, resolvent, spectral theorem, spectral radius, and spectral mapping theorem.			
4. study Banach algebras, ideals, maximal ideals, radicals, and the Gelfand–Naimark theorem in complex commutative Banach algebras.			
Unit	Topics		
OPERATOR THEORY			
I	Introduction to real Banach and real Hilbert spaces, Adjoint of an operator on a Hilbert space, Self-adjoint operators, Normal operators and Unitary operators on Hilbert spaces, Projections on a Hilbert space.		
II	Compact operators, Spectral theory of linear operators in normed linear space, Spectral theory of linear operators in finite dimensional normed linear spaces, Spectral properties of bounded linear operators.		
III	Determinant and the spectrum of an operator, Spectral theorem, Resolvent and its properties, Spectrum and its properties, Residual spectrum, Approximate spectrum, Analyticity of the resolvent operator, Use of complex analysis in spectral theory, Spectral radius and the spectral mapping theorem for polynomials.		
IV	Banach algebras, Banach algebras with identity, Division algebra, Further properties of Banach algebra, Compactness of the spectrum, Ideals and maximal ideals of a complex commutative Banach algebra, radicals, Gelfand-Naimark theorem.		
Course Learning Outcomes: After studying this course the student will be able to			
CO1: Understand the structure of real Banach spaces, real Hilbert spaces, and bounded linear operators.			
CO2: Study adjoint, self-adjoint, normal, unitary, projection, and compact operators on Hilbert spaces.			
CO3: Analyze spectral theory of bounded linear operators, including spectrum, resolvent, and spectral theorem.			
CO4: Develop understanding of Banach algebras, ideals, radicals, and the Gelfand–Naimark theorem.			
Books Recommended:			
1. G. F. Simmons, <i>Introduction to Topology and Modern Analysis</i> , McGraw-Hill, 1963.			
2. Erwin Kreyszig, <i>Introductory Functional Analysis with Applications</i> , John Wiley and Sons.			
3. George Bachman and Lawrence Narici, <i>Functional Analysis</i> , Academic Press, New York, 1966.			
4. John B. Conway, <i>A Course in Operator Theory</i> , Springer.			
5. N. Saran and S. L. Shukla, <i>Functional Analysis</i> , Pragati Prakashan, Meerut.			
6. J. N. Sharma and A. R. Vasishtha, <i>Functional Analysis</i> , Krishna Prakashan Media (P) Ltd., 2015.			



MATHEMATICS (SEMESTER-IV)

DISSERTATION/ RESEARCH PROJECT

Class: PG	Year: SECOND	Semester: FOURTH
Subject: MATHEMATICS		
Course Code: MP0408R	Course Title: DISSERTATION/ RESEARCH PROJECT	
Credits: 0 +4	Core Compulsory	
Max. Marks: 100	Min. Passing Marks: As per University CBCS Norm	
Course prerequisites: To study this course, a student must have passed Mathematics as Major Subject in UG Third Year Programme.		
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 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.		

