| | |
|---|---|
| Name of Program | **Master of Science in Mathematics** |
| Abbreviation | **M.Sc. Mathematics** |
| Duration | **2 Years** |
| Eligibility Criteria | Bachelor Degree in Mathematics or equivalent Degree. |
| Objective of Program | The core objective of the M.Sc. Mathematics programme is to prepare the students for productive career in Education sector and academia by providing an outstanding environment of teaching and research in the core and emerging areas of the discipline. |
| Program Outcome | 1. Provides knowledge of fundamentals of pure and applied mathematics.<br>2. Provide information about applications of Mathematics to the students that creates the opportunities in education , research centres and industries.<br>3. Provide strong foundation of mathematics to formulate, analyze and problem solving for advanced study and research.<br>4. Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in mathematical sciences.<br>5. Develop need based Mathematics teaching-learning resources.<br>6. Professionally inclined Mathematics educators who have sound knowledge of subject matter and specialized in constructive& alternate pedagogy |
| Program Specific Outcomes | 1. Students will be able to understand the fundamental principles of pure and applied Mathematics.<br>2. Confidence of students will increase in mathematical logic and reasoning ability.<br>3. Explore a newer way of mathematical applications.<br>4. The analytical and theoretical skills applicability ability of students will increase.<br>5. Computing skills for mathematical problem solving will be enhanced.<br>6. Students will be motivated more for research in Mathematics and related fields.<br>7. Students will be inclined towards the preparation of competitive exams like NET, GATE etc. |
| Mapping between POs and PSOs | (see mapping table below) |
| Medium of Instruction | English |

Mapping between POs and PSOs (■ = shaded cell):

| | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 |
|---|---|---|---|---|---|---|---|
| PO1 | ■ | | ■ | | | | ■ |
| PO2 | | ■ | ■ | | ■ | ■ | ■ |
| PO3 | ■ | ■ | | ■ | | ■ | ■ |
| PO4 | ■ | ■ | | | ■ | ■ | ■ |
| PO5 | | | ■ | ■ | | ■ | |
| PO6 | | ■ | ■ | ■ | ■ | | |

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

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

| M. Sc. Sem – III(Mathematics) | | | | | | |
|---|---|---|---|---|---|---|
| Theory Paper/Practical | Teaching schedule Hrs/week | Exam Schedule | | | Total Marks | Credit |
| | | Duration | Internal Marks | External Marks | | |
| Theory papers: | | | | | | |
| **1: Core Paper-I**<br>PGMTH-301:<br>- Functional Analysis-I | 4 | 3 | 30 | 70 | 100 | 4 |
| **2: Core Paper-II**<br>PGMTH-302:<br>Advanced Numerical Analysis | 4 | 3 | 30 | 70 | 100 | 4 |
| **3: Core Paper-III**<br>PGMTH-303:<br>Calculus of Variation | 4 | 3 | 30 | 70 | 100 | 4 |
| **4: Inter/Multi-Disciplinary Elective Paper**<br>PGMTH -3041<br>Fluid Dynamics<br>PGMTH -3042<br>Advanced Operation Research<br>PGMTH -3043<br>Advanced Integral Transforms-I<br>PGMTH -3044<br>Diophantine equations<br>PGMTH -3045<br>Advanced Special Functions-I | 4 | 3 | 30 | 70 | 100 | 4 |
| **5. Practical based on 301 to 304**<br>**PGMTH -305** : Practical | 12 | 10-15 | 50 | 100 | 150 | 6 |
| **6. Skilled based elective** paper / swayam/other moac courses<br>1. **Basic Financial Mathematics**<br>2. **Basics of Data Science**<br>3. **Algorithmic Mathematics**<br>4. **Curve Theory** | 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: | | | | | | |
| **1: Core Paper-I**<br>PGMTH-401-<br>Advanced Functional Analysis -II | 4 | 3 | 30 | 70 | 100 | 4 |
| **2: Core Paper-II**<br>PGMTH-402-<br>Advance Linear Algebra | 4 | 3 | 30 | 70 | 100 | 4 |
| **3: Core Paper-III**<br>PGMTH-403<br>Integral Equations | 4 | 3 | 30 | 70 | 100 | 4 |
| 4: Inter/Multi-Disciplinary **Elective Paper**<br>PGMTH -4041<br>Computational Fluid Dynamics<br>PGMTH -4042<br>Nonlinear Programing<br>PGMTH -4043<br>Advanced Integral Transforms – II<br>PGMTH -4044<br>Partition Theory and CrytographyPGMTH -4045<br>Advanced Special Functions – II | 4 | 3 | 30 | 70 | 100 | 4 |
| **5. Practical based on 401 to 404**<br>PGMTH -405: Practical | 12 | 10-15 | 50 | 100 | 150 | 6 |
| **6. Skilled based elective** paper / swayam/other moac courses<br>(Course can be taken from any faculty)<br>Skilled based elective Papers:<br>**1. Basic Financial Mathematics**<br>**2. Basics of Data Science**<br>**3. Algorithmic Mathematics**<br>**4. Curve Theory** | 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 | 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.<br>2. They will be able to use these theorems to solve problems.<br>3. Ability to handle convergence of series and sequence of functions.<br>4. Ability to differentiate functions in Rn |

Mapping between COs with PSOs

| | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---|---|---|---|---|---|---|
| CO1 | | | | | | |
| CO2 | | | | | | |
| CO3 | | | | | | |
| CO4 | | | | | | |

Course content

**Unit-I**

Algebra of sets, $\sigma$ Algebra, the extended real numbers, Open and closed set of real numbers, Borel sets, Lebesgue outer measure.

**Unit II**

Measurable sets and Lebesgue measure, Non-measurable set, Measurable function, Littlewoods's three principles (only statements).

**Unit-III:**

Riemann integral, Lebesgue integral of a bounded function over a set of finite measure, Bounded convergence theorem, Integral of a non-negative function.

**Unit-IV:**

Fatou's lemma, Monotone convergence theorem, General Lebesgue integral, Lebesgue convergence theorem, Generalized Lebesgue convergence theorem.

**References**

1. H. L. Royden: Real Analysis, Macmillan publication, 1993.

| | |
|---|---|
| | 2. G. de Barra: Measure theory and Integration, Wiley Eastern ltd.1981.<br>3. T. M. Apostol: Mathematical Analysis, Narosa Publishing House, 1985.<br>4. I. P. Natanson: Theory of Functions of real variable, Fredrick Unger pub. 1961. |


<table>
<tr><td>Course Code</td><td>PGMTH-102</td></tr>
<tr><td>Cours Title</td><td>Ordinary  Differential Equations</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per week</td><td>4 Hrs</td></tr>
<tr><td>Minimum weeks per semester</td><td>20 (Including Classwork,examination,preparation,holidays etc.)</td></tr>
<tr><td>Effective from</td><td>June 2022</td></tr>
<tr><td>Purpose of course</td><td></td></tr>
<tr><td>Course objective</td><td>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.</td></tr>
<tr><td>Course outcome</td><td>1. Students learns about differential equations and its classifications.<br>2. Students will be able to classify nature of solutions for the second order linear differential equation, existence of solutions of differential equations.<br>3. Students learns the methodology to solve second order ordinary differential equations.<br>4. Students will understand the concept of method of variation of parameters.<br>5. Students will be able to use the method of Laplace transforms.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td><td>PSO7</td></tr>
<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>
</td></tr>
</table>

| | |
|---|---|
| Course Content | **UNIT-1**<br>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<br>**UNIT-2**<br>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<br>**UNIT-3**<br>Systems of Linear Differential Equations: Introduction, Systems of First Order Equations, Existence and Uniqueness Theorem, Fundamental Matrix<br>**UNIT-4**<br>Non homogeneous Linear Systems, Linear Systems with Constant Coefficients, Linear Systems with Periodic Coefficients |
| Reference | 1. S. G. Deo, V. Lakshmikantham, V. Raghvendra: Text Book of Ordinary Differential Equations (Second Edition), Tata McGraw Hill Pub. Co. Ltd, New Delhi, 1997.<br>2. Coddington E. A., Levinson N.: Theory of Ordinary Differential Equations, Mc Graw Hill, 1955.<br>3. Hartmann P.: Ordinary Differential Equations, John Wiley International, 1964.<br>4. Somasundaram D.: Ordinary Differential Equations, Narosa, 2001.<br>5. Mandal C. R.: Ordinary Differential Equations, PHI,2003.<br>6. Rai B., Freedmanm H. I., Chaudhary D. P.: A Course in Ordinary Differential Equations, Narosa, 2002.<br>7. King A. C., Otto R.,Billingham J.: Differential Equations, Cambridge, 2005. |

| | |
|---|---|
| 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.) |

<table>
<tr><td>Effective from</td><td>June 2022</td></tr>
<tr><td>Purpose of course</td><td></td></tr>
<tr><td>Course objective</td><td>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<br>Topological Spaces, compact spaces and connected spaces.</td></tr>
<tr><td>Course outcome</td><td>1. Students should be able to define topology and its construction.<br>2. Distinguish open and closed subset, Notions of connectedness and compactness.<br>3. Students will learn various properties of compact spaces<br>4. Distinguish Cover, Sub-cover, open cover, Basic and sub-basic open cover<br>5. Topological Spaces, compact spaces and connected spaces.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td></tr>
<tr><td>CO1</td><td style="background:gray"></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO2</td><td style="background:gray"></td><td style="background:gray"></td><td style="background:gray"></td><td></td><td></td><td></td></tr>
<tr><td>CO3</td><td style="background:gray"></td><td></td><td></td><td style="background:gray"></td><td></td><td></td></tr>
<tr><td>CO4</td><td style="background:gray"></td><td></td><td></td><td style="background:gray"></td><td></td><td style="background:gray"></td></tr>
<tr><td>CO5</td><td style="background:gray"></td><td></td><td style="background:gray"></td><td style="background:gray"></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Content</td><td>UNIT-1<br>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.<br>UNIT-2<br>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.<br>UNIT-3<br>Compact space, Continuity and compactness, Finite intersection property, Heine-Borel theorem, Product topology (definition) and projection mapping (definitions), Tychnoff’s theorem (only statement), Locally compact space.<br>UNIT-4<br>Separation Axioms: $T_1$ and $T_2$ Spaces, Regular, completely regular and Normal spaces, Urysohn’s lemma, Tietze’s extension theorem</td></tr>
</table>

| | |
|---|---|
| | (Without proof). |
| **References:** | 1. George F. Simmons: “Introduction to Topology and Modern Analysis”, McGraw-Hill Book Co., 1963.<br>2. James R. Munkres: “Topology: A First Course”, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.<br>3. J. Dugundji: “Topology”, Allyn and Bacon, 1966 (Reprinted in India by Prentice Hall of India Pvt. Ltd.).<br>4. K. D. Joshi: “Introduction to General Topology”, Wiley Eastern Ltd., 1983.<br>5. J. Hocking and G. Young: “Topology”, Addison-Wesley, Reading, 1961. |

# 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 | 1. Students will get comprehensive knowledge of computer programming language.<br>2. Students learns about plotting graph, developing algorithm.<br>3. Students learns about implementation in scientific problem solving techniques.<br>4. Students will be able to solve problems using programming language. |
| Mapping between COs with PSOs | (see table below) |

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

| | |
|---|---|
| Course content | **UNIT 1:**<br>**Introduction**<br>Introduction to Matlab, variable and array, subarrays, displaying output data, data files operationon array, hierarchy of operation on array, built in function in Matlab<br>**UNIT 2:**<br>**Plotting**<br>Introduction to plotting, graph window, two dimensional plot, multiple plot, components ofgraph(legend, title,),graphical image, commet, 3D graph, additional plotting featuresSubplots, polar plots,<br>**UNIT 3:**<br>**Programming** |

<table>
<tr><td></td><td>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.<br>UNIT 4:<br>User defined function<br>Introduction to Matlab functions, variable passing in Matlab(pass by value), preserving databetween calls to functions, sub functions, private function, nested function</td></tr>
<tr><td>Reference</td><td>1. Chapman Stephen: Matlab programming for engineers, Thompson learning, 2004.<br>2. RudraPratap: getting started with Matlab, oxford university press, 2004</td></tr>
</table>

<table>
<tr><td>Course Code</td><td>PGMTH–1042</td></tr>
<tr><td>Cours Title</td><td>Linear Programming</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per week</td><td>4 Hrs</td></tr>
<tr><td>Minimum weeks per semester</td><td>20 (Including Classwork,examination,preparation,holidays etc.)</td></tr>
<tr><td>Effective from</td><td>June 2022</td></tr>
<tr><td>Purpose of course</td><td>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.</td></tr>
<tr><td>Course outcome</td><td>1. Students learns fundamentals of Linear Programming, Dynamic programming, Integer programming and sensitivity analysis.<br>2. Students will be able to convert standard business problems into linear programming problems and can solve using simplex algorithm.<br>3. Students will be able to identify and develop Linear programming problem of operational research models from the verbal description of the real System.<br>4. Students will be able to formulate and solve a linear programming problem by simplex method.<br>5. Students will be able to apply Revised simplex method, Dynamic programming, Branch and Bound Techniques.</td></tr>
<tr><td>Mapping between COs with PSO</td><td><table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td><td>PSO7</td></tr>
<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></td></tr>
<tr><td>Course Content</td><td><u>Linear Programming:</u><br>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.<br><u>Dynamic Programming:</u></td></tr>
</table>

| | |
|---|---|
| | Introduction, Recursive Equation Approach, Characteristic of Dynamic Programming, Solution of Discrete Dynamic Programming Problem, Solution of LPP by Dynamic Programming.<br>**Integer Programming:**<br>Introduction, All and Mixed Integer Programming problems (IPP), Gomory's All- IPP Method, All-IPP Algorithm, The Branch and Bound Techniques.<br>**Post-optimality Analysis:**<br>Sensitivity Analysis, Discrete Change in the Cost-vector, in Requirement-vector and in the Coefficient matrix, Structural Changes in LPP. |
| Reference | 1. Kantiswarup, P.K.Gupta and Manmohan: Operations Research ,Sultan chand and Sons.<br>2. S.D. Sharma: Operations Research, KedarNath, Ram Nath& Co.<br>3. S. S. Rao: Optimization Theory and Applications, Wiley Eastern, 1984.<br>4. J. K. Sharma: Operation Research: Theory and Applications, Macmillan India Ltd., Third Edition, 2007. |

| | |
|---|---|
| Course Code | PGMTH–1043 |
| Cours Title | Integral Transforms-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 practice of solving the real problem in scientific way using techniques of various types of Transforms. To gain command of using the transform, both specific techniques and general principles. |
| Course outcome | 1. Students will learn about the concepts of Laplace Transforms, Inverse Laplace Transforms, Finite Laplace Transforms.<br>2. Students learns about applications of Laplace transforms.<br>3. Students will be able to solve the Ordinary and Partial differential equations using Laplace transforms.<br>4. Students will be able to solve initial and boundary value problems and integral equations |
| Mapping between COs with PSOs | (see table below) |

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

| | |
|---|---|
| Content | **UNIT-1: Laplace Transforms:**<br>• Introduction and definition of Laplace transforms with examples |

| | |
|---|---|
| | • Existence condition for Laplace transforms<br>• Basic properties of Laplace transforms<br>• The convolution theorem and properties of convolution<br>**UNIT-2 Laplace Transforms:**<br>• Differentiation and integration of Laplace transforms<br>• The inverse Laplace transforms and examples<br>• Tauberian theorem<br>• Watson's lemma<br>**UNIT-3 Finite Laplace Transforms:**<br>• Introduction<br>• Definition of finite Laplace transforms and examples<br>• Basic operational properties of finite Laplace transforms<br>• Applications to Finite Laplace Transforms<br>• Tauberian theorems<br>**UNIT-4 Applications of Laplace Transforms**<br>• Applications of Laplace transforms to ordinary differential equations<br>• Applications of Laplace transforms to partial differential equations<br>• Initial and boundary value problems<br>• Solutions to Integral equations |
| Reference | 1) Lokenath Debnath: Integral Transform and their applications, CRC Pub., 1995.<br>2) Ian Sneddon: The use of Integral Transform. TMIH, 1979.<br>3) B. Davies: Integral Transforms and their applications, Springer - Verlag, 1978.<br>4) Boss M. L.: Mathematical Methods in Physical Sciences, John Wiley & Sons, 1983.<br>5) Andrews, L. G. &Shivamoggi B. K.: Integral Transforms for Engineers, |

| | |
|---|---|
| | PHI, 2003. |

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|---|---|
| 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 | 1. Students will learn about Primitive roots and Indices<br>2. Students will be able to understand the logic of the Quadratic Reciprocity Low,<br>3. Students learns about Fibonacci numbers and its various properties.<br>4. Students will be able to solve various problems and prove various theorems of number theory. |
| Mapping between COs with PSOs | (see table below) |

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

| | |
|---|---|
| Content | **Unit I: Primitive Roots**<br>The order of an integer modulo $n$, Primitive roots for primes, Composite numbers having primitive roots.<br>**Unit II: Indices and Quadratic Congruence**<br>The theory of indices, Solution of the congruences of the type $ax^n \equiv b \ (mod\ p)$ and $x^n \equiv a \ (mod\ n), \gcd(a, n) = 1$.<br>Quadratic Congruence, Euler's criterion, Quadratic residues.<br>**Unit III: Quadratic Congruence**<br>The Legendre symbol and its properties, Gauss' Lemma, Law of quadratic reciprocity, Quadratic residues and primes, Quadratic congruence with composite moduli.<br>**Unit IV: Numbers of special forms**<br>Perfect numbers, Mersenne primes, Amicable numbers, Fermat numbers, Fibonacci numbers. |
| Reference | 1. David M. Burton: Elementary Number Theory, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 7th edition, 2012. |

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|---|---|
| | 2. S. G. Talang: Number Theory, The Tata McGraw Hill Co. Ltd., New Delhi.<br>3. Neville Robbins: Beginning Number Theory, Narosa Pub. House, New Delhi, 2nd Ed., 2006.<br>4. I. Niven, S. Zuckerman, L. Montgomery: An Introduction to the Theory of Numbers, 6th edition, John Wiley and Sons, Inc., New York, 2003.<br>5. George Andrews: Number Theory, The Hindustan Pub. Corp., New Delhi. |

| | |
|---|---|
| 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 | 1. Students understands the fundamentals concept of infinite product, Gamma and Beta functions with properties.<br>2. Students understands the structure of the Gamma and Beta functions,<br>3. Gamma function, Beta function and special functions are used to evaluate different types of integral calculus problems<br>4. Students will get profound knowledge of Hypergeometric function and its properties.<br>5. Students will be able to give the rigorous proof of various theorems.. |
| Mapping between COs with PSOs | (see mapping table below) |
| Content | **UNIT-1**<br>Definition of an Infinite product, A necessary condition for convergence, The associated series of logarithms, Absolute convergence, Uniform convergence.<br>**UNIT-2:** |

Mapping between COs with PSOs (■ = shaded cell):

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

| | |
|---|---|
| | The Euler or Mascheroni constant γ, The Gama function, A series for (*z*)′ (*z*) ,Evaluation of (1) and (1)′, The Euler product for (*z*) , The difference equation (*z* +1) = *z* (*z*), The order symbols o and 0, Evaluation of certain infinite products, Euler integral for (*z*) ,<br>**<u>UNIT-3</u>**<br>TheBeta function, The value of (*z*) (1− *z*), The factorial function, Legendre's duplication formula,Gauss' multiplication theorem, A summation formula due to Euler, The behaviour of log(*z*) for large z .<br>**<u>UNIT-4</u>:**<br>The function F(a, b; c; z), A simple integral form, F(a, b; c; 1) as a function of theparameters, Evaluation of F(a, b; c; 1), the contiguous function relations, The hypergeometricdifferential equation, Logarithmic solutions of the hypergeometric equation, F(a, b; c; z) as afunction of its parameters, Simple transformations, Relation between functions of Z and 1-Z, Aquadratic transformation, other quadratic transformations, a theorem due to Kummer, Additional properties. |
| **Reference:** | 1. E. D. Rainville, Special Functions, McMillan, New York, 1990.<br>2. I. N. Sneddon, Special functions of Mathematical Physics and Chemistry, Oliver Boyd.<br>3. N. N. Lebdev, Special Functions and their applications, Dover Pub. 1972.<br>4. R. K. Saxena and D. C. Gokhroo, Special Functions, Khanna Pub. |

# 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 | 1. Summarize concepts of field theory to enhance ability of analysing pure and applied mathematical problems.<br>2. Students should be able to play around fields and field extensions in a mathematical mature way.<br>3. They will also be able to appreciate role of algebra in solving some old classical problems of algebra.<br>4. Distinguish between Extension fields and Finite extension field and splitting fields<br>5. Distinguish between Algebraic extension, Algebraic number.<br>6. Student will be able to: Demonstrate Field extensions and characterization of finite normal extensions as splitting fields and study prime fields. |

Mapping between COs with PSOs

| | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 |
|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | |
| CO2 | | | | | | | |
| CO3 | | | | | | | |
| CO4 | | | | | | | |
| CO5 | | | | | | | |
| CO6 | | | | | | | |

Content

**Unit-I**

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

**Unit II**

Polynomial rings, Primitive polynomials, Guass's lemma, the Eisenstein

| | |
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| | criterion, polynomial rings over commutative rings, unique factorization domain.<br>**Unit-III**<br>Extension fields, Finite extension field, Algebraic extension, Algebraic number, Roots of polynomials.<br>**Unit-IV**<br>Splitting fields, Uniqueness of Splitting fields, Construction with straightedge and compass, More about roots, Simple extension. |
| **Reference** | 1. I. N. Herstein: Topics in Algebra 4thEd., John Wiley Sons.<br>2. P. B. Bhattacharya, S. K. Jain, S. R. Nagpaul: Basic Abstract Algebra, 2nd Ed., Cambridge University Press.<br>3. Artin M.: Algebra, Prentice Hall, Englewood, Cliffs NJ.<br>4. J. A. Gallian: Contemporary Abstract Algebra, Narosa Publishing House. |

| | |
|---|---|
| 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 | 1. In this course students will learn the algebra and geometry of complex numbers.<br>2. Students will be able to check differentiability and the analyticity of complex valued function.<br>3. Student learns about Cauchy-Riemann relations and harmonic functions.<br>4. Student learns about Cauchy integral formula, general form of Cauchy theorem.<br>5. Understand the concepts of Fundamental theorem of Algebra, Maximum module Principle.<br>6. Understand Contour integrals related theorem and Examples |
| Mapping between COs with PSOs | |

| | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---|---|---|---|---|---|---|
| PO1 | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| PO2 | | | | | | |
| PO3 | | | | | | |
| PO4 | | | | | | |
| PO5 | | | | | | |
| PO6 | | | | | | |

Content

**UNIT-1**

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

**UNIT-2**

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.

**UNIT-3**

Series Expansions: Power Series, Uniform convergence of power series, Taylor series, Zeros of Analytic functions, Laurent Series

**UNIT-4**

Singularities and Residues: Classification of Singularities, Residues, Poles and Zeros,Behavior of functions and infinity, Meromorphic functions, Open mapping theorem

**References:**

.H. S. Kasana: “Complex Variables – Theory and Applications”, 2nd Edition (2005), PHI Learning Private Limited, Delhi.

2. J. N. Sharma: “Functions of a Complex Variable”, Krishna Prakashan, 2000.

3. S. Ponnuswamy: “Foundation of Complex Analysis”, Narosa Publishing House, 1997.

4. S. Lang: “Complex Analysis”, Addition Wesley, 1997.

5. H. A. Priestly: “Introduction to Complex Analysis”, Clarendon Press, 1990.

6. J. B. Conway: “Functions of one Complex Variable”, Springer-Verlag, 1980.

| | |
|---|---|
| Code | PGMTH–203 |
| Cours Title Course | Partial Differential Equation |

<table>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per week</td><td>4 Hrs</td></tr>
<tr><td>Minimum weeks per semester</td><td>20 (Including Classwork,examination,preparation,holidays etc.)</td></tr>
<tr><td>Effective from</td><td>June 2022</td></tr>
<tr><td>Purpose of course</td><td>To introduce first and second order partial differential equations and their classifications and methods of finding solutions of these partial differential equations.</td></tr>
<tr><td>Course outcome</td><td>
1. Students learns about the Paffian differential equations and its applications.<br>
2. Students learns about integral surfaces passing through a given curve, surfaces orthogonal to a given system of surfaces.<br>
3. Students learns about nonlinear partial differential equations of the first order, compatible systems of first-order equations, Charpit'smethod, Jacobi's method.<br>
4. Students studies about applications of separation of variable method.<br>
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.
</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td><td>PSO7</td></tr>
<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>
</td></tr>
<tr><td>Content</td><td>
UNIT-1<br>
Ordinary Differential Equations in More than Two Variables:<br>
Surfaces and Curves in Three Dimensions, Simultaneous Differential Equations of the First Order and the First Degree in Three Variables, Methods of Solutions of $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$ , Orthogonal Trajectories of a System of Curves on a Surface, Pfaffian Differential Forms and Equations, Solution of Pfaffian Differential Equations in Three Variables.<br>
UNIT-2<br>
Partial Differential Equations of the First Order:<br>
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,<br>
UNIT-3<br>
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.<br>
UNIT-4<br>
<u>Partial Differential Equations of the Second Order</u>:
</td></tr>
</table>

| | |
|---|---|
| | Linear Partial Differential Equations with Constant Coefficients, Equations with Variable Coefficients, Separation of Variables, Nonlinear Equations of the Second Order. |
| Reference | 1. Sneddon I.N.: Elements of Partial Differential Equations, McGraw Hill, International Editions, 1957<br>2. ZafarHasan: Differential Equations and their applications, Second Edition, PHI, 2009.<br>3. IyengarS.N.:Differential Equations, Anmol Publications, 2000<br>Sharma, Gupta: Differential Equations, Krishna Prakashan Media, 1997- 98. |

# 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 | 1. Students learns about the concept of mathematical modelling and its applications.<br>2. Students learns about the advantages and disadvantages of models<br>3. Students will be able to derive first and second order models.<br>4. Students will be able to analyse the real life problems through mathematical modelling. |

Mapping between COs with PSOs

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

Content

## **UNIT -1: Introduction to Mathematical modelling**

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

## **UNIT -2: Model of Linear Algebra**

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

## **UNIT -3: First Order Models**

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

## **UNIT -4: Second Order Models**

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

| | |
|---|---|
| Reference | 1. J.N.Kapur: Mathematical Modelling, Wiley eastern Ltd., 1994.<br>2. M.M. Gibbons: A concrete approach to Mathematical Modeling, John Wileyand sons, 1995.<br>3. H. Neunzert and A.H. Siddiqui: Topics in Industrial Mathematics, KluwerAcademic Publishers, London, 2000<br>4. P. E. Wellstead : Introduction to Physical System Modeling, Academic Press,1979.<br>5. Richard Haberman: Mathematical Models, Practice- Hall Inc., NJ, 1979. |

<table>
<tr><td>ode</td><td>PGMTH–2042</td></tr>
<tr><td>Cours Title Course</td><td>Operation Reserch</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per week</td><td>4 Hrs</td></tr>
<tr><td>Minimum weeks per semester</td><td>20 (Including Classwork,examination,preparation,holidays etc.)</td></tr>
<tr><td>Effective from</td><td>June 2020</td></tr>
<tr><td>Purpose of course</td><td>To enhance problem solving skills of linear programming problems. To provide knowledge of theory of inventory control, PERT-CPM, Transportation problems.</td></tr>
<tr><td>Course outcome</td><td>1. Students will be able to identify inventory problem & solve it by PERT-CPM technique, Transportation problem and simulations.<br>2. The student will be able to formulate and solve the Transportation problem.<br>3. The student will be able to solve LPP by PERT-CPM method.<br>4. Students should be able to explore various Mathematical programming algorithms to solve real life problems.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td><td>PSO7</td></tr>
<tr><td>CO1</td><td bgcolor="#4472C4"></td><td></td><td></td><td></td><td></td><td></td><td bgcolor="#4472C4"></td></tr>
<tr><td>CO2</td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td></td><td></td><td></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td></tr>
<tr><td>CO3</td><td bgcolor="#4472C4"></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>CO4</td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td></td><td bgcolor="#4472C4"></td><td bgcolor="#4472C4"></td><td></td></tr>
</table>
</td></tr>
<tr><td></td><td><u>Inventory Control:</u> 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.</td></tr>
</table>

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|---|---|
| | **PERT – CPM:**<br>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.<br>**Simulation:**<br>Introduction, Why Simulation, Methodology of Simulation, Generation of Random Numbers.<br>**Theory of Games**<br>Revision: Two-person zero-sum game, Pure strategies, Mixed Strategies.<br>The rules of dominance, Solution methods for Games without Saddle point: Algebraic method, Arithmetic method, Matrix method, Linear Programming method. |
| Reference | 1. Operations research by KantiSwarup, P.K.Gupta and Nan Mohan. S.Chand& Sons, New Delhi. Seventh Edition, 1994.<br>2.Operation Research: Theory and Applications by J. K. Sharma, Macmillan India Ltd., Third Edition, 2007.<br>3. Operations Research by S.D. Sharma. KedarnathRamnath Pub.1998. Merrut.<br>4. Optimization Methods in Operation Research and System Analysis by K. V. Mittal and C. Mohan, New Age International Publishers, Third Edition, 1996. |

| | |
|---|---|
| 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 | 1. Students will be able to learn about Hankel transform, Finite Hankel transforms<br>2. Students learns about Hilbert and Stieltjes transforms.<br>3. Students will be able to learn applications of all these transformations. |

4. Students will be able to solve the partial differential equations using Hankel transforms.
5. Students will be able to solve differential equations using Hilbert and Stieltjes transforms.

**Mapping between COs with PSOs**

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

**Content**

Unit-I:

Hankel Transforms: Introduction and definition of Hankel transform, examples on Hankel transform, Operational properties of the Hankel transform.

Unit-II:

Finite Hankel Transforms: Introduction and definition of the finite Hankel transforms. finite Hankel transforms of some elementary functions, basic operational properties with examples.

Unit-III:

Application Hankel transforms:Application of Hankel transforms to partial differential equations, Applications of finite Hankel transforms.

Unit-IV:

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.

**Reference**


1) Lokenath Debnath: Integral Transform and their applications, CRC Pub., 1995.

2) Ian Sneddon: The use of Integral Transform. TMIH, 1979.

3) B. Davies: Integral Transforms and their applications, Springer - Verlag, 1978.

4) Boss M. L.: Mathematical Methods in Physical Sciences, John Wiley & Sons, 1983.

5) Andrews, L. G. &Shivamoggi B. K.: Integral Transforms for Engineers, PHI, 2003.

| | |
|---|---|
| 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 | 1. Students know about Arithmetic functions, Dirichlet multiplication and elementary theorems on Prime numbers.<br>2. Students are able to analyze the number theoretic problems. |

Mapping between COs with PSOs

| | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 |
|---|---|---|---|---|---|---|---|
| CO1 | ■ | | | ■ | | | |
| CO2 | ■ | ■ | | | ■ | | |
| CO3 | ■ | | ■ | ■ | | ■ | |

**Unit I: Arithmetical functions and Dirichlet multiplication**

Basic introduction of the Möbius function $\mu(n)$ and the Euler totient function $\phi(n)$, relation connecting $\mu$ and $\phi$.

The Dirichlet product of two arithmetical functions (a.f.) and group structure w.r.t. this product, the Mangöldt function $\Lambda(n)$, Multiplicative a.f., the inverse of a completely multiplicative a.f.

**Unit II: Dirichlet multiplication and averages of Arithmetical functions**

Liouville's function $\lambda(n)$, the divisor functions $d(n)$ and $\sigma_\alpha(n)$, the generalized convolutions.

The big oh notation, Euler's summation formula, some elementary asymptotic formulas, the average order of divisor functions $d(n)$ and $\sigma_\alpha(n)$, the average order of functions $\phi(n), \mu(n), \Lambda(n)$.

**Unit III: Averages of Arithmetical Functions and Chebyshev's functions**

Distribution of lattice points visible from the origin, the partial sums of a Dirichlet product, applications to $\mu(n)$ and $\Lambda(n)$.

Chebyshev's functions $\psi(x)$ and $\vartheta(x)$, relation between $\psi(x), \pi(x)$ and $\vartheta(x)$, Abel's identity.

**Unit IV: Elementary theorems on the distribution of prime numbers**

Equivalent forms of prime number theorem, lower and upper bounds for $\pi(n)$

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|---|---|
| | and $p_n$ , Shapiro's Tauberian theorem and its applications, an asymptotic formula for the partial sums $\sum_{p \le x} \left(\frac{1}{p}\right)$, the partial sums of function $\mu(n)$. |
| **References** | 1. Tom M. Apostol: Introduction to Analytic Number Theory, Narosa Pub. House, New Delhi, 1998 Ed.<br>2. Mc Carthy P. J.: Introduction to Arithmetical function, Springer-Verlag, New York, 1986.<br>3. K. Chandrashekharan: Introduction to Analytic Number Theory, Springer-Verlag, New York, 1968.<br>4. Hua L. K.: Introduction to Number Theory, Springer-Verlag, New York, 1982. |

| | |
|---|---|
| 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 | 1. Students learns about orthogonal polynomials and its properties.<br>2. Students learns about Legendre polynomials and its properties.<br>3. Students learns about Hermite polynomials and its properties. |

4. Students will be able to prove the rigorous proof of various theorems.

**Mapping between COs with PSOs**

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

**Content**

**UNIT-1:**

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.

**UNIT-2:**

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,

**UNIT-3:**

Hypergeometric forms of Pn(X), Brafman's generating functions, Special properties of Pn(X), More generating functions, Laplace's first integral form, Some bounds on Pn(X), Orthogonality, An expansion theorem, Expansion of $X^n$ , Expansion of analytic functions,

**UNIT-4:**

Hermite polynomials: Definition of Hn(x), Recurence relations, The Rodrigues formula, Othergenerating functions, Integrals, The Hermite polynomial as a ${}_2F_0$ , Orthogonality, Expansion of polynomials, More generating functions.

**Reference:**

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

# 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 unctional Analysis namely normed spaces, bounded linear functionals, and study their applications and also to introduce fundamental results in Functional Analysis namely Hahn-Banach Theorem, open mapping theorem and closed graph theorem and study their applications. |
| Course Outcomes | 1. Students learns the properties of Banach spaces,<br>5. Students learns normed spaces and inner product spaces<br>6. Students learns linear operators, bounded linear operator.<br>7. Students learns difference between finite and infinite dimensional space, Banach space and Hilbert space<br>8. Student will be able to compute the dual spaces of certain Banach spaces.<br>9. Student will able to appreciate the power classical result of functional Analysis. |
| Mapping between COs with PSOs | (see table below) |

| | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---|---|---|---|---|---|---|
| CO1 | | | | | | |
| CO2 | | | | | | |
| CO3 | | | | | | |
| CO4 | | | | | | |

**Content**

**Unit- 1**

Metric Space, Further Examples of Metric Spaces, Completeness, Examples, Completeness proofs, Completion of Metric Spaces

**Unit-2**

Vector Space, Normed Space, Banach Space, Further properties of Normed Spaces, Finite Dimensional Normed Spaces and Subspaces, Compactness and Finite Dimension, Linear Operators

**Unit-3**

Bounded and Continuous Linear Operators, Linear Functionals, Linear Operators and Functionals on Finite Dimensional Spaces, Normed Spaces of Operators, Dual space

**Unit-4**

Inner Product Space, Hilbert Space, Properties of Inner Product Spaces, Orthogonal Complements and Direct Sums, Orthogonal Sets and Sequences

| | |
|---|---|
| **References:** | 1. E. Kreyszig: Introductory Functional Analysis with applications, John Wiley and Sons.<br>2. B.V. Limaye: Functional Analysis, New Age International Limited, Publishers<br>3. G.F. Simmons: Introduction to Topology and Modern Analysis, Tata McGraw - Hill.<br>4. A. R. Vashistha & J.N. Sharma: Functional Analysis, Krishna Prakashan Media (P) Ltd |

| | |
|---|---|
| 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 | 6. Students will learn about Iteration method based on second degree equation and rate of convergence.<br>7. Students should be able solve system of algebraic equations and eigen value problems<br>8. Students can learn about numerical differentiation and Newton-cotes method of Integration.<br>9. Understand the concept Initial and boundary value problem of ordinary differential equations. |

Mapping between COs with PSOs

| | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---|---|---|---|---|---|---|
| CO1 | | | | | | |
| CO2 | | | | | | |
| CO3 | | | | | | |
| CO4 | | | | | | |
| CO5 | | | | | | |

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|---|---|
| Content | **<u>UNIT-I</u>**<br>**Transcendental and Polynomial Equations**<br>Direct Methods (Introduction) , Iterative Methods (Muller Method, Chebyshev Method), Rate of convergence (Definition), First and second order General Iteration Methods<br>**System of Linear Algebraic Equations**<br>Introduction, Direct Methods (Cramer Rule, Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization Method), Iteration methods (Jacobi Iteration Method, Gauss-Seidel Iteration Method)<br><br>**<u>UNIT-2</u>**<br>**Eigen values Problems**<br>Eigen values and Eigenvectors, Jacobi method for symmetric matrices, Power method, Inverse power method.<br>**Numerical differentiation**<br>Methods based On Interpolation (Non-uniform Nodal Points, Uniform Nodal Points), Optimum Choice of Step Length<br><br>**<u>UNIT-3</u>**<br>**Numerical Integration**<br>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)<br><br>**<u>UNIT-4</u>**<br>**Numerical Solution of Ordinary Differential Equations:**<br>**Initial Value Problem,** Single step methods (Explicit Runge-Kutta Methods)<br>**Boundary Value Problem** Finite Difference Methods: linear Second Order Differential Equations, Solution of Tridiagonal System |
| **References:** | 1. M. K. Jain, S. R. K. Iyenger, R. K. Jain: "Numerical Methods for scientific and engineering computations", VI – edition, New Age International Publishers<br>2. Philips and Taylor: "Theory and Applications of Numerical Analysis Academic Press", 1996<br>3. Gourdin and Boumhart: "Applied Numerical Analysis", P.H.I., 1996<br>4. A. S. Householder: "Theory of Matrices in Numerical Analysis", Blarsedell - New York.<br>5. Jacques and Colin: "Numerical Analysis", Chapman & Hall, New-York, 1987. |

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|---|---|
| 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**

1. Students will learn about the concept of Variations and itsproperties,
2. Functionals and its properties
3. Study Variational problem with a movable boundary for afunctional dependent on two functions,
4. Students learn One-Sided Variations,Reflection and Refractionafter successful completion of the course

**Mapping between COs with PSOs**

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

**Content**

**UNIT-I**

**Variational Problems with Fixed Boundaries:**

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

**UNIT-II**

**Functionals**

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

**UNIT-III**

**Variational Problems with Moving Boundaries:**

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

**UNIT-IV**

**Sufficient Conditions for an Extremum:**

Field of Extremals, Jacobi Condition, Weir strass Function, Legendre Condition, Second Variation, Canonical Equations and Variational Principles, Complementary Variational Principles.

**References**


1. A.S. Gupta:"Calculus of Variations with Applications", Prentice Hall of India Pvt. Ltd., New Delhi.
2. Robert Weinstock: "Calculus of Variations with Applications to physics".

| | |
|---|---|
| | 3. ElsGok L. D.: "Calculus of Variation".<br>4. Mariano Giaquinta, Stefan Hildebrandt:Calculus of Variations-I", Springer Science & Business Media,2004 |


# 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 | 1. Students will learn about basic fundamentals of fluiddynamics such as Conservation Laws, Conservation ofmass, momentum and energy.<br>2. Distinguish One dimensional, two dimensional and threedimensional flow.<br>3. Student will learn about Bernoulli Equation, Potentialequation, Reynold's transport theorem, Navier-stokesequation.<br>4. They familiar with the fluid statics, kinematics of fluidand dynamics of fluid.<br>5. Enhance ability of analysing mathematical problemsrelated to Fluid dynamics. |
| Mapping between COs with PSOs | (see mapping table below) |
| Content | UNIT I<br>Vector Concept of Fluid Dynamics<br>Scalar and vector properties, cross product and dot product of vectors, magnitude and direction of a vectors, gradient, curl and divergent operators,<br><br>UNIT II:<br>Fluid Statics<br>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<br><br>UNIT III<br>Kinematics of fluid<br>Flow descriptions (Lagrangian, Eulerian, Material derivative), Motion of Fluid particles |

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

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|---|---|
| | (rate of dilation, rate of shear, rate of rotation), Uniform flow, non-uniform, steady, unsteady flow, One, two and Three Dimensional Flow, Rotational and irrational flow, Laminar and turbulent flow, Line of flow (Stream line, Path line, Strake line, Time line)<br><br>UNIT IV<br>Dynamics of fluid<br>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 |
| **Reference** | 1. Batchelor G.K.: An Introduction to Fluid Dynamics, Cambridge University Press,1999.<br>2. Emanuel G: Analytical Fluid Dynamics, CRC Press, Boca Raton, Second Edition, FL, 1999.<br>3. Panton R.L., Incompressible Flows, Wiley Interscience, 1984<br>4. Currie I.G.: Fundamental Mechanics of Fluids, McGraw-Hill, New-york, 1993.<br>5. Chorin: Mathematical introduction to Fluid Mechanics, Springer Verlag, Fourth |

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|---|---|
| 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 | 1. Students will learn about Queuing theory related problems<br>2. Students will learn about sequencing problems and its solution process<br>3. Students will learn about Theory of replacement and its utilities<br>4. Students will learn about Games and strategies and its applications<br>5. Students are able to formulate and analyse the real world problems. |
| Mapping between COs with PSOs | |

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

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| | CO5 |
| Content | **Unit I**<br>**Queuing Theory:**<br>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.<br>**Unit II**<br>**Sequencing Problems:**<br>Problems of Sequencing, Problems with n-jobs and 2-machines, Problems with n-jobs and 3-machines, Problems with n-jobs and m-machines.<br>**Unit III**<br>**Theory of Replacement:**<br>Introduction, Replacement of Equipment that Deteriorate Gradually, Replacement of Equipment that Fails completely, Other Replacement Problems.<br>**Unit IV**<br>**Information Theory**<br>Introduction, Communication Processes, A Measure of Information, Measure of other Information Quantities, Channel Capacity, Efficiency and Redundance. |
| **References:** | **References:**<br>1. Kantiswarup, P.K.Gupta and Manmohan: Operations Research ,Sultan chand and Sons.<br>2. S.D. Sharma: Operations Research, KedarNath, Ram Nath& Co.<br>3. S. S. Rao: Optimization Theory and Applications, Wiley Eastern, 1984.<br>4. J. K. Sharma: Operation Research: Theory and Applications, Macmillan India Ltd., Third Edition |

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|---|---|
| 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.<br>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**

Unit-I:

Introduction, Definition of the Z- transforms and examples, Basic operational properties of Z transform, Summation of Infinite series.

Unit-II:

The inverse Z-transform and examples,Applications of Z-transforms to Finite Difference Equations

Unit-III:

Introduction, Definition of Mellin transforms and examples. Basic operational properties of Mellin Transforms.

Unit-IV:

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

**Reference :**


1. Lokenath Debnath: Integral Transform and their applications, CRC Pub., 1995.
2. Ian Sneddon: The use of Integral Transform. TMIH, 1979.
3. B. Davies : Integral Transforms and their applications, Springer - Verlag, 1978.
4. Boss M. L.: Mathematical Methods in Physical Sciences, John Wiley & Sons, 1983.
5. Andrews, L. G. & Shivamoggi B. K.: Integral Transforms for Engineers, PHI, 2003.

<table>
<tr><td>Code</td><td>PGMTH–3044</td></tr>
<tr><td>Cours Title Course</td><td>Diophantine equations</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per week</td><td>4 Hrs.</td></tr>
<tr><td>Minimum weeks per semester</td><td>20 (Including Classwork, examination, preparation, holidays etc.</td></tr>
<tr><td>Effective from</td><td>June 2023</td></tr>
<tr><td>Course Objective</td><td>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.</td></tr>
<tr><td>Course outcome</td><td>1. Students learns about continued fractions.<br>2. Students learns about various linear and quadratic Diophantine equations and its properties.<br>3. Students learns about representation of integers as sums of squares and its applicability.<br>4. Enhance the logical ability of the students.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td><td>PSO7</td></tr>
<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>
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</td></tr>
<tr><td>Content</td><td>Unit I:<br>Continued fractions:Simple continued fractions, finite and infinite continued fractions, uniqueness,representation of rational and irrational numbers as simple continued fractions, rational approximation to irrational numbers.<br><br>Unit II:<br>Diophantine equations: Diophantine equation $ax + by = c$ and its positive solutions, Pell's equation, Fundamental solutions, Solution of Pell's equation using Continued fraction<br><br>Unit III:<br>Fermat's equation:Diophantine equations $x^2 + y^2 = z^2$ and its solutions, Fermat's equation$x^n + y^n = z^n$ for the cases $n = 3, 4$, Fermat's Last Theorem.<br><br>Unit IV:<br>Representation of integers as sum of squares: Necessary and</td></tr>
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| | sufficient conditions for a positive integer to be represented as the sum of two squares, Fermat's theorem, positive integers represented as difference of two squares, integers that are not expressible as the sum of three squares, Euler's identity, primes represented as the sum of four squares, Lagrange's theorem. |
| Reference | 1. David M. Burton: Elementary Number Theory, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 7th edition, 2012.<br>2. S. G. Talang: Number Theory, The Tata McGraw Hill Co. Ltd., New Delhi, 5th reprint, 2004.<br>3. S. K. Pundir, R. Pundir: Theory of Numbers, Pragati Prakashan, Meerut, 6th edition, 2019.<br>4. Neville Robbins: Beginning Number Theory, Narosa Pub. House, New Delhi, 2nd edition, 2006.<br>6. George Andrews: Number Theory, The Hindustan Pub. Corp., New Delhi. |
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<table>
<tr><td>Code</td><td>PGMTH–3045</td></tr>
<tr><td>Cours Title Course</td><td>Advance Special Function –I</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per week</td><td>4 Hrs.</td></tr>
<tr><td>Minimum weeks per semester</td><td>20 (Including Classwork, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective from</td><td>June 2023</td></tr>
<tr><td>Course Objective</td><td>To introduce the concepts of Generalized Hypergeometric functions, about Bessel Functions, Generating functions and analyze properties of special functions.</td></tr>
<tr><td>Course outcome</td><td>1.Students learns generalized Hypergeometric functions.<br>2. Students learns Bessel functions and its various properties,<br>3. The Confluent Hypergeometric function and its application.<br>4. Students understands the concept of Generating functions and its utilization</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td><td>PSO7</td></tr>
<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>
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<tr><td>Effective from</td><td>UNIT-1 :</td></tr>
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| | **GENERALIZED HYPERGEOMETRIC FUNCTIONS:**<br>The function pFq , The exponential and binomial functions, A differential equation, Other solutions of the differential equation, The contiguous function relations, A simple integral,ThepFq with unit argument, Saalschutz' theorem, Whipple's theorem, Dixen'stheorem,Contour integrals of Barns' type, The Berns' integrals and the function pFq , A useful integral.<br>**UNIT-2 :**<br>**BESSEL FUNCTIONS:**<br>Remarks, Definition of Jn(z), 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.<br>**UNIT-3 :**<br>**THE CONFLUENT HYPERGEOMETRIC FUNCTION:**<br>Basic properties of the $_1F_1$ ,Kummer's first formula, Kummer's second formula.<br>**UNIT-4 :**<br>**GENERATING FUNCTIONS:**<br>The generating function concept, Generating functions of the form G ($2xt - t^2$), setsgenerated by $et\ \psi$ (xt), the generating functions $A(t)\ \exp(-xt(1-t))$, another class of generating functions, Boas and Buck generating functions, An extension. |
| **Reference:** | 1. E. D. Rainville, Special Functions, McMillan, New York, 1990.<br>2. I. N. Sneddon, Special functions of Mathematical Physics and Chemistry, Oliver Boyd.<br>3. N. N. Lebdev, Special Functions and their applications, Dover Pub. 1972.<br>4. R. K. Saxena and D. C. Gokhroo, Special Functions, Khanna Pub. |

**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 | 1. Summarize concepts of field theory to enhance ability of analysing pure and applied mathematical problems.<br>2. students should be able to play around fields and field extensions in a mathematical mature way.<br>3. They will also be able to appreciate role of algebra in solving some old classical problems of algebra.<br>4. Distinguish between Extension fields and Finite extension field and splitting fields<br>5. Distinguish between Algebraic extension, Algebraic number.<br>6. the student will be able to: Demonstrate Field extensions and characterization of finite normal extensions as splitting fields and study prime fields. |
| Mapping between COs with PSOs | (see table below) |
| Content | **Unit-1**<br>Total Orthonormal Sets and Sequences, Representation of Functionals on Hilbert Spaces, Hilbert-Adjoint Operator, Self-Adjoint, Unitary and Normal Operators<br>**Unit-2**<br>Zorn's Lemma, Hahn-Banach theorem, Hahn-Banach theorem for Complex Vector Spaces and Normed Spaces, Adjoint Operator |

| | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---|---|---|---|---|---|---|
| PO1 | | | | | | |
| PO2 | | | | | | |
| PO3 | | | | | | |
| PO4 | | | | | | |
| PO5 | | | | | | |
| PO6 | | | | | | |

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|---|---|
| | **Unit-3**<br>Reflexive Spaces, Category Theorem and Uniform Boundedness Theorem, Strong and Weak Convergence<br>**Unit-4**<br>Convergence of Sequences of Operators and Functionals, Open Mapping Theorem, Closed Linear Operators, Closed Graph Theorem, Banach Fixed Point Theorem |
| Reference | 1. E. Kreyszig: Functional Analysis and its application, John Wiley and sons.<br>2. B.V. Limaye: Functional Analysis, New Age International Limited, Publishers<br>3. G.F. Simmons: Introduction to Topology and Modern Analysis, Tata McGraw - Hill.<br>4. A. R. Vashistha & J.N. Sharma: Functional Analysis, Krishna Prakashan Media (P) Ltd. |

| | |
|---|---|
| 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, Lineartransformation, Real Quadratic forms. To provide framework todeal with analytical and geometrical problems. To apply theconcepts and methods in imagination of dimension, datatransformation, Image processing, and various fields of AppliedScience |
| Course outcome | 1. 1Students will learn about properties of Vector space, Dual space, Algebra of linear transformations, Algebra of Matrices.<br>2. Students will determine a subspace, span, bases, row space, column space and null space for vector space in $n^{\text{th}}$ dimension<br>3. Students will identify linear transformations of finite dimensional vector spaces and compose their matrices in specific bases.<br>4. After successful completion of the course, students should be able to analyse the problems related to Linear algebra. |
| Mapping between COs with PSOs | |

| | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 |
|---|---|---|---|---|---|---|---|
| CO1 | (shaded) | | | | | | (shaded) |

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|---|---|---|---|---|---|---|---|
| CO2 | | | | | | | |
| CO3 | | | | | | | |
| CO4 | | | | | | | |

Content

**UNIT 1:**

Hom $(V, W)$, Dual Space of Vector Space, Second Dual, Annihilator of subspace, Dimension of annihilator of a subspace and its application to homogeneous linear equations.

**UNIT 2:**

Algebra, Algebra of linear transformations $A(V)$, Relation between algebra $A$ and $A(V)$, Minimal polynomial for linear transformation, Regular and Singular linear transformations, Rank of linear transformation.

**UNIT 3:**

Characteristic Roots and Characteristic Vectors, Algebra of Matrices, Similar linear transformations, Triangular form.

**UNIT 4:**

Nilpotent transformations, Invariants, Jordan Canonical form, Rational Canonical form.

Reference

1. I. N. Herstein: Topics in Algebra 4th Ed., John Wiley Sons.
2. Kenneth Hoffman and Ray Kunze: Linear Algebra, Eastern Economy Editions.
3. S. Friedberg, A. Insel and L. Spence: Linear Algebra, Pearson.
4. D. S. Dummit and R. M. Foote: Abstract Algebra, John Wiley & Sons, 2004.
5. N. Jacobson: Lectures in Abstract Algebra Vol. I (1951), II (1952), Van Nostrand Co., New York.

<table>
<tr><td>Code</td><td>PGMTH–403</td></tr>
<tr><td>Cours Title Course</td><td>Integral Equation</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per week</td><td>4 Hrs</td></tr>
<tr><td>Minimum weeks per semester</td><td>20 (Including Classwork, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective from</td><td>June 2023</td></tr>
<tr><td>Course Objective</td><td>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.</td></tr>
<tr><td>Course outcome</td><td>1. Students learns about the integral equations and related results and theorems.<br>2. Students will be able to classify the Integral equations.<br>3. Students will be able to apply the methods and concepts to solve integral equations.<br>4. Students will be able to recognize difference between Volterra and Fredholm Integral Equations, First kind and Second kind, homogeneous and inhomogeneous etc.<br>5. Students will be able to apply different methods to solve integral equations.</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td><td>PSO7</td></tr>
<tr><td>CO1</td><td bgcolor="blue"></td><td></td><td bgcolor="blue"></td><td></td><td></td><td bgcolor="blue"></td><td bgcolor="blue"></td></tr>
<tr><td>CO2</td><td bgcolor="blue"></td><td bgcolor="blue"></td><td></td><td></td><td></td><td bgcolor="blue"></td><td></td></tr>
<tr><td>CO3</td><td bgcolor="blue"></td><td></td><td bgcolor="blue"></td><td bgcolor="blue"></td><td bgcolor="blue"></td><td></td><td></td></tr>
<tr><td>CO4</td><td bgcolor="blue"></td><td bgcolor="blue"></td><td bgcolor="blue"></td><td bgcolor="blue"></td><td></td><td></td><td bgcolor="blue"></td></tr>
<tr><td>CO5</td><td bgcolor="blue"></td><td bgcolor="blue"></td><td></td><td bgcolor="blue"></td><td bgcolor="blue"></td><td bgcolor="blue"></td><td bgcolor="blue"></td></tr>
</table>
</td></tr>
<tr><td>Content</td><td>UNIT -1<br><u>Preliminary Concepts</u>:<br>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.<br>UNIT -2<br><u>Conversion of ODE into Integral Equations</u>:<br>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.<br>UNIT -3<br><u>Fredholm Integral Equations of second kind with Separable kernel</u>:<br>Eigenvalues and Eigenfunctions, Solution of homogeneous Fredholmintegral equations of second kind with Separable kernel, Solution of Fredholmintegral equations of second kind with Separable kernel.</td></tr>
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|---|---|
| | **UNIT -4**<br>**<u>Method of Succesive approximations</u>:**<br>Iterated Kernels, Resolvent kernels, An Important theorem on kernels, Solution of Fredholmintegral equations of second kind by successive substitution, Solution of Volterra integral equations of second kind by successive substitution. |
| Reference | 1. M. D. Raisinghania: Integral Equations and Boundary Value Problems, S. Chand & Co., New Delhi (2007).<br>2. Shanti Swarup: Linear Integral Equations, Krishna Prakashan, Meerut.<br>3. Sudir K. Pundir and RimplePundir: Integral Equations and Boundary Value Problems, PragatiPrakasan, Meerut (2005).<br>4. Ram P. Kanwal: Linear Integral Equations Theory and Technique, Academic Press, Birkhäuser, New York (2013).<br>**5.** Cordumenau, C., Integral Equations and Appplications, Cambridge University Press, 1991 |

# 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 | 1.Students will learn about basic fundamentals of fluiddynamics such as conservation Laws, Conservation ofmass, momentum and energy.<br>2. Distinguish One dimensional, two dimensional and threedimensional flow.<br>3. Student will learn about Bernoulli Equation, Potentialequation, Reynold's transport theorem, Navier-stokesequation.<br>4. They familiar with the fluid statics, kinematics of fluidand dynamics of fluid.<br>5. Enhance ability of analysing mathematical problemsrelated to Fluid dynamics. |
| Mapping between COs with PSOs | |

| | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 | PSO7 |
|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | |

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|---|---|---|---|---|---|---|---|
| CO2 | | | | | | | |
| CO3 | | | | | | | |
| CO4 | | | | | | | |
| CO5 | | | | | | | |

Content

**UNIT -1**

**Introduction and Classification of PDE's**

Introduction to PDEs', Types of PDEs', Classification of PDEs', Introduction to CFD, Applications, Scope of CFD, Governing equations and assumptions, Equation types, Model equations, Discretization of the Domain, Numerical boundary conditions

**UNIT -2**

**Heat Equation**

Introduction to heat Equations, Schmidt method, Richardson Method, Crack-Nicolson method, Du-fort Franek method,stability of schemes, convergence of scheme

**UNIT -3**

**Wave Equations**

One dimensional Euler equations, Lax – Wendroff Scheme, Mc-CormackScheme, Implicit - method, Pseudo One Dimensional Euler Equations,boundary conditions, Flux – Splitting, Artificial viscosity, Flux limiters.Multidimensional Euler equations, Lax- Wendroff and Mc-Cormack schemes,stability of multidimensional schemes, Operator splitting Implicit algorithms,

**UNIT -4**

**Laplace and poison Equation**

Finite Differences, Algorithms, Errors and Accuracy, Consistency, Stability and Convergence, Implicit algorithms,

- Practical: Numerical methods for discretizing fluid flow equations: Finite differences

Reference

1. R. J. Leveque: Numerical methods for conservation Laws, BirkhauserVerlag,Basel, 1992.

2. J. D. Anderson: Computation Fluid dynamics, Mc-Graw – Hill, New York, 1995.

3. H. K. Versteeg and W. Malasekera: An Introduction to Computational FluidDynamics: The finite volume method, Longman Scinetific and technical Essex,England, 1995.

4. J. Chorin and J. E. Marsden: A Mathematical Introduction to Fluid Mechanics

5. P. D. Lax: hyperbolic systems of conservation laws and mathematical theory of hock waves, 1973.

<table>
<tr><td>Code</td><td>PGMTH–4042</td></tr>
<tr><td>Cours Title Course</td><td>Non-Linear Programming</td></tr>
<tr><td>Credit</td><td>4</td></tr>
<tr><td>Teaching per week</td><td>4 Hrs.</td></tr>
<tr><td>Minimum weeks per semester</td><td>20 (Including Classwork, examination, preparation, holidays etc.)</td></tr>
<tr><td>Effective from</td><td>June 2023</td></tr>
<tr><td>Course Objective</td><td>The objective is to expose the student to different types of nonlinear programming problems with various methods, and various algorithms used to solve these</td></tr>
<tr><td>Course outcome</td><td>1. Students will learn about various non-linear programming methods and optimization methods.<br>2. Students are able to solve any real-life problems through non-linear programming.<br>3. Enhance the ability to analyze the industrial problems</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<tr><td></td><td>PSO1</td><td>PSO2</td><td>PSO3</td><td>PSO4</td><td>PSO5</td><td>PSO6</td><td>PSO7</td></tr>
<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>
</table>
</td></tr>
<tr><td>Content</td><td>Unit-1<br><u>One - Dimensional Non- Linear Programming Methods:</u><br>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.<br>Unit-2<br><u>Classical Optimization Methods:</u><br>Unconstraint Optimization, Constrain Multi - Variable Optimization with Equality Constrains, Constrain Multi - Variable Optimization with Inequality Constrains.<br><br>Unit-3<br><u>Non- Linear Programming Methods:</u><br>Introduction, General Non - Linear Programming Problems, Graphical Solution Method, Quadratic Programming, Application of Quadratic Programming, Separable Programming.</td></tr>
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| | **Unit-4**<br>**<u>Geometric Programming:</u>**<br>Introduction, Geometric – Arithmetic Mean Inequality, Unconstrained Geometric Programming Problem, Constrained Geometric Programming Problem. |
| Reference | 1. Kantiswarup, P.K.Gupta and Manmohan: Operations Research ,Sultan chand and Sons.<br>2. S.D. Sharma: Operations Research, KedarNath, Ram Nath& Co.<br>3. S. S. Rao: Optimization Theory and Applications, Wiley Eastern, 1984.<br>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 | 1.Students will learn about complex Fourier transforms and its properties<br>2. Students will learn about Fourier cosine and sine transforms and its properties<br>3. Students will learn about Finite Fourier, finite Fourier cosine and sine transforms and its properties<br>4. Students should be able to solve partial differential equations by these transforms. |
| Mapping between COs with PSOs | (see mapping table below) |
| Content | **UNIT 1**<br>Introduction, Basic concepts and Definitions, The Fourier Integral formulae, Definition of |

Mapping between COs with PSOs:

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

| | |
|---|---|
| | Fourier transforms and examples, Basic properties of Fourier transforms<br>**UNIT 2**<br>Definitions of Fourier Cosine and Sine transforms with examples, Properties of Fourier Cosine and Sine transforms,Evaluation of definite integrals, Solutions of integral equations<br>**UNIT 3**<br>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<br>**UNIT 4**<br>Applications of Fourier transforms to partial differential equations, Applications of Fourier Cosine and Sine transforms to partial differential equations |
| Reference | 1) Lokenath Debnath & Dambaru Bhatta: Integral Transforms and their applications, CRC Pub., 1995.<br>2) Ian Sneddon: The use of Integral Transform. TMH Edition,1979.<br>3) B. Davies: Integral Transforms and their applications, Springer - Verlag, 1978.<br>4) M. L. Boss: Mathematical Methods in Physical Sciences, John Wiley & Sons, 1983.<br>5) L. G. Andrews & B. K. Shivamoggi: Integral Transforms for Engineers, PHI, 2003 |

| 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 | 1. 1.Students learns about Laguerre polynomials and its properties<br>2. Students learns about Jacobi polynomials and its properties,<br>3. Students learns about Elliptic functions and its properties. |

<table>
<tr><td></td><td>4. Students will be able to perform operations with orthogonal polynomials, Legendre’s polynomial and Laguerre polynomial along with the corresponding differential equations</td></tr>
<tr><td>Mapping between COs with PSOs</td><td>
<table>
<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>
<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>
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</td></tr>
<tr><td>Content</td><td>
<u>UNIT-1:</u><br>
Laguerre polynomials:The polynomial Ln(X), Generating functions, Recurrence relations, The Rodrigues formula, The differential equation, Orthogonality, Expansion of polynomials, Special properties, Other generating functions, The simple Laguerre polynomials.<br>
<u>UNIT-2</u><br>
The Jacobi polynomials, Bateman’s generating functions, The Rodrigues formula, Orthogonality, Differential recurrence relations, The pure recurrence relations, Mixed relations,<br>
<u>UNIT-3:</u><br>
Appell’s functions of two variables, An elementary generating functions, Brafman’s generating functions, Expansion in series of polynomials.<br>
<u>UNIT-4:</u><br>
Elliptic functions: Doubly periodic functions, Elliptic functions, Elementary properties, Order of an elliptic function, The Weierstrass function P(Z), Other elliptic functions, A differential equation for P(Z), Connection with elliptic integrals.
</td></tr>
<tr><td>Reference</td><td>
1 E. D. Rainville, Special Functions, McMillan, New York, 1990.<br>
2 I. N. Sneddon, Special functions of Mathematical Physics and Chemistry, Oliver Boyd.<br>
3 N. N. Lebdev, Special Functions and their applications, Dover Pub. 1972.<br>
4 R. K. Saxena and D. C. Gokhroo, Special Functions, Khanna Pub
</td></tr>
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