Progressive Education Society's

Modern College of Arts, Science and Commerce (Autonomous),

Shivajinagar, Pune 5

(An Autonomous College Affiliated to Savitribai Phule Pune University)

Framework and Syllabus

For

M.Sc. (Mathematics)

(Based on NEP 2020 framework)

(To be implemented from the Academic Year 2023-24)

Semester 1 (First Year) Level 6

Course Type	Course Code	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4 + 4 + 2)	**23ScMatP111**	Major Paper 1(Theory)	Linear Algebra	4	4	50	50	100
	23ScMatP112	Major Paper 2(Theory)	Group Theory	4	4	50	50	100
	23ScMatP113	Major Paper 3(Theory)	Graph Theory	4	4	50	50	100
	23ScMatP114	Major Paper 4(Practical)	Lab Course on 23ScMatP111, 23ScMatP112 & 23ScMatP113	4	2	25	25	50
Major Electives (4)	**23ScMatP121**	Major Elective 1 (Theory + Practical)	Ordinary Differential Equations (T + P)	2 4	4	50	50	100
	23ScMatP122	Major Elective 2 (Theory + Practical)	C- Programming Language (T + P)	2 4				
RM (4)	**23ScMatP131**	RM Paper 1(Theory)	RM Paper : Core	2	4	50	50	100
		RM Paper 2 (Practical)	RM Paper : Discrete Mathematics	4				
OJT/FP								
RP								
Total				34	22			550

Semester 2 (First Year) Level 6

Course Type	Course Code	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4 + 4 + 2)	23ScMatP211	Major Paper 1(Theory)	Partial Differential Equations	4	4	50	50	100
	23ScMatP212	Major Paper 2(Theory)	Rings and Modules	4	4	50	50	100
	23ScMatP213	Major Paper 3(Theory)	General Topology	4	4	50	50	100
	23ScMatP214	Major Paper 4(Practical)	Lab Course on 23ScMatP211, 23ScMatP212 & 23ScMatP213	4	2	25	25	50
Major Electives (4)	23ScMatP221	Major Elective 1 (Theory + Practical)	Numerical Analysis (T + P)	2 4	4	50	50	100
	23ScMatP222	Major Elective 2 (Theory + Practical)	C++ and Data Structures (T + P)	2 4				
RM								
OJT/FP (4)	**23ScMatP241**		On Job Training	8	4			
RP								
Total				36	22			

Semester 3 (Second Year) Level 6.5

Course Type	Course Code	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4 + 4 + 2)	**23ScMatP311**	Major Paper 1(Theory)	Measure and Integration	4	4	50	50	100
	23ScMatP312	Major Paper 2(Theory)	Field Theory	4	4	50	50	100
	23ScMatP313	Major Paper 3(Theory)	Functional Analysis	4	4	50	50	100
	23ScMatP314	Major Paper 4(Practical)	Lab Course on 23ScMatP311, 23ScMatP312 & 23ScMatP313	4	2	25	25	50
Major Electives (4)	**23ScMatP321**	Major Elective 1 (Theory + Practical)	Mathematical Statistics and Probability (T + P)	2 4	4	50	50	100
	23ScMatP312	Major Elective 2 (Theory + Practical)	Python Programming Language (T + P)	2 4				
RM								
OJT/FP								
RP (4)	**23ScMatP351**		Research Project- I	8	4			
Total				36	22			

Semester 4 (Second Year) Level 6.5

Course Type	Course Code	Course	Course / Paper Title	Hours / Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4 + 4)	**23ScMatP411**	Major Paper 1(Theory)	Advanced Calculus	4	4	50	50	100
	23ScMatP412	Major Paper 2(Theory)	Applied Combinatorics	4	4	50	50	100
	23ScMatP413	Major Paper 3(Theory)	Number Theory	4	4	50	50	100
Major Electives (4)	**23ScMatP421**	Major Elective 1 (Theory +Practical)	Computational Geometry (T + P)	2 4	4	50	50	100
	23ScMatP422	Major Elective 2 (Theory +Practical)	Data Mining with R Package (T + P)	2 4				
RM								
OJT/FP								
RP (6)	**23ScMatP451**		Research Project-II	12	6			
Total				36	22			

OE : Open Elective
AEC: Ability Enhancement Course
VEC: value Education Courses
CC : Co-Curricular Courses
IKS : Indian Knowledge System
OJT : On Job Training
FP : Field Project
VSC : Vocational Skill Courses
CEP : Community Engagement Project

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PG Part 1 Year of M.Sc. Mathematics (Semester-I)
(2023 course under NEP 2020)

Course Code: 23ScMatP111

Course Name: Linear Algebra

Teaching Scheme: TH: 4 Hours/Week **Credits: 4**

Examination Scheme: CIE: 50 Marks **End-Sem: 50 Marks**

Prerequisites: Vector Spaces, Basis and Dimension, Linear Transformations, Inner product.

Course Objectives: To Study

- Basis and dimension of a vector spaces
- Independence and basis of a vector spaces
- Matrix of a linear transforms
- Canonical forms
- Bilinear forms

Course Outcomes:

On completion of the course, student will be able to

- Apply concept of a vector spaces in Quantum Mechanics
- Find matrix of bilinear, Quadratic and Hermitian forms
- Generate complex shapes from basic shapes such as triangles, quadrilateral etc. using linear transformations
- Partition set of square matrices with complex coefficient using Jordan canonical forms

Course Contents:

Unit 1	Vector Spaces	18 lectures
	• Definitions and Examples • Subspaces • Basis and Dimension • Linear transformations • Quotient spaces • Direct sum • The matrix of linear transformation	
Unit 2	Canonical Forms	12 lectures
	• Eigenvalues and eigenvectors • The minimal polynomial • Diagonalization and triangularization of a matrix • The Jordan canonical form	

Unit 3	Inner Product Spaces	15 lectures
	• Inner product • Orthogonality • The adjoint of linear transformation • Unitory operator • Self adjoint and normal operator	
Unit 4	Bilinear Forms	15 lectures
	• Definition and examples • Classification of bilinear forms • Quadratic forms • Hermitian forms • Euclidean vector space • Canonical representation of unitary operator • Orthogonality	
	TOTAL	60 lectures

Reference Books:

1. Linear Algebra by Vivek Sahay, Narosa Publishing House (2nd edition), 2013.
2. First Course in Linear Algebra by P. B. Bhattacharya, New Age International Publishers, 2005.
3. Beginning Linear Algebra by Seymour Lipscutz, Schaum's outline, McGraw Hill(4th edition), 2009.
4. An Introduction to Linear Algebra by V. Krishnamurthy, East-West Press, 1997.

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PG Part 1 Year of M.Sc. Mathematics (Semester-I)
(2023 course under NEP 2020)

Course Code : 23ScMatP112

Course Name : Group Theory

Teaching Scheme: TH: 4 Hours/Week **Credits: 4**

Examination Scheme: CIE : 50 Marks **End-Sem : 50 Marks**

Prerequisites: Basic group theory, Cosets, Normal subgroups

Course Objectives:- To Study

- Cyclic groups, Permutation groups
- Homomorphism and Isomorphism of groups
- Structure theory, Fundamental theorem of finite abelian groups
- Sylow theory
- Simple groups

Course Outcomes:

On completion of the course, student will be able to

- Know the applications of cyclic groups in music theory, flowers, etc.
- Apply theory of groups in chemistry and biology
- Apply sylow theory to find subgroups of prime order

Course Contents:

Unit 1	Cyclic Groups	10 lectures
	• Cyclic Groups • Properties of Cyclic Groups • Classification of Subgroups of Cyclic Groups. • Cosets and Lagranges theorem	
Unit 2	Permutation Groups	8 lectures
	• Permutation Groups • Properties of Permutation Groups • Cycle Notation	
Unit 3	Group Homomorphism and Isomorphism	12 lectures
	• Homomorphism and Isomorphism of Groups • Properties of Homomorphism, Isomorphism and Automorphism • The First Isomorphism Theorem • Cayley's Theorem	

Unit 4	External Direct Products and Internal Direct Products	14 lectures
	• External Direct Product, Internal Direct Product • Properties of External Direct Product and Internal Direct Product • Normal Subgroups and Factor Groups • Applications of Factor Groups • The Fundamental Theorem of Finite Abelian Group	
Unit 5	Sylow Theorems	8 lectures
	• Conjugacy Classes • The Class Equation • Probability that Two Elements Commute • The Sylow Theorems • Application of Sylow Theorems	
Unit 6	Finite Simple Groups	8 lectures
	• Non simplicity tests • The simplicity of alternating group	
	TOTAL	60 lectures

Reference Books:

1. Contemporary Abstract Algebra by Joseph Gallian, Narosa Publishing House (4th edition), 1999.
2. Topics in Algebra by I. N. Herstein, John Wiley and Sons (2nd edition), 1975.
3. Abstract Algebra by Dummit and Foote, Wiley (3rd edition), 2003.
4. A First Course in Abstract Algebra by J. B. Fraleigh, Pearson (7th edition), 2008.

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PG Part 1 Year of M.Sc. Mathematics (Semester-I)
(2023 Course under NEP 2020)

Course Code: 23ScMatP113

Course Name: Graph Theory

Teaching Scheme: TH: 4 Hours/Week **Credits: 4**

Examination Scheme: CIE: 50 Marks **End-Sem: 50 Marks**

Prerequisites:

- Sets and Relations, Functions and Matrices

Course Objectives: To Study

- Eulerian graphs, Hamiltonion graphs, etc.
- Connectivity of graphs
- Trees and Planarity of graphs
- Colouring of graphs
- Energy of graphs
- Shortest path problem, Matching problem, Network flow

Course Outcomes:

On completion of the course, student will be able to–

- Apply shortest path algorithm to find the shortest Eulerian and Hamiltonian path and this is useful to painters, garbage collectors, airplane pilots and all world navigators
- Apply vertex colouring in scheduling, routing, register allocation, etc.
- Apply energy of graphs in complex system design, image analysis and processing
- Use tournament graphs in fault-tolerant routing and distributed computing
- Solve the transportation and communication problems using Network flow
- Understands the algorithm of searching trees like Depth first search and Breadth first search

Course Contents:

Unit 1	Graphs	12 lectures
	• Graphs, Types of graphs, Operations on graphs • Isomorphism of graphs • Adjacency and degrees • Complement of graphs • Vertex and edge deletion • Matrix representation • Energy of graphs	

Unit 2	Paths, Cycles and Tournaments	14 lectures
	• Connectivity of graphs • Eulerian graphs and digraphs • Hamiltonian graphs and digraphs • Tournaments • Shortest path problem • Chinese postman problem • Travelling salesman problem	
Unit 3	Trees, Planarity of graphs	14 lectures
	• Trees • The enumeration of trees • Minimum connector problem • Searching trees: Depth-first search, Breadth-first search • Planar graphs • Euler's formula for planar graphs	
Unit 4	The colouring of graphs	10 lectures
	• Colouring vertices and edges • Chromatic polynomials • The proof of Brook's theorem • The colouring of maps • Applications of vertex colouring	
Unit 5	Matching and Networks	10 lectures
	• Hall's marriage theorem • Transversal theory • Menger's theorem • Network flows	
	TOTAL	60 lectures

Reference Books:

1. Introduction to graph theory by R. J. Wilson, Pearson (Third edition), 2003.
2. A first look at Graph Theory by John Clarke and D. A. Holton, Allied Publisher, 1991.
3. Graph Theory by Harary, Narosa Publishers, 1989.
4. Graph Theory by Narsingh Deo, Dover publications, 1974

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PG Part 1 Year of M.Sc. Mathematics (Semester-I)
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Course Code: 23ScMatP114

Course Name: Lab Course on 23ScMatP111, 23ScMatP112 & 23ScMatP113

Teaching Scheme: PR : 4 Hours/Week **Credits: 2**

Examination Scheme: CIE: 25 Marks **End-Sem: 25 Marks**

Prerequisite Courses:

- Linear Algebra
- Group Theory
- Graph Theory

Course Objectives:- To Study

- Basis and dimension of vector spaces
- Matrix of linear transforms, Canonical forms
- Cyclic groups, Permutation groups, Homomorphism and Isomorphism of groups
- Structure theory, Sylow theory
- Eulerian graphs, Hamiltonion graphs, Connectivity of graphs, Trees and Planarity of graphs
- Colouring of graphs, Energy of graphs
- Shortest path problem, Matching problem, Network flow

Course Outcomes:

On completion of the course, student will be able to

- Apply concept of vector spaces in Quantum Mechanics
- Partition a set of square matrices with complex coefficient using Jordan canonical forms
- Know the applications of cyclic groups in music theory, flowers, etc.
- Apply shortest path algorithm to find the shortest Eulerian and Hamiltonian path and this is useful to painters, garbage collectors, airplane pilots and all world navigators
- Apply energy of graphs in complex system design, image analysis and processing

Course Contents:

Practical 1: Vector Space

Practical 2: Linear Mapping

Practical 3: Eigenvalues and Eigenvectors

Practical 4: Jordan Canonical form

Practical 5: Bilinear form

Practical 6: Cyclic groups

Practical 7: Permutation groups

Practical 8: Isomorphism of groups

Practical 9: Normal subgroups

Practical 10: Sylow Theory

Practical 11: Energy of graphs

Practical 12: Shortest path problems

Practical 13: Trees

Practical 14: Colouring of graphs

Practical 15: Matching and Networks

Reference Books:

1. Linear Algebra by Vivek Sahai, Narosa Publishing House(2^{nd} edition), 2013.
2. Beginning Linear Algebra by Seymour Lipscutz, Schaum's outline, McGraw Hill(4^{th} edition), 2009.
3. Contemporary Abstract Algebra by Joseph Gallian, Narosa Publishing House(4^{th} edition), 1999.
4. Topics in Algebra by I. N. Herstein, John Wiley and Sons(2^{nd} edition), 1975.
5. Introduction to graph theory by R. J. Wilson, Pearson (Third edition), 2003.
6. A first look at Graph Theory by John Clarke and D. A. Holton, Allied Publisher, 1991.

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PG Part 1 Year of M.Sc. Mathematics (Semester-I)
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Course Code : 23ScMatP121

Course Name : Ordinary Differential Equations

Teaching Scheme: TH: 2 Hours/Week **Credits: 2**

Examination Scheme: CIE : 25 Marks **End-Sem : 25 Marks**

Prerequisites: Derivative, Integration, Differential equation of first order and first degree

Course Objectives: To study

- Second order linear differential equations
- Qualitative properties of solutions of differential equations
- Power series solutions of linear differential equations of order up to two
- System of first order and first degree differential equations
- Non linear differential equations
- Existence and uniqueness of solutions of differential equations

Course Outcomes:

On completion of the course, student will be able to

- To calculate the movement or flow of electricity, Motion of an object
- To check the growth of diseases in graphical representation
- To ensure the existence of a unique solution of higher-order ordinary differential equations and system of differential equations

Course Contents:

Unit 1	Second order linear equations	5 lectures
	• The general solution of Homogeneous equation with constant coefficients • Order of reduction • The method of undetermined coefficients • The method of variation of parameters	
Unit 2	Power series solutions	6 lectures
	• Review of power series • Series solutions of first order equations • Series solution of second order linear equations • Ordinary points and regular singular points • Gauss hyper geometric equations	

	• The point at infinity	
Unit 3	Systems of first order equations	5 lectures
	• System of differential equations • Linear systems of differential equations • Homogeneous linear systems with constant coefficients • Non linear systems • Volterra's Prey-Predator equations	
Unit 4	Non-linear equations	6 lectures
	• Autonomous systems • Critical points • Stability • Liapunov's direct method • Non linear mechanics • Conservative system	
Unit 5	The existence and uniqueness of solutions	4 lectures
	• The method of successive approximations • Picard's Theorem • Solution of second order initial value problem using system of first order equations	
Unit 6	Qualitative properties of solutions	4 lectures
	• Sturm separation theorem • Normal form • Standard form • Sturm's comparison theorem	
	TOTAL	30 lectures

Reference Books:

1. Differential equations with applications and historical notes by G. F. Simmons, McGraw Hill Education (India) Private Limited, 1991.
2. An introduction to differential equations and their applications by Stanley J. Farlow, Doven Publication, 2006.
3. Ordinary and partial differential equations by M. D. Raisinghania, S. Chand, 2008.
4. 500 Examples and Problems of Applied Differential Equations by Ravi Agarwal, Springer, 2019.
5. A Textbook on Ordinary Differential Equations by Shair Ahamd, Springer(2^{nd} Edition), 2015.

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PG Part 1 Year of M.Sc. Mathematics (Semester-I)
(2023 course under NEP 2020)

Course Code: 23ScMatP121

Course Name: Practicals on Ordinary Differential Equations

Teaching Scheme: PR: 4 Hours/Week **Credits : 2**

Examination Scheme: CIE: 25 Marks **End-Sem: 25 Marks**

Prerequisite Course: Ordinary differential equations

Course Objectives: To study

- Second order linear differential equations
- The importance of numerical methods in solving ordinary differential equations
- Power series solutions of linear differential equations up to order two
- Differential equations using variation of parameters
- Non linear system of ordinary differential equations
- Existence and uniqueness of solutions of differential equations
- Critical points and stability using Geogebra

Course Outcomes:

On completion of the course, student will be able to

- To solve general solutions of homogeneous and non-homogeneous differential equations
- Find solutions of differential equations using power series
- Find critical points of differential equations and check for stability of differential equations
- Find the complete solution of differential equation with constant coefficients by variation of parameters

Course Contents:

Practical 1: Homogenous differential equation

Practical 2: Method of undetermined coefficients

Practical 3: Method of variation of parameters

Practical 4: Power series solution

Practical 5: Singularity and point at infinity

Practical 6: Gauss hyper geometric equations

Practical 7: Homogeneous linear system with constant coefficient

Practical 8: Non-linear systems

Practical 9: Autonomous systems of non-linear equations

Practical 10: Critical points and stability

Practical 11: Non linear mechanics and Conservative systems

Practical 12: Method of successive approximation

Practical 13: Picard's theorem

Practical 14: Strum separation theorem

Practical 15: Strum comparison theorem

Reference Books:

1. Differential equations with applications and historical notes by G. F. Simmons, McGraw Hill Education (India) Private Limited, 1991.
2. An introduction to differential equations and their applications by Stanley J. Farlow, Doven Publication, 2006.
3. Ordinary and partial differential equations by Dr. M. D. Raisinghania, S. Chand, 2008.
4. 500 Examples and Problems of Applied Differential Equations by Ravi Agrawal, Springer, 2019.
5. A Textbook on Ordinary Differential Equations by Shair Ahamd, Springer(2^{nd} Edition), 2015.

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PG Part 1 Year of M.Sc. Mathematics (Semester-I)
(2023 Course under NEP 2020)

Course Code: 23ScMatP122

Course Name: C Programming Language

Teaching Scheme: TH: 2 Hours/Week **Credits: 2**

Examination Scheme: CIE: 25 Marks **End-Sem: 25 Marks**

Prerequisites: Basic computer knowledge

Course Objectives: To study
- C fundamentals
- Operators and expressions
- Data input and outputs
- Control statements
- Functions, arrays and pointers

Course Outcomes: On completion of the course, student will be able to design an algorithm and prepare a C program for various mathematical as well as non-mathematical problems.

Course Contents:

Unit 1	Introductory Concepts	1 lecture
	• Introduction to Computers. • Computer Characteristics. • Types of Programming Languages. • Introduction to C.	
Unit 2	C Fundamentals	4 lectures
	• The C character set. • Identifier and keywords. • Data types, Constants. • Variables and Arrays. • Declarations and Expressions. • Statements. • Symbolic Constants.	
Unit 3	Operators and Expressions	4 lectures
	• Arithmetic operators. • Unary operators. • Relational and Logical Operators. • Assignment Operators. • The Conditional Operator. • Library Functions.	
Unit 4	Data Input and Outputs	4 lectures

	• Preliminaries. • Single character Input – The getchar() function. • Single character Output – The putchar() function. • Entering Input Data – The scanf() function. • Writing Output Data – The printf() function. • The gets and puts Functions.	
Unit 5	Preparing and Running a Complete C Program	2 lectures
	• Planning and Writing a C Program. • Compiling and Executing the Program. • Error Diagnostics.	
Unit 6	Control Statements	4 lectures
	• Preliminaries. • Statements: if – else, while, do-while, for. • Nested control Structures. • Statements: switch, break and continue. • The comma operator.	
Unit 7	Functions	3 lectures
	• Defining a Function. • Accessing a Function. • Function Prototypes. • Passing Arguments to a Function. • Recursion.	
Unit 8	Arrays	3 lectures
	• Defining and processing an Array. • Passing Arrays to Functions. • Multidimensional Arrays. • Arrays and Strings. • Structures	
Unit 9	Pointers	5 lectures
	• Pointer Declarations. • Passing Pointers to Functions. • Pointer and One Dimensional Array. • Dynamic Memory Allocation. • Operations on Pointer. • Pointers and Multidimensional Arrays. • Array of Pointers.	
	TOTAL :	30 lectures

Reference Books:

1. Schaum's Outline of Programming with C by Byron Gottfried, McGraw-Hill Publishing Co. (7th edition), 2007

2. Let Us C by Yashavant Kanetkar, BPB Publications(12th edition), 2006. https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbnxwcm9ncmFtbWVyc3BvaW50MDA3fGd4OjI4ZjJhNTQ0YmY2MzE5MDE (04/07/2023).

3. Programming in C: A Practical approach by Ajay Mittal, Pearson Education India, 2010.

4. The C Programming Language by Brian W. Kernighan and Dennis M. Ritchie, 1978.

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PG Part 1 Year of M.Sc. Mathematics (Semester-I)
(2023 course under NEP 2020)

Course Code: 23ScMatP122

Course Name: Practicals on C Programming Language

Teaching Scheme: PR: 4 Hours/Week **Credits: 2**

Examination Scheme: CIE: 25 Marks **End-Sem: 25 Marks**

Prerequisite Course: C- Programming language

Course Objectives: To study the algorithms and prepare C programs for various mathematical as well as non mathematical problems.

Course Outcomes:

On completion of the course, student will be able to design an algorithm and prepare a C program for various mathematical problems such as Taylor's series, Operation on matrices, Numerical integration etc. as well as some non-mathematical problems.

Course Contents:

Practical 1: Simple programs

Practical 2: Validity of date

Practical 3: Fibonacci sequence

Practical 4: Palindromes

Practical 5: Patterns and Pascal's triangle

Practical 6: Prime numbers and perfect numbers

Practical 7: Average of n numbers

Practical 8: Sorting an array

Practical 9: Roots of quadratic equation

Practical 10: Taylor's series

Practical 11: Evaluation of definite integrals

Practical 12: Operation on matrices

Practical 13: Inverse of a matrix

Practical 14: Tower of Hanoi

Practical 15: Customer records

Reference Books:

1. Schaum's Outline of Programming with C by Byron Gottfried, McGraw-Hill Publishing Co. (7th edition), 2007

2. Let Us C by Yashavant Kanetkar, BPB Publications(12th edition), 2006. https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbnxwcm9ncmFtbWVyc3BvaW50MDA3fGd4OjI4ZjJhNTQ0YmY2MzE5MDE (04/07/2023).

3. Programming in C: A Practical approach by Ajay Mittal, Pearson Education India, 2010.

4. The C Programming Language by Brian W. Kernighan and Dennis M. Ritchie, 1978.

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PG Part 1 Year of M.Sc. Mathematics (Semester-I)
(2023 course under NEP 2020)

Course Code: 23ScMatP131

Course Name: Discrete Mathematics

Teaching Scheme: PR: 4Hours/Week **Credits: 2**

Examination Scheme: CIE: 25 Marks **End-Sem: 25 Marks**

Prerequisites: Sets, Matrices, Basic Algebra, Vertex and edge deletion, Connectivity of graph.

Course Objectives: To Study

- Homomorphism and isomorphism of lattices.
- Counting of posets and lattices.
- Distributive and modular lattices.
- Path matrix and non-singular trees.
- Energy of graphs.

Course Outcomes:

On completion of the course, student will be able to

- Posets and lattices on given number of vertices.
- Characterize distributive and modular lattices.
- Find eigenvalues and energy of a given graph.

Course Contents:

Practical 1: Lattices and Hasse diagrams
Practical 2: Counting of Posets and Lattices
Practical 3: Some Algebraic concepts
Practical 4: Polynomials, Identities and Inequalities
Practical 5: Characterization Theorem
Practical 6: Representation Theorem
Practical 7: Distributivity
Practical 8: Modularity
Practical 9: Congruence lattices
Practical 10: Path matrix
Practical 11: Generalized Inverse
Practical 12: Spectrum of graph
Practical 13: Matrix-tree theorem
Practical 14: Non-singular trees

Practical 15: Regular graphs

Reference Books:

1. General Lattice Theory by George Gratzer, Birkhauser, Second Edition, 1998.
2. A first look at Graph Theory by John Clark and D. A. Holton, Allied Publishers Ltd., 1991.
3. Graph Theory by Harary, Narosa Publishers, New Delhi, 1989.
4. Graphs and Matrices by R. B. Bapat, Hindustan Book Agency, Second Edition, 2014.
5. Algebraic Graph Theory by Norman Biigs, Cambridge University Press, 1993.

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PG Part 1 Year of M.Sc. Mathematics (Semester-II)
(2023 Course under NEP 2020)

Course Code : 23ScMatP211

Course Name : Partial Differential Equations

Teaching Scheme: TH: 4 Hours/Week **Credits: 4**

Examination Scheme: CIE : 50 Marks **End-Sem : 50 Marks**

Prerequisites: Curves and surfaces , Continuity, Integration, Partial derivative, Systems of differential equations.

Course Objectives: To study

- First and second order linear partial differential equations
- Heat and wave equations
- Boundary value problems
- Heat conduction problems
- Cauchy problem

Course Outcomes:

On completion of the course, student will be able to

- Solve first and second order linear partial differential equations
- Solve heat and wave equations
- Solve Laplace equations
- Solve Cauchy problem

Course Contents:

Unit 1	First order partial differential equations	20 lectures
	• Classification of integrals • Linear equations of first order • Pfaffian differential equations • Compatible systems • Charpit's method • Jacobi's method • Integral surfaces through a given curve • Quasi linear equations • Non linear first order partial differential equations	
Unit 2	Second order partial differential equations	40 lectures

	• Classification • One dimensional wave equation • Laplace equation • Boundary value problems • The Cauchy problem • Dirichlet and Neumann problem • Harnack's theorem • Heat conduction problem • Duhamel's principle • Families of equipotential surfaces • Kelvin's inversion theorem	
	TOTAL	60 lectures

Reference Books:

1. An elementary course in Partial Differential equations by T. Amarnath, Jones and Bartlett Publishers (2nd Edition), 1997.
2. Elements of Partial Differential equations by I. N. Sneddon, Dover Publications, 2006.
3. Ordinary and partial differential equations by M. D. Raisinghania, S. Chand, 2008.
4. Problems on Partial Differential Equations by Maciej Borodzik, Springer, 2019.

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PG Part 1 Year of M.Sc. Mathematics (Semester-II)
(2023 Course under NEP 2020)

Course Code : 23ScMatP212

Course Name : Rings and Modules

Teaching Scheme: TH: 4 Hours/Week **Credits : 4**

Examination Scheme: CIE : 50 Marks **End-Sem : 50 Marks**

Prerequisite Courses:

- Group Theory
- Vector Spaces

Course Objectives: To Study

- Various types of Rings
- Definitions and examples of Field, Integral domains and Modules

Course Outcomes:

On completion of the course, student will be able to

- Know Ring, Subring, Integral domain, Field, Ideal
- Check reduciabilty and irreduciability of polynomials
- Find number of rings up to isomorphism
- Identify modules

Course Contents:

Unit 1	Rings	14 lectures
	• Rings, Opposite rings, • Integral Domains, Fields • Ring of Matrices, Boolean rings • Polynomial Rings, Power series rings, Laurent series rings	
Unit 2	Ideals	12 lectures
	• Ideals • Maximal Ideal, Minimal Ideal, Prime Ideal, Principal Ideal • Relation between Ideals, Integral Domains , Fields	
Unit 3	Homomorphism and Isomorphism of Rings	12 lectures
	• Homomorphism and Isomorphism of Rings • Properties of Homomorphism and	

	Isomorphism ● Fundamental Theorems ● Endomorphism Rings ● Fields of Fractions ● Prime fields	
Unit 4	Factorization in Domains	12 lectures
	● Euclidean Domains ● Principal Ideal Domain ● Unique factorization Domain ● Polynomial Rings that are Unique factorization domain ● Irreducibility Criteria	
Unit 5	Modules	10 lectures
	● Modules and Submodule ● Quotient Modules ● Free Modules ● Module Homomorphism ● Tortion Free Modules	
	TOTAL	60 lectures

Reference Books:

1. Introduction to Rings and Modules by C. Musili, Narosa Publishing House (2nd edition), 1994.
2. Algebra by Martin Isaacs, Americal Mathematical Society, 1994.
3. Abstract Algebra by Dummit and Foote, Wiley (3rd edition), 2003.
4. Basic Abstract Algebra by Jain and Bhattacharya, Cambridge University Press (2nd edition), 1994.

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PG Part 1 Year of M.Sc. Mathematics (Semester-II)
(2023 Course under NEP 2020)

Course Code : 23ScMatP213

Course Name : General Topology

Teaching Scheme: TH: 4 Hours/Week **Credits: 4**

Examination Scheme: CIE : 50 Marks **End-Sem : 50 Marks**

Prerequisites: Sets, Cartesian products, Functions, Metric space.

Course Objectives: To Study

- Countable and uncountable sets.
- Basis and types of topology.
- Connectedness and compactness.
- Countability and separation axiom.

Course Outcomes:

On completion of the course, student will be able to

- Check countablity of sets.
- Compare the topologies.
- Check connectedness and compactness of spaces.
- Find limit points and closure of a set.
- Check normality and regularity of spaces

Course Contents:

Unit1	Countable and Uncountable Sets	8 Lectures
	• Infinite sets • The axiom of Choice • Continuum hypothesis • Well-ordered sets • The maximum principle	
Unit 2	Topological spaces and continuous functions	20 Lectures

	• Basis of topology • Order topology • Continuous functions • Product topology • Metric topology • Quotient topology	
Unit 3	Connectedness and compactness	20 Lectures
	• Connected spaces • Components and local connectedness • Compact spaces • Limit point compactness • Local compactness • One point compactness	
Unit 4	Countability and Separation Axioms	12 Lectures
	• The countability Axiom • Separation Axiom • Normal Spaces • The Urysohn lemma • The Urysohn metrization Theorem • The Tietze extension theorem • Tychnoff theorem	
	TOTAL	60 Lectures

Reference Books:

1. Topology by J. R. Munkres, Prentice Hall of India (Second edition), 2014.
2. Topology by J. Dugundji , Allyn and Bacon, Boston, 1966.
3. General topology by John L. Kelley, D. Van Nostrand Company, 1964.
4. Introduction to topology by Theodore. W. Gamelin, Dover Publications, Mineole, New York (Second edition), 1999.

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PG Part 1 Year of M.Sc. Mathematics (Semester-II)
(2023 Course under NEP 2020)

Course Code: 23ScMatP214

Course Name: Lab Course on 23ScMatP211, 23ScMatP212 & 23ScMatP213

Teaching Scheme: PR: 4 Hours/Week **Credits: 2**

Examination Scheme: CIE: 25 Marks **End-Sem: 25 Marks**

Prerequisite Courses:

- Partial Differential Equations
- Rings and Modules
- General Topology

Course Objectives:- To Study

- First and second order linear partial differential equations
- Boundary value problems, Heat conduction problem, Cauchy problem
- Various types of Rings, Definitions and examples of field, Integral domain, Principal ideal domains, Unique factorization domains and Modules
- Basis and types of topology, Countable and uncountable sets
- Connectedness and compactness, Countability and separation axiom

Course Outcomes:

On completion of the course, student will be able to

- Check reduciabilty and irreduciability of polynomials
- Find number of rings up to isomorphism
- Check connectedness and compactness of spaces
- Check countablity, normality and regularity of a set
- Find a solution of Cauchy problem

Course Contents:

Practical 1: Pfaffian differential equations

Practical 2: Jacobi's and Chaprit's Method

Practical 3: Integral surfaces through a given curve

Practical 4: One dimensional wave equations

Practical 5: Laplace equations

Practical 6: Rings

Practical 7: Ideals

Practical 8: Isomorphism of rings

Practical 9: Factorization in domains

Practical 10: Modules

Practical 11: Topological spaces

Practical 12: Comparison of topologies

Practical 13: Separation axioms

Practical 14: Connected and compact spaces

Practical 15: Countability

Reference Books:

1. An elementary course in Partial Differential equations by T. Amarnath, Jones and Bartlett Publishers(2nd Edition), 1997.
2. Ordinary and partial differential equations by M. D. Raisinghania, S. Chand, 2008.
3. Introduction to Rings and Modules by C. Musili, Narosa publishing House (2nd edition), 1994.
4. Topology by J. R. Munkres, Prentice Hall of India (Second edition), 2014.

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PG Part 1 Year of M.Sc (Semester-II)
(2023 Course under NEP 2020)

Course Code : 23ScMatP221

Course Name : Numerical Analysis

Teaching Scheme: TH: 2 Hours/Week **Credits: 2**

Examination Scheme: CIE : 25 Marks **End-Sem : 25 Marks**

Prerequisites: Roots of equations, System of linear and nonlinear equations, Integration and Differentiation, Eigen values and Eigen vectors of a matrix.

Course Objectives: To Study

- Root finding methods
- System of linear and nonlinear equations
- Numerical eigenvalues and eigenvectors
- Numerical differentiation and integration
- Initial value problems of ordinary differential equations

Course Outcomes:

On completion of the course, student will be able to

- Find roots of an equation
- Find solution of linear and nonlinear system of equations
- Find numerical eigenvalues and eigenvectors of matrix using numerical methods
- Find numerical differentiation and integration using Lagrange's interpolating polynomial
- Solve initial value problems of ordinary differential equations

Course Contents:

Unit 1	Preliminaries	4 lectures
	• Convergence • Floating Point Number System • Floating Point Arithmatic	
Unit 2	Root Finding Methods	4 lectures
	• Fixed Point Iteration Scheme • Newton's Method • Secant Method • Accelerating Convergenc	
Unit 3	System of Equations	8 lectures

	• Formation of System of Equations • Gaussian Elimination • Pivoting Strategies • Error Estimates and Condition Number • LU decomposition • Direct Factorization • Iterative Techniques for Linear Systems • System of non-linear equations	
Unit 4	Eigenvalues and Eigenvectors	4 lectures
	• The Power Method • The Inverse Power Method • Reduction to Symmetric Tridiagonal form	
Unit 5	Differentiation and Integration	6 lectures
	• Numerical differentiation using Lagrange's Interpolating Polynomial • Numerical Integration • Newton's Cotes Quadrature • Composite Newton's Cotes Quadrature	
Unit 6	Initial Value Problems of Ordinary Differential Equation	4 lectures
	• Euler's Method • Runge-Kutta Methods • Multistep Methods	
	TOTAL	30 lectures

Reference Books:

1. Friendly introduction to numerical analysis by Brian Bradie, Prentice Hall, 2007.
2. An introduction to numerical analysis by K.E. Atkinson, Wiley publication(2nd edition), 1988.
3. Numerical Analysis by Walter Gautschi, Birkhouser (2nd edition), 2012.
4. An introduction to numerical analysis, J. Stoer and R. Bulirsch, Springer Science+, 1975.

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PG Part 1 Year of M.Sc. Mathematics (Semester-II)
(2023 Course under NEP 2020)

Course Code: 23ScMatP221

Course Name: Practicals on Numerical Analysis

Teaching Scheme: PR: 4 Hours/Week **Credits: 2**

Examination Scheme: CIE: 25 Marks **End-Sem: 25 Marks**

Prerequisite Courses: Numerical Analysis, C programming language

Course Objectives: To Study

- Root finding methods using C programming language
- System of linear and nonlinear equations.
- Numerical eigenvalues and eigenvectors of matrix using C programming language
- Numerical differentiation and integration using C programming language
- Initial value problems of ordinary differential equations.

Course Outcomes:

On completion of the course, student will be able to

- Find roots of an equation using C programming language
- Find solution of linear and nonlinear system of equations
- Find numerical eigenvalues and eigenvectors of matrix using C programming language
- Find numerical differentiation and integration using Lagrange's interpolating polynomial
- Solve initial value problems of ordinary differential equations.

Course Contents:

Practical 1: Order and rate of convergence

Practical 2: Newton's method

Practical 3: Secant method

Practical 4: Accelerating convergence

Practical 5: Gaussian Elimination

Practical 6: Gaussian Elimination with pivoting strategies

Practical 7: Solving linear system using LU decomposition

Practical 8: Jacobi method

Practical 9: Gauss-Seidel method

Practical 10: SOR method

Practical 11: Power method

Practical 12: Numerical Differentiation

Practical 13: Numerical integration

Practical 14: Euler's method

Practical 15: Runge-Kutta method

Reference Books:

1. Numerical methods and computer programming by A. Khandelwal, Alpha Science Publication, 2012.
2. Programming and computer analysis by N. Datta, Universities Press, 2001.
3. Numerical methods and computer programming by C. V. Deshpande, 2019.
4. Friendly Introduction to numerical analysis by Brian Bradie , Prentice hall, 2007.
5. Computer oriented numerical methods by V. Rajaraman, PHI (Third edition), 2009.

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PG Part 1 Year of M.Sc. Mathematics (Semester-II)
(2023 course under NEP 2020)

Course Code: 23ScMatP222

Course Name: C++ Programming and Data structures

Teaching Scheme: TH: 2 Hours/Week **Credits : 2**

Examination Scheme: CIE: 25 Marks **End-Sem: 25 Marks**

Prerequisites: Knowledge of C programming language

Course Objectives:

- To learn principles of object oriented programming
- To use the object-oriented paradigm in program design.
- To learn the symmetric way of solving problem
- To understand the different methods of organizing large amount of data

Course Outcomes:

On completion of the course, student will be able to

- Apply principles of object oriented programming
- Design and develop applications such as games, banking Applications, internet Explorer.
- To use well-organized data structures in solving various problems such as arrays, stack, queue

Course Contents:

Unit 1	Object Oriented Programming Concepts	5 lectures
	• Procedure-oriented programming Vs Object-oriented programming • The basic anatomy of C++ program • Compiling, linking and running a C++ program • Classes , objects and abstraction • Inheritance , polymorphism and data binding • Encapsulation and message passing	
Unit 2	Programming in C++	6 lectures
	• Data types • New operators and keywords • Type casting in C++ • Reference Variables • Classes and access specifiers • Defining data members and member functions	

	• Arrays and array of object • Usage of namespace, managing console I/O, Usage of manipulators	
Unit 3	Constructors , Destructors, Function and Operator overloading	5 lectures
	• Static members call by reference, return by reference • Inline function • Friend function • Function overloading • Constructor and Destructor and their types	
Unit 4	Introduction to Data Structures and Algorithm Analysis	5 lectures
	• Introduction to data and information, Data type, Data object, ADT, Data Structure • Algorithm analysis • Space and time complexity, Graphical understanding of the relation between different functions of n, examples of linear , logarithmic, quadratic loops • Best, Worst, Average case analysis, Asymptotic notations (Big O, Omega Ω, Theta ɵ), Problems on time complexity calculation.	
Unit 5	Array and Linked List	5lectures
	• ADT of array, Operations • Array applications - Searching • List as a Data Structure, differences with array. • Dynamic implementation of Linked List, internal and external pointers • Types of Linked List – Singly, Doubly, Circular	
Unit 6	Stack and Queue	4 lectures
	• Introduction • Operations: init(), push(), pop(), isEmpty(), isFull(), peek(), • Time complexity of operations. • Operations : init(), enqueue (), dequeue (), isEmpty(), isFull(), peek(), • Time complexity of operations, Differences with stack. • Implementation - Static and Dynamic with comparison	
	TOTAL :	30 lectures

Reference Books:

1. Object Oriented Programming (C++) by Balaguruswamy, McGraw Hill Education (Seventh edition), 1994.
2. C++ How to program by Deitel, Pearson education (4^{th} Edition), 1996.
3. Classic Data Structures by D. Samanta, Prentice Hall India Pvt. Ltd. 2009.
4. Data Structures using C and C++ by Yedidyah Langsam, Moshe J. Augenstein, Aaron M., Tenenbaum, Pearson Education (5^{th} Edition), 1990.
5. Algorithms and Data Structures by Niklaus Wirth, Pearson Education, 2004.

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PG Part 1 Year of M.Sc. Mathematics (Semester-II)
(2023 Course under NEP 2020)

Course Code: 23ScMatP222

Course Name: Practicals on C++ and Data Structures

Teaching Scheme: PR: 4 Hours/Week **Credits: 2**

Examination Scheme: CIE: 25 Marks **End-Sem: 25 Marks**

Prerequisites Course: C++ and Data Structure

Course Objectives:

- To use the object- oriented paradigm in program design
- To study advantage of C++ over C language
- To study linear data structures
- To efficiently implement solutions for specific problems

Course Outcomes:

On completion of the course, student will be able to

- Design and develop applications using object oriented programming language C++
- Implementing algorithms to solve problems using appropriate data structure

Course Contents:

Practical 1: Greatest common divisors

Practical 2: Multiplication table

Practical 3: Conversation of numbers

Practical 4: Power of a number

Practical 5: Operation on matrices

Practical 6: Test and generate perfect number

Practical 7: Matrix inversion method

Practical 8: Bubble sort

Practical 9: Selection sort

Practical 10: Binary search

Practical 11: Singly linked list

Practical 12: Double linked list

Practical 13: Merge two sorted lists

Practical 14: Infix and postfix expression

Practical 15: Implementation

Reference Books:

1. Object Oriented Programming (C++) by Balaguruswamy, McGraw Hill Education (Seventh edition), 1994.
2. C++ How to program by Deitel, Pearson education (4th Edition), 1996.
3. Classic Data Structures by D. Samanta, Prentice Hall India Pvt. Ltd., 2009.
4. Data Structures using C and C++ by Yedidyah Langsam, Moshe J. Augenstein, Aaron M., Tenenbaum, Pearson Education (5th Edition), 1990.
5. Algorithms and Data Structures by Niklaus Wirth, Pearson Education, 2004.