# PERIYAR UNIVERSITY

**PERIYAR PALKALAI NAGAR**

**SALEM – 636011**

**DEGREE OF MASTER OF SCIENCE**

CHOICE BASED CREDIT SYSTEM

## SYLLABUS FOR

# M.SC. MATHEMATICS

**(SEMESTER PATTERN)**

**( For Candidates admitted in the Colleges affiliated to Periyar University from 2021-2022 onwards )**

# REGULATIONS

## 1. OBJECTIVES OF THE COURSE

In recent days Mathematics is penetrating all fields of human endeavor and therefore it is necessary to prepare the students to cope with the advanced developments in various fields of Mathematics. The objectives of this course are the following:

(a) To impart knowledge in advanced concepts and applications in various fields of Mathematics.

(b) To provide wide choice of elective subjects with updated and new areas in various branches of Mathematics to meet the needs of all students.

## 2. COMMENCEMENT OF THIS REGULATION:

These regulations shall take effect from the academic year 2021-2022, that is, for students who are admitted to the first year of the course during the academic year 2021-2022 and thereafter.

## 3. DEFINITIONS:

Programme: Programme means a course of study leading to the award of the degree in a discipline.

Course: Course refers to the subject offered under the degree Programme.

## 4. ELIGIBILITY FORADMISSION:

A candidate who has passed B.Sc., Mathematics / B.Sc., Mathematics (Computer Applications) degree of this University or any of the above degree of any other University accepted by the Syndicate equivalent thereto, subject to such condition as may be prescribed therefore are eligible for admission to M.Sc., Degree Programme and shall be permitted to appear and qualify for the Master of Science (M.Sc.) Degree Examination in Mathematics of this University.

## 5. DURATION OF THE COURSE:

The course of study of Master of Science in Mathematics shall consist of two academic years divided into four semesters. Each Semester consists of 90 working days.

**6. SYLLABUS:**

The syllabus of the PG degree Programme has been divided into the following courses:

i. Core Courses,

ii. Elective Courses, and

iii. Extra Disciplinary Course (EDC).

iv. Add On Course

i. Core Courses:

The core courses related to the programme concerned including practicals and project work offered under the programme.

ii. Elective Courses:

There are FOUR Elective Courses offered under the programme related to the major or non-major but are to be selected by the students.

iii. Extra Disciplinary Course (EDC):

There is an Extra Disciplinary Course offered under the programme related to the non-major but are to be selected by the students.

iv. Add On Course:

This course offered in II semester ,help students to attain special skills related to their subject.

**7. CREDITS:**

Weightage given to each course of study is termed as credit.

**8. CREDIT SYSTEM:**

The weightage of credits are spread over to four different semester during the period of study and the cumulative credit point average shall be awarded based on the credits earned by the students. A total of 90 credits are prescribed for the Post Graduate programme.

**9. COURSE OF STUDY:**

The course of study for the degree shall be in Branch I-Mathematics (under Choice Based Credit System) with internal assessment according to syllabi prescribed from time to time.

# COURSE OF STUDY AND SCHEME OF EXAMINATION

| S.No. | Subject | Subject Title | Hours | University Examination | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | | Internal(25%) | External (75%) | Total | |
| | | **SEMESTER I** | | | | | |
| 1 | Core I | LINEAR ALGEBRA | 6 | 25 | 75 | 100 | 5 |
| 2 | Core II | REAL ANALYSIS – I | 6 | 25 | 75 | 100 | 5 |
| 3 | Core III | ORDINARY DIFFERENTIAL EQUATIONS | 6 | 25 | 75 | 100 | 5 |
| 4 | Core IV | MECHANICS | 6 | 25 | 75 | 100 | 4 |
| 5 | Elective I | FROM GROUP – A | 6 | 25 | 75 | 100 | 4 |
| | | **SEMESTER II** | | | | | |
| 6 | Core V | ABSTRACT ALGEBRA | 6 | 25 | 75 | 100 | 5 |
| 7 | Core VI | REAL ANALYSIS – II | 6 | 25 | 75 | 100 | 5 |
| 8 | Core VII | PARTIAL DIFFERENTIAL EQUATIONS | 5 | 25 | 75 | 100 | 4 |
| 9 | Elective II | FROM GROUP – B | 5 | 25 | 75 | 100 | 4 |
| 10 | EDC – I | FROM THE LIST | 4 | 25 | 75 | 100 | 3 |
| 11 | Common Paper | HUMAN RIGHTS | 2 | 25 | 75 | 100 | - |
| 12 | Add on Course | FROM THE LIST AOC | 2 | 25 | 75 | 100 | 2 |

## M.Sc. MATHEMATICS

| S.No. | Paper Code | Subject Title | Hours | University Examination | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | | Internal (25%) | External (75%) | Total | |
| | | **SEMESTER III** | | | | | |
| 13 | Core VIII | COMPLEX ANALYSIS | 6 | 25 | 75 | 100 | 5 |
| 14 | Core IX | TOPOLOGY | 6 | 25 | 75 | 100 | 5 |
| 15 | Core X | MEASURE THEORY AND INTEGRATION | 6 | 25 | 75 | 100 | 5 |
| 16 | Core XI | GRAPH THEORY | 6 | 25 | 75 | 100 | 4 |
| 17 | Elective III | FROM GROUP – C | 6 | 25 | 75 | 100 | 4 |
| | | | | | | | |
| | | **SEMESTER IV** | | | | | |
| 18 | Core XII | FUNCTIONAL ANALYSIS | 6 | 25 | 75 | 100 | 4 |
| 19 | Core XIII | PROBABILITY THEORY | 6 | 25 | 75 | 100 | 4 |
| 20 | Core XIV | CALCULUS OF VARIATION AND INTEGRAL CALCULATIONS | 6 | 25 | 75 | 100 | 4 |
| 21 | Core XV | PROJECT | 6 | - | 100 | 100 | 5 |
| 22 | Elective IV | FROM GROUP – D<br>(Theory Paper or Practical Paper)<br>T-Theory Paper ; P-Practical Paper. | T-6<br>P-6 | T-25<br>P-40 | T-75<br>P-60 | 100 | T-4<br>P-4 |
| | | **TOTAL** | **120** | **--** | **--** | **2100** | **90** |

**(i) List of Elective Courses:**

| Semester / Elective Course | Paper Code | Paper Title |
|---|---|---|
| | **GROUP A** | |
| I | Paper I<br>Paper II | Discrete Mathematics<br>Combinatorial Mathematics |
| | **GROUP B** | |
| II | Paper I<br>Paper II | Numerical Analysis<br>Difference Equations |
| | **GROUP C** | |
| III | Paper I<br>Paper II<br>Paper III | Differential Geometry<br>Fluid Dynamics<br>Programming with C++ |
| | **GROUP D** | |
| IV | Paper I<br>Paper II<br>Practical | Number Theory (T)<br>Optimization techniques (T)<br>C++ Programming Lab (P) |

**(ii) List of Extra Disciplinary Courses (EDC):**

| S. No. | PAPER CODE | PAPER TITLE |
|---|---|---|
| 1 | Paper I | Numerical & Statistical Methods |
| 2 | Paper II | Statistics |

**(iii)List of Add on Courses (AOC):**

| S. No. | PAPER CODE | PAPER TITLE |
|---|---|---|
| 1 | Paper I | Advanced LaTeX |
| 2 | Paper II | Python Programming |
| 3 | Paper III | Artificial Intelligence |

**11. EXAMINATIONS:**

The examination shall be of Three Hours duration for each paper at the end ofeach semester. The candidate failing in any subject(s) will be permitted to appear for each failed subject(s) in the subsequent examination. Practical examinations for PG course should be conducted at the end of the even semester only. At the end of fourth semester viva-voce will be conducted on the basis of the Dissertation/ Project report by one internal and one external examiner.

**12. QUESTION PAPER PATTERN AND MARKS DISTRIBUTION:**

**(i) Question Paper Pattern and Marks Distribution for Theory Examination:**

**(ii) TITLE OF THE PAPER**

Time: Three Hours Maximum Marks: 75

**Part – A (15 X 1 = 15 Marks)**

Answer ALL objective type Questions

(Three Questions from each unit)

**Part – B (5 X 2 = 10 Marks)**

Answer ANY TWO Questions (One

Question from each unit )

**Part – C (5 X 10 = 50 Marks)**

Answer ALL questions

(Two questions from each unit with internal choice).

**(i) Question Paper Pattern and Marks Distribution for C++ Programming Lab: Question**

**Paper Pattern:**

There will be ONE question with or without subsections to be asked for the Practical examination. Every question should be chosen from the question bank prepared by the examiner(s). Every fourth student get a new question i.e. each question may be used for at most three students.

The answer should contain i) Algorithm (A), ii) Flow Chart (F), iii) Program (P), iv) Execution of the Program with correct output (E & OP), and v) viva-voce (V).

**Marks Distribution for C++ Programming Lab:**

Maximum marks:100

Internal (CIA): 40

External Assessment (EA- Practical Examination): 60

(Practical Written Exam.: 50 Marks (The split up marks of this total marks 50 is, for A-05, F-05, P- 10, E -20 & OP-05 and V-05) and Record:10 Marks).

**13. Dissertation:**

(a) Topic:

The topic of the dissertation shall be assigned to the candidate before the beginning of third semester and a copy of the same should be submitted to the University for Approval.

(b) No. of copies project / dissertation:

The students should prepare Three copies of dissertation and submit the same for the evaluation by Examiners. After evaluation one copy is to be retained in the college library and one copy is to be submitted to the university (COE) and the student can have the rest.

(c) Format to be followed:

The format of the Project / Dissertation to be prepared and submitted by the students in Semester IV is given below:

Format for the preparation of Project work:

i) Title page:

# TITLE OF THE PROJECT / DISSERTATION

Project / dissertation Submitted in partial fulfillment of the requirement for the award of the Degree of Master of Science in MATHEMATICS (under Choice Base Credit System) to the Periyar University, Periyar Palkalai Nagar, Salem -636 011.

By

**(Student's Name )**

**(Register Number)**

Under the Guidance of

**(Guide Name and Designation)**

(College Logo)

**(Name of the Department)**

**(College Address)**

(Month and Year)

**ii) BONAFIDE CERTIFICATE:**

# CERTIFICATE

This is to certify that the dissertation entitled ……submitted in partial fulfillment of the requirement of the award of the Degree of Master of Science in MATHEMATICS (Under Choice Based Credit System) to the Periyar University, Salem is a record of bonafide research work carried out by……..under my supervision and guidance and that no part of the dissertation has been submitted for the award of any degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journals or magazines

Date:

Place: Signature of the Guide

Signature of the Head of the Department.

(iii) Acknowledgement:

( Drafted by the student )

(iv) Table of contents:

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| Chapter No. | Title | Page No. |
|---|---|---|
| 1. | Introduction | |
| 2. | Review of Literature | |
| 3,4.. | Results | |
| | Summary | |
| | References | |

**14. MINIMUM MARKS FOR PASSING:**

a. Theory Papers: The candidate shall be declared to have passed the examination if the candidate secures not less than 50 marks in total (CIA mark + Theory Exam mark) with minimum of 38 marks in the Theory Exam conducted by the University. The Continuous Internal Assessment (CIA) Mark 25 is distributed to four components viz., Tests, Assignment, Seminar and Attendance as 10, 05, 05 and 05 marks, respectively.

b. Practical paper: A minimum of 50 marks out of 100 marks in the University examination and the record notebook taken together is necessary for a pass. There is no passing minimum for the record notebook. However submission of record notebook is a must.

c. Project Work/Dissertation and Viva-Voce: A candidate should secure 50% of the marks for pass. The candidate should attend viva-voce examination to secure a pass in that paper.

Candidate who does not obtain the required minimum marks for a pass in a Paper / Practical/ Project/Dissertation shall be declared Re-Appear (RA) and he / she has to appear and pass the same at a subsequent appearance.

**15. CLASSIFICATION OF SUCCESSFUL CANDIDATES:**

Candidates who secure not less than 60% of the aggregate marks in the whole examination shall be declared to have passed the examination in First Class. All other successful candidate shall be declared to have passed in the Second Class. Candidates who obtain 75% of the marks in the aggregate shall be deemed to have passed the examination in the First Class with Distinction provided they pass all the

examinations prescribed for the course at the first appearance. Candidates who pass all the examinations prescribed for the course in the first instance and within a period of two academic years from the year of admission to the course only are eligible for University Ranking.

**16. MAXIMUM DURATION FOR THE COMPLETION OF THE PG PROGRAMME:**

The maximum duration for completion of the PG Programme shall not exceed Four Years from the year of admission.

**17. TRANSITORY PROVISION:**

Candidates who were admitted to the PG course of study before 2020-2021 shall be permitted to appear for the examinations under those regulations for a period of three years, that is, up to end inclusive of the examination of April / May 2023. Thereafter, they will be permitted to appear for the examination only under the regulations then in force.

# M.Sc. MATHEMATICS SEMESTER – I
# CORE I - LINEAR ALGEBRA

**OBJECTIVE:**

The objective of this course is to develop a strong foundation in linear algebra that provide a basic for advanced studies not only in mathematics but also in other branches like engineering, physics and computers, etc. Particular attention is given to canonical forms of linear transformations, diagonalizations of linear transformations, matrices and determinants.

**UNIT I : Linear Transformation**

The algebra of linear transformations-Isomorphism of vector spaces-Representations of linear transformations by matrices - Linear functional - The double dual - The transpose of a linear transformation. (Chapter 3: Sections: 3.1 - 3.7).

**UNIT II : Algebra of Polynomials**

The algebra of polynomials - Lagrange interpolation - Polynomial ideals - The prime factorization of a polynomial - Determinant functions. (Chapter 4: Sections: 4.1 - 4.5, Chapter 5: Sections: 5.1 & 5.2).

**UNIT III : Determinants**

Permutations and the uniqueness of determinants-Classical adjoint of a (square) matrix - Inverse of an invertible matrix using determinants - Characteristic values - Annihilating polynomials. (Chapter 5: Sections: 5.3 & 5.4, Chapter 6: Sections : 6.1 - 6.3).

**UNIT IV : Diagonalization**

Invariant subspaces - Simultaneous triangulations - Simultaneous diagonalizations - Direct-sum decompositions - Invariant sums - Primary decomposition theorem. ( Chapter 6: Sections: 6.4 -6.8 ).

**UNIT V : The Rational and Jordan Forms**

Cyclic subspaces and annihilators-Cyclic decompositions and rational form-The Jordan form-Computation of invariant factors. (Chapter 7: Sections 7.1 - 7.4 ).

**TEXT BOOK:**

Kennath M. Hoffman and Ray Kunze, Linear Algebra, 2nd Edition, Pearson India Publishing, New Delhi, 2015.

**REFERENCE BOOKS:**


1. M.Artin,Algebra, Prentice Hall of India Pvt. Ltd., New Delhi ,2005
2. S.H.Friedberg,A.J.Insel and L.E.Spence, Linear Algebra,4th Edition, Prentice Hall of India Pvt. Ltd., New Delhi,2009.
3. I.N Herstein : Topics in Algebra, 2nd Edition, Wiley Eastern Ltd. New Delhi, 2013.
4. J.J. Rotman, Advanced Modern Algebra,2nd Edition, Graduate Studies in Mathematics, Vol.114, AMS, Providence, Rhode Island,2010.
5. G. Strang, Introduction to Linear Algebra,2nd Edition, Prentice Hall of India Pvt. Ltd., New Delhi,2013.


**LEARNING OUTCOMES:** At the end of the course, students will be able

- to describe a diagonalizable operator T in a language of invariant direct sum decompositions (projections which commute with T).
- to find the minimal polynomials, Jordan forms and the rational forms of real matrices.

# M.Sc. MATHEMATICS SEMESTER – I
# CORE II - REAL ANALYSIS – I

**OBJECTIVE:**

The course will develop a deeper and more rigorous understanding of calculus including defining terms and proving theorems about functions, sequences, series, limits, continuity and derivatives. The course will develop specialized techniques in problem solving.

**UNIT I: Basic Topology**

Finite, Countable and Uncountable Sets – Metric Spaces – Compact Sets – Connected Sets (Perfect sets - Omitted). (Chapter 2 Pages 24 – 40, 42 – 46).

**Unit II: Numerical Sequences and Series**

Convergent sequences – Subsequences – Cauchy sequences - Upper and lower limits - Some special sequences – Series – Series of nonnegative terms - The number *e* - The root and ratio tests. (Chapter 3 Pages 47 – 68).

**Unit III: Rearrangements of Series**

Power series - Summation by parts - Absolute convergence - Addition and multiplication of series– Rearrangements. (Chapter 3 Pages 69 – 82).

**UNIT IV: Continuity**

Limit of Functions – Continuous functions - Continuity and Compactness – Continuity and Connectedness – Discontinuities – Monotonic functions – Infinite limits and Limits at infinity. (Chapter 4 Pages 83 – 102).

**UNIT IV: Differentiation**

The derivative of a real function – Mean value theorems – The continuity of the Derivative – L' Hospital's Rule – Derivatives of Higher order – Taylor's theorem – Differentiation of Vector–valued functions. (Chapter 5 Pages 103 – 119).

**TEXT BOOK:**

1. Walter Rudin, *"Principles of Mathematical Analysis"*, 3rd Edition, McGraw Hill Book Co., Kogaskusha, 1976.

**BOOKS FOR REFERENCE:**


1. Tom M. Apostol, *"Mathematical Analysis*", Narosa Publishers, New Delhi, 2002.
2. R. G. Bartle and D.R. Sherbert, "Introduction to Real Analysis", John Wiley & Sons, New York, 1982.
3. W.J. Kaczor and M.T. Nowak, "Problems in Mathematical Analysis I – Real Numbers , Sequences and Series", American Mathematical Society, 2000.
4. W.J. Kaczor and M.T. Nowak, "Problems in Mathematical Analysis II – Continuity and Differentiation", American Mathematical Society, 2000.
5. Steven G. Krantz, Real Analysis and Foundations, 4th Edition, CRC Press, 2017.
6. H.H.Sohrab, *"Basic Real Analysis*", Springer International Edition, India, 2006.


**LEARNING OUTCOMES:**

On successful completion of this course, students will be able

- to give the definition of concepts related to metric spaces, such as continuity, compactness, completeness and connectedness that will help for further studies within topology and functional analysis.
- to demonstrate an understanding of limits and how they are used in sequences, series, continuity and differentiation.
- to construct rigorous mathematical proofs of basic results in real analysis.

# M.Sc. MATHEMATICS
## SEMESTER – I
## CORE III - ORDINARY DIFFERENTIAL EQUATIONS

**OBJECTIVE:**

The objective of this course is to equip the students with knowledge of some advanced concepts related to ordinary differential equations and to understand the concepts related to the solution of ordinary differential equations.

**UNIT I : Linear Equations with Constant Coefficients:**

Introduction – Second order homogeneous equations – Initial value problem – Linear dependence and independence – A formula for the Wronskian. (Chapter 2: Section 1 to 5).

**UNIT II : Linear Equations with Constant Coefficients (Contd.):**

Non-homogeneous equations of order two – Homogenous and non-homogeneous equations of order n – Initial value problem – Annihilator method to solve a non- homogeneous equation. (Chapter 2: Section 6 to 11).

**UNIT III : Linear Equations with Variable Coefficients:**

Initial value problems for homogeneous equations – solutions of homogeneous equations- Wronskian and linear independence – Reduction of the order of homogeneous equation. (Chapter 3: Section 1 to 5).

**UNIT IV : Linear Equations with Regular Singular Points:**

Linear equation with regular singular points – Euler equation – second order equations with regular singular points – solutions and properties of Legendre and Bessel equation. (Chapter 3: Section 8 & Chapter 4: Section 1 to 4 and 7 and 8).

**UNIT V : First Order Equation – Existence and Uniqueness:**

Introduction – Existence and uniqueness of solutions of first order equations – Equations with variable separated – Exact equations – Method of successive approximations – Lipschitz Condition – Convergence of the successive approximations. (Chapter 5: Section 1 to 6 ).

**TEXT BOOK:**

1. E.A.Codington, An Introduction to Ordinary Differential Equation, Prentice Hall of India, New Delhi, 1994.

**BOOKS FOR REFERENCE:**

1. R.P Agarwal and Ramesh C.Gupta, Essentials of Ordinary Differential Equation. McGraw Hill, NewYork,1991.
2. Somasundaram, Ordinary Differential Equations, Narosa Publ.House, Chennai – 2002.
3. D.Raj, D.P. Choudhury and H.I. Freedman, A Course in Ordinary Differential Equations, NarosaPubl.House,2004.

**LEARNING OUTCOMES:** At the end of the course, students will be able

- to solve the differential equations by using various methods.

# M.Sc. MATHEMATICS SEMESTER – I
# CORE IV – MECHANICS

**OBJECTIVE:**

The objective of this course is to understand the Lagrangian and Hamiltonian equations for dynamical systems.

**UNIT I : Mechanical Systems:**

The Mechanical System – Generalized co–ordinates – Constraints – Virtual work – Energy and Momentum. (Chapter 1 Sections 1.1 to 1.5).

**UNIT II : Lagrange's Equations:**

Lagrange's Equation – Derivation of Lagrange's Equations – Examples – Integrals of motion. (Chapter 2 Sections 2.1 to 2.3).

**UNIT III : Hamilton's Equation:**

Hamilton's Equation – Hamiltons Principle – Hamilton's Equation – Other Variational Principle. (Chapter 4 Sections 4.1 to 4.3).

**UNIT IV : Hamilton – Jacobi Theory:**

Hamilton – Jacobi Theory – Hamilton Principle Function – Hamilton – Jacobi Equation – Separability. (Chapter 5 Sections 5.1 to 5.3).

**UNIT V : Canonical Transformation:**

Canonical Transformation – Differential forms and generating functions – Special Transformations – Lagrange and Poisson brackets. (Chapter 6 Sections 6.1 to 6.3) .

**TEXT BOOK:**

1. D. Greenwood, Classical Dynamics, Prentice Hall of India, New Delhi, 1985.

**BOOKS FOR REFERENCE:**

1. H.Goldstein, Classical Mechanics, Narosa Publishing House, NewDelhi, 2001.
2. J.L. Synge and B.A. Griffth, Principles of Mechanics, McGraw Hill Book Co. New York,1970.
3. N.C. Rane and P.S.C. Joag, Classical Mechanics, Tata McGraw Hill, New Delhi, 1991.

**LEARNING OUTCOMES:**

- At the end of the course, the students will understand the formation of differential equations which will help to study the dynamics of mechanical systems.

# M.Sc. MATHEMATICS
## SEMESTER - II
## CORE V – ABSTRACT ALGEBRA

**OBJECTIVE:**

The objective of this course is to introduce the basic ideas of counting principle, Sylow subgroups, finite abelian groups, field theory and Galois Theory and to see its application to the solvability of polynomial equations by radicals.

**UNIT I: Sylow's Theorem**

Another Counting Principle – 1st, 2nd and 3rd parts of Sylow's Theorems – double coset – the normalizer of a group. (Chapter 2 Sections 2.11 to 2.12).

**UNIT II: Finite Abelian Groups**

External and Internal direct Products – structure theorem for finite abelian groups – non isomorphic abelian groups - polynomial rings. (Chapters 2 & 3 Sections 2.13, 2.14 & 3.9).

**UNIT III: Splitting Field**

Polynomials over rational fields – the Eisenstein criterion - extension fields – roots of polynomials – splitting fields. (Chapters 3 & 5 Sections 3.10, 5.1, 5.3).

**UNIT IV: Galois Theory**

More about roots – simple extension – separable extension – fixed fields – symmetric rational functions – normal extension - Galois group – fundamental theorem of Galois theory. (Chapter 5 Sections 5.5 & 5.6).

**UNIT V: Solvability by radicals**

Solvable group – the commutator subgroup – Solvability by radicals - finite fields. (Chapters 5 & 7 Sections 5.7 & 7.1).

**TEXT BOOK:**

1. N. Herstein, Topics in Algebra, 2nd Edition, John Wiley and Sons, New York, 1975.

**BOOKS FOR REFERENCE:**

1. S. Lang, *"Algebra*", 3rd Edition, Addison-Wesley, Mass, 1993.
2. John B. Fraleigh, *"A First Course in Abstract Algebra",* Addison Wesley, Mass, 1982.
3. M. Artin, *"Algebra",* Prentice-Hall of India, New Delhi, 1991.
4. V. K. Khanna and S.K. Bhambri, *"A Course in Abstract Algebra"*, Vikas Publishing House Pvt Limited, 1993.

**LEARNING OUTCOMES:** At the end of the course, students will be able

- to find the number of Sylow subgroups.
- to find the number of non-isomorphic abelian groups.
- to find the splitting field, Galois group of the given polynomial.
- to check whether the given polynomial is solvable by radicals or not.

# M.Sc. MATHEMATICS

## SEMESTER - II

## CORE VI – REAL ANALYSIS – II

**OBJECTIVE:**

The course will develop a deeper and more rigorous understanding of calculus including defining terms and proving theorems about sequence and series of functions, integration, special functions and multivariable calculus. The course will develop specialized techniques in problem solving.

**UNIT I: Riemann – Stieltjes Integral**

Definition and Existence of the Integral – Properties of the Integral – Integration and Differentiation – Integration of Vector–valued functions – Rectifiable curves. (Chapter 6 Pages 120 – 142).

**UNIT II: Sequences and Series of Functions**

Discussion of main problem – Uniform Convergence - Uniform Convergence and Continuity - Uniform Convergence and Integration – Uniform Convergence and Differentiation. (Chapter 7 Pages 143 – 154).

**Unit III: Sequences and Series of Functions (contd…)**

Equicontinuous families of functions – Stone-Weierstrass Theorems – Algebra of complex valued functions. (Chapter 7 Pages 155 – 171).

**Unit IV: Some special functions**

Power series – The Exponential and Logarithmic functions – Trigonometric Functions – Fourier series - The Gamma functions (Algebraic completeness of the complex field - omitted). (Chapter 8 Pages 172 – 203 (Omitted Theorem 8.8)).

**Unit V: Functions of several variables**

Linear transformations – Differentiation – The contraction principle - The inverse function theorem – The implicit function theorem. (Chapter 9 Pages 204 – 228).

**TEXT BOOK:**

1. Walter Rudin, *"Principles of Mathematical Analysis"*, 3rd Edition, McGraw Hill Book Co., Kogaskusha, 1976.

**BOOKS FOR REFERENCE**


1. T.M. Apostol, *"MathematicalAnalysis*", Narosa Publishers, New Delhi,1985.
2. W.J.Kaczor and M.T.Nowak, "Problems in Mathematical Analysis III - Integration", American Mathematical Society, 2000.
3. A. Browder, "*Mathematical Analysis, an Introduction"*, Springer-Verlag, New York, 1996.
4. K.A. Ross, *"Elementary Analysis: The Theory of Calculus",* 2nd Edition, Springer, New York, 2013.
5. M. Stoll, *"Introduction to Real Analysis",* 2nd Edition, Addison-Wesley Longman Inc, 2001.


**LEARNING OUTCOMES:**

On successful completion of this course, students will be able to

- find the integrals of a bounded function on a closed bounded interval
- understand sequences and series of functions and its convergence
- find the derivative of functions of several variables.

# M.Sc. MATHEMATICS

## SEMESTER -II

## CORE VII - PARTIAL DIFFERENTIAL EQUATIONS

**OBJECTIVE:**

The objective of this course is to enable the students to understand the concepts related to the solution of partial differential equations arising in various fields.

**UNIT I Second order Partial Differential Equations:**

Origin of second order partial differential equations – Linear differential equations with constant coefficients – Method of solving partial (linear ) differential equation – Classification of second order partial differential equations – Canonical forms – Adjoint operators – Riemann method. (Chapter 2 : Sections 2.1 to 2.5) .

**UNIT II Elliptic Differential Equations:**

Elliptic differential equations – Occurrence of Laplace and Poisson equations – Boundary value problems – Separation of variables method – Laplace equation in cylindrical – Spherical co-ordinates, Dirichlet and Neumann problems for circle – Sphere.(Chapter 3 : Sections 3.1 to 3.9).

**UNIT III Parabolic Differential Equations:**

Parabolic differential equations – Occurrence of the diffusion equation – Boundary condition – Separation of variable method – Diffusion equation in cylindrical – Spherical co-ordinates. (Chapter 4: Sections 4.1 to 4.5).

**UNIT IV Hyperbolic Differential Equations:**

Hyperbolic differential equations – Occurrence of wave equation – One dimensional wave equation – Reduction to canonical form – D'Alembert solution – Separation of variable method – Periodic solutions – Cylindrical – Spherical co-ordinates – Duhamel principle for wave equations.(Chapter 5 : Sections 5.1 to 5.6 and 5.9).

**UNIT V Integral Transform:**

Laplace transforms – Solution of partial differential equation – Diffusion equation – Wave equation – Fourier transform – Application to partial differential equation – Diffusion equation – Wave equation – Laplace equation. (Chapter 6 : Sections 6.2 to 6.4).

**TEXTBOOK**

1.J.N. Sharma and K.Singh, Partial Differential Equation for Engineers and Scientists, Narosa publ. House, Chennai, 2001.

**BOOKS FOR REFERENCE**

1. I.N.Snedden, Elements of Partial Differential Equations, McGraw Hill, New York 1964.
2. K. Sankar Rao, Introduction to partial Differential Equations, Prentice Hall of India, New Delhi,1995.
3. S.J. Farlow, Partial Differential Equations for Scientists and Engineers, John Wiley sons, New York, 1982.

**LEARNING OUTCOMES:** At the end of the course, students will

- be familiar with the modeling assumptions and derivations that lead to PDE's.
- recognize the major classification of PDEs and the qualitative difference between the classes of equations.
- be competent in solving linear PDEs using classical methods.

# M.Sc. MATHEMATICS SEMESTER -III

# CORE VIII – COMPLEX ANALYSIS

**OBJECTIVES**

- To learn the various intrinsic concepts and the theory of Complex Analysis.
- To study the concept of Analyticity, Complex Integration and Infinite Products in depth.

**UNIT I Complex Integration :**

Complex Integration – Fundamental Theorems – Line integrals –Rectifiable Arcs-Line Integrals as Arcs – Cauchy's Theorem for a Rectangle and in a disk – Cauchy's Integral Formula – Index of point with respect to a closed curve- The Integral formula – Higher order derivatives – Local properties of analytic functions – Taylor's Theorem – Zeros and Poles –Local mapping - Maximum Principle. (Chapter 4: Sections 1 to 3).

**UNIT II Complex Integration (Contd.):**

The general form of Cauchy's Theorem – Chains and Cycles – Simple connectivity – Homology – General statement of Cauchy's theorem – Proof of Cauchy's theorem – Locally exact differentials – Multiply connected regions – Calculus of residues – Residue Theorem – Argument Principle-Evaluation of Definite Integrals. (Chapter 4 : Sections 4 and 5) .

**UNIT III Harmonic Functions and Power Series Expansions:**

Harmonic Functions – Definition and basic properties- Mean-Value Property- Poisson's formula –Schwarz's Theorem – Reflection Principle- Weierstrass's theorem- Taylor's series –Laurent series. (Chapter 4 : Sections 6 and Chapter 5 : Sections 1).

**Unit IV Entire functions: Jenson's formula – Hadamard's theorem.**

Normal Families: Equicontinuity – Normality and compactness – Arzela's theorem – Families of analytic functions – The classical definition. (Chapter 5: Sections 3 and 5).

**UNIT V Conformal Mapping:**

The Riemann Mapping Theorem, Conformal Mapping of Polygons. A closure look at harmonic functions. (Chapter 6 : Sections 1,2 and 3).

**TEXTBOOK**

1. L.V Ahlfors, Complex Analysis, 3rd edition, Mc Graw Hill Inter., Edition, New Delhi,1979.

**BOOKS FOR REFERENCE**

1. J.B Conway, Functions of one Complex variable, Narosa Publ. House, New Delhi,1980.
2. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publ. House, New Delhi,2004.
3. S. Lang, Complex-Analysis, Addison – Wesley Mass,1977.

**LEARNING OUTCOMES:** At the end of the course, students will

- be familiar with the modeling assumptions and derivations that lead to Complex Analysis
- recognize the major classification of analytic functions, harmonic functions, conformal mappings and the qualitative difference between the complex integration & Real integration.

# M.Sc. MATHEMATICS SEMESTER - III
# CORE IX – TOPOLOGY

**OBJECTIVES:**

- To study the concepts concerned with properties that are preserved under continuous deformations of objects.
- To train the students to develop analytical thinking and the study of continuity and connectivity.

**UNIT I: Topological spaces:**

Topological spaces - Basis for a topology – The Order Topology - The Product Topology on XxY – The Subspace Topology – Closed sets and Limit points. (Chapter 2: sections 12 to17).

**UNIT II: Continuous functions:**

Continuous Functions– The Product Topology – The Metric Topology. (Chapter 2: Sections 18 to 21).

**UNIT III: Connectedness:**

Connected Spaces – Connected Subspaces of the Real line – Components and Local Connectedness. (Chapter 3: Sections 23 to 25)

**UNIT IV: Compactness:**

Compact spaces – Compact Subspace of the real line –Limit Point Compactness – Local Compactness. (Chapter 3: Sections 26 to 29).

**UNIT V: Countability and Separation axioms:**

The Countability Axioms – The Separation Axioms – Normal Spaces – The Urysohn Lemma – The Urysohn Metrization Theorem – The Tietze extension theorem. (Chapter 4: Sections 30 to 35).

**TEXT BOOK :**

1. James R.Munkres – Topology, 2nd edition, Prentice Hall of India Ltd., New Delhi, 2005.

**BOOKS FOR REFERENCE :**

1. J. Dugundji, Topology, Prentice Hall of India, New Delhi,1975.
2. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Book Co, New York,1963.
3. S.T. Hu, Elements of General Topology, Holden Day, Inc. New York, 1965.

**LEARNING OUTCOMES:** At the end of the course, students will be able

- to understand various concepts of Topology.

# M.Sc. MATHEMATICS
# SEMESTER -III
# CORE X - MEASURE THEORY AND INTEGRATION

**OBJECTIVES**

- To generalize the concept of integration using measures.
- To develop the concept of analysis in abstract situations.

**UNIT I : Lebesgue Measure:**

Lebesgue Measure – Introduction – Outer measure – Measurable sets and Lebesgue measure – Measurable functions – Little Woods' Three Principles. (Chapter 3: Sections 1 to 3, 5 and 6).

**UNIT II : Lebesgue integral :**

Lebesgue integral – The Riemann integral – Lebesgue integral of bounded functions over a set of finite measure – The integral of a nonnegative function – The general Lebesgue integral. (Chapter 4: Sections 1 to 4).

**UNIT III : Differentiation and Integration :**

Differentiation and Integration – Differentiation of monotone functions – Functions of bounded variation – Differentiation of an integral – Absolute continuity. (Chapter 5: Sections 1to 4).

**UNIT IV : General Measure and Integration :**

General Measure and Integration – Measure spaces – Measurable functions – Integration – Signed Measure – The Radon – Nikodym theorem. (Chapter 11: Sections 1 to 3, 5 and 6) .

**UNIT V : Measure and Outer Measure :**

Measure and outer measure – outer measure and measurability – The Extension theorem – Product measures. (Chapter 12: Sections 1, 2 and 4).

**TEXT BOOK:**

1. H.L.Royden, Real Analysis, Mc Millan Publ. Co, New York, 1993.

**BOOKS FOR REFERENCE:**

1. G. de Barra, Measure Theory and integration, Wiley Eastern Ltd, 1981.
2. P.K. Jain and V.P. Gupta, Lebesgue Measure and Integration, New Age Int. (P) Ltd., New Delhi,2000.
3. Walter Rudin, Real and Complex Analysis, Tata McGraw Hill Publ. Co. Ltd., New Delhi, 1966.

**LEARNING OUTCOMES:**

- At the end of the course, the students will be able get the knowledge of Measure and Outer measure, generalization of integrals with help of measures.

# M.Sc. MATHEMATICS

## SEMESTER – III

## CORE XI - GRAPH THEORY

**OBJECTIVES**

- To give a rigorous study of the basic concepts of Graph Theory.
- To study the applications of Graph Theory in other disciplines.

**UNIT I : Basic Results:**

Introduction-Basic Concepts-Subgraphs-Degrees of Vertices - Paths and Connectedness - Automorphism of a Simple Graph. (Chapter 1: Sections 1.1 - 1.6).

**Directed Graphs:** Introduction-Basic Concepts-Tournaments.(Chapter 2 : Sections 2.1 -2.3).

**UNIT II : Connectivity and Trees:**

Connectivity: Introduction-Vertex cut and Edge Cut-Connectivity and Edge Connectivity.(Chapter 3: Sections 3.1- 3.3). Trees: Introduction-Definition, Characterization and Simple Properties-Centers and Centroids- Cutting the Number of Spanning Trees-Cayley's Formula. (Chapter 4: Sections 4.1- 4.5).

**UNIT III : Independent Sets, Matchings and Cycles:**

Independent Sets and Matchings: Introduction-Vertex-Independent Sets and Vertex Coverings-Edge-Independent sets-Matchings and Factors-Matchings in Bipartite Graphs. (Chapter 5: Sections 5.1- 5.5). Cycles: Introduction-Eulerian Graphs- Hamiltonian Graphs. (Chapter 6: Sections 6.1- 6.3).

**UNIT IV: Graph Colorings:**

Introduction-Vertex Colorings-Critical Graphs-Edge colorings of Graphs-Kirkman's Schoolgirl- Problem-Chromatic Polynomials. (Chapter 7: Sections 7.1 ,7.2 ,7.3 (7.2.1 & 7.2.3 only) ,7.6, 7.8, and 7.9).

**UNIT V: Planarity:**

Introduction- Planar and Nonplanar Graphs –Euler Formula and its Consequences- $K_5$ and $K_{3,3}$ are Nonplanar Graphs – Dual of a Plane Graph- The Four-Color Theorem and the Heawood Five-Color Theorem-Hamiltonian Plane Graphs-Tait Coloring.(Chapter 8: Sections 8.1 - 8.6 ,8.8 and 8.9).

**TEXT BOOK:**

1. R. Balakrishnan and K. Ranganathan, Text Book of Graph Theory, (2nd Edition), Springer, NewYork,2012.

**BOOKS FOR REFERENCE:**

1. J.A.Bondy and U.S.R. Murty, Graph Theory with Applications, North Holland, New York, 1982.
2. Narasing Deo, Graph Theory with Application to Engineering and Computer Science, Prentice Hall of India, New Delhi. 2003.
3. F. Harary, Graph Theory, Addison – Wesely Pub. Co. The Mass. 1969.
4. L. R. Foulds, Graph Theory Application, Narosa Publ. House, Chennai, 1933.

**LEARNING OUTCOMES:** At the end of the course, students will be able

- □ to identify the graphs of connectivity and tree.
- □ to find the Independent set and cycle graph.
- □ to understand graph coloring.
- □ to check planarity.

# M.Sc. MATHEMATICS

## SEMESTER - IV

## CORE XII - FUNCTIONAL ANALYSIS

**OBJECTIVES**

- To study the three structure theorems of Functional Analysis viz., Hahn- Banach theorem, Open mapping theorem and Uniform boundedness principle.
- To introduce Hilbert spaces and operator theory leading to the spectral theory of operators on a Hilbert space.

**UNIT I : Banach Spaces:**

Banach Spaces – Definition and examples – Continuous linear transformations – Hahn Banach theorem. (Chapter 9: Sections 46 to 48).

**UNIT II : Banach Spaces and Hilbert Spaces:**

The natural embedding of N in N** - Open mapping theorem – Conjugate of an operator – Hilbert space – Definition and properties. (Chapter 9: Sections 49 to 51, Chapter 10 : Sections 52).

**UNIT III: Hilbert Spaces:**

Orthogonal complements – Orthonormal sets – Conjugate space H* - Adjoint of an operator (Chapter 10 : Sections 53 to 56).

**UNIT IV: Operations on Hilbert Spaces:**

Self-adjoint operator – Normal and Unitary operators – Projections. (Chapter 10: Sections 57 to 59).

**UNIT V: Banach Algebras:**

Banach Algebras – Definition and examples – Regular and simple elements – Topological divisors of zero – Spectrum – The formula for the spectral radius – The radical and semi simplicity. (Chapter 12 : Sections 64 to 69).

**TEXT BOOKS :**

1. G.F.Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Inter. Book Co, New York, 1963.

**BOOKS FOR REFERENCE:**

1. W. Rudin, Functional Analysis, Tata McGraw Hill Publ. Co, New Delhi, 1973.
2. H.C. Goffman and G.Fedrick, First Course in Functional Analysis, Prentice Hall of India , New Delhi, 1987.
3. D. Somasundaram, Functional Analysis S. Viswanathan Pvt.Ltd., Chennai,1994.

**LEARNING OUTCOMES:**

On successful completion of this course, students will be able to

- Understand the relationship between metric space, normed space, inner product space
- understand properties of continuous linear functionals on Banach space
- understand various types of operators on Hilbert space.
- know Regular elements, singular elements, spectrum of Banach algebra &its ideals

# M.Sc. MATHEMATICS

## SEMESTER - IV

## CORE XIII – PROBABILITY THEORY

**OBJECTIVE:**

The objective of this course is to enable the students

- to understand the concepts and results related to probability, random events,
- to understand various distributions and applications.
- To know the standard results related to probability &distribution.

**UNIT - I**

Random Events and Random Variables - Random events – Probability axioms – Combinatorial formulae – conditional probability – Bayes Theorem – Independent events – Random Variables – Distribution Function – Joint Distribution – Marginal Distribution – Conditional Distribution – Independent random variables – Functions of random variables. (Chapter 1: Sections 1.1 to 1.7, Chapter 2: Sections 2.1 to 2.9).

**UNIT II:**

Parameters of the Distribution - Expectation- Moments – The Chebyshev Inequality – Absolute moments – Order parameters – Moments of random vectors – Regression of the first and second types. ( Chapter 3: Sections 3.1 to 3.8).

**UNIT III:**

Characteristic functions - Properties of characteristic functions – Characteristic functions and moments – semi-invariants – characteristic function of the sum of the independent random variables – Determination of distribution function by the Characteristic function – Characterstic function of multidimensional random vectors
– Probability generating functions. (Chapter 4: Sections 4.1 to 4.7).

**UNIT IV:**

Some probability distributions - One point , two point , Binomial – Polya – Hypergeometric – Poisson (discrete) distributions – Uniform – normal gamma – Beta – Cauchy and Laplace (continuous) distributions. ( Chapter 5: Section 5.1 to 5.10 (Omit Section 5.11).

**UNIT V:**

Limit Theorems - Stochastic convergence – Bernoulli law of large numbers – Convergence of sequence of distribution functions – Levy-Cramer Theorems – De Moivre-Laplace Theorem – Poisson, Chebyshev, Khintchine Weak law of large numbers – Lindberg Theorem – Lyapunov Theorem – Borel-Cantelli Lemma - Kolmogorov Inequality and Kolmogorov Strong Law of large numbers. (Chapter 6: Sections 6.1 to 6.4, 6.6 to 6.9, 6.11 and 6.12 only).

**TEXT BOOK:**

1. M. Fisz, Probability Theory and Mathematical Statistics, John Wiley and Sons, New York, 1963.

**BOOKS FOR REFERENCE :**

1. R.B. Ash, Real Analysis and Probability, Academic Press, New York, 1972.
2. K.L.Chung, A course in Probability, Academic Press, New York, 1974.
3. Y.S.Chow and H.Teicher, Probability Theory, Springer Verlag. Berlin, 1988 (2nd Edition).
4. R.Durrett, Probability : Theory and Examples, (2nd Edition) Duxbury Press, New York, 1996.
5. V.K.Rohatgi, An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi, 1988(3rd Print).
6. S.I.Resnick, A Probability Path, Birhauser, Berlin, 1999.
7. B.R.Bhat, Modern Probability Theory (3rd Edition), New Age International (P)Ltd, New Delhi, 1999.
8. J.P. Romano and A.F. Siegel, Counter Examples in Probability and Statistics, Wadsworth and Brooks / Cole Advanced Books and Software, California, 1968.

**LEARNING OUTCOMES:** At the end of the course, students will be able

- to get the knowledge of Random variables and Random events.
- to understand characteristic of function and Properties of characteristic function.

# M.Sc. MATHEMATICS

## SEMESTER - IV

## CORE XIV - CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS

**OBJECTIVES.**

- To introduce the concept of calculus of variations and integral equations and their applications.
- To study solution of Fredholm &Volterra integral equations through different methods.

**UNIT I : Variational Problems with Fixed Boundaries:**

The concept of variation and its properties – Euler's equation- Variational problems for Functionals – Functionals dependent on higher order derivatives – Functions of several independent variables – Some applications to problems of Mechanics. (Chapter 1: Sections 1.1 to 1.7 of [1]).

**UNIT II: Variational Problems with Moving Boundaries:**

Movable boundary for a functional dependent on two functions – one-side variations - Reflection and Refraction of extremals - Diffraction of light rays. (Chapter 2: Sections 2.1 to 2.5 of [1]).

**UNIT III: Integral Equation:**

Introduction – Types of Kernels – Eigen Values and Eigen functions – Connection with differential equation – Solution of an integral equation – Initial value problems – Boundary value problems. (Chapter 1: Section 1.1 to 1.3 and 1.5 to 1.8 of [2]).

**UNIT IV: Solution of Fredholm Integral Equation:**

Second kind with separable kernel – Orthogonality and reality eigen function – Fredholm Integral equation with separable kernel – Solution of Fredholm integral equation by successive substitution – Successive approximation – Volterra Integral equation – Solution by successive substitution. (Chapter 2: Sections 2.1 to 2.3 and Chapter 4 Sections 4.1 to 4.5 of [2]).

**UNIT V: Hilbert – Schmidt Theory:**

Complex Hilbert space – Orthogonal system of functions- Gram Schmidt orthogonalization process – Hilbert – Schmidt theorems – Solutions of Fredholm integral equation of first kind. (Chapter 3: Section 3.1 to 3.4 and 3.8 to 3.9 of [2]).

**TEXT BOOKS :**

1. A.S Gupta, Calculus of Variations with Application, Prentice Hall of India, New Delhi, 2005.(For Units I and II),
2. Sudir K.Pundir and Rimple Pundir, Integral Equations and Boundary Value Problems, Pragati Prakasam, Meerut, 2005. (For Units III, IV and V).

**BOOKS FOR REFERENCE:**

1. F.B. Hildebrand, Methods of Applied Mathematics, Prentice – Hall of India Pvt. New Delhi, 1968.
2. R. P. Kanwal, Linear Integral Equations, Theory and Techniques, Academic Press, New York,1971.
3. L. Elsgolts, Differential Equations and Calculus of Variations, Mir Publishers, Moscow, 1973.

**LEARNING OUTCOMES:**

After the successful completion of the course, students will be able

- to know different types variational problems and finding their extremals.
- to find solution of Fredholm &Volterra integral equations through different methods.

# M.Sc. MATHEMATICS

## SEMESTER - I

## ELECTIVE I - PAPER I - DISCRETE MATHEMATICS

**OBJECTIVE:**

The objective of this course is to understand the basic ideas of logic, proof methods and strategy, the growth of functions, counting techniques, pigeonhole principle, recurrence relations, solving recurrences using generating functions, Boolean functions, apply Boolean algebra to circuits and gatting networks, use finite state-machines to model computer operations.

**UNIT I : The Foundations: Logic and Proofs :**

Propositional - Applications of Propositional -Propositional Equivalences - Predicates and Quantifiers. (Chapter 1: Sections 1.1 - 1.3). Algorithms: The Growth of Functions. ( Chapter 3: Section 3.2).

**UNIT II : Counting:**

The Basics of Counting- The Pigeonhole Principle -Permutations and Combinations - Generalized Permutations and Combinations - Generating Permutations and Combinations . (Chapter 5: Sections 5.1- 5.3, 5.5 and 5.6).

**UNIT III : Advanced Counting Techniques:**

Applications of Recurrence Relations - Solving Linear Recurrence Relations Generating Functions . (Chapter 6: Sections 6.1, 6.2 and 6.4).

**UNIT IV : Boolean Algebra:**

Boolean Functions- Representing Boolean Functions - Logic Gates - Minimization of Circuits. (Chapter 10: Sections 10.1 -10.4).

**UNIT V : Modeling Computation:**

Finite-State machines with Output- Finite-State machines with No Output-Turing Machines. (Chapter 12: Sections 12.2, 12.3 and 12.5).

**TEXT BOOK:**

1. Kenneth H. Rosen, Discrete Mathematics and it's Applications,7th Edition, WCB / McGraw Hill Education, New York,2008.

**BOOKS FOR REFERENCE:**

1. J.P. Trembley and R. Manohar, Discrete Mathematical Structures applications to Computer Science, Tata McGraw Hills, New Delhi.
2. T. Veerarajan, Discrete Mathematics with Graph Theory and Combinatorics, Tata McGraw Hills Publishing Company Limited ,7th Reprint,2008.

**LEARNING OUTCOMES:** Students completing this course will be able to

- express a logic sentence in terms of predicates, quantifiers and logical connectives.
- apply the rules of inference and methods of proof including direct and indirect proof forms, proof by contradiction and mathematical induction.
- solve mathematics problems that involve computing permutations and combinations of a set, fundamental enumeration principles.
- evaluate Boolean functions and simplify expressions using the properties of Boolean algebra.

# M.Sc. MATHEMATICS
## SEMESTER - I
## ELECTIVE I - PAPER II - COMBINATORIAL MATHEMATICS

**OBJECTIVE:**

Combinatorial mathematics is the study of the arrangements of objects, according to prescribed rules, to count the number of possible arrangements or patterns, to determine whether a pattern of a specified kind exists and to find methods of constructing arrangements of a given type. The objective of this course is to acquaint the students with the concepts of permutations and combinatorics, generating functions, recurrence relations, the principle of inclusion and exclusion and Polya's theory of counting.

**UNITI** : Permutations and Combinations. (Chapter 1 Section 1.1 to 1.7)

**UNITII** : Generating functions. (Chapter 2 Section 2.1 to 2.7).

**UNITIII:** Recurrence relations. (Chapter 3 Section 3.1 to 3.5).

**UNITIV:** Principle of inclusion and exclusion. (Chapter 4 Section 4.1 to 4.7)

**UNITV** : Polya's theory of counting. (Chapter 5 Section 5.1 to 5.7).

**TEXT BOOK:**

1. C.L. Liu, Introduction to Combinatorial Mathematics, Tata McGraw Hill, Book Co., New York, 1968. (Chapters: 1 to 5.)

**BOOKS FOR REFERENCE:**

1. C.L. Liu, M. Edberg, Solutions to problems in Introduction to Combinatorial Mathematics, MC Grow-Hill Book & Co., New York, 1968.

2. J.H. Van Lint, R.M. Wilson, A Course in Combinatorics, 2nd Edition, Cambridge University Press, Cambridge, 2001.

3. R.P. Stanley, Enumerative Combinatorics, Volume I, Cambridge Studies in Advanced Mathematics, Volume 49, Cambridge University Press, 1997. 4. P.J. Cameron, Combinatorics: Topics, Techniques, Algorithms, Cambridge University Press, Cambridge, 1998.

**LEARNING OUTCOMES:** After completing the course, students will be able to

- Use formulas for counting basic combinatorial outcomes to construct solutions to complete combinatorial enumeration problems:
  - permutation, with and without repetitions;
  - combinations, with and without repetitions;
- Apply counting strategies to solve discrete probability problems.
- Use specialized techniques to solve combinatorial enumeration problems:
  - generating functions;
  - recurrence relations;
  - Inclusion-exclusion principle.

# M.Sc. MATHEMATICS

## SEMESTER – II

## ELECTIVE II- PAPER I - NUMERICAL ANALYSIS

**OBJECTIVES:**

The objectives of this course are

- to make the students familiarize with the ways of solving complicated mathematical problems numerically.
- To provide numerical methods for solving the non-linear equations, interpolation, differentiation, integration, ordinary and partial differential equations.
- Describing and understanding error analysis in numerical methods.

**UNIT I : Numerical solutions to ordinary differential equation:**

Numerical solutions to ordinary differential equation – Power series solution – Pointwise method – Solution by Taylor's series – Taylor's series method for simultaneous first order differential equations – Taylor's series method for Higher order Differential equations – Predictor – Corrector methods – Milne's method – Adam – Bash forth method. (Chapter 11: Sections 11.1 to 11.6 and Sections 11.8 to 11.20) .

**UNIT II: Picard and Euler Methods:**

Picard's Method of successive approximations – Picard's method for simultaneous first order differential equations – Picard's method for simultaneous second order differential equations – Euler's Method – Improved Euler's method – Modified Euler's Method. (Chapter 11: Sections 11.7 to 11.12).

**UNIT III : Runge – Kutta Method:**

Runge's method – Runge-Kutta methods – Higher order Runge-Kutta methods- Runge-Kutta methods for simultaneous first order differential equations – Runge- Kutta methods for simultaneous second order differential equations.(Chapter 11: Sections 11.13 to 11.17) .

**UNIT IV : Numerical Solutions to Partial Differential Equations:**

Introduction Difference Quotients – Geometrical representation of partial differential quotients – Classifications of partial differential equations – Elliptic equation – Solution to Laplace's equation by Liebmann's iteration process. (Chapter 12: Sections 12.1 to12.6).

**UNIT V : Numerical Solutions to Partial Differential Equations (Contd.):**

Poisson equation – its solution – Parabolic equations – Bender – Schmidt method – Crank – Nicholson method – Hyperbolic equation – Solution to partial differential equation by Relaxation method. (Chapter 12: Sections 12.7 to 12.10).

**TEXT BOOK:**

V.N Vedamurthy and Ch. S.N. Iyengar, Numerical Methods, Vikas Publishing House Pvt Ltd.,1998.

**BOOKS FOR REFERENCE :**

1. S.S. Sastry, Introductory methods of Numerical Analysis, Prentice of India, 1995.
2. C.F. Gerald, and P.O. Wheathy, Applied Numerical Analysis, Fifth Edition, Addison Wesley, 1998.
3. M.K. Venkatraman, Numerical methods in Science and technology, National Publishers Company,1992.
4. P. Kandasamy, K. Thilagavathy, K. Gunavathy, Numerical Methods, S. Chand & Company, 2003.

**LEARNING OUTCOMES:** At the end of the course, students will

- learn the principles for designing numerical schemes for differential equations.
- be able to analyze the consistency, stability and convergence of a numerical scheme.
- be able to know, for each type of differential equations, what kind of numerical methods are best suited for and the reasons behind these choices?
- be able to make a connection between the mathematical equations or properties and the corresponding physical meanings.
- be able to use a programming language or mathematical software to implement and test the numerical schemes.

# M.Sc. MATHEMATICS
## SEMESTER - II
## ELECTIVE II - PAPER II - DIFFERENCE EQUATIONS

**OBJECTIVE:**

Difference equations usually describe the evolution of certain phenomena over the course of time. The aim of studying this course is

- to introduce the difference calculus.
- to study linear difference equations and to know how to solve them.
- to know the stability theory for homogeneous linear system of difference equations.
- to study the asymptotic behavior of solutions of homogeneous linear difference equations.

**UNIT I : Difference Calculus:**

Difference operator – Summation – Generating function – Approximate summation. (Chapter 2 Sections 2.1 to 2.3).

**UNIT II : Linear Difference Equations:**

First order equations – General results for linear equations. (Chapter 3 Sections 3.1 to 3.2).

**UNIT III : Linear Difference Equations(Contd.):**

Equations with constant coefficients – Equations with variable coefficients – z – transform. (Chapter 3 Sections 3.3,3.5 and 3.7).

**UNIT IV: Stability Theory**

Initial value problems for linear systems – Stability of linear systems. (Chapter 4 Sections 4.1 to 4.3).

**UNIT V: Asymptotic Methods**

Asymptotic analysis of sums – Linear equations. (Chapter 5 Sections 5.1 to 5.3).

**TEXT BOOK:**

1. W.G.Kelley and A.C.Peterson, Difference Equations, Academic press, New York,1991.

**BOOKS FOR REFERENCE:**

1. S.N.Elaydi, An Introduction to Difference Equations, Springer – Verlag, NewYork,1990.
2. R.Mickens, Difference Equations, Van Nostrand Reinhold, New York, 1990.
3. R.P.Agarwal, Difference Equations and Inequalities Marcel Dekker, New York,1992.

**LEARNING OUTCOMES:**

After the successful completion of the course, students will be able

- to know the fundamentals of difference calculus, like, the difference operator, the computation of sums, the concept of generating function and the important Euler summation formula.
- to solve linear difference equations using different methods, namely, annihilator method, z-transform method, etc.
- to find the stability results for the linear system using eigen value criteria.
- to find asymptotic analysis of sums, and asymptotic behavior of solutions to linear difference equations by the theorems of Poincare and Perron.

# M.Sc. MATHEMATICS
# SEMESTER - III

## ELECTIVE III - PAPER I - DIFFERENTIAL GEOMETRY

**OBJECTIVE:**

This course gives students basic knowledge of classical differential geometry of curves and surfaces such as the catenary, the tractrix, the cycloid and the surfaces of constant Gaussian curvature and minimal surfaces. .

**UNIT I :Theory of Space Curves:**

Theory of space curves – Representation of space curves – Unique parametric representation of a space curve – Arc-length – Tangent and osculating plane – Principle normal and binormal – Curvature and torsion – Behaviour of a curve near one of its points – The curvature and torsion of a curve as the intersection of two surfaces. (Chapter 1 : Sections 1.1 to 1.9) .

**UNIT II : Theory of Space Curves (Contd.):**

Contact between curves and surfaces – Osculating circle and osculating sphere – Locus of centre of spherical curvature – Tangent surfaces – Involutes and Evolutes – Intrinsic equations of space curves – Fundamental Existence Theorem – Helices. (Chapter 1 : Sections 1.10 to 1.13 and 1.16 to 1.18) .

**UNIT III : Local Intrinsic properties of surface:**

Definition of a surface – Nature of points on a surface – Representation of a surface – Curves on surfaces – Tangent plane and surface normal – The general surfaces of revolution – Helicoids – Metric on a surface – Direction coefficients on a surface. (Chapter 2 : Sections 2.1 to 2.10).

**UNIT IV : Local Intrinsic properties of surface and geodesic on a surface:**

Families of curves – Orthogonal trajectories – Double family of curves – Isometric correspondence – Intrinsic properties – Geodesics and their differential equations – Canonical geodesic equations – Geodesics on surface of revolution. (Chapter 2: Sections 2.11 to 2.15 and Chapter 3: Sections 3.1 to 3.4) .

**UNIT V : Geodesic on a surface:**

Normal property of Geodesics – Differential equations of geodesics using normal property – Existence theorems – Geodesic parallels – Geodesic curvature – Gauss Bonnet Theorems – Gaussian curvature – Surface of constant curvature . (Chapter 3: Sections 3.5 to 3.8 and Sections 3.10 to 3.13) .

**TEXT BOOK:**

1. D. Somasundaram, Differential Geometry, Narosa Publ. House, Chennai, 2005.

**BOOKS FOR REFERENCE:**

1. T. Willmore, An Introduction to Differential Geometry, Clarendan Press, Oxford, 1959.
2. D.T Struik, Lectures on Classical Differential Geometry, Addison – Wesely, Mass. 1950.
3. J.A. Thorpe, Elementary Topics in Differential Geometry, Springer – Verlag, New York, 1979.

**LEARNING OUTCOMES:** After successful completion of the course, students will be able to

- calculate the curvature and torsion of a curve.
- find the osculating surface and osculating curve at any point of a given curve.
- calculate the first and the second fundamental forms of surface.
- calculate the Gaussian curvature, the mean curvature, the curvature lines, the asymptotic lines, the geodesics of a surface.

# M.Sc. MATHEMATICS
## SEMESTER – III
## ELECTIVE III - PAPER II – FLUID DYNAMICS

**OBJECTIVE:** The objective of this course is

- To give fundamental knowledge of fluid, its properties and behavior under various conditions of internal and external flows.
- To understand basic laws and equations used for analysis of static and dynamic fluids.
- To develop an appreciation for the properties of Newtonian fluids.
- To understand the dynamics of fluid flows and the governing non-dimensional parameters

**Unit I: Inviscid Theory**

Introductory Notions, velocity: Streamlines and paths of the particles-stream tubes and filaments- fluid body- Density – Pressure – Bernoulli's theorem. Differentiation with respect to time- Equation of continuity- Boundary conditions: kinematical and physical – Rate of change of linear momentum– The equation of motion of an inviscid fluid. (Chapters I & III of [1] Sections 1.0 – 1.4, 3.10 – 3.31, 3.40, 3.41)

**Unit II: Inviscid Theory (contd...)**

Euler's momentum theorem- conservative forces – Lagrangian form of the equation of motion – Steady motion – The energy equation – Rate of change of circulation – Vortex motion – Permanence of vorticity. (Chapter III of [1] Sections 3.42 – 3.45, 3.50 – 3.53).

**Unit III: Two-Dimensional Motion**

Two dimensional functions: Stream function – Velocity potential – Complex potential – Indirect approach – Inverse function. Basic singularities: Source – Doublet – Vortex – Mixed flow – Method of images: Circle theorem – Flow past circular cylinder with circulation. The aerofoil: Blasius's theorem – Lift force. (Chapter 3 of [2] Sections 3.2, 3.3, 3.5 - 3.5.1, 3.5.2, 3.7.4, 3.7.5).

**Unit IV: Viscous Theory**

The equations of motion for viscous flow: The stress tensor – The Navier-Stokes equations – Vorticity and circulation in a viscous fluid. Flow between parallel flat plates: Couette flow, Plane Poiseuille flow. Steady flow in pipes: Hagen-Poiseuille flow. (Chapters 5 of [2] & 8 of [3] Sections 5.2.1- 5.2.3 & 8.3 – a, b, 8.4 – a).

**Unit V: Boundary Layer Theory**

Boundary layer concept- Boundary layer equations in two dimensional flow- Boundary layer along a flat plate: Blasius solution – Shearing stress and boundary layer thickness – Momentum integral theorem for the boundary layer: The von Karman integral relation – von Karman integral relation by momentum law. (Chapter 9 of [3] Sections 9.1, 9.2, 9.3 – a,b, 9.5 – a,b).

**TEXT BOOKS:**

1. L.M. Milne Thomson, "*Theoretical Hydrodynamics"*, Dover, 1996.
2. N. Curle and H.J. Davies, "*Modern Fluid Dynamics Vol-I"* by, D Van Nostrand Company Ltd., London, 1968.
3. S.W. Yuan, *"Foundations of Fluid Mechanics"* by Prentice- Hall of India, New Delhi, 1988.

**BOOKS FOR REFERENCES:**

1. R.K. Bansal, *"An Introduction to Fluid Dynamics",* Firewall Media, 2005.
2. G.K. Batchelor, *"An Introduction to Fluid Dynamics",* Cambridge University Press, 2000.
3. F. Chorlton, *"Text Book of Fluid Dynamics*", CBS Publications, Delhi, 1985.
4. D.E. Rutherford, *"Fluid Dynamics",* Oliver and Boyd, 1959.

**LEARNING OUTCOMES:** On successful completion of the course, the student will be able to,

- Recognize and find the values of fluid properties and relationship between them and understand the principles of continuity, momentum, and energy as applied to fluid motions.
- Identify these principles written in form of mathematical equations.
- Apply dimensional analysis to predict physical parameters that influence the flow in fluid mechanics.

# M.Sc. MATHEMATICS
# SEMESTER – III

## ELECTIVE III - PAPER III - PROGRAMMING WITH C++

**OBJECTIVE:**

The objective of this course is to introduce the basic knowledge of one of the programming language of C++.

**UNIT I :**

Software Evolution – Procedure oriented Programming – Object oriented programming paradigm – Basic concepts of object oriented programming – Benefits of oops – Object oriented Languages – Application of OOP – Beginning with C++ - what is C++ - Application of C++ - A simple C++ Program – More C++ Statements – An Example with class – Structure of C++ Program.

**UNIT II:**

Token, Expressions and control structures: Tokens – Keywords – Identifiers and Constants – Basic Data types – User defined Data types – Derived data types – Symbolic Constants in C++ - Scope resolution operator – Manipulators – Type cost operator – Expressions and their types – Special assignment expressions – Implicit Conversions – Operator Overloading – Operator precedence – Control Structure.

**UNIT III : Function in C++:**

Main Function – function prototyping – Call by reference – Return by reference – Inline functions – default arguments – Const arguments – Function overloading – Friend and Virtual functions – Math library function. Class and Objects: Specifying a class – Defining member functions – A C++ program with class – Making an outside function inline – Nesting of member functions – Private member functions – Arrays within a class – Memory allocations for objects – Static data member – Static member functions
– Array of the object – Object as function arguments – Friendly functions – Returning objects – Const member functions – Pointer to members – Local classes.

**UNIT IV : Constructors and Destructors:**

Constructors – Parameterized Constructors in a Constructor – Multiple constructors in a class – Constructors with default arguments – Dynamic Initialization of objects – Copy constructors – Dynamic Constructors – Constructing Two-dimensional arrays – Const objects – Destructors. Operator overloading and type conversions: Defining operator overloading – overloading unary operators – overloading binary operators - overloading binary operators using friends – Manipulation of strings using operators – Rules for overloading operators – Type conversions.

**UNIT V : Files:**

Introduction – Class for file stream operations – opening and closing a file – detecting End-of file – More about open () File modes – File pointer and their manipulations – Sequential input and output operations. Exception Handling: Introduction – Basics of Exception Handling – Exception Handling Mechanism – Throwing Mechanism – Catching Mechanism – Rethrowing an Exception.

**TEXT BOOK:**

1 E.Balagurusamy, Object-Oriented Programming with C++ ,2nd Edition, Tata McGraw Hill Pub. 1999.

**BOOKS FOR REFERENCE:**

1. Robert Lafore – "The Waite Group's Object Oriented Programming In Turbo C++ - Galgotia Publication Pvt. Ltd. 1998.

2. Allan Neibaver – Office 2000.

**LEARNING OUTCOMES:** At the end of the course, students will be able

- To acquire the knowledge of getting solution to mathematical problems with the help of C++.

# ELECTIVE IV - PAPER I - NUMBER THEORY

**OBJECTIVE:**

The aim of this course is to teach the students about the basics of elementary number theory starting with primes, congruences, quadratic residues, primitive roots, arithmetic functions and some Diophantine equations.

**UNIT I : Divisibility and Congruence:**

Divisibility – Primes - Congruences – Solutions of Congruences – Congruences of Degree one. (Chapter 1: Sections 1.1 to 1.3 and Chapter 2: Sections: 2.1 to 2.3).

**UNIT II : Congruence:**

The function $\varphi(n)$ – Congruence of higher degree – Prime power moduli – Prime modulus – Congruence's of degree two, prime modulus – power Residues. (Chapter 2: Sections 2.4 to 2.9).

**UNIT III : Quadratic Reciprocity:**

Quadratic residues – Quadratic reciprocity – The Jacobi symbol – Greatest Integer function. (Chapter 3: Sections 3.1 to 3.3 and Chapter 4: Section 4.1)

**UNIT IV : Some Functions of Number Theory:**

Arithmetic functions –The Mobius inverse formula – The multiplication of arithmetic functions. (Chapter 4: Sections 4.2 to 4.4).

**UNIT V : Some Diaphantine Equations:**

The equation $ax + by = c$-Positive solutions-Other linear equations-The equation $x^2 + y^2 = z^2$- The equation $x^4 + y^4 = z^2$ Sums of four and five squares – Waring's problem – Sum of fourth powers – Sum of Two squares. (Chapter 5: Sections 5.1 to 5.10).

**TEXT BOOK:**

1. Ivan Niven and H.S Zuckerman, An Introduction to the Theory of Numbers, 3rd edition, Wiley Eastern Ltd., New Delhi, 1989.

**BOOKS FOR REFERENCE:**

1. D.M. Burton, Elementary Number Theory, Universal Book Stall, New Delhi 2001.
2. K.Ireland and M.Rosen, A Classical Introduction to Modern Number Theory, Springer Verlag, New York, 1972.
3. T.M Apostol, Introduction to Analytic Number Theory, Narosa Publication, House, Chennai, 1980.

# M.Sc. MATHMATICS

## SEMESTER - IV

**LEARNING OUTCOMES:** At the end of the course, student will be able to

- apply the Law of Quadratic Reciprocity and other methods to classify numbers as primitive roots, quadratic residues and quadratic non-residues.
- formulate and prove conjectures about numeric patterns and
- produce rigorous arguments centered on the material of number theory, most notably in the use of Mathematical induction and the Well-Ordered principle in the proof of theorems.

# ELECTIVE IV- PAPER II - OPTIMIZATION TECHNIQUES

**OBJECTIVES:**

- To introduce the methods of optimization techniques.
- To understand the theory of optimization techniques for solving various types of optimization problems.
- To provide with basic skills and knowledge of optimization techniques and their applications.
- To make the students familiar in solving techniques, analyzing the results and propose recommendations to the decision-making processes.

**UNIT I : Integer linear programming:**

Introduction – Illustrative applications integer programming solution algorithms: Branch and Bound (B & B) algorithm – zero – One implicit enumeration algorithm – Cutting plane Algorithm. (Sections 9.1,9.2,9.3.1.,9.3.2,9.3.3).

**UNIT II : Deterministic dynamic programming:**

Introduction – Recursive nature of computations in DP – Forward and backward recursion – Selected DP applications cargo – Loading model – Work force size model – Equipment replacement model– Investment model– Inventory models. (Sections 10.1,10.2,10.3,10.4.1,10.4.2,10.4.3,10.4.4,10.4.5).

**UNIT III : Decision analysis and games:**

Decision environment – Decision making under certainty (Analytical Hierarchy approach) Decision making under risk – Expected value criterion – Variations of the expected value criterion – Decision under uncertainty Game theory – optimal solution of two – Person Zero – Sum games – Solution of mixed strategy games. (Sections 14.1,14.2,114.3.1,14.3.2,14.4,14.5.1,14.5.2).

**UNIT IV : Simulation modeling:**

What is simulation? – Monte Carlo Simulation – Types of Simulation – Elements of Discrete Event Simulation – Generic definition of events – Sampling from probability distributions. Methods for gathering statistical observations – Sub Interval Method – Replication Method – Regenerative (Cycle) method – Simulation Languages. Sections 18.1,18.2,18.3,18.4.1,18.4.2,18.5,18.6,18.7.1,18.7.2,18.7.3,18.8).

# M.Sc. MATHMATICS

## SEMESTER - IV

**UNIT V : Nonlinear programming algorithms:**

Unconstrained nonlinear algorithms – Direct search method – Gradient method Constrained algorithms: Separable programming – Quadratic programming – Geometric programming – Stochastic programming – Linear combinations method – SUMT algorithm. (Sections : 21.1.1, 21.1.2, 21.2.1, 21.2.2, 21.2.3, 21.2.4, 21.2.5, 21.2.6).

**TEXT BOOK:**

1. Hamdy A.Taha, Operations Research an Introduction, 6th Edison, University of Arkansas Fayetteville.

**BOOKS FOR REFERENCE:**

1. F.S. Hillier and G.J. Lieberman Introduction to Operation Research 4th edition, Mc Graw Hill Book Company, New York, 1989.
2. Philips D.T.Ravindra A. and Solbery.J. Operations Research, Principles and Practice John Wiley and Sons, New York.
3. B.E.Gillett, Operations research – A Computer Oriented Algorithmic Approach, TMH Edition, New Delhi, 1976.

**LEARNING OUTCOMES:** At the end of the course, students will be able to

- ☐ Formulate a real-world problem as linear programming and queuing models.
- ☐ Assess the existence and uniqueness of solutions and derive necessary and sufficient optimality conditions for a given optimization problem.
- ☐ Understand the mathematical tools that are needed to solve optimization problems.
- ☐ Identify and develop decision making and inventory models from the verbal description of the real system.

# M.Sc. MATHEMATICS SEMESTER - IV
# ELECTIVE IV - PRACTICAL - C++ PROGRAMMING LAB

## LIST OF PRACTICALS

1. Create two classes DM and DB, which store the value of distances. DM stores distances in meters and centimeters in DB in feet and inches. Write a program that can create the values for the class objects and add object DM with another object DB.
2. Create a class FLOAT that contains on float data member overload all the four arithmetic operators so that operates on the objects of FLOAT.
3. Design a class polar, which describes a part in a plane using polar coordinates radius and angle. A point in polar coordinates is as shown below. Use the overloads +operator to add two objects of polar. Note that we cannot add polar values of two points directly. The requires first the conversion points into rectangular coordinates and finally creating the result into polar coordinates.

   [Where rectangle co-ordinates: x = r*cos(a); y = r* sin(a); Polar co-ordinates: a = atan (x/y) r = Sqrt (x*x + y*y)]
4. Create a class MAT of size m*m. Define all possible matrix operations for MAT type objects verify the identity. (A-B)^2+B^2-2*A*B.
5. Area computation using derived class.
6. Define a class for vector containing scalar values. Apply overloading concepts for vector additions, multiplication of a vector by a scalar quantity, replace the values in a position vector.
7. Integrate a function using Simson's 1/3 rule.
8. Solve the system of equations using Gauss Seidel method.
9. Solve differential equations using Runge Kutta fourth order method.

# M.Sc. MATHEMATICS
## SEMESTER II
## EXTRA DISCIPLINARY COURSE (EDC)
## EDC - PAPER I - NUMERICAL & STATISTICAL METHODS

**(Theorems and proof are not expected)**

**OBJECTIVE:**

The objective of this course is to provide the foundation for numerical methods and statistics.

**UNIT I:**

Algebraic and Transcendental Equations: Bisection Method – Iteration Method – The Method of False Position – Newton- Raphson – Method.

**UNIT II:**

System of Linear Equation: Gauss Elimination, Gauss Jordon elimination – Triangularization method –Iterative Methods, Jacobi, Gauss-Seidel iteration, Iterative method forA-1.

**UNIT III:**

Interpolation with equal intervals – Newton forward and backward formula - Central Difference Interpolation formula – Gauss forward and backward formula – Stirling's formula – Bessel's Formula - Numerical differentiation: Maximum and minimum values of a tabulated function. Numerical Integration: Trapezoidal Rule – Simpson's Rule – Numerical double Integration.

**UNIT IV:**

Correlation Coefficient – Rank correlation coefficient of determination – Linear regression – Method of least squares – Fitting of the curve of the form $ax+b$, $ax^2+bx+c$, $ab^x$and $ax^b$ – Multiple and partial correlation (3-variable only).

**UNIT V:**

Binominal distribution – Poisson distribution – Normal distribution – Properties and Applications.

**TEXT BOOKS:**

1. S.S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall of India, Pvt. Ltd., 1995.(For Units I, II and III).
2. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, (1994).(For Units IV and V).

**BOOKS FOR REFERENCE:**

1. S.Kalavathy, Numerical Methods, Vijay Nicole, Chennai, 2004.
2. Dr.Kandasamy, Numerical Methods, Sultan Chand, New Delhi.

**LEARNING OUTCOMES:**

- After successful completion of the course, the students will be able to apply these concepts to solve algebraic and transcendental equations, system of linear equations, evaluate derivatives and integrals using numerical techniques. Further, students will be able to analyze the given data with the help of the above statistical tools.

# M.Sc. MATHEMATICS SEMESTER – II

**EXTRA DISCIPLINARY COURSE (EDC) EDC - PAPER II - STATISTICS**
**(Theorems and proof are not expected)**

**OBJECTIVE:**

The aim of this course is to teach the students about the basics of measuring ideas and calculations methods.

**UNIT I:**

Collection, classification and tabulation of data, graphical and diagrammatic representation – Bar diagrams, Pie diagram, Histogram, Frequency polygon, frequency curve and Ogives.

**UNIT II:**

Measures of central tendency – Mean, Median and Mode in series of individual observations, Discrete series, Continuous series (inclusive), More than frequency, Less than frequency, Mid-value and open-end class.

**UNIT III:**

Measures of dispersion – Range, Quartile deviation, Mean deviation about an average, Standard deviation and co-efficient of variation for individual, discrete and continuous type data.

**UNIT IV:**

Correlation – Different types of correlation – Positive, Negative, Simple, Partial Multiple, Linear and non-Linear correlation. Methods of correlation – Karl-Pearson's coefficient of correlation-Spearman's rank correlations and Concurrent deviation.

**UNIT V:**

Regression types and method of analysis, Regression line, Regression equations, Deviation taken from arithmetic mean of X and Y, Deviation taken from assumed mean, Partial and multiple regression coefficients – Applications.

**TEXT BOOK:**

1. S.C.Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Sons, New Delhi, 1994.

**BOOKS FOR REFERENCE:**

1. Freund J.E. (2001); Mathematical Statistics, Prentice Hall of India.
2. Goon, A.M., Gupta M.K., Dos Gupta, B, (1991), Fundamentals of Statistics, Vol. I, World Press,Calcutta.

**LEARNING OUTCOMES:** After successful completion of the course, students will be able to

- calculate Mean, Median and Mode in series of individual observations.
- find Discrete series, Continuous series.
- calculate the first and the second fundamental forms of surface.
- calculate the Range, Quartile deviation, Mean deviation about an average, Standard deviation and co-efficient of variation for individual, discrete and continuous type data.

# M.Sc. MATHEMATICS SEMESTER – II

**ADD ON COURSE (AOC) - PAPER I – ADVANCED LATEX**

**Objectives: The course aims**

- To create understanding of the LaTeX
- To typeset typical mathematical papers using the article style and figure out LaTeX errors, download and use packages, create simple diagrams.
- To prepare a short presentation using the beamer class.

**Unit – I :** **No. of Hours : 12**

**Introduction and the Structure of a LaTeX Document**

Installation of the software LaTeX - Environments and commands - Classes and packages – Errors - Files created - How to use LAEX at CUED - Document Classes - Arara- Counters and Length parameters - Document and page organization – Page breaks, footnotes. Environments , Matrix-like environments . Chapter - 1 and 2 in I & Chapter - 1 in II ; Chapter – 4 in I & Chapter – 5 in II; Chapter -8 (Section 8.3) in III

**Unit – II :**

**Display and alignment structures** **No. of Hours : 12**

Display and alignment structures for equations Comparison with standard LaTeX - A single equation on one line - A single equation on several lines: no alignment - A Single equation on several lines: with alignment - Equation groups without alignment - Equation groups with simple alignment- Multiple alignments: align and flalign - Display environments as mini-pages- Interrupting displays, **Variable symbol commands** - **Symbols in formulas** Chapter – 8 (Section 8.2, 8.5, 8.6 and 8.9) in III

**Unit – III :**

**Figures Directly in LaTex** **No. of Hours : 12**

Inserting Images, Positioning Images, List of Figures, Drawing diagrams directly in LaTex, TikZ package, Graphics and PSTricks Pictures and graphics in LaTeX, simple pictures using PSTricks, Plotting of functions.

**Unit – IV : Presentations (The beamer Class)** **No. of Hours : 12**

Overlays -Themes **Assignments and Examinations** The exam Class - The exsheets Package - The probsoln Package - Using the data tool Package for Exams or Assignment Sheets - Random Numbers. **Charts** Flow Charts - Pie Charts - The datapie Package - The pgf-pie Package - Bar Charts - The bchart Package - The databar Package - Gantt Charts - Plots . Chapter – 8, 9 and 12 in II .

**Unit – V : Structuring Your Document** **No. of Hours : 12**

Author and Title Information, Abstract, Chapters, Sections, Subsections, Creating a Table of Contents, Cross-Referencing, Creating a Bibliography, Page Styles and Page Numbering, Multi-Lingual Support: using the babel package. **(5.1-5.7; in V)**

**Books for Study:**

I. Advanced LATEX by Tim Love**,** 2006,

II. http://www.h.eng.cam.ac.uk/help/documentation/docsource/latex_advanced.pdf
III. LaTeX for Administrative Work by Nicola L. C. Talbot, Dickimaw Books, 2015, http://www.dickimaw-books.com/latex/admin/
IV. The LaTeX Companion by Frank Mittelbach and Michel Goossens, Addison-Wesley, Library of Congress Cataloging-in-Publication Data (Second Edition)
V. Nicola L. C. Talbot, LATEX for Complete Novices Version 1.4, Dickimaw Books http://www.dickimaw-books.com/2012.

**References:**

1) Bindner, Donald & Erickson, Martin. (2011). A Student's Guide to the Study, Practice, and Tools of Modern Mathematics. CRC Press, Taylor & Francis Group, LLC.
2) Lamport, Leslie (1994). LaTeX: A Document Preparation System, User's Guide and Reference Manual (2nd ed.). Pearson Education. Indian Reprint.
3) George Gratzer, More Math into LATEX, 4th Edition, 2007 Springer Science
4) Frank Mittelbach, Michel Goossens, The LaTex Companion, Second Edition, Addision-Wesley, 2004
5) A Primer, Latex, Tutorials, Indian TEX users group, Trivandrum, India.www.tug.org.in

**Learning Outcomes:**

This course will enable the students to:

- Create and typeset a LaTeX document
- Typeset a mathematical document
- Draw pictures in LaTeX
- Create beamer presentations
- Prepare the projects or dissertations in LaTeX

# M.Sc. MATHEMATICS SEMESTER – II

## ADD ON COURSE (AOC) - PAPER II
## PYTHON PROGRAMMING

**Objectives:** This course aims

- To introduce to students Python programming.
- To learn python coding to implement algorithms for Mathematical problems.

**Unit-1 Introduction to Python**

Basic syntax, variable types, basic operators, numbers, strings, lists, tuples, functions and input/output statements. Some simple programs to understand the relational, conditional and logical operators. Compare two numbers (less than, greater than) using *if* statement. Sum of natural numbers using *while* loop; Finding the factors of a number using *for* loop; To check the given number is prime or not (use *if... else* statement); Find the factorial of a number (use *if...if...else*).; Simple programs to illustrate *logical operators* (*and, or, not*).

**Unit-2 Matrices, Differential Calculus & Analytical Geometry of Three Dimensions**

Python commands to reduce given matrix to echelon form and normal form with examples. Python program/command to establish the consistency or otherwise and solving system of linear equations. Python command to find the nth derivatives. Python program to find nth derivative with and without Leibnitz rule. Obtaining partial derivative of some standard functions Verification of Euler's theorem, its extension and Jacobean. Python program for reduction formula with or without limits. Python program to find equation and plot sphere, cone, cylinder.

**Unit-3 Roots of High-Degree Equations- Systems of Linear Equations**

Introduction, Simple Iterations Method - Finite Differences Method, Gauss Elimination Method: Algorithm, Gauss Elimination Method, Jacobi's Method, Gauss-Seidel's Method.

**Unit-4 Numerical differentiation, Integration and Ordinary Differential Equations**

Introduction & Euler's Method, Second Order Runge-Kutta's Method, Fourth Order Runge-Kutta's Method, Fourth Order Runge-Kutta's Method: Plot Numerical and Exact Solutions.

**Unit-5 Two-Point Boundary Value Problems**

Introduction to two-point boundary value Problems: second order differential equations - Higher order differential equations - solution of second order differential equation using Finite Difference Method.

**Text Books:**


1. www.python.org
2. www.rosettacode.org
3. http://faculty.msmary.edu/heinold/python.html
4. J. Kiusalaas, Numerical methods in engineering with Python 3. Cambridge University Press, 2013.
5. H. P. Langtangen, *Solving PDEs in Python: the FEniCS tutorial I*. Springer Open, 2016

**Reference Books:**

1. Hans Fangohr, Introduction to Python for Computational Science and Engineering (A beginner's guide), University of Southampton, 2015.
2. J. Crank, H. G. Martin, and D. M. Melluish, Non-Linear Ordinary Differential Equations. Oxford University Press.
3. Brain Heinold, A practical Introduction to Python Programming, Department of Mathematics and Computer Science, Mount St. Maru's University, 2019.
4. H. P. Langtangen and Anders Logg, *Solving PDEs in Python,* Springer Open, 2017.

**Learning outcomes:**

This course enable the students to

- Get solution to their various mathematical problems quickly through Phython programming.
- Implement the skill to find out the solution to dynamical systems given as differential equations.
- Do computational Mathematics easily.

# M.Sc. MATHEMATICS SEMESTER – II

**ADD ON COURSE (AOC) - PAPER III**

**ARTIFICIAL INTELLIGENCE**

**Course Objectives: The course aims to**

1. Describe the role of Mathematics and Statistics in Machine Learning
2. Introduce the associated frameworks in large scale computation

**Unit - I** **No. of Hours : 12**

**When Models Meet Data-** Data, Models, and Learning - Empirical Risk Minimization - Parameter Estimation - Probabilistic Modeling and Inference - Directed Graphical Models – Model selection

Chapter-8-sec: 8.1 to 8.6 (Page No: 251 - 283)

**Unit - II** **No. of Hours : 12**

**Linear Regression** - Problem Formulation - Parameter Estimation - Bayesian Linear Regression - Maximum Likelihood as Orthogonal Projection

Chapter-9-sec: 9.1 to 9.4 (Page No: 289 - 315)

**Unit - III** **No. of Hours : 12**

**Dimensionality Reduction with Principal Component Analysis -** Problem Setting - Maximum Variance Perspective - Projection Perspective - Eigenvector Computation and Low-Rank Approximations - PCA in High Dimensions - Key Steps of PCA in Practice - Latent Variable Perspective

Chapter-10-sec: 10.1 to 10.7 (Page No: 317 - 342)

**Unit - IV** **No. of Hours : 12**

**Density Estimation with Gaussian Mixture Models**- Gaussian Mixture Models - Parameter Learning via Maximum Likelihood - EM Algorithm - Latent-Variable Perspective

Chapter-11-sec: 11.1 to 11.4 (Page No: 348 - 367)

**Unit - V** **No. of Hours : 12**

**Classification with Support Vector Machines-** Separating Hyperplanes **-** Primal Support Vector Machine - Dual Support Vector Machine - Kernels - Numerical Solution

Chapter-12-sec: 12.1 to 12.5 (Page No: 370 - 392)

**Text Book:**

**Mathematics for Machine Learning** by **M. P**. **Deisenroth**, A. A. Faisal, C. S. Ong. Published by Cambridge University Press (2020).

**Course Outcomes:** This course enable the students to

- understand the role of Mathematics and Statistics in Machine Learning
- understand the associated frameworks in large scale computation