Name of Program	**Master of Science in Mathematics**
Abbreviation	**M.Sc. Mathematics**
Duration	**2 Years**
Eligibility Criteria	Bachelor Degree in Mathematics or equivalent Degree.
Objective of Program	The core objective of the M.Sc. Mathematics programme is to prepare the students for productive career in Education sector and academia by providing an outstanding environment of teaching and research in the core and emerging areas of the discipline.
Program Outcome	1. Provides knowledge of fundamentals of pure and applied mathematics. 2. Provide information about applications of Mathematics to the students that creates the opportunities in education , research centres and industries. 3. Provide strong foundation of mathematics to formulate, analyze and problem solving for advanced study and research. 4. Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in mathematical sciences. 5. Develop need based Mathematics teaching-learning resources. 6. Professionally inclined Mathematics educators who have sound knowledge of subject matter and specialized in constructivist & alternate pedagogy
Program Specific Outcomes	1. Understand the fundamental principles of Pure and Applied mathematics. 2. Confidence increase in mathematical logic and reasoning ability . 3. Explore a newer way of mathematical applications. 4. Able to apply analytical and theoretical skills 5. Enhanced Computing skills to solve mathematical problems. 6. Prepare and motivate students for research studies in mathematics and related fields. 7. Assist students in preparing (personal guidance, books) for competitive exams e.g. NET, GATE, etc.

Mapping between POs and PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	PO1	■		■				■
	PO2		■	■		■	■	■
	PO3	■	■		■		■	■
	PO4	■	■			■	■	■
	PO5			■	■		■	
	PO6		■	■	■	■		

Medium of Instruction	English

Program Structure — Semester 1

Course Code	Title	Teaching per week		Course Credits	University Examination		Internal Marks	Total Marks
		Theory	Practical		Duration	Marks		
PGMTH-101	Real Analysis-1	4	0	4	3 Hrs	70	30	100
PGMTH-102	Complex Analysis-1	4	0	4	3 Hrs	70	30	100
PGMTH-103	Topology-1	4	0	4	3 Hrs	70	30	100
PGMTH-104	Abstract Algebra-1	4	0	4	3 Hrs	70	30	100
PGMTH-105	Ordinary Differential equations-1	4	0	4	3 Hrs	70	30	100
PGMTH-106	Numerical Anlysis-1	4	0	4	3 Hrs	70	30	100

Program Structure — Semester 2

Course Code	Title	Teaching per week		Course Credits	University Examination		Internal Marks	Total Marks
		Theory	Practical		Duration	Marks		
PGMTH-201	Real Analysis-2	4	0	4	3 Hrs	70	30	100
PGMTH-202	Complex Analysis-2	4	0	4	3 Hrs	70	30	100
PGMTH-203	Topology -2	4	0	4	3 Hrs	70	30	100
PGMTH-204	Abstract Algebra-2	4	0	4	3 Hrs	70	30	100
PGMTH-205	ODE-2	4	0	4	3 Hrs	70	30	100
PGMTH-206	Numerical Analyis-2	4	0	4	3 Hrs	70	30	100
	Total	20	10	24				

Program Structure		Semester 3						
Course Code	Title	Teaching per week		Course Credits	University Examination		Internal Marks	Total Marks
		Theory	Practical		Duration	Marks		
301	Functional Analysis-I	4	0	4	3 Hrs	70	30	100
302	Differential Equations	4	0	4	3 Hrs	70	30	100
303	Calculus of Variations	4	0	4	3 Hrs	70	30	100
304	Advanced Linear Algebra-I	4	0	4	3 Hrs	70	30	100
	ELECTIVE GROUP							
PGMTH3001	Fluid Dynamics	4	0	4	3 Hrs	70	30	100
PGMTH3002	Mathematical Software	4	4	4	3 Hrs	70	30	100 **
PGMTH3003	Linear programming	4	4	4	3 Hrs	70	30	100 **
PGMTH3004	Operation Research	4	4	4	3 Hrs	70	30	100 **
PGMTH3005	Integral Transforms-I	4	0	4	3 Hrs	70	30	100
PGMTH3006	Advanced Integral Transforms-I	4	0	4	3 Hrs	70	30	100
PGMTH3007	Advanced Number Theory-I	4	0	4	3 Hrs	70	30	100
PGMTH3008	Analytic Number Theory	4	0	4	3 Hrs	70	30	100
PGMTH3009	Special Functions-I	4	0	4	3 Hrs	70	30	100
PGMTH3010	Advanced Special Functions-I	4	0	4	3 Hrs	70	30	100

**Theory: 18 (Internal) 42(External)
**   Practical: 12 (Internal) 28(External)
**   Total: 30 (Internal) 70(External)

Program Structure		Semester 4						
Course Code	Title	Teaching per week		Course Credits	University Examination		Internal Marks	Total Marks
		Theory	Practical		Duration	Marks		
401	Functional Analysis-II	4	0	4	3 Hrs	70	30	100
402	Differential Geometry	4	0	4	3 Hrs	70	30	100
403	Integral Equations	4	0	4	3 Hrs	70	30	100
404	Advanced Linear Algebra-II	4	0	4	3 Hrs	70	30	100
	ELECTIVE GROUP							
PGMTH4001	Computational Fluid Dynamics	4	4	4	3 Hrs	70	30	100**
PGMTH4002	Mathematical Modelling	4	0	4	3 Hrs	70	30	100
PGMTH4003	Non-Linear programming	4	4	4	3 Hrs	70	30	100 **
PGMTH4004	Advanced Operation Research	4	4	4	3 Hrs	70	30	100 **
PGMTH4005	Integral Transforms-II	4	0	4	3 Hrs	70	30	100
PGMTH4006	Advanced Integral Transforms-II	4	0	4	3 Hrs	70	30	100
PGMTH4007	Advanced Number Theory-II	4	0	4	3 Hrs	70	30	100
PGMTH4008	Introduction to Partition Theory and Cryptography	4	0	4	3 Hrs	70	30	100
PGMTH4009	Special Functions-II	4	0	4	3 Hrs	70	30	100
PGMTH4010	Advanced Special Functions-II	4	0	4	3 Hrs	70	30	100

**Theory: 18 (Internal) 42(External)
**   Practical: 12 (Internal) 28(External)
**   Total: 30 (Internal) 70(External)

M.SC. 1ˢᵗ Semester

Course Code	PGMTH-101

Course Title	Real Analysis – I
Credit	4
Teaching per Week	4 Hrs
Minimum weeks per Semester	20 (Including Classwork, examination, preparation, holidays etc.)
Effective From	June 2020
Course Objectives	The course objective is to develop problem solving skills and to acquire knowledge on some of the basic concepts convergence of series and function, Uniform convergence and continuity, open and closed sets, Outer measure, measurable sets and Lebesgue measure.
Course Outcomes	1. To develop an in-depth mathematical understanding of the theory of Real Analysis and Students will be able to give rigorous proofs of many theorems of real analysis. 2. They will be able to use these theorems to solve problems. 3. Ability to handle convergence of series and sequence of functions. 4. Ability to differentiate functions in Rn

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	■						
	CO2	■		■				
	CO3	■	■			■		
	CO4		■	■	■		■	■

Course Content	**UNIT-1** **Sequences and Series of Functions:** Sequence of functions, Series of functions, Uniform Convergence, Uniform Convergence and Continuity, Uniform Convergence and Integration, Uniform Convergence and Differentiation, Equicontinuous families of Functions, The Stone-Weierstrass theorem. UNIT-2 **Pre-requisite:** The extended real numbers, Open and closed sets of real numbers, Borel sets. UNIT-3 **Lebsgue Measure – 1:** Outer measure, measurable sets and Lebesgue measure, UNIT-4 **Lebsgue Measure – 2:**

	A non-measurable sets, measurable function, Littlewoods's three principles.
Reference Books	1. H. L. Royden: "Real Analysis", Macmillan publication, 1993. 2. G. de Barra: "Measure theory and Integration", Wiley Eastern limited 1981. 3. Walter Rudin: "Principles of Mathematical Analysis", McGraw Hill, 1976. 4. T. M. Apostol: "Mathematical Analysis", Narosa Publishing House, 1985. 5. I. P. Natanson: "Theory of Functions of real variable", Fredrick Unger pub. 1961.

PGMTH-102 COMPLEX ANALYSIS-I

Course objective	The objective of this course includes: To introduce and develop the fundamental concepts of complex analysis such as analytic functions, Cauchy-Riemann relations and harmonic functions etc., To study Cauchy integral formula, general form of Cauchy theorem, the Fundamental theorem of Algebra, Maximum module Principle., To enable students to acquire skills of contour integration to evaluate definite integrals involving sins and cosines via residue calculus.
Course outcomes	1. In this course students will learn the algebra and geometry of complex numbers, 2. students should be able to check differentiability and the analyticity of complex valued function, 3. Student will learn Cauchy-Riemann relations and harmonic functions 4. Cauchy integral formula, general form of Cauchy theorem. 5. Fundamental theorem of Algebra, Maximum module Principle 6. Contour integrals related theorem and Examples.

Mapping between COs with PSOs								
		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	■						■
	CO2		■	■				■
	CO3	■			■		■	
	CO4		■		■		■	
	CO5	■		■				■
	CO6		■			■		

Course content	**UNIT-1** **Algebra of Complex Numbers:** Complex Numbers, Triangle Inequality and its Applications, Polar and Exponential forms, Powers and Roots, Region in the Complex Plane, Extended Complex Plane. **UNIT-2**

	Analytic Functions: Functions of a Complex variables, Limits, Continuity, Differentiability, Cauchy-Riemann Equations, Analytic functions, Harmonic functions. **UNIT-3** **Elementary Functions:** Exponential function, Trigonometric functions, Hyperbolic functions, Multivalued function and its branches, Logarithmic function, Complex Exponents, Inverse Trigonometric and Hyperbolic functions. **UNIT-4** **Complex Integration:** Contour Integral, Primitives, Cauchy-Goursat Theorem, Extension of Cauchy-Goursat Theorem, Winding Number, Cauchy Integral formula, Consequences of Cauchy Integral formula, Concept of Maximum Moduli of functions.
Reference books	1. H. S. Kasana: "Complex Variables – Theory and Applications", 2nd Edition (2006), PHI, N. Delhi. 2. J. N. Sharma:"Functions of a Complex Variable", Krishna Prakashan, 2000. 3. S. Ponnuswamy: "Foundation of Complex Analysis", Narosa Publishing House, 1997. 4. S. Lang:"Complex Analysis", Addition Wesley, 1997. 5. H. A. Priestly: "Introduction to Complex Analysis", Clarendon Press, 1990. 6. J. B. Conway:"Functions of one Complex Variable", Springer-Verlag, 1980
	PGMTH-103 TOPOLOGY-I
Course objective	To generalize the concept of distance, open sets, closed sets and related theorems in real line and to learn basic concepts in Metric Spaces, Derived set, Open Base and Open sub-base, First and second countable spaces, Separable spaces. Cover, Sub-cover, open cover, Basic and sub-basic open cover Topological Spaces, compact spaces and connected spaces.
Course outcomes	1. Students should be able to define topology and its construction.

		2. Distinguish open and closed subset, Notions of connectedness and compactness. 3. Students will learn various properties of compact spaces 4. Distinguish Cover, Sub-cover, open cover, Basic and sub-basic open cover 5. Topological Spaces, compact spaces and connected spaces.						

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	▓						
	CO2	▓	▓	▓				
	CO3	▓			▓			▓
	CO4	▓			▓		▓	▓
	CO5	▓		▓	▓		▓	▓

Course content

Unit-1
Metric Spaces and Topological Spaces:

Sets and functions, Metric Spaces: Definitions and examples. Topological Space, Relative Topology, Continuity and Convergence, Open and Closed sets, Closure of a set, Neighborhood of a point, Interior point, limit point, Derived set, Open Base and Open sub-base, First and second countable spaces, Separable spaces.

Unit-2
Compactness:

Cover, Sub-cover, open cover, Basic and sub-basic open cover, countable open cover, Continuity and Compactness, Finite intersection property, Heine-Borel property.

Unit-3
Product Spaces:

Definition and examples, Projection mappings and its continuity, Open and closed sub-base for product space.

Tychonoff's Theorem and Locally Compact Spaces:

Tychonoff's theorem, Generalized Heine-Borel theorem.

Unit-4
Compactness for Metric Spaces:

Sequentially Compact Metric Space, Bolzano-Weierstrass Property (BWP),Totally bounded Space, Ascoli's theorem.

Reference books

1. George F. Simmons:"Introduction to Topology and Modern Analysis", McGraw-Hill Book Co., 1963.
2. James R. Munkres:"Topology : A First Course", Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
3. J. Dugundji: "Topology",Allyn and Bacon, 1966 (Reprinted in India by Prentice Hall of India Pvt. Ltd.).
4. K. D. Joshi:"Introduction to General Topology", Wiley

| | | Eastern Ltd., 1983. |
| | | 5. J. Hocking and G. Young:"Topology", Addison-Wesley, Reading, 1961. |

	PGMTH-104 ABSTRACT ALGEBRA-1
Course objectives	To introduce the concepts Groups, Permutation groups, Direct product of groups, Rings, Euclidean Rings, Polynomial Rings and some related theories and to develop working knowledge of these concepts and also skills for applying them in number theory and construction of certain fields.
Course outcomes	1. Acquaintance with the fundamental algebraic structures, namely Groups, Rings, Fields and Vector spaces. 2. Students will learn about Group theory, ring theory and modules. 3. students should be able to apply the conceptual structure of group theory 4. Distinguish Group and Ring 5. Distinguish Fields , Vector space, modules 6. To gain skill in problem solving and critical thinking. 7. Essential for further study of Algebra.

Mapping between COs with PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	■	■	■	■			■
CO2	■		■			■	
CO3		■					■
CO4	■			■			
CO5	■	■		■			■
CO6		■					■
CO7						■	

Course content

Unit I:

Group Theory: Conjugate of an element, class equation, and Cauchy theorem, Sylow's theorem, Direct Products, Fundamental theorem of Finite Abelian Groups.

Unit II:

Ring Theory: Primitive polynomials, Guass's lemma, the Eisenstein criterion, polynomial rings over commutative rings, unique factorization domain.

Unit III:

Modules: Modules, sub-modules, finitely generated module. Direct sum of sub-modules, Homomorphism and quotient modules, Fundamental theorem of R-homomorphism.

	Unit IV: Completely reducible modules, Schur's lemma, Free modules.
References:	1. I.N. Herstein : Topics in Algebra 4[th]Ed., John Wiley Sons. 2. P.B. Bhattacharya : Basic Abstract Algebra 2[nd]Ed., Cambridge University Press. 3. ArtinM. :Algebra, Prentice Hall, Englewood, Cliffs NJ. 4. J. A. Gallian: Contemporary Abstract Algebra, Narosa Publishing House

PGMTH-105 ORDINARY DIFFERENTIAL EQUATIONS-I

Course objectives	To provide some standard methods for solving first-order, second-order and higher-order homogeneous and non homogeneous ordinary differential equations with constant and variable coefficients, linear equation with regular singular points, and to study the method of successive approximations, Lipshitz condition and non-local existence of solutions, wronskian.
Course outcomes	1. Students will learn about differential equations and its classifications. 2. Students should be able to classify nature of solutions for the second order linear differential equation, Existence of solutions of differential equations. 3. Students will learn the methodology to solve second order ordinary differential equations. 4. Understand the concept of Method of variation of parameters 5. Able to use Method of Laplace transforms.

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	▓						
	CO2	▓		▓				▓
	CO3		▓			▓		
	CO4			▓		▓		▓
	CO5		▓			▓	▓	▓

Course content	**Unit-I** Basic concepts and Linear Equations of the first order: Introduction, Formation of Differential Equations (DE), Classification of DE, Initial and Boundary Value Problems, Definition of Solutions of DE, First Order Linear Equation, Exact Equations, Separable Equations. **Unit-II** Linear Differential Equations of Higher Order: Introduction, Higher Order Differential Equations, Linear Independence, Equations with Constant Coefficients, Equations with Variable Coefficients **Unit-III**

	Wronskian, Variation of Parameters, Some Standard Methods, Method of Laplace Transforms. **Unit-IV** Solutions in Power Series:Introduction, Second Order Linear Equations with Ordinary Points, Legendre Equation and Legendre Polynomials, Second Order Equation with Regular Singular Point, Properties of Bessel Functions.
References:	1. S. G. Deo, V. Lakshmikantham,V.Raghvendra: Text Book of Ordinary Differential Equations (Second Edition),Tata McGraw Hill Pub. Co. Ltd, New Delhi, 1997. 2. CoddingtonE.A.,Levinson N.: Theory of Ordinary Differential Equations, Mc Graw Hill, 1955. 3. HartmannP.: Ordinary Differential quations,JohnWileyInternational, 1964. 4. SomasundaramD.:Ordinary Differential Equations,Narosa, 2001. 5. Mandal C.R.: Ordinary Differential Equations,PHI,2003. 6. Rai B., FreedmanmH.I.,Chaudhary D.P.:A Course in Ordinary Differential Equations, Narosa, 2002. 7. King A.C., Otto R.,BillinghamJ.:Differential Equations, Cambridge, 2005.
	PGMTH-106 NUMERICAL ANALYSIS –I
Course objectives	To expose the student to the various numerical methods available for different kinds of problems. The study of numerical methods for Interpolation of polynomials and Approximation roots of functions .Wide variety of numerical techniques to solve mathematical problems arising in diverse scientific contexts. Implementation of stable algorithms for finding roots of nonlinear equations, solving linear system of equations, and solution for ODE.
Course outcome	1. Students will able to find roots of equations/nonlinear equations. 2. Learn about the concept of Eigen values and Eigen vectors. 3. Learn about theory of interpolations. 4. Various interpolation method. 5. Implementing numerical methods algorithms.

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	■						
	CO2	■			■	■		■
	CO3	■	■					■
	CO4	■						■
	CO5		■	■		■		

Course content	
	UNIT-1 **Transcendental Equations:** Bisection method, Iteration method based on first and second degree equation, Rate of convergence, General iteration Methods, System of nonlinear equations, Methods for complex roots. **UNIT-2** **Polynomial Equations & System of Linear Algebraic Equations:** Polynomial equations, Choice of iterative method. Direct Methods, Error analysis for direct root methods, Iteration methods. **UNIT-3** **Eigen values problems:** Eigen values and Eigenvectors, Bound on Eigen values, Jacobi method for symmetric matrices, Givens method for arbitrary Matrices, Power method, Inverse power method. **UNIT-4** **Interpolation:** Lagrangian and Newton interpolations, Finite difference operators, Interpolating polynomials, Hermite interpolation, Piecewise and Spline interpolations.

Reference Books:	
	1. M.K. Jain, S.R.K. Iyenger, R.K. Jain: "Numerical Methods for scientific and engineering computations", VI – edition, New Age International Publishers 2. Philips and Taylor: "Theory and Applications of Numerical Analysis Academic Press", 1996

	3. Gourdin and Boumhart: "Applied Numerical Analysis", P.H.I., 1996 4. A.S. Householder: "Theory of Matrices in Numerical Analysis", Blarsedell - New York. 5. Jacques and Colin: "Numerical Analysis", Chapman & Hall, New-York, 1987.
SEMESTER-II	
	PGMTH-201 REAL ANALYSIS –II
Course objectives	The course objective is to develop problem solving skills and to acquire knowledge on some of the basic concepts in the Riemann integral, the Lebesgue integral, various convergence theorem, Functions of a bounded variation.
Course outcomes	1. Summarize concepts of real analysis to enhance ability of analysing pure and applied mathematical problems. 2. Students will be able to give rigorous proofs of many theorems of convergence theorem related to Lebesgue integral. 3. Also they will be able to use these theorems to solve problems. 4. students should be able to appreciate the niceties provided by Lebesgue Integration theory. 5. LP Spaces, The Minkowski and Holder inequalities.

Mapping between COs with PSOs

	PSO 1	PSO 2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	▓		▓	▓			
CO2							
CO3		▓		▓			
CO4		▓	▓	▓			▓
CO5			▓	▓			▓

Course content

UNIT -1
Lebesgue Integral – 1:
The Riemann integral, The Lebesgue integral of a bounded function over a set of finite measure, the integral of a non-negative function,

UNIT -2
Lebesgue Integral – 2:
The general Lebesgue integral, Lebesgue convergence theorem, monotone convergence theorem, Fatau's lemma, generalized

	Lebesgue convergence theorem. # UNIT -3 **Differentiation and integration:** Differentiation of monotone functions, Functions of a bounded variation, Differentiation of an Integral, Absolute continuity, Convex functions. # UNIT -4 **Inequalities in LP Spaces:** LP Spaces, The Minkowski and Holder inequalities.	
Reference books	1. H. L. Royden: "Real Analysis", Macmillan publication, 1993. 2. G. de Barra: "Measure theory and Integration", Wiley Eastern limited 1981. 3. Walter Rudin: "Principles of Mathematical Analysis", McGraw Hill, 1976. 4. T. M. Apostol: "Mathematical Analysis", Narosa Publishing House, 1985. 5. I. P. Natanson: "Theory of Functions of real variable", Fredrick Unger pub. 1961.	
	PGMTH-202 COMPLEX ANALYSIS-II	
	To introduce and develop the fundamental concepts of complex analysis such as analytic functions, Cauchy-Riemann relations and harmonic functions etc., To study Classification of Singularities, Residues, To enable students to acquire skills of contour integration to evaluate definite integrals involving sins and cosines via residue calculus. Conformal mapping.	
Course outcome	1. Students will learn about properties of power series 2. students should be able to find and classify Singularities, 3. Evaluation of residues and improper real integrals, Identify zeros and singular points of functions. **4.** The will study about binomial transformations. Exponential Transformation, Trigonometric Transformation. 5. Upon completion of this unit, the student will be able to: Evaluate Complex integrals by applying Cauchy integral formula and various method.	

Mapping between COs with PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	▓						▓
CO2		▓	▓				▓
CO3	▓			▓		▓	
CO4		▓				▓	
CO5	▓		▓				▓

Course content	**UNIT-1** **Series Expansions:** Sequence of Functions, Series of Functions. Power Series,

	Uniform convergence of power series, Taylor series, Zeros of Analytic functions, Laurent Series, Integration and Differentiation of power series, Multiplication and Division of power series. **UNIT-2** **Singularities and Residues:** Classification of Singularities, Residues, Poles and Zeros, Behaviour of functions and infinity, Meromorphic functions, Open mapping theorem, Partial fraction expansions, Regular points and singularities. **UNIT-3** **Sums and Definite Integrals:** Estimation of sums, Definite Integrals involving Sines and Cosines, Improper integrals, Integration along indented Contours, Other types of Contours. **UNIT-4** **Conformal Mappings:** Conformality Theorem, Bilinear Transformation, Special Bilinear Transformations, Exponential Transformation, Trigonometric Transformation.
Reference books	1. H. S. Kasana: "Complex Variables – Theory and Applications", 2nd Edition (2006), PHI, N. Delhi. 2. J. N. Sharma:"Functions of a Complex Variable", Krishna Prakashan, 2000 3. S. Ponnuswamy: "Foundation of Complex Analysis", Narosa Publishing House, 1997. 4. S. Lang:"Complex Analysis", Addition Wesley, 1997. 5. H. A. Priestly: "Introduction to Complex Analysis", Clarendon Press, 1990 6. J. B. Conway:"Functions of one Complex Variable", Springer-Verlag, 1980
	PGMTH-203 TOPOLOGY-II
Course objectives	To generalize the concept of Separation Axioms and related theorems in real line and to learn basic concepts in compact spaces and connected spaces, Component of space, Totally Disconnected Space, Locally Disconnected Space.
Course outcome	1. Students will understand separation axioms. 2. Know about connected spaces and its properties 3. Having a grasp on basic results related to connectedness.

	4. Student will distinguish and learn about Component of space, Totally Disconnected Space, locally connected space.

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	▓						
	CO2	▓	▓	▓				
	CO3	▓			▓			▓
	CO4	▓					▓	▓

Course content	**UNIT-1** **Separation Axioms:** T_1 and T_2 Spaces, Regular, Completely regular and Normal spaces, Uryshon's lemma and Tietz's extension theorem. # UNIT-2 **Connected Spaces:** Connected Space, Continuity and connectedness, Disconnected spaces, Product of connected spaces, Connectedness of R^n and C^n. **UNIT-3** **Component of space:** Component of space, Theorems and examples on component spaces. **UNIT-4** **Totally Disconnected Space:** Definition and examples, Theorems and examples on totally disconnected spaces **Locally Connected space:** Definition and examples, Theorems related to locally connected spaces.
Reference books	1. George F. Simmons: "Introduction to Topology and Modern Analysis", McGraw-Hill Book Co., 1963. 2. James R. Munkres: "Topology : A First Course", Prentice Hall of India Pvt. Ltd., New Delhi, 2000. 3. J. Dugundji: "Topology", Allyn and Bacon, 1966 (Reprinted in India by Prentice Hall of India Pvt. Ltd.). 4. K. D. Joshi: "Introduction to General Topology", Wiley Eastern Ltd., 1983. 5. J. Hocking and G. Young: "Topology", Addison-Wesley, Reading, 1961.
	PGMTH-204 ABSTRACT ALGEBRA-II
Course objective	To develop skills and to acquire knowledge on some of the basic concepts in Galois theory, Algebraic Extensions, Splitting fields,

	Polynomials solvable by radicals. When one completes an introductory course on Galois theory one will be able to visualize and appreciate the necessity of acquiring deep mathematical thought to be able to solve certain seemingly simple questions such as insolvability of quintic by radicals. The course provides an opportunity to the student to learn highly sophisticated and deep concepts in algebra such as Algebraically closed fields, splitting fields, normal and separable extensions.
Course outcome	1. Summarize concepts of field theory to enhance ability of analysing pure and applied mathematical problems. 2. students should be able to play around fields and field extensions in a mathematical mature way. 3. They will also be able to appreciate role of algebra in solving some old classical problems of algebra. 4. Distinguish between Extension fields and Finite extension field and splitting fields 5. Distinguish between Algebraic extension, Algebraic number. 6. the student will be able to: Demonstrate Field extensions and characterization of finite normal extensions as splitting fields and study prime fields. 7. the student will be able to: Understand cyclotomis polynomials, cyclic extensions, Radical field extensions and Ruler & Compass constructions. Know the important applications of Galois Theory.
Mapping between COs with PSOs	

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	■	■	■	■			■
CO2	■		■	■		■	
CO3		■					■
CO4	■			■			
CO5	■	■		■			■
CO6		■					■
CO7						■	

Course content	UNIT 1: **Field Theory:** Extension fields, Finite extension field, Algebraic extension, Algebraic number. UNIT 2: Roots of polynomials, splitting fields, Uniqueness of Splitting fields,Construction with Straightedge and compass, UNIT 3: More about roots, Simple extension. **Galois Theory:** Fixed fields, Elementary symmetric functions, normal extension, UNIT 4: Galois group, The fundamental theorem of Galois theory. **Solvability by Radicals & Finite Fields:**Solvable Groups,

	Abel's Theorem, Finite Fields.
Reference	1. I.N. Herstein : Topics in Algebra 4thEd., John Wiley Sons. 2. P.B. Bhattacharya : Basic Abstract Algebra 2ndEd., Cambridge University Press. 3. Artin M. :Algebra, Prentice Hall, Englewood, Cliffs NJ. 4. J. A. Gallian: Contemporary Abstract Algebra, Narosa Publishing House.

	PGMTH-205 ORDINARY DIFFERENTIAL EQUATIONS-II
Course objectives	To introduce the concept of system of linear differential equations, Linear Systems with Constant Coefficients and Periodic Coefficients, solution of linear system.
Course outcome	1. Identify the essential characteristics of Systems of first order Linear Differential Equations 2. Know about the existence and uniqueness of solutions. 3. Students should be able to solve system of linear differential equations. 4. Concept of fundamental Matrix. 5. Know about approximate method.

Mapping between COs with PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	▓						
CO2	▓		▓	▓			▓
CO3		▓			▓		
CO4			▓		▓		▓
CO5		▓			▓	▓	▓

Course content	**UNIT-1** Systems of Linear Differential Equations: Introduction, Systems of First Order Equations, Model for Arms Competition between Two Nations, Existence and Uniqueness Theorem **UNIT-2** Fundamental Matrix, Non homogeneous Linear Systems **UNIT-3** Linear Systems with Constant Coefficients, Linear Systems with Periodic Coefficients **UNIT-4** Existence and Uniqueness of Solutions:Introduction, Preliminaries, Successive Approximations, Picard's Theorem.
Reference	1. S. G. Deo, V. Lakshmikantham, V. Raghvendra: Text Book of Ordinary Differential Equations (Second Edition),Tata McGraw Hill Pub. Co. Ltd, New Delhi, 1997. 2. Coddington E.A., Levinson N.: Theory of Ordinary Differential Equations, Mc Graw Hill, 1955. 3. Hartmann P.: Ordinary Differential Equations, John

Wiley International, 1964.

4. Somasundaram D.: Ordinary Differential Equations, Narosa, 2001.
5. Mandal C.R.: Ordinary Differential Equations, PHI,2003.
6. Rai B., Freedmanm H.I., Chaudhary D.P.: A Course in Ordinary Differential Equations, Narosa, 2002.
7. King A.C., Otto R., Billingham J.: Differential Equations, Cambridge, 2005.

PGMTH-206 NUMERICAL ANALYSIS –II

Course Objectives	To expose the student to the various numerical methods used for Numerical integration and Differentiation and also for initial value problems and Boundary value problems To develop appreciation of the applicability of numerical methods. To increase computational ability.
Course outcome	1. Students will learn about Numerical differentiations and Integrations 2. Students will learn Single step methods, Multistep methods with Stability analysis . 3. Students should be able to apply various numerical methods available for different kinds of Initial value and boundary problems. 4. Students can be able to use suitable numerical methods for IVP and BVP. 5. They learn Shooting method, Finite difference methods.

Mapping between COs with PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	
CO1	■							
CO2	■			■	■		■	
CO3	■	■					■	
CO4	■						■	
CO5		■	■		■			

Course content	UNIT-1 Numerical Differentiations: Numerical differentiations, Optimum choice of step-length, Extrapolation methods, Partial differentiations. UNIT-2 Numerical Integrations: Numerical Integrations, Methods based on interpolations, Methods based on Undetermined coefficients, Composite integration methods, Romberg Integration. UNIT-3 Ordinary Differential Equations (Initial Value Problem): Difference equations, Single step methods, Stability analysis

	of single step methods, Multistep methods, Stability analysis of Multistep methods. UNIT-4 Ordinary Differential Equations (Boundary Value Problem): Shooting method, Finite difference methods.
Reference	1. M.K. Jain, S.R.K. Iyenger, R.K. Jain: "Numerical Methods for scientific and engineering computations", VI – edition, New Age International Publishers 2. Philips and Taylor: "Theory and Applications of Numerical Analysis Academic Press", 1996 3. Gourdin and Boumhart: "Applied Numerical Analysis", P.H.I., 1996 4. A.S. Householder: "Theory of Matrices in Numerical Analysis", Blarsedell - New York. 5. Jacques and Colin: "Numerical Analysis", Chapman & Hall, New-York, 1987.

SEMESTER-III

PGMTH-301 Functional Analysis-I

Course objective	To introduce basic concepts of Functional Analysis namely normed spaces, bounded linear functionals, and study their applications and also to introduce fundamental results in Functional Analysis namely Hahn-Banach Theorem, open mapping theorem and closed graph theorem and study their applications.
Course outcomes	1. Students will learn properties of Banach spaces, 2. Normed spaces, and inner product spaces 3. Linear operators, bounded linear operator. 4. Difference between finite and infinite dimensional space, Banach space and Hilbert space 5. Computing the dual spaces of certain Banach spaces 6. Students will be able to appreciate the power of classical results of Functional Analysis.

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	■			■			
	CO2	■						■
	CO3	■			■		■	
	CO4	■						■
	CO5	■					■	■
	CO6		■		■		■	■

Course content	**UNIT-1** Metric Space:Metric Space, Further Examples of Metric Spaces, Examples. Completeness proofs **UNIT-II**

	Normed Spaces and Banach Spaces:Vector Space, Normed Space, Banach Space, Further Properties of Normed Spaces, Finite Dimensional Normed Space and Subspaces, Compactness and Finite Dimension **UNIT**-III Linear Operators, Bounded and Continuous Linear Operators, Linear Functionals, Linear Operators and Functionals on Finite Dimensional Spaces, Normed Spaces of Operators, Dual space. **UNIT**-IV Inner Product Spaces, Hilbert Spaces:Inner Product space, Hilbert space, Further Properties of Inner Product Spaces, Orthogonal complements and Direct sums.
Reference	1. E. Kreyszig: Introductory Functional Analysis with applications, John Wiley and Sons. 2. B.V. Limaye: Functional Analysis, Wiley Eastern Ltd. 3. G.F. Simmons: Introduction to Topology and Modern Analysis, McGraw - Hill. 4. J.N. Sharma &A.Vashistha: Functional Analysis.
	PGMTH-302 Differential Equations
Course objectives	To introduce first and second order partial differential equations and their classifications and methods of finding solutions of these partial differential equations.
Course outcomes	1. Students will learn about the paffian differential equations and its applications. 2. Integral Surfaces Passing through a Given Curve, Surfaces Orthogonal to a Given System of Surfaces, 3. Nonlinear Partial Differential Equations of the First Order, Compatible Systems of First-order Equations, Charpit's Method,Jacobi's method 4. They study about applications of separation of variable method. 5. After successful completion of the course, students should be able to find the solutions of first and second order linear and non-linear partial differential equations.
Mapping between COs with PSOs	

Course content	**UNIT-1** <u>**Ordinary Differential Equations in More than Two Variables**</u>**:** Surfaces and Curves in Three Dimensions, Simultaneous Differential Equations of the First Order and the First Degree in Three Variables, Methods of Solutions of $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$, Orthogonal Trajectories of a System of Curves on a Surface, Pfaffian Differential Forms and Equations, Solution of Pfaffian Differential Equations in Three Variables. **UNIT-2** <u>**Partial Differential Equations of the First Order**</u>**:** Partial Differential Equations, Origins of First-Order Partial Differential Equations, Linear Equations of the First Order, Integral Surfaces Passing through a Given Curve, Surfaces Orthogonal to a Given System of Surfaces, **UNIT-3** Nonlinear Partial Differential Equations of the First Order, Compatible Systems of First-order Equations, Charpit's Method, Special Types of FirstorderEquations, Solutions Satisfying Given Conditions, Jacobi's Method. **UNIT-4** <u>**Partial Differential Equations of the Second Order**</u>**:** Linear Partial Differential Equations with Constant Coefficients, Equations with Variable Coefficients, Separation of Variables, Nonlinear Equations of the Second Order.
Reference	1. Sneddon I.N.: Elements of Partial Differential Equations, McGraw Hill, International Editions, 1957 2. ZafarHasan: Differential Equations and their applications, Second Edition, PHI, 2009. 3. Iyengar S.N.:Differential Equations, Anmol Publications, 2000 4. Sharma, Gupta: Differential Equations, Krishna Prakashan Media, 1997- 98.

PGMTH-303 Calculus of Variations	
Course objectives	Introduce the concept of bounded variation, Variational problems and principal, functional, Jacobi Condition, Weirstrass Function, Legendre Condition, Second Variation
Course outcome	1. Students will learn about the concept of Variations and its properties, 2. Functionals and its properties 3. Study Variational problem with a movable boundary for a functional dependent on two functions, One-Sided Variations, Reflection and Refraction 4. After successful completion of the course, students should be able to solve variational problems.

Mapping between COs with PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	■		■			■	■
CO2	■	■				■	
CO3	■		■	■	■		
CO4	■	■	■				■
CO5	■	■		■	■	■	■

Course content

UNIT-1

Variational Problems with Fixed Boundaries:

The concept of Variation and its properties, Euler's Equation, Fundamental lemma of Calculus of Variation,

UNIT-2

Functionals

Functionals dependent on several functions of independent variable, Functionals dependent on Higher-Order derivatives, Functionals dependent on functions of several independent variables, Variational problems in parametric form.

UNIT-3

Variational Problems with Moving Boundaries:

Variation of Functional with moving boundary, Variational problem with a movable boundary for a functional dependent on two functions, One-Sided Variations, Reflection and Refraction of Extremals.

UNIT-4

Sufficient Conditions for an Extremum:

	Field of Extremals, Jacobi Condition, Weirstrass Function, Legendre Condition, Second Variation, Canonical Equations and Variational Principles, Complementary Variational Principles.
Reference	1. A.S. Gupta:"Calculus of Variations with Applications", Prentice Hall of India Pvt. Ltd., New Delhi. 2. Robert Weinstock: "Calculus of Variations with Applications to physics". 3. ElsGok L. D.: "Calculus of Variation". 4. Mariano Giaquinta, Stefan Hildebrandt: "Calculus of Variations-I", Springer Science & Business Media, 2004

PGMTH-304- Advanced Linear Algebra-I

Course objectives	Provide knowledge of Vector space, Dual space, Linear transformation, Real Quadratic forms.To provide framework to deal with analytical and geometrical problems. To apply the concepts and methods in imagination of dimension, data transformation, Image processing, and various fields of Applied Science.
Course outcome	1. Students will learn about properties of Vector space, Dual space, Algebra of linear transformations, Algebra of Matrices. 2. Determine a subspace, span, bases, row space ,column space and null space for vector space in n^{th} dimension 3. identify linear transformations of finite dimensional vector spaces and compose their matrices in specific bases. 4. After successful completion of the course, students should be able to analyse the problems related to Linear a

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	
	CO1	■						■	
	CO2	■	■	■	■		■	■	
	CO3	■					■		
	CO4	■		■	■	■	■		

Course content	**UNIT 1:** **Vector Space:** Vector Space, Homeomorphisms, Quotient Space, Internal Direct Sum, External Direct Sum, Linear Independence and Basis. **UNIT 2:** **Dual Spaces:** Hom (V, W), dimension ofHom(V, W), Dual Space of Vector Space, Second Dual, Annihilator of subspace, Dimension of an

	annihilator of a subspace and its application to homogeneous linear equations. **UNIT 3:** **Linear Transformations:** Algebra, Algebra of linear transformations $A(V)$, Relation between algebra A and $A(V)$, Minimal Polynomial for linear transformation,Regular and Singular linear transformations, Rank of linear transformation, Characteristic Roots and Characteristic Vectors, Algebra of Matrices. **UNIT 4:** **Real Quadratic Forms:** Quadratic form, Rank and Signature of Quadratic forms.
Reference	1. I.N. Herstein : Topics in Algebra 4thEd., John Wiley Sons. 2. Kenneth Hoffman and Ray Kunze : Linear Algebra, Eastern Economy Editions. 3. D. S. Dummit and R. M. Foote: Abstrac-t Algebra, John Wiley & Sons, 2004. 4. N. Jacobson: Lectures in Abstract Algebra Vol. I (1951),II(1952), Van Nostrand Co., New York.
	OPTIONAL PAPER
	PGMTH-3001 : Fluid Dynamics
Course objective	Provide the knowledge of Theory of Fluid Dynamics
Course outcome	1. Students will learn about basic fundamentals of fluid dynamics such as Conservation Laws, Conservation of mass, momentum and energy. 2. Distinguish One dimensional, two dimensional and three dimensional flow. 3. Student will learn about Bernoulli Equation, Potential equation, Reynold's transport theorem, Navier-stokes equation. 4. They familiar with the fluid statics, kinematics of fluid and dynamics of fluid. 5. Enhance ability of analyzing mathematical problems related to Fluid dynamics.

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	
	CO1	■		■	■				

CO2	■		■	■			
CO3	■	■		■	■	■	■
CO4	■	■	■	■	■	■	■
CO5	■			■		■	

Course content	UNIT 1 Vector Concept of Fluid Dynamics Scalar and vector properties, cross product and dot product of vectors, magnitude and direction of a vectors, gradient, curl and divergent operators, UNIT 2: Fluid Statics Basic Definitions of fluid, Pascal's law, basic property of a static fluid, pressure at the vertical level, Equality of pressure at the same level, General equation for the variation of pressure, Buoyancy UNIT 3: Kinematics of fluid : Flow descriptions (Lagrangian, Eulerian, Material derivative), Motion of Fluid particles(rate of dilation, rate of shear, rate of rotation),Uniform flow, non-uniform, steady, unsteady flow One, two and Three Dimensional Flow,Rotational and irrational flow,Laminar and turbulent flow Line of flow(Stream line, Path line, Strake line, Time line) UNIT 4: Dynamics of fluid:Velocity of a fluid particle at a point, stream tube, Euler Equation, Bernoulli Equation,Conservation Laws, Potential equation, Reynold's transport theorem, onservation of mass, Conservation of momentum, Conservation of energy ,Navier-stokes equation.
Reference	1. Batchelor G.K.: An Introduction to Fluid Dynamics, Cambridge University Press,1999. 2. Emanuel G: Analytical Fluid Dynamics, CRC Press, Boca Raton, Second Edition, FL, 1999. 3. Panton R.L., Incompressible Flows,Wiley Interscience, 1984 4. Currie I.G.: Fundamental Mechanics of Fluids, McGraw-Hill, New-york, 1993. 5. Chorin: Mathematical introduction to Fluid Mechanics, Springer Verlag, Fourth Edition

PGMTH-3002 Mathematical Software

Course objective	To provide knowledge of Computer programming and problem solving methodology through MATLAB
Course outcomes	1. To give comprehensive knowledge of computer programming language 2. Ploting graph, developing algorithm. 3. Implementation in scientific problem solving techniques. 4. Students should be able to solve problems using programming language.

Mapping between COs with PSOs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	■				■	■	■
CO2	■					■	
CO3	■	■	■			■	
CO4	■	■	■	■	■	■	

Course content	
	UNIT 1: **Introduction** Introduction to Matlab, variable and array, suba rrays, displaying output data, data files operation on array, hierarchy of operation on array, built in function in Matlab **UNIT 2:** **Plotting** Introduction to plotting, graph window, two dimensional plot, multiple plot, components of graph(legend, title,),graphical image, commet, 3D graph, additional plotting features Subplots, polar plots, **UNIT 3:** **Programming** The if construct, switch construct, The try-catch construct, relational operators, logic operators,logical function, while loop, for loop, The break and continue statements, Nesting loops. **UNIT 4:** **User defined function** Introduction to Matlab functions, variable passing in Matlab(pass by value), preserving data between calls to functions, sub functions, private function, nested function
Reference	1. Chapman Stephen: Matlab programming for engineers, Thompson learning, 2004. 2. RudraPratap: getting started with Matlab, oxford university press, 2004

PGMTH-3003 Linear programming

Course objectives	To develop problem solving skills and to acquire knowledge on basic concepts of in linear programming problems, Transportation problems, Integer programming, Dynamic programming. Assignment problems and Job sequencing.
Course outcomes	1. Students will learn fundamentals of Linear Programming, Dynemic programming, Integer programing and sensitivity analysis. 2. Able to: Convert standard business problems into linear programming problems and can solve using simplex algorithm. 3. Students should be able to Identify and develop Linear programming problem of operational research models from the verbal description of the real System.

4. Formulate and solve a linear programming problem by simplex method.							
5. They are able to apply Revised simplex method, Dynamic programming, Branch and Bound Techniques.							

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	■					■	■
	CO2	■	■		■	■		
	CO3	■		■	■	■	■	
	CO4	■		■	■	■	■	
	CO5	■	■	■	■	■	■	

Course content	**UNIT-1** **Linear Programming:** General Linear Programming Problem (LPP), Canonical and Standard Form of LPP, Graphical Method, Simplex Method, Fundamental Properties of the Solution, Degeneracy in LPP, Solution of LPP using Simplex Method, Concept of Duality, Fundamental Theorem of Duality, Properties of Duality, Revised Simplex Method. **UNIT-2** **Dynamic Programming:** Introduction, Recursive Equation Approach, Characteristic of Dynamic Programming, Solution of Discrete Dynamic Programming Problem, Solution of LPP by Dynamic Programming. **UNIT-3** **Integer Programming:** Introduction, All and Mixed Integer Programming problems (IPP), Gomory's All- IPP Method, All-IPP Algorithm, The Branch and Bound Techniques. **UNIT-4** **Post-optimality Analysis:** Sensitivity Analysis, Discrete Change in the Cost-vector, in Requirement-vector and in the Coefficient matrix, Structural Changes in LPP.

Reference	1. Kantiswarup, P.K.Gupta and Manmohan: Operations Research ,Sultan chand and Sons. 2. S.D. Sharma: Operations Research, KedarNath, Ram Nath& Co. 3. S. S. Rao: Optimization Theory and Applications, Wiley Eastern, 1984. 4. J. K. Sharma: Operation Research: Theory and Applications, Macmillan India Ltd., Third Edition, 2007

PGMTH-3004 Operation Research	
Course objectives	To enhance problem solving skills of linear programming problems. To provide knowledge of theory of inventory control, PERT-CPM, Transportation problems.
Course outcome	1. Students will learn about inventory problem, PERT-CPM technique, Transportation problem and simulations 2. The student will be able to: Formulate and solve the Transportation problem. 3. The student will be able to solve LPP by PERT-CPM method 4. Students should be able to explore various Mathematical programming algorithms to solve real life problems.

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	■						■
	CO2	■	■				■	■
	CO3	■						
	CO4	■	■	■		■	■	

Course content	**UNIT-1** **Inventory Control:** Introduction to Various Types of Inventory Problems, Method with known Demand Function, Economic Order Quantity (EOQ), Deterministic Inventory Problems when Shortages are Allowed Deterministic Inventory Problems when Shortages are Not Allowed, EOQ Problems with Price Breaks. **UNIT-2** **PERT – CPM:** Introduction to Network with Basic Components, Rules of Network Construction, Time Calculation in Network, CPM – PERT, PERT Calculations, Advantages of PERT-CPM, Project Cost, Time Cost, Optimization Algorithm, Resource Allocation and Scheduling. **UNIT-3** **Transportation Problem:** Definition of Transportation Problem, Basic Feasible Solution (BFS) to Transportation Problem, Different Methods for Finding BFS to the Transportation Problem, Method of Finding Optimum Solution to the Transportation Problem, Degeneracy for Transportation Problem, Unbalanced Transportation Problem. **UNIT-4** **Simulation:** Introduction, Why Simulation, Methodology of Simulation, Generation of Random Numbers.
Reference	**Reference:** 1. Operations research by KantiSwarup, P.K.Gupta and

	Nan Mohan. S. Chand & Sons, New Delhi. Seventh Edition, 1994. 2. Operation Research: Theory and Applications by J. K. Sharma, Macmillan India Ltd., Third Edition, 2007. 3. Operations Research by S.D. Sharma. Kedarnath Ramnath Pub.1998. Merrut. 4. Optimization Methods in Operation Research and System Analysis by K. V. Mittal and C. Mohan, New Age International Publishers, Third Edition, 1996.

PGMTH-3005 Integral Transforms-I

Course objectives	To provide practice for of solving the real problem in scientific way using techniques of Different types of Transforms.To gain a facility with using the transform, both specific techniques and general principles.
Course outcome	1. Students will learn about the basics of Laplace Transforms, Inverse Laplace Transforms, Finite Laplace Transforms 2. An application of Laplace transforms. 3. Students are able to solve the Ordinary and partial differential equations using Laplace transforms. 4. Students are able to solve Initial and boundary value problems and Integral equations.

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	
	CO1	■					■	■	
	CO2	■					■	■	
	CO3	■					■	■	
	CO4	■	■	■	■	■	■		

Course content	**UNIT-1:** **Laplace Transforms:** Introduction and definition of Laplace transforms with examples, Existence condition and basic properties of Laplace transforms, The convolution theorem and properties of convolution, Differentiation and integration of Laplace transforms, **UNIT-2** **Inverse Laplace Transforms:** The inverse Laplace transforms and examples, Tauberian theorem and Watson's lemma,Laplace transforms of fractional integrals and fractional derivatives, **UNIT-3** **Finite Laplace Transforms:**

	Introduction, Definition of finite Laplace transforms with examples,Basic operational properties of finite Laplace transforms, **UNIT-4** # **Applications of Laplace Transforms** Application of Laplace transforms to ordinary and partial differential equations; Initial and boundary value problems and Integral equations; Evaluation of definite integral
Reference	1. Lokenath Debnath: Integral Transform and their applications, CRC Pub., 1995. 2. Ian Sneddon : The use of Integral Transform. TMIH, 1979. 3. B. Davies : Integral Transforms and their applications, Springer - Verlag, 1978. 4. Boss M. L. : Mathematical Methods in Physical Sciences, John Wiley & Sons, 1983. 5. Andrews, L. G. & : Integral Transforms for Engineers, PHI, 2 Shivamoggi B. K.

PGMTH-3006 Advanced Integral Transforms-I									

Course objectives	To provide practice for of solving the real problem in scientific way using techniques of Different types of Transforms.To gain a facility with using the transform, both specific techniques and general principles
Course outcomes	1. Students will learn about Hankel transform, Finite Hankel transforms , 2. Also learn Hilbert and Stieltjes transforms. 3. Students will learn applications of all these transformation 4. Students are able to solve the partial differential equations using Hankel transforms. 5. Students are able to solve various differential equations using Hilbert and Stieltjes transforms.

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	
	CO1	■						■	
	CO2	■						■	
	CO3	■						■	
	CO4	■			■	■	■		
	CO5	■	■	■	■	■	■		

Course content	**UNIT-1** # **Hankel Transforms:** Introduction and definition of Hankel transform, Examples on

	Hankel transform, Operational properties of the Hankel transform **UNIT-2** ## Finite Hankel Transforms: Introduction and definition of the finite Hankel transforms. Finite Hankel transforms of some elementary functions.Basic operational properties with examples, **UNIT-3** ## Application Hankel transforms: Application of Hankel transforms to partial differential equations, Applications of finite Hankel transforms, **UNIT-4** ## Hilbert and Stieltjes Transforms (HST): Introduction and definition of HST with examples,Basic operational properties of HST, Hilbert transform in the complex plane and its applications, theorem for Stieltjes transform and its application, Asymptotic expansion of the one sided Hilbert transform, The generalized Stieltjes transform, Basic properties of the generalized Stieltjes transforms with applications.
Reference	1. Lokenath Debnath: Integral Transform and their applications, CRC Pub., 1995. 2. Ian Sneddon : The use of Integral Transform. TMIH, 1979. 3. B. Davies : Integral Transforms and their applications, Springer - Verlag, 1978. 4. Boss M. L. : Mathematical Methods in Physical Sciences, John Wiley & Sons, 1983. 5. Andrews, L. G. & : Integral Transforms for Engineers, PHI, 2003. Shivamoggi B. K.

PGMTH-3007 Advanced Number Theory-I

Course objectives	To get knowledge of key concepts in number theory (e.g. Primitive roots and indices, Quadratic Reciprocity Law: Quadratic congruence, The Fibonacci sequence, Identities involving Fibonacci numbers) and able to solve problems by using number theory.
Course outcome	1. Students will learn about Primitive roots and Indices, 2. The Quadratic Reciprocity Low, 3. Fibonacci numbers and its properties. 4. Able to solve problems and theorems of number theory.

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	▨					▨	

CO2	■					■		
CO3	■	■	■	■		■		
CO4	■	■		■		■		

Course content	UNIT-1:
	Primitive Roots and Indices: The order of an integer modulo n, Primitive roots for primes, Composite numbers having primitive roots.
	UNIT-2:
	The theory of indices.
	The Quadratic Reciprocity Law: Euler's criterion, The Legendre symbol and its properties, Gauss' Lemma.
	UNIT-3:
	Quadratic Reciprocity and Quadratic Reciprocity law, Quadratic congruence with composite moduli.
	UNIT-4:
	Fibonacci numbers: The Fibonacci sequence, Identities involving Fibonacci numbers.
Reference	1. David M. Burton : Elementary Number Theory, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 7th edition, 2012.
	2. S.G.Talang : Number Theory, The Tata McGraw Hill Co. Ltd., New Delhi.
	3. Neville Robbins : Beginning Number Theory, Narosa Pub. House, New Delhi, 2nd Ed., 2006.
	4. I. Niven, S. Zuckerman, L. Montgomery: An Introduction to the Theory of Numbers, 6th edition, John Wiley and Sons, Inc., New York, 2003.
	5. George Andrews : Number Theory, The Hindustan Pub. Corp., New Delhi.

PGMTH-3008 Analytic Number Theory

Course objectives	The main goals of the course are to help students develop an understanding of: - arithmetic functions and their utility in the analytic theory of numbers including the distribution of primes - the use of generating functions as an essential tool in understanding a variety of combinatorial phenomena that arise in the additive theory of numbers and elsewhere - the relationship between combinatorial and analytic aspects of the theory of numbers - how to apply these concepts and techniques in various applications.
Course outcome	1. Students know about Arithmetic functions, Dirichlet multiplication and elementary theorems on Prime numbers.

2. Chebyshev's functions, divisor functions $d(n)$, Mangöldt function, Abel's identity
3. Students are able to analyze the number theoretic problems.

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	■			■			
	CO2	■	■			■		
	CO3	■		■	■		■	

Course content	UNIT-1:

UNIT-1:

Arithmetical functions and Dirichlet multiplication: The Dirichlet product of two arithmetical functions (a.f.) and group structure w.r.t. this product, The Mangöldt function, Multiplicative a.f., the inverse of a completelymultiplicative a.f., Liouville's function $\lambda(n)$, the divisor functions $d(n)$ and $\sigma_\alpha(n)$, generalized convolution.

UNIT-2:

Averages of Arithmetical Functions: The big oh notation, Euler's summation formula, Some elementary asymptotic formulas, the average order of divisor functions $d(n)$ and $\sigma_\alpha(n)$.

UNIT-3:

The average order of functions $\phi(n), \mu(n), \Lambda(n)$, Lattice points visible from the origin,the partial sums of a Dirichlet product, applications to $\mu(n)$ and $\Lambda(n)$.

UNIT-4:

Some elementary theorems on the distribution of prime numbers: Chebyshev's functions $\psi(x)$ and $\vartheta(x)$, Abel's identity, relation between$\psi(x), \pi(x)$ and $\vartheta(x)$, equivalent forms of prime number theorem, lower and upper bounds for $\pi(n)$ and p_n.

Reference

1. Tom M.Apostol : Introduction to Analytic Number Theory, Narosa Pub. House,New Delhi, 1998 Ed.
2. Mc CarthyP.J. : Introduction to Arithmetical function, Springer-Verlag, NewYork, 1986.
3. K. Chandrashekharan : Introduction to Analytic Number Theory, Springer-Verlag, New York, 1968.
4. Hua L.K. : Introduction to Number Theory, Springer-Verlag, New York, 1982.

PGMTH-3009 Special Functions-I	
Course outcomes	Introduc the concept of Infinite product, Gamma and Beta functions and Hypergeometric functions. To analyze properties of special functions by their integral representations and symmetries.
Course outcome	1. Students are understand the fundamentals concept of Infinite product, Gamma and Beta functions with properties. 2. Understand purpose and functions of the gamma and beta functions, 3. Use the gamma function, beta function and special functions to: evaluate different types of integral calculus problems 4. Get profound knowledge of Hypergeometric function and its properties. 5. Students should be able to prove the rigorous proof of various theorems.

Mapping between COs with PSOs	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	■						■
CO2	■						■
CO3	■						■
CO4		■	■	■	■		
CO5		■		■		■	

Course content

UNIT-1

Definition of an Infinite product, A necessary condition for convergence, The associated series of logarithms, Absolute convergence, Uniform convergence.

UNIT-2:

The Euler or Mascheroni constant γ, The Gama function, A series for $(z)'$ (z) ,Evaluation of (1) and $(1)'$, The Euler product for (z) , The difference equation $(z +1) = z (z)$, The order symbols o and 0, Evaluation of certain infinite products, Euler integral for (z) ,

UNIT-3

The Beta function, The value of $(z) (1- z)$, The factorial function, Legendre's duplication formula,Gauss' multiplication theorem, A summation formula due to Euler, The behaviour of $\log(z)$ for large z .

UNIT-4:

The function F(a, b; c; z), A simple integral form, F(a, b; c; 1) as a function of the parameters, Evaluation of F(a, b; c; 1), the contiguous function relations, The hypergeometric differential

	equation, Logarithmic solutions of the hypergeometric equation, F(a, b; c; z) as a function of its parameters, Simple transformations, Relation between functions of Z and 1-Z, Aquadratic transformation, other quadratic transformations, a theorem due to Kummer, Additional properties.
Reference	1. E. D. Rainville, Special Functions, McMillan, New York, 1990. 2. I. N. Sneddon, Special functions of Mathematical Physics and Chemistry, Oliver Boyd. 3. N. N. Lebdev, Special Functions and their applications, Dover Pub. 1972. 4. R. K. Saxena and D. C. Gokhroo, Special Functions, Khanna Pub.

PGMTH-3010 Advanced Special Functions-I								
Course objectives	Introduce the concept of Generalized Hypergeometric functions, Bessel Functions, the Confluent Hypergeometric function. To analyze properties of special functions by their integral representations and symmetries.							
Course outcome	1. Students will learn about Generalized Hypergeometric functions, 2. Study about Bessel Functions and its various properties, the Confluent Hypergeometric function and its application. 3. Concept of Generating functions and its utilization 4. Enhance the ability to prove the complicated theorem.							

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	■			■			■
	CO2	■			■			■
	CO3	■			■			■
	CO4	■	■	■	■		■	

Course content	**UNIT-1 :GENERALIZED HYPERGEOMETRIC FUNCTIONS:** The function pFq , The exponential and binomial functions, A differential equation,Other solutions of the differential equation, The contiguous function relations, A simple integral,ThepFq with unit argument, Saalschutz' theorem, Whipple's theorem, Dixen'stheorem,Contour integrals of Barns' type, The Berns' integrals and the function pFq , A useful integral. **UNIT-2 :BESSEL FUNCTIONS:** Remarks, Definition of Jn(z), Bessel's differential equation, Differential

	recurrencerelations, A pure recurrence relations, A generating function, Bessel's integral, Index half of aninteger, Modified Bessel functions, Neumann polynomials, Neumann series. **UNIT-3 :THE CONFLUENT HYPERGEOMETRIC FUNCTION:** Basic properties of the 1F1 ,Kummer's first formula, Kummer's second formula. **UNIT-4 :GENERATING FUNCTIONS:** The generating function concept, Generating functions of the form $G(2xt - t^2)$, sets generated by $et\psi$ (xt) , the generating functions $A(t)$ $\exp(-xt(1-t))$, another class of generating functions, Boas and Buck generating functions, An extension.
Reference	1. E. D. Rainville, Special Functions, McMillan, New York, 1990. 2. I. N. Sneddon, Special functions of Mathematical Physics and Chemistry, Oliver Boyd. 3. N. N. Lebdev, Special Functions and their applications, Dover Pub. 1972. 4. R. K. Saxena and D. C. Gokhroo, Special Functions, Khanna Pub.
	SEM-4
	PGMTH-401-Functional Analysis-II
Course objectives	To develop skills and to acquire knowledge on advanced concepts in Hilbert spaces, Representation of functional on Hilbert spaces, Category theorem, Open mapping theorem, Closed Graph theorem, Banach's theorem and it's applications, Spectral theory etc.
Course outcome	1. Students should be able to appreciate the Hilbert space theory and the Hahn-Banach Theorem. They will also have close encounter with normal, unitary and self adjointoperators . 2. The student will be able to: Characterize the category of normed spaces using Category theorem and differentiate weak and pointwise convergence of linear operators. 3. Upon completion of this unit, the student will be able to: Demonstrate Spectral properties of Bounded Linear Operators 4. The student will be able to: Understand Banach algebras, Demonstrate spectral properties of compact linear operators. 5. The student will be able to: Study Operator equations involving Compact linear operators.

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	■			■			
	CO2	■						■
	CO3	■	■		■		■	

| | CO4 | ■ | ■ | | ■ | | | ■ |
| | CO5 | ■ | | | ■ | | ■ | ■ |

Course content	**UNIT -1** Inner product spaces and Hilbert spaces:Total Orthonormal Sets and Sequences, Representation of Functionals on Hilbert Spaces, Hilbert-AdjointOperator, Self-adjoint, Unitary and Normal Operators **UNIT -2** Fundamental Theorems for Normed and Banach Spaces: Zorn's Lemma, Hahn-Banach theorem, Hahn-Banach Theorem for Complex Vector Spaces and Normed Spaces **UNIT -3** Adjoint Operator, Reflexive Spaces, Category theorem, Uniform Boundedness Theorem **UNIT -4** Strong and Weak convergence, Convergence of Sequences of operators and Functionals, Open Mapping Theorem, Closed Linear Operators, Closed Graph Theorem.
References	1. E. Kreyszig: Functional Analysis and its application, John Wiley and sons. 2. B.V. Limaye: Functional Analysis, Wiley Eastern Ltd. 3. G.F. Simmons: Introduction to Topology and Modern Analysis, McGraw – Hill. 4. J.N. Sharma &A.Vashistha: Functional Analysis.
PGMTH-402	Differential Geometry
Course outcomes	To Understand the concept of curvature of a space curve and signed curvature of a plane curve. To understand the fundamental theorem for plane curves. To get introduced to the notion of Serret-Frenet frame for space curves and the involutes and evolutes of space curves with the help of examples. To be able to compute the curvature and torsion of space curves. To be able to understand the fundamental theorem for space curves
Course outcome	1. Students will learn about Curvatures, tangent, Involutes, Evolutes and developable surfaces. 2. To be able to compute the curvature and torsion of space curves. 3. To be able to understand the fundamental theorem for space curves 4. Students should be able to build up Geometry Intuition by

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	■		■			■	
	CO2	■	■		■		■	
	CO3	■			■		■	
	CO4	■	■	■		■		■

incorporating classical curves and related results along with this course.

Course content	**UNIT-1** Tangent, Principal Normal, Curvature, Binormal Torsion Serret-Frenet formulae, Helices, Spherical indicatrix of tangent etc. UNIT-2 Involutes, Evolutes, Bertrand curves. **UNIT-3** Surfaces, Tangent Plane Normal, Envelope Characteristics, Edge of regression, **UNIT-4** Developable Surfaces, Osculating developable,Envelope Characteristic points.
Reference	1. WhetherburnC.E. : Differential Geometry of 3-D, Radha Publishing, Calcutta. 2. T.J. Willmore: An Introduction to Differential Geometry, Oxford University Press(India). 3. Bansilal:Differential Geometry, 1994 Atma Ram and sons, Allahabad. 4. S.C. Mittal and D. C. Agrawal : Differential Geometry, Krishna Publication, 1976 5. S. Kumaresan : A Course in Differential Geometry and Lie Groups, Hindustan Book Agency, 2002 6. Sinha B.B. : An Introduction to Modern Differential geometry,Kalyani Publishers, New Delhi, 1982

PGMTH-403	Integral Equations
Course objectives	This course emphasizes concepts and techniques for solving integral equations from an applied mathematics perspective. optimal control theory. To make the students familiar with the methods of solving Integral Equations.
Course outcome	1. Students will learn about Integral equations and related results

	and theorems.
	2. Students should be able to classify the Integral equations
	3. They are able to apply the methods and concepts to solve integral equations.
	4. Students will be able to recognize difference between Volterra and Fredholm Integral Equations, First kind and Second kind, homogeneous and inhomogeneous etc.
	5. They apply different methods to solve Integral Equations.

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	■		■			■	■
	CO2	■	■				■	
	CO3	■		■	■	■		
	CO4	■	■	■				■
	CO5	■	■		■	■	■	■

Course content	**UNIT -1**
	Preliminary Concepts:
	Integral equations, Classification of integral equations, Solution of integral equations, Some examples related to solutions of integral equations, Leibnitz's Rule (for differentiation under integral sign), Important formula for converting a multiple integral into a single ordinary integral, Classification of kernels, Regularity Conditions, Inner or Scalar product of functions.
	UNIT -2
	Conversion of ODE into Integral Equations:
	Method of converting IVP into Volterra integral equation, Alternative method of converting IVP into Volterra integral equation, Method of converting BVP into Fredholm integral equation.
	UNIT -3
	Fredholm Integral Equations of second kind with Separable kernel:
	Eigenvalues and Eigenfunctions, Solution of homogeneous Fredholmintegral equations of second kind with Separable kernel, Solution of Fredholmintegral equations of second kind with Separable kernel.
	UNIT -4
	Method of Succesive approximations:
	Iterated Kernels, Resolvent kernels, An Important theorem on kernels, Solution of Fredholmintegral equations of second kind by successive substitution, Solution of Volterraintegral equations of second kind by successive substitution.

Reference	1. M. D. Raisinghania: Integral Equations and Boundary Value Problems, S. Chand & Co., New Delhi (2007).
	2. Shanti Swarup: Linear Integral Equations, Krishna Prakashan, Meerut.

<table>
<tr><td></td><td>
3. Sudir K. Pundir and RimplePundir: Integral Equations and Boundary Value Problems, PragatiPrakasan, Meerut (2005).
4. Ram P. Kanwal: Linear Integral Equations Theory and Technique, Academic Press, Birkhäuser, New York (2013).
5. Cordumenau, C., Integral Equations and Appplications, Cambridge University Press, 1991
</td></tr>
<tr><td>PGMTH-404</td><td style="text-align:center">Advanced Linear Algebra-II</td></tr>
<tr><td>Course objectives</td><td>Introduce the concept to use mathematically correct language and notation for Linear Algebra. To enhance the computational proficiency involving procedures in Linear Algebra. To understand the axiomatic structure of a modern mathematical subject and learn to construct simple proofs. Knowledge to solve problems that apply Linear Algebra to Chemistry, Economics and Engineering.</td></tr>
<tr><td>Course outcome</td><td>
1. Students will learn about Canonical forms , Linear transformations related with matrix theory.
2. Apply principles of matrix algebra to linear transformations.
3. Demonstrate understanding of inner products and associated norms
4. Students should be able to solve problems related to matrices and linear equation, to follow complex logical arguments and develop modest logical arguments .
</td></tr>
</table>

Mapping between COs with PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	■						■
CO2	■	■	■	■		■	■
CO3	■	■				■	
CO4			■	■	■	■	

Course content

UNIT -1

 Canonical Forms:

Similar linear transformations, Triangular form, Nilpotent transformations, Invariants, Jordan Canonical form, Rational Canonical form, Companion Matrix.

UNIT -2

 More about Linear Transformations:

Trace and its properties, Transpose and its properties, Symmetric and Skew Symmetric matrices, Adjoint and Hermitian Adjoint,

UNIT -3

	Determinants Determinants and its properties, invertible properties, Cramer's rule, characteristic roots ## UNIT -4 **Hermitian, Unitary and Normal transformations.** Symmetric and Skew- symmetric Matrices, Hermitian and its properties, Unitary and its properties, Normal Transformation and its properties, orthogonal matrices
Reference	1. I.N. Herstein: Topics in Algebra 4thEd., John Wiley Sons. 2. Kenneth Hoffman and Ray Kunze: Linear Algebra, Eastern Economy Editions. 3. D. S. Dummit and R. M. Foote: Abstract Algebra, John Wiley & Sons, 2004. 4. N. Jacobson: Lectures in Abstract Algebra Vol. I (1951),II(1952), Van Nostrand Co., New York.
	OPTIONAL PAPER
PGMTH4001	Computational Fluid Dynamics
Course objectives	**To introduce the student to widely used techniques in the numerical solution of fluid equations,** issues that arise in the solution of such equations, and modern trends in CFD. The use of modern computational fluid dynamics software in mechanical engineering. Build, solve, and visualize fluid-flow models to gain a deeper understanding of the principles of fluid mechanics.
Course outcome	1. Students will learn about various methods for solving Heat equations, 2. Wave equations, Laplace equations and poison equations. 3. Should be able to solve any Partial differential equations related to fluid dynamics using mathematical software and promming. 4. Provide the student with a significant level of experience in the use of modern CFD software for the analysis of complex fluid-flow systems. 5. Improve the student's understanding of the basic principles of fluid mechanics. 6. Improve the student's research and communication skills using a self-directed, detailed study of a complex fluid-flow problem and to communicate the results in written form.

Mapping between COs with PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	■		■	■			
CO2	■		■	■			
CO3	■			■	■	■	■
CO4	■	■	■	■	■	■	■

	CO5	▦			▦	▦	▦	
	CO6	▦	▦		▦	▦	▦	▦

Course content	**UNIT -1** **Introduction and Classification of PDE's** Introduction to PDEs', Types of PDEs', Classification of PDEs', Introduction to CFD, Applications, Scope of CFD, Governing equations and assumptions, Equation types, Model equations, Discretization of the Domain, Numerical boundary conditions **UNIT -2** **Heat Equation** Introduction to heat Equations, Schmidt method, Richardson Method, Crack- Nicolson method, Du-fort Franek method, stability of schemes, convergence of scheme **UNIT -3** **Wave Equations** One dimensional Euler equations, Lax – Wendroff Scheme, Mc-CormackScheme, Implicit – method, Pseudo One Dimensional Euler Equations, boundary conditions, Flux – Splitting, Artificial viscosity, Flux limiters. Multidimensional Euler equations, Lax-Wendroff and Mc-Cormack schemes, stability of multidimensional schemes, Operator splitting Implicit algorithms, **UNIT -4** **Laplace and poison Equation** Finite Differences, Algorithms, Errors and Accuracy, Consistency, Stability and Convergence, Implicit algorithms,
Reference	1. R. J. Leveque: Numerical methods for conservation Laws, BirkhauserVerlag,Basel, 1992. 2. J. D. Anderson: Computation Fluid dynamics, Mc-Graw – Hill, New York, 1995. 3. H. K. Versteeg and W. Malasekera: An Introduction to Computational FluidDynamics: The finite volume method, Longman Scinetific and technical Essex,England, 1995. 4. J. Chorin and J. E. Marsden: A Mathematical Introduction to Fluid Mechanics 5. P. D. Lax: hyperbolic systems of conservation laws and mathematical theory of hock waves, 1973.
PGMTH4002	Mathematical Modelling
Course objectives	This course is an introductory course on Mathematical Modelling. It introduces students to basic concepts in mathematical modelling. It also equips the students with mathematical modelling skills with emphasis on using mathematical models to solve real- life problems. Topics to be covered

	in this course includes: methodology of model building, problem identification and definition, model formulation and solution, consideration of varieties of models involving equations like algebraic, ordinary differential equation, partial differential equation, difference equation, integral and functional equations, consideration of some specific applications of mathematical models to biological, social, and behavioural sciences.
Course outcome	1. Students will learn about the concept of Mathematical modelling and its applications. 2. Learn about Advantages and Disadvantages of Models 3. Students should be able to derive First order models, Second order models. 4. Students should be able to analyze the real life problems through mathematical modelling.

Mapping between COs with PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	■				■	■	■
CO2	■						
CO3		■	■			■	
CO4	■	■	■	■	■	■	

Course content

UNIT -1: Introduction to Mathematical modelling

Needs and Techniques of mathematical 44 odeling: Idea of mathematical 44 odeling, need for mathematical 44 odeling, Advantages and Disadvantages of Model, steps in mathematical 44 odeling, Characteristics of mathematical 44 odeling, Interpretation

UNIT -2: Model of Linear Algebra

Modeling Explorations, Input-Output Economies, Traffic Networks, Balancing Chemical Equations

UNIT -3: First Order Models

Models for Birth, Death, and Immigration, Difference Equations and Differential Equations, Stability and Equilibria, Euler's Method: Numerical Solutions for Differential Equations, Classifying Difference and Differential Equations, Modelling Explorations with Difference and Differential Equations

UNIT -4: Second Order Models

Modelling Oscillations, Homogeneous Linear 2nd Order Differential Equations, Forced Oscillations, Energy in Mass Spring Systems, Modelling Explorations with 2nd Order Differential Equations

Reference

1. J.N.Kapur: Mathematical Modelling, Wiley eastern Ltd., 1994.
2. M.M. Gibbons: A concrete approach to Mathematical Modeling, John Wileyand sons, 1995.
3. H. Neunzert and A.H. Siddiqui: Topics in Industrial Mathematics, KluwerAcademic Publishers, London, 2000
4. P. E. Wellstead : Introduction to Physical System Modeling,

		Academic Press,1979. 5. Richard Haberman: Mathematical Models, Practice- Hall Inc., NJ, 1979.						

PGMTH4003	Non-Linear programming
Course objectives	The objective is to expose the student to different types of nonlinear programming problems with various methods, and various algorithms used to solve these.
Course outcome	1. Students will learn about various non-linear programming methods and optimization methods. 2. Students are able to solve any real life problems through non-linear programming . 3. Enhance the ability to analyze the industrial problems

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	■					■	■
	CO2	■	■		■			
	CO3	■		■	■	■	■	

Course content	**UNIT -1** **One - Dimensional Non- Linear Programming Methods:** Unimodal Function, Unrestricted Search, Exhaustive Search, Dichotomous Search, Interval Halving Method, Fibonacci Search, Golden Section Method, Comparison of Elimination Methods, Quadratic Interpolation, Direct Search Method. **UNIT -2** **Classical Optimization Methods:** Unconstraint Optimization, Constrain Multi - Variable Optimization with Equality Constrains, Constrain Multi - Variable Optimization with Inequality Constrains. **UNIT -3** **Non- Linear Programming Methods:** Introduction, General Non - Linear Programming Problems, Graphical Solution Method, Quadratic Programming, Application of Quadratic Programming, Separable Programming. **UNIT -4** **Geometric Programming:** Introduction, Geometric – Arithmetic Mean Inequality, Unconstrained Geometric Programming Problem, Constrained Geometric Programming Problem.
Reference	1. Kantiswarup, P.K.Gupta and Manmohan: Operations Research ,Sultan chand and Sons. 2. S.D. Sharma: Operations Research, KedarNath, Ram Nath& Co. 3. S. S. Rao: Optimization Theory and Applications, Wiley Eastern, 1984.

		4. J. K. Sharma: Operation Research: Theory and Applications, Macmillan India Ltd., Third Edition, 2007.

PGMTH4004	Advanced Operation Research

Course objectives	To enhance problem solving skills and acquire the knowledge of Queuing theory problems, sequencing problems, replacement problems, Games and strategies.

Course outcome	1. Students will learn about Queuing theory related problems 2. Students will learn about sequencing problems and its solution process 3. Students will learn about Theory of replacement and its utilities 4. Students will learn about Games and strategies and its applications 5. Students are able to formulate and analyse the real world problems.

Mapping between COs with PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	■						■
CO2	■	■				■	■
CO3	■						
CO4	■	■	■		■	■	
CO5			■	■		■	

Course content

UNIT -1
Queuing Theory:
Definition and Characteristic of a Queuing System, Poisson Process and Exponential Distribution, Classification of Queues, Detailed Study of M/M/1 and M/M/s Queuing Models.

UNIT -2
Sequencing Problems:
Problems of Sequencing, Problems with n-jobs and 2-machines, Problems with n-jobs and 3-machines, Problems with n-jobs and m-machines.

UNIT -3
Theory of Replacement:
Introduction, Replacement of Equipment that Deteriorate Gradually, Replacement of Equipment that Fails completely, Other Replacement Problems.

UNIT -4
Games and Strategies:
Introduction, Two-person Zero-Sum Games, The Maximum-Minimum Principle, Games Without Saddle Points-Mixed Strategies.

Reference	1. Kantiswarup, P.K.Gupta and Manmohan: Operations Research ,Sultan chand and Sons. 2. S.D. Sharma: Operations Research, KedarNath, Ram Nath& Co.

	3. S. S. Rao: Optimization Theory and Applications, Wiley Eastern, 1984. 4. J. K. Sharma: Operation Research: Theory and Applications, Macmillan India Ltd., Third Edition, 2007.							

PGMTH4005	Integral Transforms-II
Course objectives	To provide practice for of solving the real problem in scientific way using techniques of Different types of Transforms.To gain a facility with using the transform, both specific techniques and general principles.
Course outcome	1. Students will learn about complex Fourier transforms and its properties 2. Students will learn about Fourier cosine and sine transforms and its properties 3. Students will learn about Finite Fourier , finite forier cosine and sine transforms and its properties 4. Students should be able to solve partial differential equations by these transforms.

Mapping between COs with PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	■					■	■
CO2	■					■	■
CO3	■					■	■
CO4	■	■	■	■	■	■	

Course content

UNIT-1 <u>Complex Fourier Transforms:</u>

Introduction, Basic concepts and definitions, The Fourier Integral formulae, Definition and examples of Fourier transforms, Basic properties of Fourier transforms, Inversion of Fourier transforms

UNIT-2: <u>Fourier Cosine and sine Transforms</u>

Definitions of Fourier cosine and sine transforms with examples, Properties of Fourier cosine and sine transforms,Proof of basic Properties of Fourier cosine and sine transforms,

UNIT-3: <u>Finite Fourier transform and finite fourier Cosine and Sine Transforms:</u>

Introduction and definition of finite cosine and sine transforms with examples, Basic properties of finite Fourier cosine and sine transforms , Inversion of finite Fourier transforms, finite Fourier cosine and sine transforms.

UNIT-4: <u>Applications of Fourier Transforms:</u>

Applications of Fourier transforms to solve partial differential equations,Applications of Fourier cosine and sine transforms to partial

	differential equations,Evaluation of definite integrals,Applications of finite Fourier transforms, finite Fourier cosine and sine transforms, Basic properties of finite Fourier cosine and sine transforms
Reference	1) LokenathDebnath: Integral Transform and their applications, CRC Pub., 1995. 2) Ian Sneddon : The use of Integral Transform. TMIH, 1979. 3) B. Davies : Integral Transforms and their applications, Springer - Verlag, 1978. 4) Boss M. L. : Mathematical Methods in Physical S John Wiley & Sons, 1983. 5) Andrews, L. G. & : Integral Transforms for Engineers, PH Shivamoggi B. K.

PGMTH4006	Advanced Integral Transforms-II
Course objective	To provide practice for of solving the real problem in scientific way using techniques of Different types of Transforms.To gain a facility with using the transform, both specific techniques and general principles.
Course outcome	1. Students will learn about Mellin transforms and its properties 2. Students will learn about Z-transforms and its propertie 3. Students will learn about Inverse Z transforms and its properties 4. Students will learn about applications of all these transformations 5. Students should be able to solve difference equations

Mapping between COs with PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	■						■
CO2	■						■
CO3	■						■
CO4	■			■	■	■	
CO5	■	■	■	■	■	■	

Course content

UNIT-1 Mellin Transforms:

Introduction and definition of Mellin transforms with examples,Basic operational properties,Inverse Mellin transforms, Mellin transforms of the Weyl fractional integralsand derivatives, Convolution theorems for Mellin Transforms

UNIT -2 Applications of Mellin Transforms:

Applications of the Mellin transforms to solve BVP, Application of Mellin transforms to summation of series.

UNIT -3: Z-Transforms:

Introduction, Dynamic linear systems and Impulse response, Definition of the Z-transforms and examples,Basic operational properties,

UNIT -4: Inverse Z Transforms and Applications:

	The inverse Z-transform and examples,Application of Z-transforms to finite difference equations.
Reference	1) LokenathDebnath: Integral Transform and their applications, CRC Pub., 1995. 2) Ian Sneddon : The use of Integral Transform. TMIH, 197⌀ 3) B. Davies : Integral Transforms and their applications, Springer - Verlag, 1978. 4) Boss M. L. : Mathematical Methods in Physical Science John Wiley & Sons, 1983. 5) Andrews, L. G. & : Integral Transforms for Engineers, PHI, 2⌀ Shivamoggi B. K.
PGMTH4007	Advanced Number Theory-II
Course objectives	To get knowledge of key concepts in number theory (e.g. continued fractions, Diophantine equations, Representation of integers as sum of square) and able to solve problems by using number theory.
Course outcome	1. Students will learn about continued fractions, 2. Students will learn about Diophantine equations and its properties 3. Representation of integers as sum of squares and its applicability 4. Enhance the logical ability of the students

Mapping between COs with PSOs							
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
CO1	■					■	
CO2	■					■	
CO3	■	■	■	■		■	
CO4	■	■		■	■		■

Course content	**UNIT-1:** **Continued fractions:**Simple continued fractions, finite and infinite continued fractions, uniqueness,representation of rational and irrational numbers as simple continued fractions, rational approximation to irrational numbers. UNIT-2: **Diophantine equations:**Diophantine equation $ax + by = c$ and its positive solutions, Pell's equation, Continued fractionsolution of Pell's equation. **UNIT-3**: Pythagorean equation $x^2 + y^2 = z^2$, the case $n = 4$ in Fermat's Last Theorem. **UNIT-4**:

	Representation of integers as sum of squares: Necessary and sufficient conditions for a positive integer to be represented as the sum of two squares, Fermat's theorem, positive integers represented as difference of two squares, integers that are not expressible as the sum of three squares, Euler's identity, primes represented as the sum of four squares, Lagrange's theorem.
Reference	1. David M. Burton : Elementary Number Theory, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 7thedition, 2012. 2. S.G.Talang : Number Theory, Tata McGraw Hill Pub. Co. Ltd., New Delhi, 5th reprint, 2004. 3. Neville Robbins : Beginning Number Theory, Narosa Pub. House, New Delhi, 2nd Ed., 2006. 4. Martin Erickson, Anthony Vazzana : Introduction to Number Theory, Chapman & Hall/CRC, New York, 2008 Ed. 5. I. Niven, S.Zuckerman& L. Montgomery: An Introduction to the Theory of Numbers, 6th edition, John Wiley and Sons, Inc., New York, 2003. 6. George Andrews : Number Theory, The Hindustan Pub. Corp., New Delhi.
PGMTH4008	Introduction to Partition Theory and Cryptography
Course objectives	This course is designed to provide students an introduction to classical number theory and enable them to study higher courses in number theory, and to apply the learnt concepts of number theory using public-key cryptography
Course outcome	1. Students will learn about Partition theory and Cryptography 2. Enhance the logical ability of the students 3. Enhance the ability to use the partition theory and cryptography in real life applications.

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	
	CO1	▓			▓				
	CO2	▓	▓			▓			
	CO3	▓	▓	▓	▓		▓		

Course content	**UNIT-1:** **Partition theory:** An introduction, generating functions, partitions into exactly k parts, recurrence relations for $p(n, k)$ and $P(n, k)$ and relation between them, an inequality for $p(n, k)$.

	UNIT-2: Graphs of partitions, Euler's identity, a recursion formula for $p(n)$, Durfee's identity, two line partitions, the formula for $R(A, B)$. **UNIT-3:** **Cryptography:** Cesar Cipher, Vigenère cipher, Autokey cipher, Hill's cipher, RSA algorithm. **UNIT-4:** Knapsack problem, Superincreasing knapsack problem, Knapsack cryptosystem, An application of primitive roots to cryptography.
Reference	1. HansrajGupta:Selected Topics in Number Theory, Abacus Press, England, 1980 Ed. 2. Tom M.Apostol : Introduction to Analytic Number Theory, Narosa Pub. House,New Delhi, 1998 Ed. 3. George Andrews, Kimmo Eriksson : Integer Partitions, Cambridge Univ. Press, UK, 2004 Ed. 4. David M. Burton : Elementary Number Theory, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 7th edition, 2012. 5. Martin Erickson, Anthony Vazzana : Introduction to Number Theory, Chapman & Hall/CRC, New York, 2008 Ed.
PGMTH4009	Special Functions-II
Course objectives	Introduce the concept of orthogonal polynomials,, Legendre polynomials and Hermite polynomials. To analyze properties of special functions by their integral representations and relations between them.
Course outcome	1. Students will learn about orthogonal polynomials and its properties, 2. Students will learn about Legendre polynomials and its properties 3. Students will learn about Hermite polynomials and its properties. 4. Students should be able to prove the rigorous proof of various theorems. 5. Students should be think in specific direction

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	■						■
	CO2	■						■
	CO3	■						■
	CO4		■	■	■	■	■	
	CO5		■		■		■	

Course content	**UNIT-1:**
	Orthogonal polynomials, Simple set of polynomials, Orthogonality, an equivalent condition forOrthogonality, zeros of orthogonal polynomials , Expansion of polynomials, The threeterm recurrence relations, The Christoffel-Darboux formula, Normalization; Bessel'sinequality.
	UNIT-2:
	Legendre polynomials, A generating function, differential recurrence relations, The pure recurrencerelations, Legendre's differential equation, The Rodrigues formula, Bateman's generatingfunction, Additional generating functions,
	UNIT-3:
	Hypergeometric forms of Pn(X), Brafman'sgenerating functions, Special properties of Pn(X), More generating functions, Laplace'sfirst integral form, Some bounds on Pn(X), Orthogonality, An expansion theorem,Expansion of X^n , Expansion of analytic functions,
	UNIT-4:
	Hermite polynomials**:**Definition of Hn(x), Recurence relations, The Rodrigues formula, Othergenerating functions, Integrals, The Hermite polynomial as a 2F0 , Orthogonality,Expansion of polynomials, More generating functions.

Reference	1. E. D. Rainville, Special Functions, McMillan, New York, 1990.
	2. I. N. Sneddon, Special functions of Mathematical Physics and Chemistry, Oliver
	Boyd.
	3. N. N. Lebdev, Special Functions and their applications, Dover Pub. 1972.
	4. R. K. Saxena and D. C. Gokhroo, Special Functions, Khanna Pub.

PGMTH4010	Advanced Special Functions-II

Course objectives	Introduce the concept of Laguerre polynomials, Jacobi polynomials, Elliptic functions . To analyze properties of special functions by their integral representations and relations between them.
Course outcome	1. Students will learn about Laguerre polynomials and its properties 2. Students will learn about Jacobi polynomials and its properties, 3. Students will learn about Elliptic functions and its properties. 4. Perform operations with orthogonal polynomials, Legendre's polynomial and Laguerre polynomial with their differential equations along with the corresponding 5. Students should be think logically in specific direction

Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1	■			■			■
	CO2	■			■			■
	CO3	■			■			■
	CO4	■	■	■	■	■	■	
	CO5		■				■	

| Course content | **UNIT-1:**

Laguerre polynomials:The polynomial Ln(X), Generating functions, Recurrence relations, The Rodriguesformula, The differential equation, Orthogonality, Expansion of polynomials, Specialproperties, Other generating functions, The simple Laguerre polynomials.

UNIT-2

The Jacobi polynomials, Bateman's generating functions, The Rodrigues formula,Orthogonality, Differential recurrence relations, The pure recurrence relations, Mixedrelations,

UNIT-3:

Appell's functions of two variables, An elementary generating functions,Brafman's generating functions, Expansion in series of polynomials.

UNIT-4:

Elliptic functions:Doubly periodic functions, Elliptic functions, Elementary properties, Order of anelliptic function, The Weierstrass function P(Z), Other elliptic functions, A differential

equation for P(Z), Connection with elliptic integrals. |
| Reference | 1 E. D. Rainville, Special Functions, McMillan, New York, 1990.
2 I. N. Sneddon, Special functions of Mathematical Physics and Chemistry, Oliver |

	Boyd.
	3 N. N. Lebdev, Special Functions and their applications, Dover Pub. 1972.
	4 R. K. Saxena and D. C. Gokhroo, Special Functions, Khanna Pub.