Progressive Education Society's

Modern college of Arts, Science and Commerce,

Ganeshkhind,Pune-16

Autonomous

NEP 2020(1)

Two year Degree program in Mathematics

(Faculty of Science and Technology)

M.Sc. (Mathematics) : Part - I

Choice Based Credit System Syllabus

To be implemented from Academic Year 2024-2025

Aims and Objectives of the curriculum :

1) To maintain updated curriculum.
2) To take care of fast development in the knowledge of mathematics.
3) To enhance the quality and standards of Mathematics Education.
4) To provide a broad common frame work, for exchange, mobility and free dialogue across the Indian Mathematical and associated community.
5) To create and aptitude for Mathematics in those students who show a promise for higher studies and creative work in Mathematics.
6) To create confidence in others, for equipping themselves with that part of Mathematics which is needed for various branches of Sciences or Humanities in which they have aptitude for higher studies and original work.

Course Outcome

CO	Details After completing M.Sc. (Mathematics) Program students will
CO1	Get advanced knowledge of principles, methods and clear perception of innumerous power of mathematical ideas and tools.
CO2	Be able to apply their skills and knowledge, which translate information presented verbally into Mathematical form select and use appropriate mathematical formulae or techniques in order to process the information and draw relevant conclusion in other areas.
CO3	Be able to find out or analyze scientific reasoning for various things and student will get knowledge about both pure as well as applied mathematics branches.
CO4	Develop capacity of critical reasoning, theoretical applied and communication skills and develop abilities for logical thinking and problem solving used for community.
CO5	Get adequate exposure to global and local concerns that explore them many aspects of Mathematical sciences in higher studies.

Course Structure

M.Sc. Part-I

Semester-I

Course Type	Course and Title	Subject Code	No of Credits
Disciplinary Major/ Core Mandatory 14Cr(4*3+2)	Major Paper-1 : Advance Course in Linear Algebra(Theory)	24MAT51101	4
	Major Paper-2 : Real Analysis(Theory)	24MAT51102	4
	Major Paper-3: Advance Course in Group Theory (Theory)	24MAT51103	4
	Major Paper-4: Practical in Python Programming – I (Practical)	24MAT51104	2
DSE Elective 4Cr	Major Elective-1 : Advance Calculus (Theory)	24MAT51105	4
	Major Elective-2 : Advance Course in Ordinary Differential Equations(Theory)	24MAT51106	4
Minor RM : 4 Cr	RM : Research Methodology (Theory)	24MAT51107	2
	RM : Research Methodology (Practical)	24MAT51108	2

Semester-II

Course Type	Course and Title	Subject Code	No of Credits
Disciplinary Major/ Core Mandatory 14 Cr (4*3+2)	Major Paper-1 : Advance Course in Complex Analysis (Theory)	24MAT52101	4
	Major Paper-2 : General Topology (Theory)	24MAT52102	4
	Major Paper-3: Rings and Modules (Theory)	24MAT52103	4
	Major Paper-4: Practical in Python Programming – II (Practical)	24MAT52104	2
DSE Elective 4 Cr	Major Elective-1 : Advance Course in Numerical Analysis (Theory)	24MAT52105	4
	Major Elective-2 : Advance Course in Partial Differential Equations (Theory)	24MAT52106	4
OJT,FP,CEP,CC, RP , OJT 4 Cr	On Job Training	24MAT52107	4

M.Sc. Part-II

Semester-III

Course Type	Course and Title	Subject Code	No of Credits
Disciplinary Major/ Core Mandatory 14 Cr (4*3+2)	Major Paper-1 : Functional Analysis (Theory)	24MAT63101	4
	Major Paper-2 : Field Theory (Theory)	24MAT63102	4
	Major Paper-3: Integral Equations (Theory)	24MAT63103	4
	Major Paper-4 : Practical in Combinatorics (Practical)	24MAT63104	2
DSE Elective 4 Cr	Major Elective-1(A) : Advance Complex Analysis (Theory)	24MAT63105	2
	Major Elective-1(B) : Mathematics Practical based on Advance Complex Analysis0 (Practical)	24MAT63106	2
	Major Elective-2(A) : Mathematical Techniques using Python (Theory)	24MAT63107	2
	Major Elective-2(B) : Mathematics Practical based on Mathematical Techniques using Python (Practical)	24MAT63108	2
OJT,FP,CEP,CC, RP , OJT 4 Cr	Research Project 4 Cr	24MAT63109	4

M.Sc. Part-II

Semester-IV

Course Type	Course and Title	Subject Code	No of Credits
Disciplinary Major/ Core Mandatory 12 Cr (4*3)	Major Paper-1 : Fourier Series and Boundary Value Problems (Theory)	24MAT64101	4
	Major Paper-2 : Differential Geometry (Theory)	24MAT64102	4
	Major Paper-3: Probability and Statistics (Theory)	24MAT64103	4
DSE Elective 4 Cr	Major Elective-1(A) : Number Theory and it's Applications (Theory)	24MAT64104	2
	Major Elective-1(B) : Mathematics based on Number Theory and it's Applications. (Practical)	24MAT64105	2
	Major Elective-2(A) : Introduction to Data Science (Theory)	24MAT64106	2
	Major Elective-2(B) : Mathematics Practical based on Introduction to Data Science (Practical)	24MAT64107	2
OJT,FP,CEP,CC, RP , OJT 6 Cr	Research Project 6 Cr	24MAT64108	6

Evaluation Pattern

M.Sc. Part-I : Semester-I

Sr. No.	Course Code	Name of the Course	% of Assessment		Total Marks	Credits
			IA	SEE		
1	24MAT51101	Major Paper-1 : Advance Course in Linear Algebra (Theory)	40	60	100	4
2	24MAT51102	Major Paper-2 : Real Analysis (Theory)	40	60	100	4
3	24MAT51103	Major Paper-3: Advance Course in Group Theory (Theory)	40	60	100	4
4	24MAT51104	Major Paper-4: Practical in Python Programming - I (Practical)	20	30	50	2
5	24MAT51105	Major Elective-1 : Advance Calculus (Theory)	40	60	100	4
	24MAT51106	Major Elective-2 : Advance Course in Ordinary Differential Equations (Theory)	40	60	100	4
6	24MAT51107	RM : Research Methodology (Theory)	20	30	50	2
	24MAT51108	RM : Research Methodology (Practical)	20	30	50	2

Semester-II

Sr. No.	Course Code	Name of the Course	% of Assessment		Total Marks	Credits
			IA	SEE		
1	24MAT52101	Major Paper-1 : Advance Course in Complex Analysis (Theory)	40	60	100	4
2	24MAT52102	Major Paper-2 : General Topology (Theory)	40	60	100	4
3	24MAT52103	Major Paper-3: Rings and Modules (Theory)	40	60	100	4
4	24MAT52104	Major Paper-4: Practical in Python Programming - II (Practical)	20	30	50	2
5	24MAT52105	Major Elective-1 : Advance Course in Numerical Analysis (Theory)	40	60	100	4
	24MAT52106	Major Elective-2 : Advance Course in Partial Differential Equations (Theory)	40	60	100	4
6	24MAT52107	On Job Training	40	60	100	4

IA : Internal Assessment , SEE : Semester End Examination

*Study tour should arrange in each academic year.

Detailed Syllabus

M.Sc. Part-I : Semester-I

Major Paper 1 : Name of the Paper : Advance Course in Linear Algebra

(Theory).

Paper Code : 24MAT51101 **Total No. of Credits : 4**

Total No. of lectures : 60

Course Outcomes

CO	Details
CO1	Student will learn the importance and applications of linear transformation.
CO2	Student will learn matrix and it's properties , system of equations which has wide variety of applications in various science subjects.
CO3	Student will learn concepts of vector space from various dimensions , which is used in other pure mathematical subjects and engineering.
CO4	Student will get introduced to finite dimensional spectral theorem.

Course Content

Unit I. Vector Spaces. **[06 Hours]**

1.1Vector Spaces.

1.2Subspaces and linear dependence.

1.3 The concepts of basis and dimension

1.4Some general theorems about finitely generated vector spaces..

Unit II. Linear Transformation and Matrices. **[06 Hours]**

2.1 Linear Transformations

2.2 Addition and multiplication of matrices.
2.3 Linear Transformations and matrices.

Unit III. Vector Spaces with an Inner product. [10 Hours]

3.1The concept of symmetry

3.2 Inner Product.

Unit IV. The Theory of a single Linear Transformation. [10 Hours]

4.1 Basic Concepts
4.2 Invariant Subspaces
4.3 The Triangular form theorem
4.4 The rational and Jorden canonical forms.

Unit V. Dual Vector Spaces and Multilinear Algebra. [14 Hours]

5.1 Quotient spaces and dual vector spaces
5.2 Bilinear forms and duality
5.3 Direct sums and tensor products
5.3 A proof of the elementary divisor theorem.

Unit VI. Orthogonal and Unitary Transformations [14Hours]

6.1 The structure of orthogonal transformations
6.2 The principal axis theorem
6.3 Unitary transformation and the spectral theorem.

Recommended Book : Charles W. Curtis : Linear Algebra An Introductory Approach, Springer. Chapter 2: Sect- 3, 4, 5, 7. Chapter 3: Sect-11 (except Theorem 11.7, Definition 11.8, Theorem 11.7′, Definition 11.10, Theorem 11.11, Theorem 11.12), 13.Chapter 4: Section 15. Chapter 7: Sections 22, 23, 24, 25. Chapter 8: Sections 26, 27, 28, 29.Chapter 9: Sections 30, 31,32

Reference Books:

1) Vivek Sahai, Vikas Bist, Linear Algebra, Narosa Publication.

2) K. Hoffman, Ray Kunze, Linear Algebra, Prentice Hall of India Private Ltd.
3) P. B. Bhattacharya, S. R. Nagpaul, S. K. Jain, First Course in Linear Algebra, 2 nd Edition, New Age International Publishers.
4)S. Kumaresan, Linear Algebra A Geometric Approach, PHI Learning Private Ltd.

Major Paper 2 : Name of the Paper : Real Analysis (Theory).

Paper Code : 24MAT51102 **Total No. of Credits : 4**
Total No. of lectures : 60

Course Outcomes

CO	Details
CO1	The student will gain confidence in proving theorems and solving problems.
CO2	Student will understand the generalized concept of measure and integration.
CO3	Student will be able to understand Lebesgue integration and compare it with Riemann Integration.
CO4	Students will learn the convergence theorems, which have wide variety of applications.

Course Content

Unit-I. The Real Numbers: Sets, Sequences and Functions [3 Hours]

1.1Countable and uncountable sets
1.2Open sets, closed sets and Borel sets of Real Numbers

Unit-II. Lebesgue Measure: [17 Hours]

2.1Lebesgue Outer Measure

2.2σ- algebra of Lebesgue Measurable Sets
2.3 Outer and Inner Approximation of Lebesgue Measurable Sets
2.4Countable Additivity
2.5 Continuity
2.6 Borel-Cantelli Lemma
2.7 Non-measurable Set, Cantor Set, Cantor-Lebesgue Function.

Unit-III. Lebesgue Measurable Functions: [12 Hours]

3.1Definition and algebra of Lebesgue Measurable Functions
3.2Sequential Point wise Limits and Approximations by Simple Functions
3.3 Littlewood's Three Principles
3.4 Egoroff's Theorem
3.5 Lusin's Theorem.

Unit IV. Lebesgue Integration [15 Hours]

4.1 The Riemann Integral

4.2 The Lebesgue integral of a Bounded Measurable Function over a set of finite Measure

4.3 The Lebesgue integral of a Measurable Non-negative Function

4.4 The General Lebesgue Integral

4.5 Countable Additivity and Continuity of Integration

4.6 Uniform Integrability : The Vitali Convergence Theorem

Unit-V. Differentiation and Integration: [13 Hours]

5.1Continuity of Monotone Functions (Statements and definitions only)
5.2Lebesgue's Differentiation Theorem (Statements and definitions only)
5.3Functions of Bounded Variation
5.4 Jordan's Theorem, Absolutely Continuous Functions
5.5 Integration of Derivatives
5.6Differentiation of Indefnite Integral
5.7 Fundamental Theorem of Calculus.

Recommended Book

Real Analysis-Fourth Edition, Authors: H. L. Royden, P. M. Fitzpatrick.

Sections: Chapter 1- sections 1.3,1.4, Chapter 2 – sections 2.1 to 2.7, Chapter 3 – sections 3.1 to 3.3, Chapter 4 – 4.1,4.2, 4.3(Linearity and monotonicity only statement), 4.4(Linearity and monotonicity only statement),4.5, 4.6 Chapter 6 – sections 6.1 to 6.5.

Reference Books

1. Real Analysis: Authors: Elias M. Stein, Rami Shakarchi.
2. Basic Real Analysis: Author: Anthony W. Knapp.
3. Beginning Functional Analysis: Authors: Karen Saxe (Springer International Edition)

Major Paper 3 : Name of the Paper : Advance Course in Group Theory (Theory).

Paper Code : 24MAT51103 **Total No. of Credits : 4**

Total No. of lectures : 60

Course Outcomes

CO	Details
CO1	Student will be able to recognize the mathematical objects that are groups, and classify them as abelian, cyclic and permutation groups, etc;
CO2	This course will enhance abstract thinking of students.
CO3	Student will learn to compare two different algebraic structures and study transfer of properties in-between these structures through homomorphism and isomorphism.
CO4	Student will understand the significance of sylow theorem, group action and their applications.
CO5	With this course students are prepared for higher mathematical courses such as ring theory and field theory ,Galois theory etc.

Course Content

UNIT-I: Groups, Subgroups and Cyclic Groups [12 Hours]

1.1 Definition and Examples of Groups; Properties of Groups; Order of a finite group; Order of an element in group; Subgroups; Subgroup Tests.

1.2 Cyclic Groups; Properties of Cyclic Groups; Classification of Subgroups of Cyclic Groups.

UNIT-II: Permutation Groups- Isomorphism [12 Hours]

2.1 Permutations Groups; Definition and notation; Cycles; Properties of Permutations; Even and odd permutations; Alternating Group of degree n.

2.2 Isomorphism of Group; Properties of Isomorphisms; Cayley's Theorem; Automorphisms.

UNIT-III: Cosets, Lagrange's Theorem, External Direct Product [12 Hours]

3.1 Cosets; Lagrange's Theorem and consequences; Stabilizer and orbit; Orbitstabilizer theorem.

3.2 External Direct Products; Properties of External Direct Products; Group of units modulo n as an external direct product.

UNIT-IV: Normal Subgroups, Homomorphisms [12 Hours]

4.1 Normal Subgroups; Factor Groups; Application of Factor Groups; Internal Direct Products.

4.2 Group Homomorphisms; Definition and examples; Properties of Homomorphisms; First Isomorphism Theorem.

UNIT-V: Sylow Theorems [8 Hours]

5.1 Fundamental Theorem of Finite Abelian Groups; Isomorphism Classes of Abelian Groups; Proof of the Fundamental Theorem.

5.2 Conjugacy Classes; Class Equation; The Sylow Theorems; Applications of Sylow's Theorems.

UNIT-VI: Group Actions [4 Hours]

6.1 Group Actions; Definition and examples; Permutation representation associated to a given action; Faithful action; Kernel; Left regular action.

Recommended Books

1) **Joseph Gallian, Contemporary Abstract Algebra**, 9 th Edition, CengageLearning India Pvt. Ltd. ISBN-10 9353502527
Chapters 2, 3, 4, 5 (except last article: A check Digit Scheme based on D5).Chapters 6, 7 (except: Rotations of a cube and Soccer Ball and subsequent Article). Chapter 8 (except: Applications). Chapters 9, 10, 11, 24.
2) **David S. Dummit, Richard M. Foote**, Abstract Algebra, 2 nd Edition, JohnWiley and Sons (Indian Edition)
In chapter 1 only Article 1.7.

Reference Books

1) I. S. Luthar, I. B. S. Passi, Algebra (Vol 1), Groups; Narosa Publication House.
2) I. N. Herstein, Topics in Algebra, Wiley Eastern Ltd.
3) M. Artin, Algebra, Prentice Hall.
4) N. S. Gopalkrishnan, University Algebra, Wiley Eastern Ltd.
5) J. B. Fraleigh, A First Course in Abstract Algebra, 7 th Edition, Pearson EditionLtd.

Major Paper 4 : Name of the Paper : Practical in Python Programming

(Practical).

Paper Code : 24MAT51104 **Total No. of Credits : 2**

Total No. of Practical : 15

Syllabus

Unit 1 : Introduction to Python

1.1 : Installation of Python
1.2 : Features of Python
1.3 : Print ( ) function
1.4 : Value and types
1.5 : Variables
1.6 : Operators and Operands
1.7 : Strings and Operations on strings

1.7.1 : Slicing
1.7.2 : Indexing
1.8 List and Tuple

Unit 2 : Boolean Operations

2.1: Logical Operators
2.2: Mathematics Modules (math, cmath)
2.3 : Calculus

Unit 3 : Linear Algebra

3.1 : Matrix Construction

3.2 : Operations on Matrices

3.3 : Accessing rows and columns , Deleting and inserting rows and columns

3.4: Determinant , Reduced row echelon form , null space , column space , rank

Unit 4 : Dictionary and sorting

4.1: Introduction to dictionary

4.2 : Dictionary with default value

4.3 : Accessing Values of a dictionary

4.4 : Creating Dictionary

Unit 5 : Solving Linear system of equations

5.1 : Gauss Elimination

5.2 : Gauss Jorden

5.3 : LU decomposition

Unit 6 : Eigenvalues , Eigenvectors and Diagonalization

6.1 : Eigenvalues

6.2 : Eigenvectors

6.3 : Diagonalization

Unit 7 : Conditional Statements

7.1 : if-else , nested if

7.2 : while loop

7.3 : for loop

7.4 : Range function

Unit 8 : Functions

8.1 : Features of Functions

8.2 : Types of function

8.3 : Parameters and Arguments

8.4 : Recursion

Unit 9 : 2D-3D Graphs

9.1 : Installation of numpy , Matplotlib packages

9.2 : 2D Plot

9.3 : Decoration of Graphs with plot style and type

9.4 : Polar plots

Unit 10 : Numerical Integration

10.1 : Trapezoidal Rule

10.2 : Simpson's $1/3^{rd}$ Rule

10.3 : Simpson's $3/8^{th}$ Rule

Unit 11 : Computational Geometry

11.1 : Points

11.2 : Transformation of Points

11.3 : Lines

11.4 : Polygon

Unit 12 : Operations Research

12.1: Linear Programming in Python

12.2 : Transportation Problem

Books

1. Allen Downey , Think Python , How to think like a computer Scientist , Green Tea Press Needham Massachusetts , 2015
2. Robert Johansson , Introduction to Scientific Computing in Python 2016
3. Jim Arlow , Interactive Computational Geometry in Python
4. Python : Notes for Professionals , Goalkicker.com , free programming Books

List of Practical

1. Practical 1: Practical on Unit 1

2. Practical 2 : Practical on Unit 2

3. Practical 3 : Practical on Unit 3

4. Practical 4 : Practical on Unit 4

5. Practical 5 : Practical on Unit 5

6. Practical 6 : Practical on Unit 6

7. Practical 7 : Practical on Unit 7

8. Practical 8 : Practical on Unit 8

9. Practical 9 : Practical on Unit 9

10. Practical 10 : Practical on Unit 10

11. Practical 11 : Practical on Unit 11

12. Practical 12 : Practical on Unit 12

13. Practical 13 : Miscellaneous

14. Practical 14 : Miscellaneous

15. Practical 15 : Miscellaneous

Major Elective 1 : Name of the Paper : Advanced Calculus (Theory)

Paper Code : 24MAT51105 **Total No. of Credits : 4**
Total No. of Practical : 60

Course Outcomes

CO	Details
CO1	The basic concepts in multivariable calculus will be strengthened.
CO2	Student will learn the advanced concepts in several variable calculus.
CO3	Student will learn to evaluate line integral, multiple integrals and surface integrals.
CO4	Student will learn Green's and Stoke's theorem which have wide applications in other physical sciences.

Course Content

UNIT-I: Differential Calculus of Scalar and Vector Fields [20 Hours]

1.1 Functions from R^n to R^m . Scalar and vector fields; Limits and continuity.

1.2 The derivative of a scalar field with respect to a vector; Directional derivatives and partial derivatives; Partial derivatives of higher order; Inverse function theorem and Implicit Function theorem . (without proof)

1.3 Directional derivatives and continuity; The total derivatives; The gradient of a scalar field; A sufficient condition for differentiability.

1.4 A chain rule for derivatives of scalar fields; Applications to geometry. Level sets. Tangent planes; Derivatives of vector fields; Differentiability implies continuity; The chain rule for derivatives of vector fields; Matrix form of the chain rule.

UNIT-II: Line Integrals [10 Hours]

2.1 Paths and line integrals; Other notations for line integrals; Basic properties of line integrals.

2.2 The concept of work as a line integral; Line integrals with respect to arc length; Further applications of line integrals.

2.3 Open connected sets. Independence of the path; The first and second fundamental theorem of calculus for line integrals; Necessary and sufficient conditions for a vector field to be a gradient; Necessary conditions for a vector field to be a gradient.

UNIT-III: Multiple Integrals [15 Hours]

3.1 Partitions of rectangles. Step functions; The double integral of a step function; The definition of the double integral of a function defined and bounded on a rectangle ; Upper and lower double integrals; Evaluation of double integral by repeated one-dimensional integration; Geometric interpretation of the double integral as a volume; Worked examples.

3.2 Integrability of continuous functions; Integrability of bounded functions with discontinuities ; Double integrals extended over more general regions; Applications to area and volume; Worked examples.

3.3 Green's theorem in the plane; Some applications of Green's theorem; A necessary and sufficient condition for a two dimensional vector field to be a gradient.

3.4 Change of variables in a double integral; Special cases of the transformation formula with proof; General case of the transformation formula with proof; Extensions to higher dimensions; Change of variables in an n-fold integral; Worked examples.

UNIT-IV: Surface Integrals [15 Hours]

4.1 Parametric representation of a surface; The fundamental vector product; The fundamental vector product as a normal to the surface; Area of a parametric surface.

4.2 Surface integrals; Change of parametric representation ; Other notations for surface integrals

4.3 The theorem of Stokes; Curl and divergence of a vector field; Properties of curl and divergence; the divergence theorem (Gauss' theorem) and applications of divergence theorem.

4.4 Parametric representation of a surface; The fundamental vector product; The fundamental vector product as a normal to the surface; Area of a parametric surface.

4.5 Surface integrals; Change of parametric representation ; Other notations for surface integrals

4.6 The theorem of Stokes; Curl and divergence of a vector field; Properties of curl and divergence; the divergence theorem (Gauss' theorem) and applications of divergence theorem.

Recommended Book

1) **Tom M. Apostol**, Calculus Volume II (Second Edition) Indian Reprint 2016 (JohnWiley & Sons, Inc) ISBN:978-81-265-1520-2. Unit 1: Chapt 8 : 8.1 to 8.22. ;Unit 2: Chapt 10 : 10.1 to 10.11, 10.14 to 10.16. Unit 3: Chapt 11 : 11.1 to 11.15; 11.19 to 11.22, 11.26 to 11.34.; Unit 4: Chapt 12: 12.1 to 12.15, 12.19 and 12.21.
   For " Inverse Function Theorem" and "Implicit Function Theorem", use Tom M. Apostol, Mathematical Analysis 2nd Edition Narosa Publication 20th Reprint 2002. ISBN 978-81-85015-66-8. Unit-I: Chapter 13: Sections 13.3 and 13.4.

Reference Books

1) Gerald B. Folland, Advanced Calculus , Pearson Edn 2012. 2) A Devinatz,Advanced Calculus (Holt , Reinhart & Winston) 1968.

Major Elective 2 : Name of the Paper : Advanced Course in Ordinary Differential Equations (Theory) Paper Code : 24MAT51106
Total No. of Credits : 4 Total No. of Lectures : 60

Course Outcomes

CO	Details
CO1	Students will able to solve the problems using multiple approaches and will learn to classify ODEs.
CO2	Students will demonstrate an understanding of the theory of ODEs and will work with a variety of applications of ODE.
CO3	Students will learn to visualize ODEs in graphical, numerical form.
CO4	Student will have a working knowledge of basic application problems described by second order linear differential equations with constant coefficients.
CO5	Students will understand the concepts of existence and uniqueness of solutions.

Course Content

Unit I: Linear equations of the first order [04 hours]

1.1 Linear equations of the first order
1.2 The equation y'+ay=0
1.3 The equation y'+ay=b(x)
1.4 The general linear equations of first order

Unit II: Linear equations with constant coefficients [14 hours]

2.1 Second order homogeneous equations
2.2 Initial value problems for second order equations
2.3 Linear dependence and independence
2.4 Formula for the Wronskian
2.5 Non homogeneous equations of order two
2.6 Homogeneous equations of order n
2.7 Non homogeneous equations of order n
2.8 Algebra of constant coefficients equations

Unit III: Linear equations with variable coefficients [14 hours]

3.1 Initial value problems for the homogeneous equation
3.2 Solutions of the homogeneous equation
3.3 Wronskian and linear independence
3.4 Reduction of order of the homogeneous equation
3.5 Non homogeneous equations with analytic coefficients
3.6 Homogeneous equations
3.7 Legendre equation

Unit IV: Linear Equations with regular singular points [14 hours]

4.1 Euler equation
4.2 Second order equation with regular singular points
4.3 Exceptional cases
4.4 Bessel's equation
4.5 Regular singular point at infinity

Unit V: Existence and uniqueness of solutions to first order equations [14 hours]

5.1 Equations with variables separated
5.2 Exact equations
5.3 Method of successive approximations
5.4 Lipschitz condition
5.5 Approximation to, and uniqueness of, solutions

Recommended Book:

E. A. Coddington, An Introduction to Ordinary Differential Equations (Prentice-Hall).

Chapter- 1.4 -1.7; 2.1-2.12; 3.1-3.8; 4.1- 4 .4, 4.6- 4.8; 5.1 -5.8.

Reference Books :

G. F. Simmons and S. G. Krantz, Dfferential Equatins (Tata McGraw-Hill).

Minor : Name of the Paper : Research Methodology (Theory)

Paper Code : 24MAT51107 **Total No. of Credits : 2**

Total No. of Lectures : 30

Course Objective :

- To enable students to undertake independent research of a business problem, and to analyse and present their findings.
- To familiarize students with the basic techniques of collection, analysis, interpretation and presentation of data.
- To formulate a research proposal for a business project.
- To obtain knowledge of research methodology.

Course Outcomes

CO	Details After successful completion of course students will be able to:
CO1	Understand research terminology.
CO2	Be aware of the ethical principles of research, ethical challenges and approval processes.
CO3	Describe quantitative, qualitative and mixed methods approaches to research.
CO4	Identify the components of a literature review process.
CO5	Critically analyse published research.

Course Content

Unit 1: Introduction to Research Definition, meaning, characteristics of Research. **[2 Hours]**

Unit 2: Types of Research, Introduction Nature of qualitative and quantitative research, Research in functional areas of management, Process of Research, Formulation of Research Design. **[5 Hours]**

Unit 3: Meaning and sources of Research problem, characteristics of good Research problem, Research process, outcomes, application of Research. **[3 Hours]**

Unit 4: Literature Review Process – Role, importance, sources, methods, software tools for literature review. Formulation of Research Problem. **[2 Hours]**

Unit 5: Research Design – Meaning, Need, Types of research design – Exploratory, Descriptive, components of research design and features of good research design. **[5 Hours]**

Unit 6: Sampling: Sampling design: Meaning, logic and application of sampling. **[3 Hours]**

Unit 7: Data Collection Methods: Types and Sources of Data. **[5 Hours]**

Unit 8: Data Analysis: Organization and presentation of data, Data Analysis Methods. **[2 Hours]**

Unit 9: Presentation and Publication of Research: Research **[3 Hours]**

Proposal, Research Paper, Research Thesis, Research Report, Report Writing Format for writing reports, bibliography, and references.

Reference Books

1. Research methodology techniques and methods https://ccsuniversity.ac.in/bridge-library/pdf/Research-Methodology-CR-Kothari.pdf , , C R Kothari New age International publishers.
2. Probability and Statistics for Engineers and Scientists , Sheldon Ross , Elsevier Academic Press.
3. Research Methodology , R. Panneerselvam , PHI,New Delhi 2005.
4. Researching Information Systems and Computing , Oates B J , Sage Publications.
5. https://onlinecourses.nptel.ac.in/noc22_ge08/preview

Minor : Name of the Paper : Research Methodology (Practical)
Paper Code : 24MAT51108 **Total No. of Credits : 2**
Total No. of Lectures : 15

Course Objective : To enable students to publish research paper.

Course Outcomes

CO	Details After successful completion of course students will be able to:
CO1	Understand research terminology.
CO2	Publish research paper/ research article.

Course Content

Practicals 1 , 2, 3 : Based on ICT Tools for Research , Use of Internet in Research: Browsing the internet through standard features, Accessing and Downloading information, E-resources for research, Impact Factor: E – Information, H-Index, citation index, , e-journals etc.
Practicals 4 , 5, 6, 7 : Based on Identification of Research Problem and Literature Survey , Various Referencing Styles.
Practicals 8 , 9 , 10 : Based on Publishing a research paper.
Practical 11 to 15 : Miscellaneous.

SEMESTER-II

Major Paper 1 : Name of the Paper : Advanced Course in Complex Analysis (Theory)

Paper Code : 24MAT52101 **Total No. of Credits : 4**
Total No. of Lectures : 60

Course Outcomes

CO	Details
CO1	Student will understand the significance of differentiability of complex functions leading to the understanding of Cauchy-Riemann equations and its applications.
CO2	Student will learn to evaluate the contour integrals and understand the role of Cauchy-Goursat theorem and the Cauchy integral formula.
CO3	Student will study how to represent functions as Laurent series, classify singularities and poles, also evaluate complex integrals and improper integrals.
CO4	With this course students are prepared to learn about advance complex analysis.

Course Content

Unit I: Basic Properties of Complex Numbers: [04 hours]

1.1 Arithmetic of Complex Numbers

1.2 The Fundamental Theorem of Algebra

Unit II Complex Differentiability and Conformality: [10 hours]

2.1 Definition and Basic Properties

2.2 Polynomials and Rational Functions

2.3 Analytical Functions: Power Series

2.4 Cauchy- Riemann Equations

2.5 Review of Calculus of Two Real Variables

Unit III: Contour Integration: [14 hours]

3.1 Definition and Basic Properties

3.2 Existence of Primitives

3.3 Cauchy-Goursat Theorem

3.4 Cauchy's Theorem via Green's Theorem

3.5 Cauchy's Integral Formulae

3.6 Analyticity of Complex Differentiable Functions

3.7 A Global Implication: Liouville

3.8 Mean Value and Maximum Modulus

Unit IV: Zeros and Poles: [14 hours]

4.1 Zeros of Holomorphic Functions

4.2 Open Mapping Theorem

4.3 Singularities

4.4 Laurent Series

4.5 Residues

Unit V: Application to Evaluation of Definite Real Integrals: [12 hours]

5.1 Trigonometric Integrals

5.2 Improper Integrals

5.3 Jordan's Inequality

Unit VI: Local And Global Properties: [06 hours]

6.1 Schwarz's Lemma

6.2 Local mapping

Recommended Book

1. **Anant R. Shastri, Basic Complex Analysis of One Variable**, MacmillanPublishers India, 2010 .

Ch. 1: 1.1 , 1.8.1 , Ch. 2: 2.1,2.2, 2.3(only 2.3.1); Ch. 3: 3.1, 3.2, Ch. 4: 4.1 to 4.5, 4.7,4.8 , Ch. 5: 5.1 to 5.5, Ch. 6: 6.1 to 6.3; Ch. 7: 7.1, 7.2

Reference Books

1. J. W. Brown and R.V. Churchill, Complex Variables and Applications, IndianEdition. (Eighth Edition)
2. John. B. Conway, Functions of One Complex Variable, Springer InternationalStudent Edition. (Second Edition)
3. S. Ponnusamy, Foundation of Complex Analysis, Narosa Publications. (SecondEdition)
4. L.V. Alfors, Complex Analysis, McGraw Hill, 1979.

Major Paper 2 : Name of the Paper : General Topology (Theory)

Paper Code : 24MAT52102 **Total No. of Credits : 4**

Total No. of Lectures : 60

Course Outcomes

CO	Details
CO1	Students will study a number of ways of constructing a topology on a set so as to make into a topological space.
CO2	Students will learn the elementary concepts associated with topological spaces.
CO3	. Students will learn the notion of connectedness and compactness which are fundamental in higher analysis.
CO4	Students will be able to write cohesive and comprehensive solutions to exercises and be able to defend their arguments.
CO5	Student will understand the natural generalization of the previously learned ideas such as open sets, continuous functions, limit points etc.

Course Content

Unit 1. Prerequisites **[10 Hours]**

1.1 : Cartesian Products
1.2 : Finite Sets
1.3 : Countable and Uncountable Sets
1.4 : Infinite Sets and Axiom of Choice
1.5 : Well Ordered Sets

Unit 2. Topological Spaces and Continuous Functions **[20 Hours]**

2.1 : Topological Spaces
2.2 : Basis for a Topology
2.3 : Order Topology
2.4 : Product Topology on X× Y
2.5 : Subspace Topology
2.6 : Closed Sets and Limit Points
2.7 : Continuous Functions
2.8 : The Product Topology, Metric Topology
2.9 : Quotient Topology

Unit 3. Connected and Compact Spaces **[15 Hours]**

3.1 : Connected spaces
3.2 : Connected Subspaces of Real Line
3.3 : Components and Local Connectedness
3.4 : Compact spaces
3.5 : Compact Subspaces of the Real Line
3.6 : Limit point compactness
3.7 : Local Compactness

Unit 4. Countablity and Separation Axioms **[15 hours]**

4.1 : The Countability Axioms
4.2 : The Separation axioms and Normal Spaces
4.3 : Urysohn Lemma (State Only)
4.4 : The Urysohn Metrization Theorem (State Only)
4.5 : Tietze Extension Theorem
4.6 : Tychonoff's Theorem.

Text Book

J. R. Munkres, Topology: A First Course, (Prentice Hall, Second Edition), 2000.Chapter 1 : Sec. 5 to 7, Sec. 9 to 10. ;Chapter 2: Sec.12 to 22.

Chapter 3 : Sec. 23 to 29. ; Chapter 4 : Sec. 30 to 35 ; Chapter 5 : Sec. 37.

Reference Books

1. K J¨anich. Topology. Springer, 1984.
2. M A Armstrong. Basic Topology. Springer, 1983.
3. O Viro, O Ivanov, V Kharlamov, and N Netsvetaev. Elementary Topology: ProblemTextbook, AMS Publication, 2008.
4. K. D. Joshi, Introduction to General Topology, John Wiley & Sons .

Major Paper 3 : Name of the Paper : Rings and Modules (Theory)

Paper Code : 24MAT52103 **Total No. of Credits : 4**
Total No. of Lectures : 60

Course Outcomes

CO	Details
CO1	Student will study the algebraic structure Ring and its properties in detail through various examples.
CO2	Student will study the notion of ideals , factorization domain and Module through various examples.
CO3	Student will learn the significance and interconnection of algebraic structures ranging from groups, rings, domains, Ideals to modules.
CO4	The thinking and analytical power of students in algebra will be strengthened.

Course Content

Unit I : Rings **[16 hours]**

1.1 Basic Terminologies
1.2 Rings of Continuous functions

1.3 Matrix Rings, Polynomial Rings, Power Series Rings, Laurent Rings, Boolean Rings, Some Special Rings,
1.4 Direct Products
1.5 Several Variables
1.6 Opposite Rings
1.7 Characteristic of a Ring.

Unit II : Ideals **[12 hours]**

2.1 Definitions
2.2 Maximal Ideals
2.3 : Generators
2.4 Basic Properties of Ideals
2.5 Algebra of Ideals
2.6 Quotient Rings
2.7 Ideals in Quotient Rings
2.8 Local Rings.

Unit III : Homomorphisms of Rings **[10 hours]**

3.1 Definitions and Basic Properties
3.2 Fundamental theorems
3.3 Endomorphism Rings
3.4 Field of Fractions, Prime fields

Unit IV : Factorization Domains **[12 hours]**

4.1 Division in Domains
4.2 Euclidean Domains
4.3 Principal Ideal Domains
4.4 Factorization Domains
4.5 Unique Factorization Domains
4.6 Eisenstein's Criterion.

Unit V : Modules **[10 hours]**

5.1 Definitions and Examples
5.2 Direct Sums
5.3 Free Modules
5.4 Quotient Modules
5.5 Homomorphism
5.6 Simple Modules

5.7 Modules over PID.

Recommended Book:

C. Musili, Rings and Modules, 2nd Revised Edition, Narosa Publishing House.(Chapters 1, 2, 3, 4, 5)

Reference Books :

1. Dummit and Foote, Abstract Algebra, second edition (Wiley India).
2. Luther and Passi, Algebra II, Narosa Publishing House.
3. Jain and Bhattacharya, Basic Abstract Algebra, 2nd Edition, Cambridge UniversityPress.
4. Joseph Gallian, Contemporary Algebra, 7th Edition, Narosa Publishing House.

Major Paper 4 : Name of the Paper : Introduction to MS Excel (Practical)

Paper Code : 24MAT52104 **Total No. of Credits : 2**

Total No. of Practical : 15

Course Objectives: This course aims on

1.Basic Essential Computing skills companies are looking for.

2.Hands-on Practical Knowledge.

3.Boosting their resume.

4.Providing an edge over other applicants in the competitive job market.

5.Providing valuable experience and confidence.

6.Heightening their earning potential.

Course Outcomes

CO	Details The student will be able to
CO1	Create, save and print worksheets
CO2	Create formulas
CO3	Use functions for SUM, AVERAGE, MIN, and MAX
CO4	Use the function for IF
CO5	Format cells using many of the formatting tools
CO6	Present the Data Graphically

Course Content

Unit1 : The Excel environment

Navigating a worksheet
Spreadsheet terminology
Getting help

Unit 2 : Entering and editing data

Entering and editing text and values
Entering and editing formulas
Saving and updating workbooks

Unit 3: Modifying a worksheet

Moving and copying data
Moving and copying formulas
Inserting and deleting ranges,
rows and columns Cell comments

Unit 4: Using functions

Entering functions

AutoSum

Other common functions

Unit 5: Formatting

Text formatting
Row and column formatting
Number formatting
Conditional formatting
Additional formatting options

Unit 6: Printing

Preparing to print
Page Setup options
Printing worksheets

Unit 7: Charts

Chart basics
Column

Char
t
Pie
Cha
rt
Bar Chart
Pie Chart
Line Chart

Unit 8: Case Study modifying existing worksheetUse shortcut keys

Create and email worksheet

Unit 9: Review Basics

Downloading from Account reconciliation

The Excel environment

The
spar
klin
e
The Trendline

Unit 10: Subtotal Functions

Create an outline and consolidate dataCreate subtotals in a list

Use multiple subtotal functions- SUBTOTAL, SUMIF
Create custom views to save different sets of worksheet display and print settings

Unit 11: Range names and Filter date

Define and apply cell and
range namesUse names
in Formulas
Filter data based on
complex criteriaUse
conditional filters
Copy filtered results to another range

Unit 12: Pivot Tables

Prepare data in a table format and
name the tableCreate a PivotTable
for analyzing
Use the Download Actuals page in Account
Reconciliation as example
Modify or re-arrange fields

Unit 13: Selected Functions

Using IF and SUMIF functions to calculate a value based on
specified criteria
Use ROUND function to round off numbers
Use VLOOKUP to find values in worksheet data
Use HLOO

Unit 14: Simulation

Scatter
Area
Stock
Surface
Rader

Unit 15: Applications

Applications of Ms-excel

business analysis

data entry and storage
data analysis
accounting and budgeting

Reference Book:

Beginning Excel 2019 by Noreen Brown; Barbara Lave; Hallie Puncochar; Julie Romey; Mary Schatz; Art Schneider; and Diane Shingledecker

List of Practical

1. Practical 1: Practical based on Unit 1.
2. Practical 2 : Practical based on Unit 2.
3. Practical 3 : Practical based on Unit 3.
4. Practical 4 : Practical based on Unit 4.
5. Practical 5 : Practical based on Unit 5.
6. Practical 6 : Practical based on Unit 6.
7. Practical 7 : Practical based on Unit 7.
8. Practical 8 : Practical based on Unit 8.
9. Practical 9 : Practical based on Unit 9.
10. Practical 10 : Practical based on Unit 10.
11. Practical 11 : Practical based on Unit 11.
12. Practical 12 : Practical based on Unit 12.
13 . Practical 13 : Practical based on Unit 13.
14. Practical 14 : Practical based on Unit 14.
15 . Practical 15 : Practical based on Unit 15.

Major Elective 1 : Name of the Paper : Advanced Numerical Analysis

(Theory)

Paper Code : 24MAT52105 **Total No. of Credits : 4**
Total No. of Lectures : 60

Course Outcomes

CO	Details
CO1	This course enhances theoretical view of students towards numerical methods.
CO2	This course enhances theoretical view of students towards numerical methods.
CO3	This course gives different types of methods to calculate LU factorization, floating point numbers.
CO4	This course enhances the quality and standards of Mathematical Education.
CO5	This course takes care of fast development in the knowledge of Mathematics.

Course Content

UNIT-I: Root Finding Methods [10 H0urs]

1.1 Convergence; Floating Point Number Systems; Floating Point Arithmetic.
1.2 Fixed Point Interaction Schemes; Newton's Method; Secant Method; Accelerating Convergence.

UNIT-II: System of Equations [14 Hours]

2.1 Gaussian Elimination; Pivoting Strategies.
2.2 Error Estimates and Condition Number; LU decomposition; Direct Factorization.

2.3 Iterative Techniques for Linear Systems: Basic Concepts and Methods.
2.4 Nonlinear Systems of Equations.

UNIT-III: Eigenvalues and Eigenvectors [10 Hours]

3.1 The Power Method.
3.2 The Inverse Power Method.
3.3 Reduction to Symmetric Tridiagonal Form.
3.4 Eigenvalues of Symmetric Tridiagonal Matrices.

UNIT-IV: Differentiation and Integration [14 Hours]

4.1 Numerical Differentiation, Part II.
4.2 Numerical Integration – The Basics and Newton-Cotes Quadrature; CompositeNewton-Cotes Quadrature.

UNIT-V: Initial Value Problems of Ordinary Differential Equations [12 Hours]

5.1 Euler's Method; Higher-Order One-Step Methods: Taylor Methods.
5.2 Runge-Kutta Methods.
5.3 Multistep Methods.
5.4 Convergence and Stability Analysis.

RECOMMEDNDED BOOK

1) **Brian Bradie**, A Friendly Introduction to Numerical Analysis, Pearson PrenticeHall 2007, ISBN 978-81-317-0942-9.
Sections: 1.2 – 1.4, 2.3 – 2.6, 3.1, 3.2, 3.4 -3.6, 3.8, 3.10, 4.1, 4.2, 4.4, 4.5, 6.2,
6.4, 6.5, 7.2-7.6
2) **John H. Mathews, Kurtis D. Fink**, Numerical Methods Using Matlab, 4th Edition, Pearson Education (Singapore) Pte. Ltd., Indian Branch, Delhi 2005.(SciLab commands similar to MatLab commands can be used for problems)

REFERENCE BOOKS

1) **K .E. Atkinson**, An Introduction to Numerical Analysis, Second Edition, JohnWiley & Sons.
2) **J. L. Buchaman, P. R. Turner**, Numerical Methods and Analysis, McGraw Hill,1992 cop.
3) **M.K. Jain, S.R.K. Iyengar, R.K. Jain**, Numerical Methods for Scientific & Engineering Computation

Major Elective 2 : Name of the Paper : Advance Course in Partial Differential Equations Numerical Analysis

(Theory)

Paper Code : 24MAT52106 **Total No. of Credits : 4**
Total No. of Lectures : 60

Course Outcomes

CO	Details
CO1	Classify partial differential equations and transform into canonical form.
CO2	Solve linear partial differential equations of both first and second order.
CO3	Identify real phenomena as models of partial derivative equations.
CO4	Solve Elliptic, parabolic and Hyperbolic differential equations.
CO5	Apply specific methodologies, techniques to conduct research and produce innovative results in the area of specialization.

Course Content

1. INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATIONS OF FIRSTORDER [12 Hours]

1.1 Genesis of first order P.D.E.
1.2 Compatible systems
1.3 Charpit's method
1.4 Jacobi's method
1.5 Non Linear first order P.D.E

2. FUNDAMENTAL CONCEPTS [16 Hours]

2.1 First order partial differential equations

2.2 Classification of Second Order PDE

2.3Canonical Forms, Canonical Form for Hyperbolic Equation , Canonical Formfor Parabolic Equation , Canonical Form for Elliptic Equation.

2.4Linear Partial Differential Equations with Constant Coefficients, General Method for Finding CF of Reducible Non-homogeneous Linear PDE ,General Method to Find CF of Irreducible Non-homogeneous Linear PDE

3. ELLIPTIC AND PARABOLIC DIFFERENTIAL EQUATIONS [20 Hours]

3.1 Occurrence of the Laplace and Poisson Equations ,

Derivation of LaplaceEquation , Derivation of Poisson

Equation

3.2Boundary Value Problems (BVPs)

3.3 Green's first and second identities

3.4 Dirichlet Problem for a Rectangle Occurrence of the Diffusion Equation

3.5 Boundary Conditions

3.6 Elementary Solutions of the Diffusion Equation

3.7 Dirac Delta Function

3.8 Separation of Variables Method (with examples)

4 HYPERBOLIC DIFFERENTIAL EQUATIONS [12 Hours]

4.1 Occurrence of the Wave Equation

4.2 Derivation of One-dimensional Wave Equation

4.3 Solution of One-dimensional Wave Equation by Canonical Reduction

4.4 Vibrating string- Variable separable solution(examples)

Recommended Books

1. An Elementary Course in Partial Differential Equations, T Amarnath ,NarosaPublication (Chapter 1)
2. Intoduction to Partial Differential Equations, K.Sankara Rao (Third Edition) PHILearning Private Limited

Reference Books

1. Elements of Partial Differential Equations, Ian Sneddon, Dover Publication
2. An Introduction to Partial Differential Equations, Yehud Pinchor & JacoRubinstein, Cambridge University Press

On Job Training

Code : 24MAT52107 **Total No. of Credits : 4**