

Name of Program	<b>Master of Science in Mathematics</b>							
Abbreviation	<b>M.Sc. Mathematics</b>							
Duration	<b>2 Years</b>							
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	<ol style="list-style-type: none"> <li>1. Provides knowledge of fundamentals of pure and applied mathematics.</li> <li>2. Provide information about applications of Mathematics to the students that creates the opportunities in education , research centres and industries.</li> <li>3. Provide strong foundation of mathematics to formulate, analyze and problem solving for advanced study and research.</li> <li>4. Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in mathematical sciences.</li> <li>5. Develop need based Mathematics teaching-learning resources.</li> <li>6. Professionally inclined Mathematics educators who have sound knowledge of subject matter and specialized in constructive&amp; alternate pedagogy</li> </ol>							
Program Specific Outcomes	<ol style="list-style-type: none"> <li>1. Students will be able to understand the fundamental principles of pure and applied Mathematics.</li> <li>2. Confidence of students will increase in mathematical logic and reasoning ability.</li> <li>3. Explore a newer way of mathematical applications.</li> <li>4. The analytical and theoretical skills applicability ability of students will increase.</li> <li>5. Computing skills for mathematical problem solving will be enhanced.</li> <li>6. Students will be motivated more for research in Mathematics and related fields.</li> <li>7. Students will be inclined towards the preparation of competitive exams like NET, GATE etc.</li> </ol>							
Mapping between POs and PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	PO1							
	PO2							
	PO3							
	PO4							
	PO5							
	PO6							
Medium of Instruction	English							

<b>M. Sc. Sem – I ( Mathematics)</b>						
Theory Paper/Practical	Teaching schedule Hrs/week	Exam Schedule			Total Marks	Credit
		Duration	Internal Marks	External Marks		
Theory papers:						
<b>1: Core Paper-I</b> PGMTH-101: - Advanced Real Analysis	4	3	30	70	100	4
<b>2: Core Paper-II</b> PGMTH-102: Ordinary Differential Equations	4	3	30	70	100	4
<b>3: Core Paper-III</b> PGMTH-103: Topology	4	3	30	70	100	4
<b>4: Inter/Multi-Disciplinary Elective Paper</b> PGMTH -1041 Mathematical Software PGMTH -1042 Operation Research PGMTH -1043 Integral Transforms-I PGMTH -1044 Advanced Number Theory PGMTH -1045 Special Functions-I	4	3	30	70	100	4
<b>5. Practical based on 101 to 104</b> PGMTH -105 : Practical	12	10-15	50	100	150	6
<b>6. Skilled based elective paper / swayam/other moac courses ( Course can be taken from any faculty)</b> PGMTH-106 1. Vedic Mathematics 2. Mathematics For Competitive Examinations	2	0	20	30	50	2
		Total	190	410	600	24

<b>M. Sc. Sem – II ( Mathematics)</b>					
Theory Paper/Practical	Teaching schedule	Exam Schedule		Total Marks	Credit

	Hrs/week	Duration	Internal Marks	External Marks		
Theory papers:						
<b>1: Core Paper-I</b> PGMTH-201- Advanced Abstract Algebra	4	3	30	70	100	4
<b>2: Core Paper-II</b> PGMTH-202- Complex Analysis	4	3	30	70	100	4
<b>3: Core Paper-III</b> PGMTH-203-Partial Differential Equations	4	3	30	70	100	4
<b>4:Inter/Multi-Disciplinary Elective Paper</b> PGMTH -2041 Mathematical Modelling PGMTH -2042 Operation Research  PGMTH -2043 Advanced Integral Transforms-I PGMTH -2044 Analytic Number Theory PGMTH -2045 Special Functions-II	4	3	30	70	100	4
<b>5. Practical based on 101 to 104</b> PGMTH -205 :Practical	12	10-15	50	100	150	6
<b>6. Skilled based elective paper</b> / swayam/other moac courses ( Course can be taken from any faculty) PGMTH-206 3. Vedic Mathematics Mathematics For Competitive Examinations	2	0	20	30	50	2
		Total	190	410	600	24

<b>M. Sc. Sem – III(Mathematics)</b>				
Theory Paper/Practical	Teaching	Exam Schedule	Total	Credit

	schedule Hrs/week				Marks	
		Duration	Internal Marks	External Marks		
Theory papers:						
<b>1: Core Paper-I</b> PGMTH-301: - Functional Analysis-I	4	3	30	70	100	4
<b>2: Core Paper-II</b> PGMTH-302: Advanced Numerical Analysis	4	3	30	70	100	4
<b>3: Core Paper-III</b> PGMTH-303: Calculus of Variation	4	3	30	70	100	4
<b>4: Inter/Multi-Disciplinary Elective Paper</b> PGMTH -3041 Fluid Dynamics PGMTH -3042 Advanced Operation Research PGMTH -3043 Advanced Integral Transforms-I PGMTH -3044 Diophantine equations PGMTH -3045 Advanced Special Functions-I	4	3	30	70	100	4
<b>5. Practical based on 301 to 304</b> PGMTH -305 : Practical	12	10-15	50	100	150	6
<b>6. Skilled based elective paper / swayam/other moac courses</b> <b>1. Basic Financial Mathematics</b> <b>2. Basics of Data Science</b> <b>3. Algorithmic Mathematics</b> <b>4. Curve Theory</b>	2	0	20	30	50	2
		Total	190	410	600	24

M. Sc. Sem – IV (Mathematics)						
Theory Paper/Practical	Teaching schedule Hrs/week	Exam Schedule			Total Marks	Credit
		Duration	Internal Marks	External Marks		
Theory papers:						
<b>1: Core Paper-I</b> PGMTH-401- Advanced Functional Analysis -II	4	3	30	70	100	4
<b>2: Core Paper-II</b> PGMTH-402- Advance Linear Algebra	4	3	30	70	100	4
<b>3: Core Paper-III</b> PGMTH-403 Integral Equations	4	3	30	70	100	4
4: Inter/Multi-Disciplinary <b>Elective Paper</b> PGMTH -4041 Computational Fluid Dynamics PGMTH -4042 Nonlinear Programing PGMTH -4043 Advanced Integral Transforms – II PGMTH -4044 Partition Theory and CryptographyPGMTH -4045 Advanced Special Functions – II	4	3	30	70	100	4
<b>5. Practical based on 401 to 404</b> PGMTH -405: Practical	12	10-15	50	100	150	6
<b>6. Skilled based elective paper /</b> swayam/other moac courses (Course can be taken from any faculty) Skilled based elective Papers: <b>1. Basic Financial Mathematics</b> <b>2. Basics of Data Science</b> <b>3. Algorithmic Mathematics</b> <b>4. Curve Theory</b>	2	0	20	30	50	2
		Total	190	410	600	24

Course Code	PGMTH-101						
Course Title	Advanced Real Analysis						
Credit	4						
Teaching per Week	4 Hrs						
Minimum weeks per Semester	20 (Including Classwork, examination, preparation, holidays etc.)						
Effective From	June 2022						
Purpose of Course							
Course Objective	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	<ol style="list-style-type: none"> <li>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.</li> <li>2. They will be able to use these theorems to solve problems.</li> <li>3. Ability to handle convergence of series and sequence of functions.</li> <li>4. Ability to differentiate functions in <math>R^n</math></li> </ol>						
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
	CO1						
	CO2						
	CO3						
	CO4						
Course content	<p><b>Unit-I</b> Algebra of sets, <math>\sigma</math> Algebra, the extended real numbers, Open and closed set of real numbers, Borel sets, Lebesgue outer measure.</p> <p><b>Unit II</b> Measurable sets and Lebesgue measure, Non-measurable set, Measurable function, Littlewoods's three principles (only statements).</p> <p><b>Unit-III:</b> Riemann integral, Lebesgue integral of a bounded function over a set of finite measure, Bounded convergence theorem, Integral of a non-negative function.</p>						

	<b>Unit-IV:</b> Fatou's lemma, Monotone convergence theorem, General Lebesgue integral, Lebesgue convergence theorem, Generalized Lebesgue convergence theorem.
<b>References</b>	<ol style="list-style-type: none"> <li>1. H. L. Royden: Real Analysis, Macmillan publication, 1993.</li> <li>2. G. de Barra: Measure theory and Integration, Wiley Eastern ltd.1981.</li> <li>3. T. M. Apostol: Mathematical Analysis, Narosa Publishing House, 1985.</li> <li>4. I. P. Natanson: Theory of Functions of real variable, Fredrick Unger pub. 1961.</li> </ol>

Course Code	PGMTH-102
Cours Title	Ordinary Differential Equations
Credit	4
Teaching per week	4 Hrs
Minimum weeks per semester	20 (Including Classwork,examination,preparation,holidays etc.)
Effective from	June 2022
Purpose of course	
Course objective	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 outcome	<ol style="list-style-type: none"> <li>1. Students learns about differential equations and its classifications.</li> <li>2. Students will be able to classify nature of solutions for the second order linear differential equation, existence of solutions of differential equations.</li> <li>3. Students learns the methodology to solve second order ordinary differential equations.</li> <li>4. Students will understand the concept of method of variation of parameters.</li> <li>5. Students will be able to use the method of Laplace transforms.</li> </ol>

Mapping between COs with PSOs	<table border="1"> <thead> <tr> <th></th> <th>PSO1</th> <th>PSO2</th> <th>PSO3</th> <th>PSO4</th> <th>PSO5</th> <th>PSO6</th> <th>PSO7</th> </tr> </thead> <tbody> <tr> <td>CO1</td> <td style="background-color: #cccccc;"></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>CO2</td> <td style="background-color: #cccccc;"></td> <td></td> <td style="background-color: #cccccc;"></td> <td style="background-color: #cccccc;"></td> <td></td> <td></td> <td style="background-color: #cccccc;"></td> </tr> <tr> <td>CO3</td> <td></td> <td style="background-color: #cccccc;"></td> <td></td> <td></td> <td style="background-color: #cccccc;"></td> <td></td> <td></td> </tr> <tr> <td>CO4</td> <td></td> <td></td> <td style="background-color: #cccccc;"></td> <td></td> <td></td> <td></td> <td style="background-color: #cccccc;"></td> </tr> <tr> <td>CO5</td> <td></td> <td style="background-color: #cccccc;"></td> <td></td> <td></td> <td style="background-color: #cccccc;"></td> <td style="background-color: #cccccc;"></td> <td style="background-color: #cccccc;"></td> </tr> </tbody> </table>		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	CO1								CO2								CO3								CO4								CO5							
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7																																										
CO1																																																	
CO2																																																	
CO3																																																	
CO4																																																	
CO5																																																	
Course Content	<p><b>UNIT-1</b> Linear Differential Equations of Higher Order: Equations with Variable Coefficients, Wronskian, Variation of Parameters, Some Standard Methods: (i) Method of Undetermined Coefficients (ii) Reduction of the order of equation</p> <p><b>UNIT-2</b> 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</p> <p><b>UNIT-3</b> Systems of Linear Differential Equations: Introduction, Systems of First Order Equations, Existence and Uniqueness Theorem, Fundamental Matrix</p> <p><b>UNIT-4</b> Non homogeneous Linear Systems, Linear Systems with Constant Coefficients, Linear Systems with Periodic Coefficients</p>																																																
Reference	<ol style="list-style-type: none"> <li>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.</li> <li>2. Coddington E. A., Levinson N.: Theory of Ordinary Differential Equations, Mc Graw Hill, 1955.</li> <li>3. Hartmann P.: Ordinary Differential Equations, John Wiley International, 1964.</li> <li>4. Somasundaram D.: Ordinary Differential Equations, Narosa, 2001.</li> <li>5. Mandal C. R.: Ordinary Differential Equations, PHI, 2003.</li> <li>6. Rai B., Freedmanm H. I., Chaudhary D. P.: A Course in Ordinary Differential Equations, Narosa, 2002.</li> <li>7. King A. C., Otto R., Billingham J.: Differential Equations, Cambridge, 2005.</li> </ol>																																																

Course Code	PGMTH-103																																										
Cours Title	Topology																																										
Credit	4																																										
Teaching per week	4 Hrs																																										
Minimum weeks per semester	20 (Including Classwork,examination,preparation,holidays etc.)																																										
Effective from	June 2022																																										
Purpose of course																																											
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 outcome	<ol style="list-style-type: none"> <li>1. Students should be able to define topology and its construction.</li> <li>2. Distinguish open and closed subset, Notions of connectedness and compactness.</li> <li>3. Students will learn various properties of compact spaces</li> <li>4. Distinguish Cover, Sub-cover, open cover, Basic and sub-basic open cover</li> <li>5. Topological Spaces, compact spaces and connected spaces.</li> </ol>																																										
Mapping between COs with PSOs	<table border="1"> <thead> <tr> <th></th> <th>PSO1</th> <th>PSO2</th> <th>PSO3</th> <th>PSO4</th> <th>PSO5</th> <th>PSO6</th> </tr> </thead> <tbody> <tr> <th>CO1</th> <td style="background-color: #cccccc;"></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <th>CO2</th> <td style="background-color: #cccccc;"></td> <td style="background-color: #cccccc;"></td> <td style="background-color: #cccccc;"></td> <td></td> <td></td> <td></td> </tr> <tr> <th>CO3</th> <td style="background-color: #cccccc;"></td> <td></td> <td></td> <td style="background-color: #cccccc;"></td> <td></td> <td></td> </tr> <tr> <th>CO4</th> <td style="background-color: #cccccc;"></td> <td></td> <td></td> <td style="background-color: #cccccc;"></td> <td></td> <td style="background-color: #cccccc;"></td> </tr> <tr> <th>CO5</th> <td style="background-color: #cccccc;"></td> <td></td> <td style="background-color: #cccccc;"></td> <td style="background-color: #cccccc;"></td> <td></td> <td></td> </tr> </tbody> </table>		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	CO1							CO2							CO3							CO4							CO5						
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6																																					
CO1																																											
CO2																																											
CO3																																											
CO4																																											
CO5																																											
Content	<p><b>UNIT-1</b></p> <p>Topological Spaces: Definition and some examples, Metrizable space, Relative Topology, Continuity and Homeomorphism. Some elementary concepts: Open and Closed sets, Closure of a set, Isolated point, limit point, Derived set.</p> <p><b>UNIT-2</b></p> <p>Interior of a set, Boundary of a set, Perfect set, Dense and Nowhere dense sets. Open base and Open sub-base, First and second countable spaces, Lindelof's theorem, Separable spaces.</p> <p><b>UNIT-3</b></p> <p>Compact space, Continuity and compactness, Finite intersection property, Heine-Borel theorem, Product topology (definition) and projection mapping (definitions), Tychonoff's theorem (only</p>																																										

	<p>statement), Locally compact space.</p> <p><b>UNIT-4</b></p> <p>Separation Axioms: <math>T_1</math> and <math>T_2</math> Spaces, Regular, completely regular and Normal spaces, Urysohn's lemma, Tietze's extension theorem (Without proof).</p>
<p><b>References:</b></p>	<ol style="list-style-type: none"> <li>1. George F. Simmons: "Introduction to Topology and Modern Analysis", McGraw-Hill Book Co., 1963.</li> <li>2. James R. Munkres: "Topology: A First Course", Prentice Hall of India Pvt. Ltd., New Delhi, 2000.</li> <li>3. J. Dugundji: "Topology", Allyn and Bacon, 1966 (Reprinted in India by Prentice Hall of India Pvt. Ltd.).</li> <li>4. K. D. Joshi: "Introduction to General Topology", Wiley Eastern Ltd., 1983.</li> <li>5. J. Hocking and G. Young: "Topology", Addison-Wesley, Reading, 1961.</li> </ol>

**ELECTIVE PAPER**

Course Code	PGMTH–1041							
Cours Title	Mathematical Software							
Credit	4							
Teaching per week	4 Hrs							
Minimum weeks per semester	20 (Including Classwork,examination,preparation,holidays etc.)							
Effective from	June 2022							
Purpose of course	To provide knowledge of Computer programming and problem solving methodology through software							
Course outcome	<ol style="list-style-type: none"> <li>1. Students will get comprehensive knowledge of computer programming language.</li> <li>2. Students learns about plotting graph, developing algorithm.</li> <li>3. Students learns about implementation in scientific problem solving techniques.</li> <li>4. Students will be able to solve problems using programming language.</li> </ol>							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1							
	CO2							
	CO3							
	CO4							
Course content	<p><b>UNIT 1:</b>  <b>Introduction</b>  Introduction to Matlab, variable and array, subarrays, displaying output data, data files operationon array, hierarchy of operation on array, built in function in Matlab</p> <p><b>UNIT 2:</b>  <b>Plotting</b>  Introduction to plotting, graph window, two dimensional plot, multiple plot, components ofgraph(legend, title,),graphical image, commet, 3D graph, additional plotting featuresSubplots, polar plots,</p> <p><b>UNIT 3:</b>  <b>Programming</b>  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.</p> <p><b>UNIT 4:</b>  <b>User defined function</b>  Introduction to Matlab functions, variable passing in Matlab(pass by value), preserving databetween calls to functions, sub functions, private function, nested function</p>							
Reference	<ol style="list-style-type: none"> <li>1. Chapman Stephen: Matlab programming for engineers, Thompson learning, 2004.</li> <li>2. RudraPratap: getting started with Matlab, oxford university press, 2004</li> </ol>							

Course Code	PGMTH-1042							
Cours Title	Linear Programming							
Credit	4							
Teaching per week	4 Hrs							
Minimum weeks per semester	20 (Including Classwork,examination,preparation,holidays etc.)							
Effective from	June 2022							
Purpose of course	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 outcome	<ol style="list-style-type: none"> <li>1. Students learns fundamentals of Linear Programming, Dynamic programming, Integer programming and sensitivity analysis.</li> <li>2. Students will be able to convert standard business problems into linear programming problems and can solve using simplex algorithm.</li> <li>3. Students will be able to identify and develop Linear programming problem of operational research models from the verbal description of the real System.</li> <li>4. Students will be able to formulate and solve a linear programming problem by simplex method.</li> <li>5. Students will be able to apply Revised simplex method, Dynamic programming, Branch and Bound Techniques.</li> </ol>							
Mapping between COs with PSO		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1							
	CO2							
	CO3							
	CO4							
	CO5							
Course Content	<p><b><u>Linear Programming:</u></b>  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.</p> <p><b><u>Dynamic Programming:</u></b>  Introduction, Recursive Equation Approach, Characteristic of Dynamic Programming, Solution of Discrete Dynamic Programming Problem, Solution of LPP by Dynamic Programming.</p> <p><b><u>Integer Programming:</u></b>  Introduction, All and Mixed Integer Programming problems (IPP), Gomory's All- IPP Method, All-IPP Algorithm, The Branch and Bound Techniques.</p> <p><b><u>Post-optimality Analysis:</u></b>  Sensitivity Analysis, Discrete Change in the Cost-vector, in Requirement-vector and in the Coefficient matrix, Structural Changes in LPP.</p>							
Reference	<ol style="list-style-type: none"> <li>1. Kantiswarup, P.K.Gupta and Manmohan: Operations Research ,Sultan chand and Sons.</li> <li>2. S.D. Sharma: Operations Research, KedarNath, Ram Nath&amp; Co.</li> <li>3. S. S. Rao: Optimization Theory and Applications, Wiley Eastern, 1984.</li> <li>4. J. K. Sharma: Operation Research: Theory and Applications, Macmillan India Ltd., Third Edition, 2007.</li> </ol>							



Content	<p><b>UNIT-1: <u>Laplace Transforms:</u></b></p> <ul style="list-style-type: none"> <li>• Introduction and definition of Laplace transforms with examples</li> <li>• Existence condition for Laplace transforms</li> <li>• Basic properties of Laplace transforms</li> <li>• The convolution theorem and properties of convolution</li> </ul> <p><b>UNIT-2 <u>Laplace Transforms:</u></b></p> <ul style="list-style-type: none"> <li>• Differentiation and integration of Laplace transforms</li> <li>• The inverse Laplace transforms and examples</li> <li>• Tauberian theorem</li> <li>• Watson's lemma</li> </ul> <p><b>UNIT-3 <u>Finite Laplace Transforms:</u></b></p> <ul style="list-style-type: none"> <li>• Introduction</li> <li>• Definition of finite Laplace transforms and examples</li> <li>• Basic operational properties of finite Laplace transforms</li> <li>• Applications to Finite Laplace Transforms</li> <li>• Tauberian theorems</li> </ul> <p><b>UNIT-4 <u>Applications of Laplace Transforms</u></b></p> <ul style="list-style-type: none"> <li>• Applications of Laplace transforms to ordinary differential equations</li> <li>• Applications of Laplace transforms to partial differential equations</li> <li>• Initial and boundary value problems</li> <li>• Solutions to Integral equations</li> </ul>
Reference	<p>1) Lokenath Debnath: Integral Transform and their applications, CRC Pub., 1995.</p> <p>2) Ian Sneddon: The use of Integral Transform. TMIH, 1979.</p> <p>3) B. Davies: Integral Transforms and their applications, Springer - Verlag, 1978.</p>

	<p>4) Boss M. L.: Mathematical Methods in Physical Sciences, John Wiley &amp; Sons, 1983.</p> <p>5) Andrews, L. G. &amp; Shivamoggi B. K.: Integral Transforms for Engineers, PHI, 2003.</p>
--	--

Code	PGMTH-1044							
Cours Title Course	Advance Number Theory							
Credit	4							
Teaching per week	4 Hrs							
Minimum weeks per semester	20 (Including Classwork,examination,preparation,holidays etc.)							
Effective from	June 2022							
Purpose of course	To get knowledge of key concepts in number theory, like - Primitive roots and indices, Quadratic Reciprocity Law, Quadratic congruence. To get familiar with the sequence of Fibonacci numbers and to derive various identities involving Fibonacci numbers.							
Course outcome	<ol style="list-style-type: none"> <li>1. Students will learn about Primitive roots and Indices</li> <li>2. Students will be able to understand the logic of the Quadratic Reciprocity Law,</li> <li>3. Students learns about Fibonacci numbers and its various properties.</li> <li>4. Students will be able to solve various problems and prove various theorems of number theory.</li> </ol>							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1							
	CO2							
	CO3							
	CO4							
Content	<p><b>Unit I: Primitive Roots</b></p> <p>The order of an integer modulo <math>n</math>, Primitive roots for primes, Composite numbers having primitive roots.</p> <p><b>Unit II: Indices and Quadratic Congruence</b></p> <p>The theory of indices, Solution of the congruences of the type <math>ax^n \equiv b \pmod{p}</math> and <math>x^n \equiv a \pmod{n}</math>, <math>\gcd(a, n) = 1</math>. Quadratic Congruence, Euler's criterion, Quadratic residues.</p>							

	<p><b>Unit III: Quadratic Congruence</b> The Legendre symbol and its properties, Gauss' Lemma, Law of quadratic reciprocity, Quadratic residues and primes, Quadratic congruence with composite moduli.</p> <p><b>Unit IV: Numbers of special forms</b> Perfect numbers, Mersenne primes, Amicable numbers, Fermat numbers, Fibonacci numbers.</p>
Reference	<ol style="list-style-type: none"> <li>1. David M. Burton: Elementary Number Theory, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 7<sup>th</sup> edition, 2012.</li> <li>2. S. G. Talang: Number Theory, The Tata McGraw Hill Co. Ltd., New Delhi.</li> <li>3. Neville Robbins: Beginning Number Theory, Narosa Pub. House, New Delhi, 2<sup>nd</sup> Ed., 2006.</li> <li>4. I. Niven, S. Zuckerman, L. Montgomery: An Introduction to the Theory of Numbers, 6<sup>th</sup> edition, John Wiley and Sons, Inc., New York, 2003.</li> <li>5. George Andrews: Number Theory, The Hindustan Pub. Corp., New Delhi.</li> </ol>

Code	PGMTH-1045							
Cours Title Course	Special Function -I							
Credit	4							
Teaching per week	4 Hrs							
Minimum weeks per semester	20 (Including Classwork,examination,preparation,holidays etc.)							
Effective from	June 2022							
Purpose of course	To Learn the concept of Infinite product, Gamma and Beta functions and Hypergeometric functions. To analyse properties of Special Functions by their integral representations and symmetries.							
Course outcome	<ol style="list-style-type: none"> <li>1. Students understands the fundamentals concept of infinite product, Gamma and Beta functions with properties.</li> <li>2. Students understands the structure of the Gamma and Beta functions,</li> <li>3. Gamma function, Beta function and special functions are used to evaluate different types of integral calculus problems</li> <li>4. Students will get profound knowledge of Hypergeometric function and its properties.</li> <li>5. Students will be able to give the rigorous proof of various theorems..</li> </ol>							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7

	CO1						
	CO2						
	CO3						
	CO4						
	CO5						
Content	<p><b><u>UNIT-1</u></b>  Definition of an Infinite product, A necessary condition for convergence, The associated series of logarithms, Absolute convergence, Uniform convergence.</p> <p><b><u>UNIT-2:</u></b>  The Euler or Mascheroni constant <math>\gamma</math>, The Gama function, A series for <math>(z)'</math> (<math>z</math>) ,Evaluation of <math>(1)</math> and <math>(1)'</math>, The Euler product for <math>(z)</math> , The difference equation <math>(z +1) = z (z)</math>, The order symbols <math>o</math> and <math>0</math>, Evaluation of certain infinite products, Euler integral for <math>(z)</math> ,</p> <p><b><u>UNIT-3</u></b>  TheBeta function, The value of <math>(z) (1- z)</math>, The factorial function, Legendre's duplication formula,Gauss' multiplication theorem, A summation formula due to Euler, The behaviour of <math>\log(z)</math> for large <math>z</math> .</p> <p><b><u>UNIT-4:</u></b>  The function <math>F(a, b; c; z)</math>, A simple integral form, <math>F(a, b; c; 1)</math> as a function of the parameters, Evaluation of <math>F(a, b; c; 1)</math>, the contiguous function relations, The hypergeometric differential equation, Logarithmic solutions of the hypergeometric equation, <math>F(a, b; c; z)</math> as a function of its parameters, Simple transformations, Relation between functions of <math>Z</math> and <math>1-Z</math>, Aquadratic transformation, other quadratic transformations, a theorem due to Kummer, Additional properties.</p>						
Reference:	<ol style="list-style-type: none"> <li>1. E. D. Rainville, Special Functions, McMillan, New York, 1990.</li> <li>2. I. N. Sneddon, Special functions of Mathematical Physics and Chemistry, Oliver Boyd.</li> <li>3. N. N. Lebedev, Special Functions and their applications, Dover Pub. 1972.</li> <li>4. R. K. Saxena and D. C. Gokhroo, Special Functions, Khanna Pub.</li> </ol>						

**SYLLABUS FOR M.Sc. (MATHEMATICS)**  
**SEMESTER – II**  
**Effective from June 2022**

Code	PGMTH–201							
Cours Title Course	Advanced Abstract Algebra							
Credit	4							
Teaching per week	4 Hrs							
Minimum weeks per semester	20 (Including Classwork,examination,preparation,holidays etc.)							
Effective from	June 2022							
Purpose of course	To develop skills and to acquire knowledge on some of the basic concepts in Galois theory, Algebraic Extensions, Splitting fields, Polynomials solvable by radicals; to visualize and appreciate the necessity of acquiring deep mathematical thought to be able to solve certain seemingly simple questions.							
Course outcome	<ol style="list-style-type: none"> <li>1. Summarize concepts of field theory to enhance ability of analysing pure and applied mathematical problems.</li> <li>2. Students should be able to play around fields and field extensions in a mathematical mature way.</li> <li>3. They will also be able to appreciate role of algebra in solving some old classical problems of algebra.</li> <li>4. Distinguish between Extension fields and Finite extension field and splitting fields</li> <li>5. Distinguish between Algebraic extension, Algebraic number.</li> <li>6. Student will be able to: Demonstrate Field extensions and characterization of finite normal extensions as splitting fields and study prime fields.</li> </ol>							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1							
	CO2							
	CO3							
	CO4							
	CO5							
	CO6							
Content	<b>Unit-I</b> Conjugate of an element, class equation, Cauchy theorem,							

	<p>Sylow's theorem, Direct Products, Fundamental theorem of Finite Abelian Groups.</p> <p><b>Unit II</b> Polynomial rings, Primitive polynomials, Gauss's lemma, the Eisenstein criterion, polynomial rings over commutative rings, unique factorization domain.</p> <p><b>Unit-III</b> Extension fields, Finite extension field, Algebraic extension, Algebraic number, Roots of polynomials.</p> <p><b>Unit-IV</b> Splitting fields, Uniqueness of Splitting fields, Construction with straightedge and compass, More about roots, Simple extension.</p>
<b>Reference</b>	<ol style="list-style-type: none"> <li>1. I. N. Herstein: Topics in Algebra 4thEd., John Wiley Sons.</li> <li>2. P. B. Bhattacharya, S. K. Jain, S. R. Nagpaul: Basic Abstract Algebra, 2<sup>nd</sup> Ed., Cambridge University Press.</li> <li>3. Artin M.: Algebra, Prentice Hall, Englewood, Cliffs NJ.</li> <li>4. J. A. Gallian: Contemporary Abstract Algebra, Narosa Publishing House.</li> </ol>

Code	PGMTH-202
Cours Title Course	Complex Analysis
Credit	4
Teaching per week	4 Hrs
Minimum weeks per semester	20 (Including Classwork,examination,preparation,holidays etc.)
Effective from	June 2022
Purpose of course	The objective of this course is 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 sines and cosines via residue calculus.						
Course outcome	<ol style="list-style-type: none"> <li>1. In this course students will learn the algebra and geometry of complex numbers.</li> <li>2. Students will be able to check differentiability and the analyticity of complex valued function.</li> <li>3. Student learns about Cauchy-Riemann relations and harmonic functions.</li> <li>4. Student learns about Cauchy integral formula, general form of Cauchy theorem.</li> <li>5. Understand the concepts of Fundamental theorem of Algebra, Maximum module Principle.</li> <li>6. Understand Contour integrals related theorem and Examples</li> </ol>						
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
	PO1						
	PO2						
	PO3						
	PO4						
	PO5						
	PO6						
Content	<p><b>UNIT-1</b></p> <p>Analytic Functions: Functions of a Complex variables, Limits, Continuity, Differentiability, Cauchy-Riemann Equations, Analytic functions, Harmonic functions. Elementary Functions: Exponential function, Trigonometric functions, Hyperbolic functions</p> <p><b>UNIT-2</b></p> <p>Complex Integration: Contour Integral, Primitives, Cauchy-Goursat Theorem, Extension of Cauchy-Goursat Theorem, Cauchy Integral formula, Consequences of Cauchy Integral formula, Concept of Maximum Moduli of functions.</p> <p><b>UNIT-3</b></p> <p>Series Expansions: Power Series, Uniform convergence of power series, Taylor series, Zeros of Analytic functions, Laurent Series</p> <p><b>UNIT-4</b></p> <p>Singularities and Residues: Classification of Singularities, Residues, Poles and Zeros, Behavior of functions and infinity, Meromorphic functions, Open mapping theorem</p>						
References:	<p>1. H. S. Kasana: "Complex Variables – Theory and Applications", 2nd Edition (2005), PHI Learning Private Limited, Delhi.</p> <p>2. J. N. Sharma: "Functions of a Complex Variable", Krishna Prakashan, 2000.</p> <p>3. S. Ponnuswamy: "Foundation of Complex Analysis", Narosa Publishing House, 1997.</p>						

	<p>4. S. Lang: “Complex Analysis”, Addison Wesley, 1997.</p> <p>5. H. A. Priestly: “Introduction to Complex Analysis”, Clarendon Press, 1990.</p> <p>6. J. B. Conway: “Functions of one Complex Variable”, Springer-Verlag, 1980.</p>
--	---

Code	PGMTH-203							
Cours Title Course	Partial Differential Equation							
Credit	4							
Teaching per week	4 Hrs							
Minimum weeks per semester	20 (Including Classwork,examination,preparation,holidays etc.)							
Effective from	June 2022							
Purpose of course	To introduce first and second order partial differential equations and their classifications and methods of finding solutions of these partial differential equations.							
Course outcome	<ol style="list-style-type: none"> <li>1. Students learns about the Paffian differential equations and its applications.</li> <li>2. Students learns about integral surfaces passing through a given curve, surfaces orthogonal to a given system of surfaces.</li> <li>3. Students learns about nonlinear partial differential equations of the first order, compatible systems of first-order equations, Charpit’smethod, Jacobi’s method.</li> <li>4. Students studies about applications of separation of variable method.</li> <li>5. After successful completion of the course, students will be able to find the solutions of first and second order linear and non-linear partial differential equations.</li> </ol>							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1							
	CO2							
	CO3							
	CO4							
	CO5							
Content	<p><b>UNIT-1</b></p> <p><b>Ordinary Differential Equations in More than Two Variables:</b></p> <p>Surfaces and Curves in Three Dimensions, Simultaneous Differential Equations of the First Order and the First Degree in Three Variables, Methods of Solutions of <math>\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}</math>, Orthogonal Trajectories of a System of Curves on a Surface, Pfaffian Differential Forms and Equations, Solution</p>							

	<p>of Pfaffian Differential Equations in Three Variables.</p> <p><b>UNIT-2</b></p> <p><b>Partial Differential Equations of the First Order:</b></p> <p>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,</p> <p><b>UNIT-3</b></p> <p>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.</p> <p><b>UNIT-4</b></p> <p><b>Partial Differential Equations of the Second Order:</b></p> <p>Linear Partial Differential Equations with Constant Coefficients, Equations with Variable Coefficients, Separation of Variables, Nonlinear Equations of the Second Order.</p>
Reference	<ol style="list-style-type: none"> <li>1. Sneddon I.N.: Elements of Partial Differential Equations, McGraw Hill, International Editions, 1957</li> <li>2. ZafarHasan: Differential Equations and their applications, Second Edition, PHI, 2009.</li> <li>3. IyengarS.N.:Differential Equations, Anmol Publications, 2000 Sharma, Gupta: Differential Equations, Krishna Prakashan Media, 1997- 98.</li> </ol>

## ELECTIVE PAPERS

Code	PGMTH-2041																																														
Cours Title Course	Mathematical Modeling																																														
Credit	4																																														
Teaching per week	4 Hrs																																														
Minimum weeks per semester	20 (Including Classwork, examination, preparation, holidays etc.)																																														
Effective from	June 2022																																														
Purpose of course	This course introduces the basic concepts in mathematical modelling. It equips the students with mathematical modelling skills with emphasis on using mathematical models to solve real- life problems.																																														
Course outcome	<ol style="list-style-type: none"> <li>1. Students learns about the concept of mathematical modelling and its applications.</li> <li>2. Students learns about the advantages and disadvantages of models</li> <li>3. Students will be able to derive first and second order models.</li> <li>4. Students will be able to analyse the real life problems through mathematical modelling.</li> </ol>																																														
Mapping between COs with PSOs	<table border="1" style="width: 100%; text-align: center;"> <thead> <tr> <th></th> <th>PSO1</th> <th>PSO2</th> <th>PSO3</th> <th>PSO4</th> <th>PSO5</th> <th>PSO6</th> <th>PSO7</th> </tr> </thead> <tbody> <tr> <td>CO1</td> <td style="background-color: #4a7ebb; color: white;">X</td> <td></td> <td></td> <td></td> <td style="background-color: #4a7ebb; color: white;">X</td> <td style="background-color: #4a7ebb; color: white;">X</td> <td style="background-color: #4a7ebb; color: white;">X</td> </tr> <tr> <td>CO2</td> <td style="background-color: #4a7ebb; color: white;">X</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>CO3</td> <td style="background-color: #4a7ebb; color: white;">X</td> <td style="background-color: #4a7ebb; color: white;">X</td> <td style="background-color: #4a7ebb; color: white;">X</td> <td></td> <td></td> <td style="background-color: #4a7ebb; color: white;">X</td> <td></td> </tr> <tr> <td>CO4</td> <td style="background-color: #4a7ebb; color: white;">X</td> <td style="background-color: #4a7ebb; color: white;">X</td> <td style="background-color: #4a7ebb; color: white;">X</td> <td style="background-color: #4a7ebb; color: white;">X</td> <td style="background-color: #4a7ebb; color: white;">X</td> <td style="background-color: #4a7ebb; color: white;">X</td> <td></td> </tr> </tbody> </table>								PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	CO1	X				X	X	X	CO2	X							CO3	X	X	X			X		CO4	X	X	X	X	X	X	
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7																																								
CO1	X				X	X	X																																								
CO2	X																																														
CO3	X	X	X			X																																									
CO4	X	X	X	X	X	X																																									
Content	<p><b><u>UNIT -1: Introduction to Mathematical modelling</u></b> Needs and Techniques of mathematical modelling: Idea of mathematicalmodelling, need for mathematical modelling, Advantages and Disadvantages of Model, steps in mathematical modelling, Characteristics of mathematical modelling, Interpretation</p> <p><b><u>UNIT -2: Model of Linear Algebra</u></b> Modeling Explorations, Input-Output Economies, Traffic Networks, Balancing Chemical Equations</p> <p><b><u>UNIT -3: First Order Models</u></b> 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</p>																																														

	<p>Equations, Modelling Explorations with Difference and Differential Equations</p> <p><b>UNIT -4: <u>Second Order Models</u></b>  Modelling Oscillations, Homogeneous Linear 2nd Order Differential Equations, Forced Oscillations, Energy in Mass Spring Systems, Modelling Explorations with 2nd Order Differential Equations</p>
Reference	<ol style="list-style-type: none"> <li>1. J.N.Kapur: Mathematical Modelling, Wiley eastern Ltd., 1994.</li> <li>2. M.M. Gibbons: A concrete approach to Mathematical Modeling, John Wiley and sons, 1995.</li> <li>3. H. Neunzert and A.H. Siddiqui: Topics in Industrial Mathematics, Kluwer Academic Publishers, London, 2000</li> <li>4. P. E. Wellstead : Introduction to Physical System Modeling, Academic Press, 1979.</li> <li>5. Richard Haberman: Mathematical Models, Practice- Hall Inc., NJ, 1979.</li> </ol>

Code	PGMTH-2042
Cours Title Course	Operation Reserch
Credit	4
Teaching per week	4 Hrs
Minimum weeks per semester	20 (Including Classwork,examination,preparation,holidays etc.)
Effective from	June 2020
Purpose of course	To enhance problem solving skills of linear programming problems. To provide knowledge of theory of inventory control, PERT-CPM, Transportation problems.
Course outcome	<ol style="list-style-type: none"> <li>1. Students will be able to identify inventory problem &amp; solve it by PERT-CPM technique, Transportation problem and simulations.</li> <li>2. The student will be able to formulate and solve the Transportation problem.</li> </ol>

	<p>3. The student will be able to solve LPP by PERT-CPM method.</p> <p>4. Students should be able to explore various Mathematical programming algorithms to solve real life problems.</p>							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1							
	CO2							
	CO3							
	CO4							
	<p><b><u>Inventory Control:</u></b> 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.</p> <p><b><u>PERT – CPM:</u></b> 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.</p> <p><b><u>Simulation:</u></b> Introduction, Why Simulation, Methodology of Simulation, Generation of Random Numbers.</p> <p><b><u>Theory of Games</u></b> Revision: Two-person zero-sum game, Pure strategies, Mixed Strategies. The rules of dominance, Solution methods for Games without Saddle point: Algebraic method, Arithmetic method, Matrix method, Linear Programming method.</p>							
Reference	<p>1. Operations research by KantiSwarup, P.K.Gupta and Nan Mohan. S.Chand&amp; Sons, New Delhi. Seventh Edition, 1994.</p> <p>2.Operation Research: Theory and Applications by J. K. Sharma, Macmillan India Ltd., Third Edition, 2007.</p> <p>3. Operations Research by S.D. Sharma. KedarnathRamnath Pub.1998. Merrut.</p> <p>4. Optimization Methods in Operation Research and System Analysis by K. V. Mittal and C. Mohan, New Age International Publishers, Third Edition, 1996.</p>							

Code	PGMTH-2043							
Cours Title Course	Advanced Integral Transform –I							
Credit	4							
Teaching per week	4 Hrs							
Minimum weeks per semester	20 (Including Classwork,examination,preparation,holidays etc.)							
Effective from	June 2022							
Purpose of course	To provide command over solving the real-life problems using techniques of various types of Transforms. To get familiar with using the transform, both specific techniques and general principles.							
Course outcome	<ol style="list-style-type: none"> <li>1. Students will be able to learn about Hankel transform, Finite Hankel transforms</li> <li>2. Students learns about Hilbert and Stieltjes transforms.</li> <li>3. Students will be able to learn applications of all these transformations.</li> <li>4. Students will be able to solve the partial differential equations using Hankel transforms.</li> <li>5. Students will be able to solve differential equations using Hilbert and Stieltjes transforms.</li> </ol>							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1							
	CO2							
	CO3							
	CO4							
	CO5							
Content	<p><u>Unit-I:</u> Hankel Transforms: Introduction and definition of Hankel transform, examples on Hankel transform, Operational properties of the Hankel transform.</p> <p><u>Unit-II:</u> Finite Hankel Transforms: Introduction and definition of the finite Hankel transforms. finite Hankel transforms of some elementary functions, basic operational properties with examples.</p> <p><u>Unit-III:</u> Application Hankel transforms:Application of Hankel transforms to partial differential equations, Applications of finite Hankel transforms.</p> <p><u>Unit-IV:</u> 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.</p>							
Reference	<ol style="list-style-type: none"> <li>1) Lokenath Debnath: Integral Transform and their applications, CRC Pub., 1995.</li> <li>2) Ian Sneddon: The use of Integral Transform. TMIH, 1979.</li> </ol>							

	<p>3) B. Davies: Integral Transforms and their applications, Springer - Verlag, 1978.</p> <p>4) Boss M. L.: Mathematical Methods in Physical Sciences, John Wiley &amp; Sons, 1983.</p> <p>5) Andrews, L. G. &amp; Shivamoggi B. K.: Integral Transforms for Engineers, PHI, 2003.</p>
--	--

Code	PGMTH-2044							
Cours Title Course	Analytic Number Theory							
Credit	4							
Teaching per week	4 Hrs							
Minimum weeks per semester	20 (Including Classwork,examination,preparation,holidays etc.)							
Effective from	June 2022							
Purpose of course	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 as an essential tool in understanding a variety of combinatorial phenomena that arise in the additive theory of numbers and elsewhere.							
Course outcome	<ol style="list-style-type: none"> <li>1. Students know about Arithmetic functions, Dirichlet multiplication and elementary theorems on Prime numbers.</li> <li>2. Students are able to analyze the number theoretic problems.</li> </ol>							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1							
	CO2							
	CO3							
	<p><b>Unit I: Arithmetical functions and Dirichlet multiplication</b></p> <p>Basic introduction of the Möbius function <math>\mu(n)</math> and the Euler totient function <math>\phi(n)</math>, relation connecting <math>\mu</math> and <math>\phi</math>.</p> <p>The Dirichlet product of two arithmetical functions (a.f.) and group</p>							

	<p>structure w.r.t. this product, the Mangöldt function <math>\Lambda(n)</math>, Multiplicative a.f., the inverse of a completely multiplicative a.f.</p> <p><b>Unit II: Dirichlet multiplication and averages of Arithmetical functions</b></p> <p>Liouville's function <math>\lambda(n)</math>, the divisor functions <math>d(n)</math> and <math>\sigma_\alpha(n)</math>, the generalized convolutions.</p> <p>The big oh notation, Euler's summation formula, some elementary asymptotic formulas, the average order of divisor functions <math>d(n)</math> and <math>\sigma_\alpha(n)</math>, the average order of functions <math>\phi(n), \mu(n), \Lambda(n)</math>.</p> <p><b>Unit III: Averages of Arithmetical Functions and Chebyshev's functions</b></p> <p>Distribution of lattice points visible from the origin, the partial sums of a Dirichlet product, applications to <math>\mu(n)</math> and <math>\Lambda(n)</math>.</p> <p>Chebyshev's functions <math>\psi(x)</math> and <math>\vartheta(x)</math>, relation between <math>\psi(x), \pi(x)</math> and <math>\vartheta(x)</math>, Abel's identity.</p> <p><b>Unit IV: Elementary theorems on the distribution of prime numbers</b></p> <p>Equivalent forms of prime number theorem, lower and upper bounds for <math>\pi(n)</math> and <math>p_n</math>, Shapiro's Tauberian theorem and its applications, an asymptotic formula for the partial sums <math>\sum_{p \leq x} \left(\frac{1}{p}\right)</math>, the partial sums of function <math>\mu(n)</math>.</p>
<p><b>References</b></p>	<ol style="list-style-type: none"> <li>1. Tom M. Apostol: Introduction to Analytic Number Theory, Narosa Pub. House, New Delhi, 1998 Ed.</li> <li>2. Mc Carthy P. J.: Introduction to Arithmetical function, Springer-Verlag, New York, 1986.</li> <li>3. K. Chandrashekharan: Introduction to Analytic Number Theory, Springer-Verlag, New York, 1968.</li> <li>4. Hua L. K.: Introduction to Number Theory, Springer-Verlag, New York, 1982.</li> </ol>

Code	PGMTH-2045							
Course Title Course	Special functions -II							
Credit	4							
Teaching per week	4 Hrs							
Minimum weeks per semester	20 (Including Classwork,examination,preparation,holidays etc.)							
Effective from	June 2022							
Purpose of course	To 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	<ol style="list-style-type: none"> <li>1. Students learns about orthogonal polynomials and its properties.</li> <li>2. Students learns about Legendre polynomials and its properties.</li> <li>3. Students learns about Hermite polynomials and its properties.</li> <li>4. Students will be able to prove the rigorous proof of various theorems.</li> </ol>							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1							
	CO2							
	CO3							
	CO4							
	CO5							
Content	<p><b><u>UNIT-1:</u></b>  Orthogonal polynomials, Simple set of polynomials, Orthogonality, an equivalent condition for Orthogonality, zeros of orthogonal polynomials , Expansion of polynomials, The three term recurrence relations, The Christoffel-Darboux formula, Normalization; Bessel's inequality.</p> <p><b><u>UNIT-2:</u></b>  Legendre polynomials, A generating function, differential recurrence relations, The pure recurrence relations, Legendre's differential equation, The Rodrigues formula, Bateman's generating function, Additional generating functions,</p> <p><b><u>UNIT-3:</u></b>  Hypergeometric forms of <math>P_n(X)</math>, Brafman's generating functions, Special</p>							

	<p>properties of <math>P_n(X)</math>, More generating functions, Laplace's first integral form, Some bounds on <math>P_n(X)</math>, Orthogonality, An expansion theorem, Expansion of <math>X^n</math>, Expansion of analytic functions,</p> <p><b>UNIT-4:</b></p> <p>Hermite polynomials: Definition of <math>H_n(x)</math>, Recurrence relations, The Rodrigues formula, Other generating functions, Integrals, The Hermite polynomial as a <math>{}_2F_0</math>, Orthogonality, Expansion of polynomials, More generating functions.</p>
<b>Reference:</b>	<ol style="list-style-type: none"> <li>1. E. D. Rainville, Special Functions, McMillan, New York, 1990.</li> <li>2. I. N. Sneddon, Special functions of Mathematical Physics and Chemistry, Oliver Boyd.</li> <li>3. N. N. Lebedev, Special Functions and their applications, Dover Pub. 1972.</li> <li>4. R. K. Saxena and D. C. Gokhroo, Special Functions, Khanna Pub.</li> </ol>

**VEER NARMAD SOUTH GUJARAT UNIVERSITY, SURAT.**  
**Syllabus to be offered at M. Sc. (Mathematics) Semester: III**  
**w.e.f. June 2023**

Course Code	PGMTH-301
Course Title	Functional Analysis-I
Credit	4
Teaching per Week	4 Hrs
Minimum weeks per Semester	20 (Including Classwork, examination, preparation, holidays etc.)
Effective From	June 2023
Purpose of Course	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	<ol style="list-style-type: none"> <li>1. Students learn the properties of Banach spaces,</li> <li>5. Students learn normed spaces and inner product spaces</li> <li>6. Students learn linear operators, bounded linear operator.</li> <li>7. Students learn difference between finite and infinite dimensional space, Banach space and Hilbert space</li> <li>8. Student will be able to compute the dual spaces of certain Banach spaces.</li> </ol>

	9. Student will able to appreciate the power classical result of functional Analysis.						
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
	CO1						
	CO2						
	CO3						
	CO4						
Content	<p><b>Unit- 1</b> Metric Space, Further Examples of Metric Spaces, Completeness, Examples, Completeness proofs, Completion of Metric Spaces</p> <p><b>Unit-2</b> Vector Space, Normed Space, Banach Space, Further properties of Normed Spaces, Finite Dimensional Normed Spaces and Subspaces, Compactness and Finite Dimension, Linear Operators</p> <p><b>Unit-3</b> Bounded and Continuous Linear Operators, Linear Functionals, Linear Operators and Functionals on Finite Dimensional Spaces, Normed Spaces of Operators, Dual space</p> <p><b>Unit-4</b> Inner Product Space, Hilbert Space, Properties of Inner Product Spaces, Orthogonal Complements and Direct Sums, Orthogonal Sets and Sequences</p>						
<b>References:</b>	<ol style="list-style-type: none"> <li>1. E. Kreyszig: Introductory Functional Analysis with applications, John Wiley and Sons.</li> <li>2. B.V. Limaye: Functional Analysis, New Age International Limited, Publishers</li> <li>3. G.F. Simmons: Introduction to Topology and Modern Analysis, Tata McGraw - Hill.</li> <li>4. A. R. Vashistha &amp; J.N. Sharma: Functional Analysis, Krishna Prakashan Media (P) Ltd</li> </ol>						

Course Code	PGMTH-302
Cours Title	Advanced Numerical Analysis
Credit	4

Teaching per week	4 Hrs.
Minimum weeks per semester	20 (Including Classwork, examination, preparation, holidays etc.)
Effective from	June 2023
Course objective	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	<ol style="list-style-type: none"> <li>6. Students will learn about Iteration method based on second degree equation and rate of convergence.</li> <li>7. Students should be able solve system of algebraic equations and eigen value problems</li> <li>8. Students can learn about numerical differentiation and Newton-cotes method of Integration.</li> <li>9. Understand the concept Initial and boundary value problem of ordinary differential equations.</li> </ol>

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

Content	<p><b><u>UNIT-1</u></b>  <b>Transcendental and Polynomial Equations</b>  Direct Methods (Introduction) , Iterative Methods (Muller Method, Chebyshev Method), Rate of convergence (Definition), First and second order General Iteration Methods</p> <p><b>System of Linear Algebraic Equations</b>  Introduction, Direct Methods (Cramer Rule, Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization Method), Iteration methods (Jacobi Iteration Method, Gauss-Seidel Iteration Method)</p> <p><b><u>UNIT-2</u></b>  <b>Eigen values Problems</b>  Eigen values and Eigenvectors, Jacobi method for symmetric matrices, Power method, Inverse power method.</p> <p><b>Numerical differentiation</b>  Methods based On Interpolation (Non-uniform Nodal Points, Uniform Nodal Points), Optimum Choice of Step Length</p> <p><b><u>UNIT-3</u></b>  <b>Numerical Integration</b>  Methods based on interpolations (Newton-Cotes Method), Methods based on Undetermined coefficients (Newton-Cotes Method, Gauss Quadrature Method, Gauss-Legendre Integration Method, Gauss-Chebyshev Integration Method)</p> <p><b><u>UNIT-4</u></b>  <b>Numerical Solution of Ordinary Differential Equations:</b>  <b>Initial Value Problem</b>, Single step methods (Explicit Runge-Kutta Methods)</p>
---------	--

	<b>Boundary Value Problem</b> Finite Difference Methods: linear Second Order Differential Equations, Solution of Tridiagonal System
<b>References:</b>	<ol style="list-style-type: none"> <li>1. M. K. Jain, S. R. K. Iyenger, R. K. Jain: "Numerical Methods for scientific and engineering computations", VI – edition, New Age International Publishers</li> <li>2. Philips and Taylor: "Theory and Applications of Numerical Analysis Academic Press", 1996</li> <li>3. Gourdin and Boumhart: "Applied Numerical Analysis", P.H.I., 1996</li> <li>4. A. S. Householder: "Theory of Matrices in Numerical Analysis", Blarsedell - New York.</li> <li>5. Jacques and Colin: "Numerical Analysis", Chapman &amp; Hall, New-York, 1987.</li> </ol>

Course Code	PGMTH-303							
Cours Title	Calculus of Variation							
Credit	4							
Teaching per week	4 Hrs.							
Minimum weeks per semester	20 (Including Classwork, examination, preparation, holidaysetc.)							
Effective from	June 2023							
Course objective	Introduce the concept of bounded variation, Variational problems and principal, functional, Jacobi Condition, Weirstrass Function, Legendre Condition, Second Variation							
Course outcome	<ol style="list-style-type: none"> <li>1. Students will learn about the concept of Variations and its properties,</li> <li>2. Functionals and its properties</li> <li>3. Study Variational problem with a movable boundary for a functional dependent on two functions,</li> <li>4. Students learn One-Sided Variations, Reflection and Refraction after successful completion of the course</li> </ol>							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1							
	CO2							
	CO3							
	CO4							
Content	<b>UNIT-I</b> <b>Variational Problems with Fixed Boundaries:</b> The concept of Variation and its properties, Euler’s Equation, Fundamental lemma of Calculus of Variation, <b>UNIT-II</b> <b>Functionals</b>							

	<p>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.</p> <p><b>UNIT-III</b></p> <p><b>Variational Problems with Moving Boundaries:</b></p> <p>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.</p> <p><b>UNIT-IV</b></p> <p><b>Sufficient Conditions for an Extremum:</b></p> <p>Field of Extremals, Jacobi Condition, Weir strass Function, Legendre Condition, Second Variation, Canonical Equations and Variational Principles, Complementary Variational Principles.</p>
<b>References</b>	<ol style="list-style-type: none"> <li>1. A.S. Gupta: "Calculus of Variations with Applications", Prentice Hall of India Pvt. Ltd., New Delhi.</li> <li>2. Robert Weinstock: "Calculus of Variations with Applications to physics".</li> <li>3. ElsGok L. D.: "Calculus of Variation".</li> <li>4. Mariano Giaquinta, Stefan Hildebrandt: "Calculus of Variations-I", Springer Science &amp; Business Media, 2004</li> </ol>

### ELECTIVE PAPERS

Course Code	PGMTH-3041
Cours Title	Fluid Dynamics
Credit	4
Teaching per week	4 Hrs.

Minimum weeks per semester	20 (Including Classwork, examination, preparation, holidays etc.)								
Effective from	June 2023								
Course Objective	To provide the knowledge of Theory of Fluid Dynamics								
Course outcome	<p>1. Students will learn about basic fundamentals of fluid dynamics such as Conservation Laws, Conservation of mass, momentum and energy.</p> <p>2. Distinguish One dimensional, two dimensional and three dimensional flow.</p> <p>3. Student will learn about Bernoulli Equation, Potential equation, Reynold's transport theorem, Navier-stokes equation.</p> <p>4. They familiar with the fluid statics, kinematics of fluid and dynamics of fluid.</p> <p>5. Enhance ability of analysing mathematical problems related to Fluid dynamics.</p>								
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	
	CO1								
	CO2								
	CO3								
	CO4								
	CO5								
Content	<p>UNIT I 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,</p> <p>UNIT II: 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</p> <p>UNIT III 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 irrotational flow, Laminar and turbulent flow, Line of flow (Stream line, Path line, Strake line, Time line)</p> <p>UNIT IV 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, Conservation of mass, Conservation of momentum, Conservation of energy, Navier-stokes equation</p>								
Reference	<p>1. Batchelor G.K.: An Introduction to Fluid Dynamics, Cambridge University Press, 1999.</p> <p>2. Emanuel G: Analytical Fluid Dynamics, CRC Press, Boca Raton, Second Edition, FL, 1999.</p> <p>3. Panton R.L., Incompressible Flows, Wiley Interscience, 1984</p> <p>4. Currie I.G.: Fundamental Mechanics of Fluids, McGraw-Hill, New-york, 1993.</p> <p>5. Chorin: Mathematical introduction to Fluid Mechanics, Springer Verlag, Fourth</p>								

--	--

Course Code	PGMTH-3042																																																
Cours Title	Advanced Operations Research.																																																
Credit	4																																																
Teaching per week	4 Hrs.																																																
Minimum weeks per semester	20 (Including Classwork, examination, preparation, holidays etc.)																																																
Effective from	June 2023																																																
CourseObjective	To enhance problem solving skills and acquire the knowledge of Queuing theory problems, sequencing problems, replacement problems, Games and strategies.																																																
Course outcome	<ol style="list-style-type: none"> <li>1. Students will learn about Queuing theory related problems</li> <li>2. Students will learn about sequencing problems and its solution process</li> <li>3. Students will learn about Theory of replacement and its utilities</li> <li>4. Students will learn about Games and strategies and its applications</li> <li>5. Students are able to formulate and analyse the real world problems.</li> </ol>																																																
Mapping between COs with PSOs	<table border="1"> <thead> <tr> <th></th> <th>PSO1</th> <th>PSO2</th> <th>PSO3</th> <th>PSO4</th> <th>PSO5</th> <th>PSO6</th> <th>PSO7</th> </tr> </thead> <tbody> <tr> <td>CO1</td> <td style="background-color: #4F81BD;"></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td style="background-color: #4F81BD;"></td> </tr> <tr> <td>CO2</td> <td style="background-color: #4F81BD;"></td> <td style="background-color: #4F81BD;"></td> <td></td> <td></td> <td></td> <td style="background-color: #4F81BD;"></td> <td style="background-color: #4F81BD;"></td> </tr> <tr> <td>CO3</td> <td style="background-color: #4F81BD;"></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>CO4</td> <td style="background-color: #4F81BD;"></td> <td style="background-color: #4F81BD;"></td> <td style="background-color: #4F81BD;"></td> <td></td> <td style="background-color: #4F81BD;"></td> <td style="background-color: #4F81BD;"></td> <td></td> </tr> <tr> <td>CO5</td> <td></td> <td></td> <td style="background-color: #4F81BD;"></td> <td style="background-color: #4F81BD;"></td> <td></td> <td style="background-color: #4F81BD;"></td> <td></td> </tr> </tbody> </table>		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	CO1								CO2								CO3								CO4								CO5							
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7																																										
CO1																																																	
CO2																																																	
CO3																																																	
CO4																																																	
CO5																																																	
Content	<p><b>Unit I</b>  <b>Queuing Theory:</b>  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.</p> <p><b>Unit II</b>  <b>Sequencing Problems:</b>  Problems of Sequencing, Problems with n-jobs and 2-machines, Problems with n-jobs and 3-machines, Problems with n-jobs and m-machines.</p> <p><b>Unit III</b>  <b>Theory of Replacement:</b>  Introduction, Replacement of Equipment that Deteriorate Gradually, Replacement of Equipment that Fails completely, Other Replacement Problems.</p> <p><b>Unit IV</b>  <b>Information Theory</b>  Introduction, Communication Processes, A Measure of Information, Measure of other Information Quantities, Channel Capacity, Efficiency and</p>																																																

	Redundance.
<b>References:</b>	<b>References:</b> 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

Course Code	PGMTH-3043							
Cours Title	Advanced Integral Transforms-I							
Credit	4							
Teaching per week	4 Hrs.							
Minimum weeks per semester	20 (Including Classwork, examination, preparation, holidays etc.)							
Effective from	June 2023							
Course Objective	To provide practice of solving the real problems using techniques of various types of transforms. To gain a facility with using the transform, both specific techniques and general principles.							
Course outcome	5. Students learns about Mellin transforms and its properties 6. Students learns about Z-transforms and its properties 7. Students learns about Inverse Z transforms and its properties 8. Students learns about applications of all these transformations 9. Students will be able to solve difference equations							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1							
	CO2							
	CO3							
	CO4							
	CO5							
Content	<u>Unit-I:</u> Introduction, Definition of the Z- transforms and examples, Basic operational properties of Z transform, Summation of Infinite series.  <u>Unit-II:</u> The inverse Z-transform and examples,Applications of Z-transforms to Finite							

	<p>Difference Equations</p> <p><u>Unit-III:</u></p> <p>Introduction, Definition of Mellin transforms and examples. Basic operational properties of Mellin Transforms.</p> <p><u>Unit-IV:</u></p> <p>Applications of the Mellin transforms, Application of Mellin transforms to summation of series.</p>
Reference :	<ol style="list-style-type: none"> <li>1. Lokenath Debnath: Integral Transform and their applications, CRC Pub., 1995.</li> <li>2. Ian Sneddon: The use of Integral Transform. TMIH, 1979.</li> <li>3. B. Davies : Integral Transforms and their applications, Springer - Verlag, 1978.</li> <li>4. Boss M. L.: Mathematical Methods in Physical Sciences, John Wiley &amp; Sons, 1983.</li> <li>5. Andrews, L. G. &amp; Shivamoggi B. K.: Integral Transforms for Engineers, PHI, 2003.</li> </ol>

Code	PGMTH-3044							
Cours Title Course	<b>Diophantine equations</b>							
Credit	4							
Teaching per week	4 Hrs.							
Minimum weeks per semester	20 (Including Classwork, examination, preparation, holidays etc.							
Effective from	June 2023							
Course Objective	To study the various concepts like continued fractions, linear and quadratic Diophantine equations, representation of integers as sums of squares and to solve various problems by using these techniques.							
Course outcome	<ol style="list-style-type: none"> <li>1. Students learns about continued fractions.</li> <li>2. Students learns about various linear and quadratic Diophantine equations and its properties.</li> <li>3. Students learns about representation of integers as sums of squares and its applicability.</li> <li>4. Enhance the logical ability of the students.</li> </ol>							
Mapping between COs with		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7

PSOs	<table border="1"> <tr> <td>CO1</td> <td style="background-color: #0056b3;"></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td style="background-color: #0056b3;"></td> <td></td> </tr> <tr> <td>CO2</td> <td style="background-color: #0056b3;"></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td style="background-color: #0056b3;"></td> <td></td> </tr> <tr> <td>CO3</td> <td style="background-color: #0056b3;"></td> <td style="background-color: #0056b3;"></td> <td style="background-color: #0056b3;"></td> <td style="background-color: #0056b3;"></td> <td></td> <td></td> <td style="background-color: #0056b3;"></td> <td></td> </tr> <tr> <td>CO4</td> <td style="background-color: #0056b3;"></td> <td style="background-color: #0056b3;"></td> <td></td> <td style="background-color: #0056b3;"></td> <td style="background-color: #0056b3;"></td> <td></td> <td></td> <td style="background-color: #0056b3;"></td> </tr> </table>	CO1									CO2									CO3									CO4								
CO1																																					
CO2																																					
CO3																																					
CO4																																					
Content	<p><b>Unit I:</b>  <b>Continued fractions:</b> Simple continued fractions, finite and infinite continued fractions, uniqueness, representation of rational and irrational numbers as simple continued fractions, rational approximation to irrational numbers.</p> <p><b>Unit II:</b>  <b>Diophantine equations:</b> Diophantine equation <math>ax + by = c</math> and its positive solutions, Pell's equation, Fundamental solutions, Solution of Pell's equation using Continued fraction</p> <p><b>Unit III:</b>  <b>Fermat's equation:</b> Diophantine equations <math>x^2 + y^2 = z^2</math> and its solutions, Fermat's equation <math>x^n + y^n = z^n</math> for the cases <math>n = 3, 4</math>, Fermat's Last Theorem.</p> <p><b>Unit IV:</b>  <b>Representation of integers as sum of squares:</b> 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.</p>																																				
Reference	<ol style="list-style-type: none"> <li>1. David M. Burton: Elementary Number Theory, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 7<sup>th</sup> edition, 2012.</li> <li>2. S. G. Talang: Number Theory, The Tata McGraw Hill Co. Ltd., New Delhi, 5<sup>th</sup> reprint, 2004.</li> <li>3. S. K. Pundir, R. Pundir: Theory of Numbers, Pragati Prakashan, Meerut, 6<sup>th</sup> edition, 2019.</li> <li>4. Neville Robbins: Beginning Number Theory, Narosa Pub. House, New Delhi, 2<sup>nd</sup> edition, 2006.</li> <li>6. George Andrews: Number Theory, The Hindustan Pub. Corp., New Delhi.</li> </ol>																																				

Code	PGMTH-3045							
Cours Title Course	Advance Special Function –I							
Credit	4							
Teaching per week	4 Hrs.							
Minimum weeks per semester	20 (Including Classwork, examination, preparation, holidays etc.)							
Effective from	June 2023							
Course Objective	To introduce the concepts of Generalized Hypergeometric functions, about Bessel Functions, Generating functions and analyze properties of special functions.							
Course outcome	<ol style="list-style-type: none"> <li>1. Students learns generalized Hypergeometric functions.</li> <li>2. Students learns Bessel functions and its various properties,</li> <li>3. The Confluent Hypergeometric function and its application.</li> <li>4. Students understands the concept of Generating functions and its utilization</li> </ol>							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1							
	CO2							
	CO3							
	CO4							
Effective from	<p><b>UNIT-1 :</b></p> <p><b>GENERALIZED HYPERGEOMETRIC FUNCTIONS:</b></p> <p>The function <math>{}_pF_q</math> , The exponential and binomial functions, A differential equation, Other solutions of the differential equation, The contiguous function relations, A simple integral, <math>{}_pF_q</math> with unit argument, Saalschutz’ theorem, Whipple’s theorem, Dixon’s theorem, Contour integrals of Barnes’ type, The Berns’ integrals and the function <math>{}_pF_q</math> , A useful integral.</p> <p><b>UNIT-2 :</b></p> <p><b>BESSEL FUNCTIONS:</b></p> <p>Remarks, Definition of <math>J_n(z)</math>, Bessel’s differential equation, Differential recurrence relations, A pure recurrence relations, A generating function, Bessel’s integral, Index half of an integer, Modified Bessel functions, Neumann polynomials, Neumann series.</p> <p><b>UNIT-3 :</b></p> <p><b>THE CONFLUENT HYPERGEOMETRIC FUNCTION:</b></p> <p>Basic properties of the <math>{}_1F_1</math> ,Kummer’s first formula, Kummer’s second formula.</p>							

	<p><b>UNIT-4 :</b></p> <p><b>GENERATING FUNCTIONS:</b></p> <p>The generating function concept, Generating functions of the form <math>G(2xt - t^2)</math>, sets generated by <math>et \psi(xt)</math>, the generating functions <math>A(t) \exp(-xt(1-t))</math>, another class of generating functions, Boas and Buck generating functions, An extension.</p>
<b>Reference:</b>	<ol style="list-style-type: none"> <li>1. E. D. Rainville, Special Functions, McMillan, New York, 1990.</li> <li>2. I. N. Sneddon, Special functions of Mathematical Physics and Chemistry, Oliver Boyd.</li> <li>3. N. N. Lebedev, Special Functions and their applications, Dover Pub. 1972.</li> <li>4. R. K. Saxena and D. C. Gokhroo, Special Functions, Khanna Pub.</li> </ol>

**M.Sc. (Mathematics) Semester: IV**  
**Syllabus to be in force from July 2023**

Code	PGMTH-401
Cours Title Course	Advanced Functional Analysis –II
Credit	4
Teaching per week	4 Hrs
Minimum weeks per semester	20 (Including Classwork, examination, preparation, holidays etc.)
Effective from	June 2023
Course Objective	To develop skills and to acquire knowledge of advanced concepts in Hilbert spaces, Representation of functional on Hilbert spaces, Category theorem, Open mapping theorem, Closed Graph theorem, Hahn-Banach theorem and its applications, Spectral theory.
Course outcome	<ol style="list-style-type: none"> <li>1. Summarize concepts of field theory to enhance ability of analysing pure and applied mathematical problems.</li> <li>2. students should be able to play around fields and field extensions in a mathematical mature way.</li> <li>3. They will also be able to appreciate role of algebra in solving some old classical</li> </ol>

	<p>problems of algebra.</p> <p>4. Distinguish between Extension fields and Finite extension field and splitting fields</p> <p>5. Distinguish between Algebraic extension, Algebraic number.</p> <p>6. the student will be able to: Demonstrate Field extensions and characterization of finite normal extensions as splitting fields and study prime fields.</p>																																																	
Mapping between COs with PSOs	<table border="1"> <thead> <tr> <th></th> <th>PSO1</th> <th>PSO2</th> <th>PSO3</th> <th>PSO4</th> <th>PSO5</th> <th>PSO6</th> </tr> </thead> <tbody> <tr> <td>PO1</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>PO2</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>PO3</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>PO4</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>PO5</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>PO6</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PO1							PO2							PO3							PO4							PO5							PO6						
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6																																												
PO1																																																		
PO2																																																		
PO3																																																		
PO4																																																		
PO5																																																		
PO6																																																		
Content	<p><b>Unit-1</b> Total Orthonormal Sets and Sequences, Representation of Functionals on Hilbert Spaces, Hilbert-Adjoint Operator, Self-Adjoint, Unitary and Normal Operators</p> <p><b>Unit-2</b> Zorn's Lemma, Hahn-Banach theorem, Hahn-Banach theorem for Complex Vector Spaces and Normed Spaces, Adjoint Operator</p> <p><b>Unit-3</b> Reflexive Spaces, Category Theorem and Uniform Boundedness Theorem, Strong and Weak Convergence</p> <p><b>Unit-4</b> Convergence of Sequences of Operators and Functionals, Open Mapping Theorem, Closed Linear Operators, Closed Graph Theorem, Banach Fixed Point Theorem</p>																																																	
Reference	<ol style="list-style-type: none"> <li>1. E. Kreyszig: Functional Analysis and its application, John Wiley and sons.</li> <li>2. B.V. Limaye: Functional Analysis, New Age International Limited, Publishers</li> <li>3. G.F. Simmons: Introduction to Topology and Modern Analysis, Tata McGraw - Hill.</li> <li>4. A. R. Vashistha &amp; J.N. Sharma: Functional Analysis, Krishna Prakashan Media (P) Ltd.</li> </ol>																																																	

Code	PGMTH-402							
Cours Title Course	Advanced Linear Algebra							
Credit	4							
Teaching per week	4 Hrs							
Minimum weeks per semester	20 (Including Classwork, examination, preparation, holidays etc.)							
Effective from	June 2023							
Purpose of course	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	<ol style="list-style-type: none"> <li>1 Students will learn about properties of Vector space, Dual space, Algebra of linear transformations, Algebra of Matrices.</li> <li>2. Students will determine a subspace, span, bases, row space, column space and null space for vector space in <math>n^{\text{th}}</math> dimension</li> <li>3. Students will identify linear transformations of finite dimensional vector spaces and compose their matrices in specific bases.</li> <li>4. After successful completion of the course, students should be able to analyse the problems related to Linear algebra.</li> </ol>							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1							
	CO2							
	CO3							
	CO4							
Content	<p><b>UNIT 1:</b>  <math>\text{Hom}(V, W)</math>, Dual Space of Vector Space, Second Dual, Annihilator of subspace, Dimension of annihilator of a subspace and its application to homogeneous linear equations.</p> <p><b>UNIT 2:</b>  Algebra, Algebra of linear transformations <math>A(V)</math>, Relation between algebra <math>A</math> and <math>A(V)</math>, Minimal polynomial for linear transformation, Regular and Singular linear transformations, Rank of linear transformation.</p> <p><b>UNIT 3:</b>  Characteristic Roots and Characteristic Vectors, Algebra of Matrices, Similar linear transformations, Triangular form.</p> <p><b>UNIT 4:</b></p>							

	Nilpotent transformations, Invariants, Jordan Canonical form, Rational Canonical form.
Reference	<ol style="list-style-type: none"> <li>1. I. N. Herstein: Topics in Algebra 4<sup>th</sup> Ed., John Wiley Sons.</li> <li>2. Kenneth Hoffman and Ray Kunze: Linear Algebra, Eastern Economy Editions.</li> <li>3. S. Friedberg, A. Insel and L. Spence: Linear Algebra, Pearson.</li> <li>4. D. S. Dummit and R. M. Foote: Abstract Algebra, John Wiley &amp; Sons, 2004.</li> <li>5. N. Jacobson: Lectures in Abstract Algebra Vol. I (1951), II (1952), Van Nostrand Co., New York.</li> </ol>

Code	PGMTH-403							
Cours Title Course	Integral Equation							
Credit	4							
Teaching per week	4 Hrs							
Minimum weeks per semester	20 (Including Classwork, examination, preparation, holidays etc.)							
Effective from	June 2023							
Course Objective	This course emphasizes concepts and techniques for solving integral equations from an applied mathematics perspective. To make the students familiar with the methods of solving Integral equations.							
Course outcome	<ol style="list-style-type: none"> <li>1. Students learns about the integral equations and related results and theorems.</li> <li>2. Students will be able to classify the Integral equations.</li> <li>3. Students will be able to apply the methods and concepts to solve integral equations.</li> <li>4. Students will be able to recognize difference between Volterra and Fredholm Integral Equations, First kind and Second kind, homogeneous and inhomogeneous etc.</li> <li>5. Students will be able to apply different methods to solve integral equations.</li> </ol>							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7

	<table border="1"> <tr> <td>CO1</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>CO2</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>CO3</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>CO4</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>CO5</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </table>	CO1								CO2								CO3								CO4								CO5							
CO1																																									
CO2																																									
CO3																																									
CO4																																									
CO5																																									
Content	<p><b>UNIT -1</b>  <b><u>Preliminary Concepts:</u></b>  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.</p> <p><b>UNIT -2</b>  <b><u>Conversion of ODE into Integral Equations:</u></b>  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.</p> <p><b>UNIT -3</b>  <b><u>Fredholm Integral Equations of second kind with Separable kernel:</u></b>  Eigenvalues and Eigenfunctions, Solution of homogeneous Fredholm integral equations of second kind with Separable kernel, Solution of Fredholm integral equations of second kind with Separable kernel.</p> <p><b>UNIT -4</b>  <b><u>Method of Successive approximations:</u></b>  Iterated Kernels, Resolvent kernels, An Important theorem on kernels, Solution of Fredholm integral equations of second kind by successive substitution, Solution of Volterra integral equations of second kind by successive substitution.</p>																																								
Reference	<ol style="list-style-type: none"> <li>1. M. D. Raisinghania: Integral Equations and Boundary Value Problems, S. Chand &amp; Co., New Delhi (2007).</li> <li>2. Shanti Swarup: Linear Integral Equations, Krishna Prakashan, Meerut.</li> <li>3. Sudir K. Pundir and Rimple Pundir: Integral Equations and Boundary Value Problems, Pragati Prakashan, Meerut (2005).</li> <li>4. Ram P. Kanwal: Linear Integral Equations Theory and Technique, Academic Press, Birkhäuser, New York (2013).</li> <li>5. Corduneanu, C., Integral Equations and Applications, Cambridge University Press, 1991</li> </ol>																																								

## ELECTIVE PAPERS

Code	PGMTH-4041							
Cours Title Course	Computational Fluid Dynamics							
Credit	4							
Teaching per week	4 Hrs.							
Minimum weeks per semester	20 (Including Classwork, examination, preparation, holidays etc.)							
Effective from	June 2023							
Course Objective	Provide the knowledge of Theory of Fluid Dynamics							
Course outcome	<ol style="list-style-type: none"> <li>1. Students will learn about basic fundamentals of fluid dynamics such as conservation Laws, Conservation of mass, momentum and energy.</li> <li>2. Distinguish One dimensional, two dimensional and three dimensional flow.</li> <li>3. Student will learn about Bernoulli Equation, Potential equation, Reynold's transport theorem, Navier-stokes equation.</li> <li>4. They familiar with the fluid statics, kinematics of fluid and dynamics of fluid.</li> <li>5. Enhance ability of analysing mathematical problems related to Fluid dynamics.</li> </ol>							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1							
	CO2							
	CO3							
	CO4							
	CO5							
Content	<p><b>UNIT -1</b>  <b><u>Introduction and Classification of PDE's</u></b></p> <p>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</p> <p><b>UNIT -2</b>  <b><u>Heat Equation</u></b></p> <p>Introduction to heat Equations, Schmidt method, Richardson Method, Crank-Nicolson method, Du-fort Franek method, stability of schemes, convergence of scheme</p> <p><b>UNIT -3</b>  <b><u>Wave Equations</u></b></p> <p>One dimensional Euler equations, Lax – Wendroff Scheme, Mc-Cormack Scheme, Implicit - method, Pseudo One Dimensional Euler Equations, boundary conditions, Flux – Splitting, Artificial viscosity, Flux</p>							

	<p>limiters. Multidimensional Euler equations, Lax- Wendroff and Mc-Cormack schemes, stability of multidimensional schemes, Operator splitting Implicit algorithms,</p> <p><b>UNIT -4</b></p> <p><b><u>Laplace and poisson Equation</u></b></p> <p>Finite Differences, Algorithms, Errors and Accuracy, Consistency, Stability and Convergence, Implicit algorithms,</p> <ul style="list-style-type: none"> <li>• Practical: Numerical methods for discretizing fluid flow equations: Finite differences</li> </ul>
Reference	<ol style="list-style-type: none"> <li>1. R. J. Leveque: Numerical methods for conservation Laws, Birkhauser Verlag, Basel, 1992.</li> <li>2. J. D. Anderson: Computation Fluid dynamics, Mc-Graw – Hill, New York, 1995.</li> <li>3. H. K. Versteeg and W. Malasekera: An Introduction to Computational Fluid Dynamics: The finite volume method, Longman Scinetific and technical Essex, England, 1995.</li> <li>4. J. Chorin and J. E. Marsden: A Mathematical Introduction to Fluid Mechanics</li> <li>5. P. D. Lax: hyperbolic systems of conservation laws and mathematical theory of hock waves, 1973.</li> </ol>

Code	PGMTH-4042
Cours Title Course	Non-Linear Programming
Credit	4
Teaching per week	4 Hrs.
Minimum weeks per semester	20 (Including Classwork, examination, preparation, holidays etc.)
Effective from	June 2023
Course Objective	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	<ol style="list-style-type: none"> <li>1. Students will learn about various non-linear programming methods and optimization methods.</li> <li>2. Students are able to solve any real-life problems through non-linear</li> </ol>

	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							
Content	<p><b>Unit-1</b>  <b><u>One - Dimensional Non- Linear Programming Methods:</u></b>  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.</p> <p><b>Unit-2</b>  <b><u>Classical Optimization Methods:</u></b>  Unconstraint Optimization, Constrain Multi - Variable Optimization with Equality Constrains, Constrain Multi - Variable Optimization with Inequality Constrains.</p> <p><b>Unit-3</b>  <b><u>Non- Linear Programming Methods:</u></b>  Introduction, General Non - Linear Programming Problems, Graphical Solution Method, Quadratic Programming, Application of Quadratic Programming, Separable Programming.</p> <p><b>Unit-4</b>  <b><u>Geometric Programming:</u></b>  Introduction, Geometric – Arithmetic Mean Inequality, Unconstrained Geometric Programming Problem, Constrained Geometric Programming Problem.</p>							
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,							

Code	PGMTH-4043
------	------------

Cours Title Course	Advanced Integral Transform –II							
Credit	4							
Teaching per week	4 Hrs.							
Minimum weeks per semester	20 (Including Classwork, examination, preparation, holidays etc.)							
Effective from	June 2023							
Purpose of course	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	<p>1.Students will learn about complex Fourier transforms and its properties</p> <p>2. Students will learn about Fourier cosine and sine transforms and its properties</p> <p>3. Students will learn about Finite Fourier, finite Fourier cosine and sine transforms and its properties</p> <p>4. Students should be able to solve partial differential equations by these transforms.</p>							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1							
	CO2							
	CO3							
	CO4							
Content	<p><b>UNIT 1</b> Introduction, Basic concepts and Definitions, The Fourier Integral formulae, Definition of Fourier transforms and examples, Basic properties of Fourier transforms</p> <p><b>UNIT 2</b> Definitions of Fourier Cosine and Sine transforms with examples, Properties of Fourier Cosine and Sine transforms,Evaluation of definite integrals, Solutions of integral equations</p> <p><b>UNIT 3</b> Introduction, Definition of finite Cosine and Sine transforms with examples,Basic properties of finite Fourier Cosine and Sine transforms, Applications of finite Fourier Cosine and Sine transforms</p> <p><b>UNIT 4</b> Applications of Fourier transforms to partial differential equations, Applications of Fourier Cosine and Sine transforms to partial differential equations</p>							
Reference	<p>1) Lokenath Debnath &amp; Dambaru Bhatta: Integral Transforms and their applications, CRC Pub., 1995.</p> <p>2) Ian Sneddon: The use of Integral Transform. TMH Edition,1979.</p> <p>3) B. Davies: Integral Transforms and their applications, Springer - Verlag, 1978.</p> <p>4) M. L. Boss: Mathematical Methods in Physical Sciences, John Wiley &amp; Sons, 1983.</p> <p>5) L. G. Andrews &amp; B. K. Shivamoggi: Integral Transforms for Engineers, PHI, 2003</p>							

Code	PGMTH-4045							
Cours Title Course	Advanced Special functions –II							
Credit	4							
Teaching per week	4 Hrs							
Minimum weeks per semester	20 (Including Classwork, examination, preparation, holidays etc.)							
Effective from	June 2023							
Purpose of course	To introduce the concepts of Laguerre polynomials, Jacobi polynomials and Elliptic functions. To analyze properties of special functions by their integral representations and relations between them.							
Course outcome	<ol style="list-style-type: none"> <li>1. 1.Students learns about Laguerre polynomials and its properties</li> <li>2. Students learns about Jacobi polynomials and its properties,</li> <li>3. Students learns about Elliptic functions and its properties.</li> <li>4. Students will be able to perform operations with orthogonal polynomials, Legendre’s polynomial and Laguerre polynomial along with the corresponding differential equations</li> </ol>							
Mapping between COs with PSOs		PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7
	CO1							
	CO2							
	CO3							
	CO4							
Content	<p><b><u>UNIT-1:</u></b> Laguerre polynomials:The polynomial <math>L_n(X)</math>, Generating functions, Recurrence relations, The Rodrigues formula, The differential equation, Orthogonality, Expansion of polynomials, Special properties, Other generating functions, The simple Laguerre polynomials.</p> <p><b><u>UNIT-2</u></b> The Jacobi polynomials, Bateman’s generating functions, The Rodrigues formula, Orthogonality, Differential recurrence relations, The pure recurrence relations, Mixed relations,</p> <p><b><u>UNIT-3:</u></b> Appell’s functions of two variables, An elementary generating functions,</p>							

	<p>Brafman's generating functions, Expansion in series of polynomials.</p> <p><b>UNIT-4:</b></p> <p>Elliptic functions: Doubly periodic functions, Elliptic functions, Elementary properties, Order of an elliptic function, The Weierstrass function <math>P(Z)</math>, Other elliptic functions, A differential equation for <math>P(Z)</math>, Connection with elliptic integrals.</p>
Reference	<ol style="list-style-type: none"> <li>1 E. D. Rainville, Special Functions, McMillan, New York, 1990.</li> <li>2 I. N. Sneddon, Special functions of Mathematical Physics and Chemistry, Oliver Boyd.</li> <li>3 N. N. Lebedev, Special Functions and their applications, Dover Pub. 1972.</li> <li>4 R. K. Saxena and D. C. Gokhroo, Special Functions, Khanna Pub</li> </ol>