COURSES OF STUDIES
FOR
M.A./M. Sc. IN
MATHEMATICS

ACADEMIC SESSION 2023-2024

DEPARTMENT OF MATHEMATICS

SHAILABALA WOMENS
AUTONOMOUS COLLEGE
CUTTACK-753003, ODISHA

S. B. WOMEN'S (AUTONOMOUS) COLLEGE, CUTTACK
COURSE STRUCTURE FOR M.A./ M.SC (MATHEMATICS)

Semester – I								
Sl. No.	**Nature of Course**	**Course Code**	**Paper Title**	**Units**	**Credits**	**Marks**		**Total**
						Mid-Sem	**End-Sem**	
1	Hard Core	HC-101	Abstract Algebra	**5**	**5**	**30**	**70**	**100**
2	Hard Core	HC-102	Real Analysis	**5**	**5**	**30**	**70**	**100**
3	Hard Core	HC-103	Topology	**5**	**5**	**30**	**70**	**100**
4	Hard Core	HC-104	Advanced Programming using C++		**5**	**30**	**70**	**100**
5	Allied Core	AC-101	Computer Application Course by elearning Centre	**3**	**3**	Mid-sem 10 + Practical 10-20 marks	**30**	**50**
			TOTAL		**23**	**140**	**310**	**450**

Semester – II								
Sl. No.	**Nature of Course**	**Course Code**	**Paper Title**	**Units**	**Credits**	**Marks**		**Total**
						Mid-Sem	**End-Sem**	
6	Hard Core	HC-201	Complex Analysis	**5**	**5**	**30**	**70**	**100**
7	Hard Core	HC-202	Differential Equations	**5**	**5**	**30**	**70**	**100**
8	Hard Core	HC-203	Linear Algebra	**5**	**5**	**30**	**70**	**100**
9	Hard Core	HC-204	Advanced Programming with MATLAB		**5**	**30**	**70**	**100**
10	Core Elective	CE-201	Core Elective-I	**5**	**5**	30	**70**	**100**
11	Open Elective		Open Elective (Open for other P.G. Students)		**4**		**50**	**50**
			TOTAL		**29**	**150**	**400**	**550**

Semester – III								
Sl. No.	**Nature of Course**	**Course Code**	**Paper Title**	**Units**	**Credits**	**Marks**		**Total**
						Mid-Sem	**End-Sem**	
12	Hard Core	HC-301	Functional Analysis	**5**	**5**	**30**	**70**	**100**
13	Hard Core	HC-302	Discrete Mathematics	**5**	**5**	**30**	**70**	**100**
14	Hard Core	HC-303	Programming with Python		**5**	**30**	**70**	**100**
15	Core Elective	CE-301	Core Elective-II	**5**	**5**	**30**	**70**	**100**
16	Core Elective	CE-302	Core Elective-III	**5**	**5**	30	**70**	**100**
17	Debt Internship	FI-301	Field Internship /Project / Community Service		**3**		**50**	**50**
			TOTAL		**28**	**150**	**400**	**550**

Semester – IV								
Sl. No.	**Nature of Course**	**Course Code**	**Paper Title**	**Units**	**Credits**	**Marks**		**Total**
						Mid-Sem	**End-Sem**	
18	Hard Core	HC-401	Numerical Analysis	**5**	**5**	**30**	**70**	**100**
19	Hard Core	HC-402	Advanced Programming with Python and Latex		**5**	**30**	**70**	**100**
20	Hard Core	HC-403	Dissertation		**5**		**100**	**100**
21	Core Elective	CE-401	Core Elective-IV	**5**	**5**	**30**	**70**	**100**
22	Allied Core	AC-401	Theory: Women and Society (For all PG Subjects / Programs)	**3**	**3**	**15**	**35**	**50**
			TOTAL		**23**	**105**	**345**	**450**

Summary:

HC: Hard Core	14 x 100	1400
CE: Core Elective	4 x 100	400
OE: Open Elective	1 x 50	50
Ac – Allied Core	2 x 50	100
FI – Field of Internship	1 x 50	50
	Total Marks	**2000**

N. B.: The Department also offers the following Core Elective Papers (Students are to choose any one Paper from each Elective)

1. Elective – I
(a) Number Theory & Cryptography
(b) Differential Geometry
(c) Fuzzy Sets and their applications
2. Elective – II
(a) Operations Research
(b) Mathematical Modelling
(c) Operator Theory
3. Elective – III
(a) Numerical Solution of Ordinary Differential Equations
(b) Optimization Theory
(c) Probability and Statistical Methods
4. Elective – IV
(a) Fluid Dynamics
(b) Theory of Computation
(c) Numerical Solution of Partial Differential Equations

DEPARTMENT OF MATHEMATICS
VISION

Our Guiding Principle:

Pure Mathematics is in its way the poetry of Logical Ideas – Albert Einstein

To discover the poetry of logical ideas and to understand the world and solve its problems.

MISSION

• To achieve excellence in Teaching and Research in Mathematics as an Post Graduate Department.
• To offer and administer a Curriculum
• Relevant to our Students
• To improve their employability
• To make our students solvers of scientific and socio-economic problems.
• To converge discipline/branches of knowledge in Science – Arts – Commerce, through study of Mathematics.
• Mathematics is the Queen of all Sciences and King of all Arts.

Mathematics is not about numbers, equations, computations or algorithms: It is about UNDERSTANDING – William Paul Thurston

PROGRAM OUTCOME OF MATHEMATICS

Each post graduate in mathematics should be able to demonstrate fundamental
systematic knowledge of mathematics and its applications in engineering, science, technology and mathematical sciences. It should also enhancethe subject specific knowledge and help in creating jobs in various sectors.

PO-1: DISCIPLINARY KNOWLEDGE:

Capability of demonstrating comprehensive knowledge of mathematics and understanding of one or more disciplines which form a part of an undergraduate program of study. This also leads to study of related areas like computer science and statistics. Thus, this program helps learners in building a solid foundation for higher studies in mathematics.

PO-2: COMMUNICATION SKILLS:

i. Ability to communicate various concepts of mathematics effectively using examples and their geometrical visualizations.
ii. Capability to use mathematics as a precise language of communication in other branchesof human knowledge.
iii. Develop skills to communicate long standing unsolved problems in mathematics.
iv. Ability to show the importance of mathematics as precursor to various scientificdevelopments since the beginning of the civilization.
v. Capability to explain the development of mathematics in the

civilizational context and itsrole as queen of all sciences.
vi. Demonstrate educational skills in areas of analysis, geometry, algebra, mechanics, differential equations etc.

PO-3: CRITICAL THINKING AND ANALYTICAL REASONING:

i. Ability to employ critical thinking in understanding the concepts in every area ofmathematics.
ii. Ability to analyze the results and apply them in various problems appearing indifferent branches of mathematics.
iii. The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilized in modelling and solving real life problems.

PO-4: PROBLEM SOLVING:

i. Capability to solve problems in computer graphics using concepts of linear algebra.
ii. Ability to solve various models such as growth and decay models, radioactive decay model, drug assimilation, LCR circuits and population models using techniquesof differential equations.
iii. Ability to solve linear system of equations, linear programming problems and network flow problems. Ability to provide new solutions using the domain knowledge of Mathematics acquired during this program.
iv. Apply knowledge, understanding and skills to identify the difficult/unsolved problemsin mathematics and to collect the required information in possible range of sources and try to analyses and evaluate these problems using appropriate methodologies.

PO-5: RESEARCH-RELATED SKILLS:

i. Capability for inquiring about appropriate questions relating to the concepts in various fields of mathematics.
ii. To know about the advances in various branches of mathematics.
iii. Fulfil one's learning requirements in mathematics, drawing from a range of contemporary research works and their applications in diverse areas of mathematical sciences

PO-6: INFORMATION/DIGITAL LITERACY:

i. Capability to use appropriate software to solve system of equations and differential equations.
ii. Understand and apply the concept of programming of C++ to mathematical investigations and problem solving.

PO-7: SELF-DIRECTED LEARNING:

Ability to work independently and do in-depth study of various notions of mathematics. Apply one's disciplinary knowledge and skills in mathematics

in newer domains and uncharted areas. Identify challenging problems in mathematics and obtain well-defined solutions.

PO-8: MORAL AND ETHICAL AWARENESS/REASONING:

Ability to identify unethical behavior such as fabrication, falsification or misrepresentation of data and adopting objective, unbiased and truthful actions in all aspects.

PO-9: LIFELONG LEARNING:

Ability to think, acquire knowledge and skills through logical reasoning and to inculcate the habit of self-learning. Exhibit subject-specific transferable knowledge in mathematics relevant to job trends and employment opportunities. The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilized in modelling and solving real life problems.

PORGRAMM SPECIFIC OUTCOMES

After successful completion of two-year degree program in Mathematics a student should be able to:

PSO-1: learn to logically question assertions, to recognize patterns and to distinguish between essential and irrelevant aspects of problems. They also share ideas and insights while seeking and benefitting from knowledge and insight of others.

PSO-2: understand to behave responsibly in a rapidly changing interdependent society. Students undergoing this Programme learn to logically question assertions, to recognize patterns and to distinguish between essential and irrelevant aspects of problems. They also share ideas and insights while seeking and benefitting from knowledge and insight of others. This helps them to learn behave responsibly in a rapidly changing interdependent society.

PSO-3: present mathematics clearly and precisely, make vague ideas precise by formulating them in the language of mathematics, describe mathematical ideas from
multiple perspectives and explain fundamental concepts of mathematics to nonmathematicians.

PSO-4: join teaching profession in primary and secondary schools.

PSO-5: enhance their employability for government jobs, jobs in banking, insurance and investment sectors, data analyst jobs and jobs in various other public and private enterprises.

SEMESTER-I

HARD CORE-101 (ABSTRACT ALGEBRA)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: The main objective of this course is to imbibe in the minds of the students the deeper idea of abstract algebra. Having fundamental ideas of group theory, ring theory, matrices and linear algebra, the students will acquire advanced phase of knowledge of abstract algebra.

Learning Outcomes: Having finished this course, the students will able to

1. Know the structure of a group, direct and semi-direct products, nilpotent and solvable groups.

2. Learn different concepts such as Euclidean Domains (U.D.), Principal Ideal Domains (P.I.D), Unique Factorization Domains (U.F.D) and Polynomial Rings over fields having Grobner bases.

3. Learn some basics of field theory such as field extensions and Galois theory.

4. Understand what is Noetherian ring and Affine algebraic sets.

Unit-I **14 Marks**

Introduction to Groups: Basic Axioms and Examples, Dihedral Groups, Symmetric Groups,

Matrix Groups, Group Actions. Subgroups: Definition and Examples, Centralizer and normalizers, Stabilizers and Kernels, Cyclic Groups and Cyclic Sub Groups.

Unit-II **14 Marks**

Automorphisms, the Sylow Theorems, the Simplicity of An, Direct Products, The Fundamental theorem of Finitely Generated Abelian Groups, p-groups, Nilpotent Groups and Solvable Groups.

Unit-III **14 Marks**

Ring Theory: Ring Homomorphism and Quotient Rings, Properties of Ideals, Rings of Fractions, The Chineese Remainder Theorem,

Unit-IV **14 Marks**

Euclidean Domains (U.D.), Principal Ideal Domains (P.I.D), Unique Factorization Domains (U.F.D),

Unit-V **14 Marks**

Polynomial Ring, Definition and Basic Properties, Polynomial Rings over Fields. Polynomials Rings that are unique Factorization Domains, Irreducible Criteria.

Book Recommended:

David S., Dummit and Richard M. Foote: Abstract Algebra, Third Edition, Wiley Student Edition, 2013.

Unit-I: Chapter (1.1-1.3) Chapter (2.1-2.3)

Unit-II: Chapter-4(4.4 -4.6), Chapter-5 (5.1-5.2), Chapter-6 (6.1)

Unit-III: Chapter-7(7.3-7.6),

Unit-IV: Chapter-8(8.1- 8.3),

Unit-V: Chapter-9(9.1-9.4)

COURSE OUTCOMES

C0-1: Learn about Group, Subgroup, Homomorphism and Isomorphism

CO-2: Know the structure of a Group, Direct and Semi-direct products, Nilpotent and Solvable groups.

CO-3: Learn different concepts such as Euclidean Domains (U.D.), Principal Ideal Domains (P.I.D), Unique Factorization Domains (U.F.D) and Polynomial Rings over fields having Grobner bases.

CO-4: Learn some basics of Field theory such as Field extensions and Galois theory.

CO-5: Understand what is Noetherian ring and Affine algebraic sets.

HARD CORE-102 (REAL ANALYSIS)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: The main objective is to familiarize with the Riemann-Stieltjes Integral, convergence of sequence and series of real valued function, Lebesgue outer measure, Measurable sets, Measurable functions, Integration, Convergence of sequences of functions and their integrals, Functions of bounded variation, Lp - spaces.

Learning Outcomes: After studying this course the student will be able to

1. Understand the existence of Riemann - Stieltjes integral and their evaluation.

2. Know convergence of sequence and series of real valued functions.

3. Understand the concept of the Lebesgue integral (a generalization of the Reimann integration) along with its properties.

4. Learn and apply Holder and Minkowski inequalities in L^P -spaces and understand completeness of *Lp*spaces and convergence in measures.

Unit-I **14 Marks**

Metric Space, Sequences and Series of Functions: Uniform convergence, Uniform convergence and Continuity, Uniform convergence and Integration, Uniform convergence and Differentiation, Equi continuous Families of function, the Stone- Weierstress theorem.

Unit-II **14 Marks**

The Riemann - Stieltjes Integral: Definition and Existence of the integral, Properties of the integral, Integration and differentiation, Integration of vector valued functions.

Unit-III **14 Marks**

Lebesgue Measure: Introduction, Outer measure, Measurable sets and Lebesgue measure, A non-measurable set, Borel and Lebsgue Measurable function.

Unit-IV **14 Marks**

The Lebesgue Integral: Riemann integral, The Lebesgue Integral of a bounded function over a set of finite measure. The integral of a non-negative function, The general Lebesgue integral.

Unit-V **14 Marks**

Differentiation and Integration: Differentiation of monotone functions, Functions of bounded variations, Differentiation of an integral, absolute continuity. The L^P spaces, the Holder and Minkowski inequalities, Convergence and Completeness, Bounded linear functionals on the L^P spaces spaces.

BOOKS RECOMMENDED:

1. Walter Rudin: Principles of Mathematical Analysis, Third Edition, McGraw-Hill Int. Edition.

Unit-I: Chapter 2(2.15 to 2.30) Chapter-7(7.1 to 7.27)

Unit-II: Chapter - 6(6.1-6.25),

2. H. L. Royden: Real Analysis, Third Edition, MacMillan Publishing Co., Inc., New York.

Unit-III: Chapter -2(7) Chapter-3(1 to 5),

Unit-IV: Chapter-4(1 to 4)

Unit-V Chapter-5(1 to 4), Chapter-6.

Book for References: G. de Barra: Measure Theory and Integration, New Age Int. (P) Ltd, 2000.

COURSE OUTCOMES

CO-1: Learn about the Metric Space, Sequences and Series of functions, Uniform convergence and Continuity and also Integration.

CO-2: Learn about Lebesgue measure and integral and Non-measurable set, Borel and Lebsgue measurable function.

C0-3: Understand the concept of the Lebesgue integral (a generalization of the Reimann integration) along with its properties.

C0-4: Understand the existence of Riemann - Stieltjes integral and their evaluation.

C0-5: Learn and apply Holder and Minkowski inequalities in Lp -spaces and understand completeness of Lp spaces and Convergence in measures.

HARD CORE-103 (TOPOLOGY)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: The main objective of this course is to make the student aware of topology, which is the major branch of modern mathematics. This course is applied in many branches of mathematics, such as differentiable equations, Riemann surfaces in complex analysis etc. The course is designed to introduce the concepts of elementary properties of topological spaces and structures defined on them, maps between the topological spaces.

Learning Outcomes: After completing the course, the students will be able to

1. Learn the elementary properties of topological spaces and structures defined on them, constructing maps between topological spaces.

2. Understand the concepts of metric spaces and their role in mathematics.

3. Learn the basic results about completeness, connectedness and convergence within these structures.

4. Understand separable spaces and separable axioms, differentiating regular and normed spaces, components and path components, Uryson lemma and Urysohn Metrization theorem.

Unit – I **14 Marks**

Topological spaces, Basis for a topology, the Order topology, the Product topology on $X \times Y$, the Subspace topology, Closed sets and limit points.

Unit – II **14 Marks**

Continuous functions, The Product topology, The Metric Topology.

Unit – III **14 Marks**

Connectedness: Connected Spaces, Connected sets in the real line, Components and path Components, Local Connectedness.

Unit- IV **14 Marks**

Compactness**:** Compact Spaces, Compact sets in the real line, Limit point compactness, Local compactness.

Unit – V **14 Marks**

Countability and Separation axioms**:** Countability Axioms, Separation axioms, T he Urysohn lemma, the Urysohn Metrization theorem.

Book Recommended:

J. R. Munkres: Topology A First course, PHI.

Unit-I: Chapter-2(2.1-2.6)

Unit –II Chapter-2(2.7-2.9)

Unit-III: Chapter -3(3.1-3.4)

Unit-IV: Chapter-3(3.5 -3.8)

Unit-V Chapter-4(4.1-4.4)

Book for References:

1. K. D. Joshi: Introduction to General Topology, Wiley Eastern Ltd., 1983.

2. W. J. Pervin: Foundation of General Topology, Academic Press, 1964.

3. S. Nanda and S. Nanda: General Topology, Macmillan India.

Course Outcomes

CO-1: Learn about the Finite sets, Countable and Uncountable sets, Infinite sets and Well ordering property

CO-2: Learn the elementary properties of Topological spaces and structures defined on them, Constructing maps between topological spaces.

CO-3: Understand the concepts of Connectedness, Components and Path components.

CO-4: Learn the basic results about Compactness and Limit point and Local compactness.

CO-5: Understand Separable spaces and Separable axioms, Differentiating regular and normed spaces, Components and path components, Uryson lemma and Urysohn metrization theorem.

HARD CORE-104 (ADVANCED PROGRAMMING USING *C*++)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Mid Term from Part-A and Part-B

(Record-10, Viva-15, Experiment -45

(Part-C-15, Part-D-15 & Part-E-15))

PART-A: Introduction to Computers

Definition Of Computers, Basic Structure, Computer Generation, Classification of

Computers, Communication with Computers, Hierarchy of Computer Languages, System

and Application Software (MS DOS, WINDOWS AND LINUX)

PART-B:

1. Fundamentals of ***C***++
2. Control Structures
3. Array
4. Function
5. Structures
6. Pointers

PART-C:

1. Write a Program that generates random integer between 0 to 99. Given that first two Fibonacci number are 0 and 1, generate all Fibonacci numbers less than equal to generated numbers.

2. Enter 10 integers into an array and short them in an ascending order and print the largest and smallest number.

3. Enter 10 integers into an array and short them in an descending order and print the largest and smallest number

4. Enter 10 into an array and then search for a particular integer in the Array.

5. Addition of two matrices using two dimensional arrays.

6. Multiplication of two matrices using two dimensional arrays.

PART-D:

1. To find the length of a string with and without using library function.

2. To copy contents of one string to another with and without using library function.

3. To combine 2 strings and display the output obtained.

4. To compare 2 strings alphabetically with and without using library function.

5. To accept a string and convert all characters in a single from upper case to lower case with and without using library function.

6. To accept a string and convert all characters in a single from lower case to upper case with and without using library function.

7. To accept a string and arrange all characters of string in reverse order with and without using library function.

PART-E:

1. Write a program to apply various arithmetic functions on two operands using function.

2. Write a program to enter any number and find the reverse of that number using functions

3. Write a program to display first n multiples of a number using recursion.

4. Write a program to ask a number and the power is to be calculated for that number using recursion.

5. Write a program to generate a series of prime numbers depending upon 'n' where 'n' being entered by a user.

6. Write a Program to generate a table of a number entered by a user.

7. Write a program to find greatest common divisor between 2 numbers.

Books Recommended:

Object Oriented Programming Using C++ by G. K. Baluja and G. S. Baluja, Dhanapati Rai & Co.(P) Ltd.

SEMESTER-II

HARD CORE-201 (COMPLEX ANALYSIS)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: The course on complex analysis is aimed to introduce the theories of functions of complex variables; analytic functions and their power series representation; Mobius transformation; application of Cauchy's theorem, Cauchy integral formula and residue theorem to evaluate contour integration.

Learning Outcomes: On successful completion of the course, the students will be able to

1. Analyze limit, continuity and differentiation of functions of complex variables; apply concepts of Cauchy-Riemann equations, harmonic functions and analytic functions.

2. Understand the concept of Mobius transformation and its properties.

3. Evaluate complex integration using Cauchy's theorem and Cauchy integral formula.

4. Classify singularities, find residues and evaluate complex integrals using the residue theorem.

UNIT – I **14 Marks**

Elementary Properties of Analytic Functions: Power series, Analytic functions, Cauchy- Riemannequations, Analytic Function as mappings, Mobius Transformations.

UNIT – II **14 Marks**

Complex integration. Riemann -Stieltjes integrals, Power series representation of analytic functions, Zeros of an analytic functions.

UNIT – III **14 Marks**

Index of a closed curve, Cauchy's theorem and Integral formula, Counting zeros, Open mappingtheorem, Goursat's theorem.

UNIT – IV **14 Marks**

Singularities and Classifications of Singularities, Laurent series, Residue's, The Argument principle, Rouche's theorem.

UNIT-V

The Maximum modulus theorem: The Maximum principle, Schwartz's lemma.

Book Recommended:

J. B. Conway: Functions of one Complex Variable, Springer-Verlag, International

Student-Edition, Narosa Publishing House, 1980.

Unit-I: Chapter -III

Unit-II: Chapter – IV (1, 2 & 3)

Unit-III: Chapter -IV (4,5,7 &8)

Unit-IV: Chapter –V

Unit-V: Chapter-VI (1 & 2)

COURSE OUTCOMES

CO-1: Analyse Limit, Continuity and Differentiation of functions of complex variables;

apply conceptsof Cauchy-Riemann equations, Harmonic functions and Analytic

functions.

CO-2: Understand the concept of Mobius transformation and its properties.

CO-3: Evaluate Complex integration using Cauchy's theorem and Cauchy integral

formula.

CO-4: Classify Singularities, find Residues and evaluate Complex integrals using the

Residue theorem.

CO-5: Learn about the Space of continuous function, Meromorphic function,

Riemann mapping, Riemann Zetta Function.

HARD CORE-202 (DIFFERENTIAL EQUATIONS)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: The main objective of teaching this paper is to prepare the students to learn different methods for solving ordinary differential equations and boundary value problems. They can acquire advance phase of knowledge and their applications to real life problems.

Learning Outcomes: At the end of this course, the student will be able to

1. Learn boundary value problems and its method of solution, power series solution and specialfunctions.

2. Understand Picard's theorem, Fixed point theorem and apply them to solve the IVP of thelinear differential equation.

3. Know how to solve Wave equation, Laplace equation and Diffusion equation using Fourierseries and Fourier transforms

4. Apply of Fourier series and Fourier transforms to BVPs.

Unit – I **14 Marks**

Boundary Value Problems for ODEs: Introduction, Sturm-Liouville problem,

Orthogonality of eigen functions; Green's functions, Solution of BVP using the appropriate Green's functions. Power Series Solutions and Special Functions: Series solution about an ordinary point, Legendre equation and Legendre polynomial, Power series solution about singular points (Frobenius method), Bessel's equation and Bessel functions. Properties of Bessel functions.

Unit – II **14 Marks**

Existence and Uniqueness of Solutions: Introduction, Lipschitz condition & Lipschitz constant, Gronwall Inequality, Successive approximations, Picard's theorem, Continuation and dependence on initial conditions, Existence of solutions in the large, Existence and uniqueness ofsolutions of systems, Fixed point method.

Unit – III **14 Marks**

Fourier Series and Fourier Transform: Periodic functions and Fourier series, Fourier series for a function with arbitrary period, Half-range Fourier series; Fourier transform, Application ofFourier series and Fourier transforms to BVPs.

Unit-IV

Wave Equation: Solution of the one-dimensional wave equation, D'Alembert's solution of the wave equation, three-dimensional wave equation, n-dimensional wave equation, Solution ofwave equation by method of Fourier transforms.

Unit – V **14 Marks**

Diffusion Equation: Elementary solution of one-dimensional diffusion equation, Method of separation of variables, Solution of diffusion equation in n-dimensions using method of Fourier transforms.

Books Recommended:

1. S. G. Deo, V. Lakshmikantham and V.Raghavendra: Text Book of

OrdinaryDifferential Equations, 2nd Edition, TMH, 2011. Unit-II Chapter-5

2. J. Sinha Roy and S. Padhy: A Course on Ordinary and Partial DifferentialEquations, Kalyani Publishers, 4th Edition, 2014.

Unit-I Chapter-10(10.1-10.3), 7(7.1-7.3.1, 7.4-7.4.2)

Unit-IIIChapter-14(14.1-14.6),

Unit-IV Chapter-16(16.1-16.5)

Unit-V Chapter-17(17.1-17.4)

Course Outcomes

CO-1: Learn Boundary value problems and its method of solution, Power series solution and special functions Bessel function & equation with its properties.

CO-2: Understand Picard's theorem, Fixed point theorem and apply them to solve the IVP of the linear differential equation.

CO-3: Apply of Fourier series and Fourier transforms to BVPs.

CO-4: Know how to solve Wave equation,

CO-5: Learn about Diffusion equation using Fourier series and Fourier transform

HARD CORE-203 (LINEAR ALGEBRA)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: The main objective is to familiarize with algebra of linear transformations, representation of transformations by Matrices, Linear functional, double dual, the transpose of linear transformation, Modules, elementary canonical forms, triangulation, and diagonalization, Jordan forms, computation of invariant factors, Inner product spaces and bilinear forms.

Learning Outcomes: After studying this course, the students will be able to

1. Understand what is meant by linear transformations, algebra of linear transformations and represent transformation by matrices and vice-versa.

2. Find the different canonical forms of a given matrix, and test the similarity of two matrices.

3. Know about rational and Jordan forms, cyclic subspaces and annihilators, cyclic decompositions, inner product spaces with idea of adjoints, unitary operators and normal operators.

4. Understand the operators on inner product spaces, Spectral theory and bilinear forms.

Unit – I **14 Marks**

Linear Transformations: Linear transformations, the Algebra of linear

transformations, Isomorphism, Representation of transformations by Matrices, Linear functional, the Double dual,the transpose of linear transformation, Modules.

Unit – II **14 Marks**

Elementary Canonical Forms: Introduction, Characteristic values , Annihilating polynomials, Invariant Subspaces, Simultaneous Triangulation; Simultaneous Diagonalisation, Direct-sum Decompositions, Invariant Direct sums, the Primary Decomposition Theorem.

Unit – III **14 Marks**

The Rational and Jordan Forms: Cyclic subspaces and Annihilators, Cyclic Decompositions and the Rational Form, the Jordan Form, Computation of Invariant Factors.

Unit – IV **14 Marks**

Inner Product Spaces: Inner Products, Inner Product Spaces, Linear Functional and Adjoints, Unitary Operators, Normal Operators.

Unit – V **14 Marks**

Operators on Inner Product Spaces: Introduction, Forms on inner product spaces, PositiveForms, More on Forms,

Book Recommended:

K. Hoffman & R. Kunz: Linear Algebra, 2nd Edition,

Pearson, 2018.

Unit-I- Chapter-3, Chapter-5(5.5)

Unit-II- Chapter-6

Unit-III- Chapter-7(7.1-7.4),

Unit-IV-Chapter-8

Unit-V -Chapter-9(9.1-9.4)

Course Outcomes

CO-1: Learn about Vector space, Subspace, LI & LD of vector and basis, Dimension of vector Space.

CO-2: Understand what is meant by Linear transformations, Algebra of linear transformations and represent transformation by matrices and vice-versa.

CO-3: Find the different Canonical forms of a given matrix, and test the similarity of two matrices.

CO-4: Know about Rational and Jordan forms, Cyclic subspaces and Annihilators, Cyclic decompositions, Inner product spaces with idea of adjoints, Unitary operators and Normal operators.

CO-5: Understand the Operators on inner product spaces, Spectral theory and Bilinear forms

HARD CORE-204 (ADVANCED PROGRAMMING USING MATLAB)
Full Marks: 100 (Mid Semester:30, End Semester:70)

Mid Term From Part-A
(Record -10, Viva-15, Experiment-45
(Part B-15 Marks, Part C-15 Marks, Part D-15 Marks)

Part A

Fundamentals of MATLAB: Introduction, The Basics, Directional Explorations, Interactive computation, Programming in MATLAB: Scripts and Functions, Applications and Graphics.

Part B

1. Plotting the graph of a polynomial of degree 4, the derivative graph, the second derivative graph and comparing theorem.
2. Plotting the graph of a polynomial of degree 5, the derivative graph, the second derivative graph and comparing theorem.
3. Sketching the Parametric Curve Trochoid
4. Sketching the Parametric Curve Cycloid
5. Sketching the Parametric Curve Epicycloids
6. Sketching the Parametric Curve Hypocycloid
7. Plotting of family of solutions of second order differential equations.

Part C

1. Obtaining surface of revolution of sine curve from 0 to π.
2. Obtaining surface of revolution of sine curve from 0 to 2π.
3. Obtaining surface of revolution of exponential curve from 0 to $\frac{\pi}{2}$
4. Obtaining surface of revolution of exponential curve from 0 to π.
5. Obtaining surface of revolution of exponential curve from 0 to $\frac{3\pi}{2}$.
6. Obtaining surface of revolution of exponential curve from 0 to 2π.
7. Plotting of family of solutions of third order differential equations.

Part D

1. Sketching Ellipsoid.
2. Sketching of Hyperboloid of one sheet.
3. Sketching of Hyperboloid of two sheet.
4. Sketching of Elliptic Paraboloid.
5. Sketching of Hyperbolic Paraboloid.
6. Sketching of Elliptic Cone.
7. Matrix operation (addition, multiplication, inverse and transpose).

Book Recommended:

Getting started with MATLAB- A Quick Introduction for scientist and engineers-Rudra Pratap- Oxford University Press, Chapter-1,2,3,4,5 & 6

CORE ELECTIVE-I (NUMBER THEORY AND CRYPTOGRAPHY)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: The main objective of this course is to build up the basic theory of the integers, prime numbers and their primitive roots, the theory of congruence, quadratic reciprocitylaw and number theoretic functions, finite fields and Quadratic Residues, finite fields, to acquire knowledge in cryptography specially in RSA encryption and decryption, Enciphering matrices.

Learning Outcomes: Upon successful completion of this course students will able to

1. Apply divisibility theory in integers
2. Learn the theory of congruence.
3. Know the basic concepts of finite field, Quadratic residues and reciprocity
4. Understand modular arithmetic number-theoretic functions and apply them tocryptography.

Unit - I 14 Marks

Divisibility Theory in the Integers, Primes and their Distribution.

Unit-II 14 Marks

The Theory of Congruences, Fermat's Theorem

Unit-III 14 Marks

Number – Theoretic Functions, Euler's generalization of Fermat's Theorem

Unit - IV 14 Marks

The Quadratic Reciprocity Law, Certain Nonlinear Diophantine Equations

Unit – V 14Marks

Introduction to Cryptography, Numbers of Special Form

Book Recommended:

Elementary Number Theory David M Burton TATA MC GRAW HILL

Unit: I-Chapter -2,3

Unit: II-Chapter -4,5

Unit: III-Chapter -6,7

Unit: IV-Chapter -9,12

Unit: V-Chapter -10,11

COURSE OUTCOMES

CO-1: Apply Divisibility theory in integers.

CO-2: Learn the Theory of congruence.

CO-3: Know the basic concepts of Finite field, Quadratic residues and reciprocity.

CO-4: Understand Modular arithmetic number-theoretic functions and apply them to Cryptography.

CO-5: Development of skills in Number theory.

CORE ELECTIVE-I (DIFFERENTIAL GEOMETRY)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: The main objective of teaching this paper is to make the student

aware of abstract knowledge about differential geometry.

Learning Outcomes: At the end of this course, the students will be able to

1. Understand the topological manifold, abstract manifold and idea of tangent space.

2. Acquire knowledge about vector fields, differentiable manifolds.

3. Interpretation of Riemannian manifolds as metric spaces.

4. Learn about tensor fields, different types of multiplications of tensors

and exterior differentiation.

Unit - I **14 Marks**

Topological Manifold, Cutting and Pasting, Abstract Manifolds, The Space of Tangent Vectorsat a point of R^n, Another definition of $T_a(R^N)$.

Unit – II **14 Marks**

Vector Fields on Open Subsets of R^n, The Inverse Function theorem, The definition of a Differentiable Manifolds.

Unit – III **14 Marks**

The tangent Space at a point of a Manifold, Vector Fields, Tangent Co-vectors, Bilinear Forms, The Riemannian Metric, Riemannian Manifolds as Metric Spaces.

Unit - IV **14 Marks**

Tensor Field, Multiplication of Tensors, Exterior differentiation,

Unit-V **14 Marks**

Differentiation of Vector Fields on Sub-manifolds of R^n, Differentiation on Riemannian Manifolds

Book Recommended:

William M. Boothby: An introduction to Differentiable Manifolds and Riemannian Geometry, Academic Press, New York.

Unit –I: Chapter-I (3, 4, 5), Chapter-II (3, 4)

Unit –II: Chapter-II (5, 6), Chapter-III (1)

Unit –III: Chapter-IV (1, 2), Chapter-V(1, 2, 3)

Unit-IV: Chapter-V(5, 6, 8),

Unit-V: Chapter-VII(2, 3)

COURSE OUTCOMES

CO-1: Understand the Topological manifold, Abstract manifold and idea of Tangent space.

CO-2: Acquire knowledge about Vector fields, Differentiable manifolds.

CO-3: Interpretation of Riemannian manifolds as metric spaces.

CO-4: Learn about Tensor fields, different types of multiplications of tensors and

exterior differentiation.

CO-5: Development of skills in Differential geometry.

CORE ELECTIVE-I (FUZZY SETS AND THEIR APPLICATION)

Full marks: 100 (mid semester:30, end semester:70)

Course Objectives: The main objective of this paper is to guide the students to learn Fuzzy sets, relations and their applications to real life problems.

Learning Outcomes: At the end of this course, the student will be able to

1. Understand the basic concepts of Fuzzy sets and operations of Fuzzy sets.

2. Learn Zadeh's extension principle image and inverse image of Fuzzy arithmetic.

3. Learn Fuzzy relation and Fuzzy graphs.

4. Compare the possibility theory versus probability theory and apply to real life problems.

Unit I **14 Marks**

Fuzzy sets - Basic definition a -level sets. Convex fuzzy sets. Baic operations Fuzzy sets.

Unit II **14 Marks**

Type of Fuzzy sets. Cartesian products. Algebraic products. Bounded sum and difference t-norms and t-conorms.

Unit III **14 Marks**

The extension Principle- The Zadeh's extension principle image and inverse image of Fuzzy arithmetic.

Unit IV **14 Marks**

Fuzzy Relation and Fuzzy Graphs-Fuzzy equivalence equations. Fuzzy graphs, Similarity relation.

Unit V **14 Marks**

Possibility theory-Fuzzy measures, Evidence theory necessity measure, Possibility theory versus probability theory.

Books Recommended:

1. U. Z. Zimmermann: Fuzzy Set Theory and its Application,Allied Publisher, New Delhi,1991.

2. G J Klir & B Yuan: Fuzzy Set and Fuzzy Logic,Prentice Hall of India, New Delhi, 1995.

COURSE OUTCOMES

CO-1: Understand the basic concepts of Fuzzy sets and operations of Fuzzy sets.

CO-2: Learn Zadeh's extension principle image and inverse image of Fuzzy arithmetic.

CO-3: Learn Fuzzy relation and Fuzzy graphs.

CO-4: Compare the possibility theory versus probability theory and apply to real life problems.

CO-5: Development of skills in Fuzzy sets.

OPEN ELECTIVE

(NUMERICAL ANALYSIS)

Full Marks: 50, End Semester:50)

Course Objectives:

Calculation of error and approximation is a necessity in all real life, industrial and scientific computing. The objective of this course is to acquaint students with various numerical methods of finding solution of different types of problems which arises in different branches of science such as locating roots of equations, finding solutions of polynomial equations and interpolation and evaluating integration.

Learning Outcomes:

Students can handle physical problems to find an approximate solution. After getting trained a student can opt for advance courses in numerical analysis in higher mathematics. Use of good mathematical software will help in getting the accuracy one needs from the computer and can asses the reliability of the numerical results and determine the affect of round off error or loss of significance.

Unit-I **16 Marks**

Convergence, Errors: Relative, Absolute, Round off, Truncation. Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method. Rate of convergence of these methods.

Unit-II **17 Marks**

Interpolation: Lagrange and Newtons methods. Error bounds. Finite difference operators.

Unit-III **17 Marks**

Numerical Integration: Trapezoidal rule, Simpson rule, Simpson 3/8 rule, Midpoint rule, Composite Trapezoidal rule, Composition Simpson rule.

Book Recommendation: -

B P Acharya and R. N. Das, Numerical Analysis, Kalyani Publishers

Unit-1: Chapter -0(0.2) Chapter -1(1.8) Chapter -3(3.8)

Unit-2: Chapter 2(2.1-2.9)

Unit-3: Chapter-6(6.1-6.5)

COURSE OUTCOMES

CO-1: Learn about different types of Errors in numerical approximation, Order of convergence and Stability of all methods. To solve the Linear and Non-linear equations in numerical methods.

CO-2: Analyse approximation of polynomials using Lagrange's and Newton's method and their error bounds and also its drawbacks. Understand Finite difference operators and its applications.

CO-3: Apply integration using Numerical methods like Trapezoidal rule, Simpson's 1/3rd rule and 3/8 rule. Learn composite methods and their advantages over general methods and Truncation error analysis of all these methods by studying accuracy of all methods.

SEMESTER-III

HARD CORE-301 (FUNCTIONAL ANALYSIS)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: The main objective of this course is familiarizing the students to the ideas and some of the fundamental theorem of functional analysis, which is an important branch ofmathematics developed with the purpose to cover theoretical needs of partial differential equation, measure theory and other branches of mathematics. It aims to study normed linear spaces and some of linear maps between them. Further, the objective of the course is the study of the main properties of uniform boundedness along with open mapping theorem. Also, the students will be familiarized with the basic results associated to different types of convergences in normed spaces and some of its applications. Another objective of this course aims at duality and Inner product spaces with formation of orthonormal sets. The prerequisites of this course are set theory and algebra of functions.

Learning Outcomes: Upon completing the course, students will be able to

1. Learn to recognize the fundamental properties of normed spaces and of the transformationbetween them.

2. Understand the inner product spaces and apply to construct orthonormal sets.

3. Corelate the functional analysis problem arising in uniform boundedness along with conceptof closed graph and open mapping theorems.

4. Understand the concepts of inner product spaces and orthonormal sets.

Unit-I **14 Marks**

Normed spaces, Continuity of Linear maps, Hahn- Banach theorems.

Unit-II **14 Mark**

Uniform Boundedness Principle, Closed Graph and Open Mapping Theorems.

Unit-III **14 Marks**

Duals and Transposes.

Unit-IV **14 Marks**

Inner Product Spaces, Orthonormal Sets, Riesz Representation Theorems.

Unit-V **14 Marks**

Bounded Operator and Adjoints, Normal, Unitary and Self Adjoint Operators.

Book Recommended:

B.V. Limaye: Functional Analysis, 3rd Edition, New Age International Ltd., 2015.

Unit-I Chapter- II (5.1-5.5, 6.1-6.3, 6.6, 7.5, 7.8)

Unit-II Chapter III (9.1, 10.1, 10.2, 10.6)

Unit-III Chapter IV (13.1-13.4)

Unit-IV Chapter VI (21, 22.1, 22.4--22.7, 24.1-24.3)

Unit-V Chapter VII (25,26)

Book for References:

Erwin Kreyszig: Introductory Functional Analysis with Applications, Wiley Student Edition,2010.

COURSE OUTCOMES

CO-1: Learn to recognize the fundamental properties of Normed spaces and the transformation between them and knowledge about the Inner product spaces and apply to construct Orthonormal sets.

CO-2: Corelate the functional analysis problem arising in Uniform boundedness along with conceptof Closed graph and Open mapping theorems.

CO-3: Learn about the Dual and Transpose.

CO-4: Understand the concepts of Inner product spaces and Orthonormal sets.

CO-5: Learn about the Bounded operator and adjoints and Adjoint operators.

CORE -302 (DISCRETE MATHEMATICS)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: The course on discrete mathematics is aimed to provide the concept of relation and digraphs, order relations, Hasse diagrams, lattices and operations on relations. The students are introduced to graph theory and its applications; Boolean algebra; and network flows.

Learning Outcomes: After studying this course, the students will be able to

1. Know about the directed graphs, special properties of binary relations, order relations, latticesand operations on relations.

2. Understand the basic concepts of graph; associate adjacency matrix to a graph; define and explain planar, Eulerian and Hamiltonian graphs; define the properties of bipartite graphs and understand the four Color problem; define trees and obtain spanning trees.

3. Learn basic operations in Boolean algebra; relate Boolean operations to equivalent truth tables;simplify Boolean functions by using the basic Boolean properties.; minimize Boolean functions using Karnaugh maps.

4. Model flow of commodities as graphs and apply flow techniques to the design ofnetwork optimization problems.

Unit – I **14 Marks**

Generating Function of Sequences, Calculating Coefficient of Generating Function, Recurrence Relation solving Recurrence Relation by Substitution and generating Functions, Characteristic Roots Methods, Solution of non-homogeneous Recurrence Relation.

Unit – II **14 Marks**

Relations and Digraphs: Relation and directed graphs, Special properties of binary relations, Equivalence relation, Order relations, Lattices, Enumerations, Operation on relations, Paths and closures, Directed graphs and Adjacency matrices, Applications.

Unit-III **14 Marks**

Graphs: Basic concepts, Isomorphic graphs, Sub-graphs, Trees and properties, Spanning trees, Directed trees and Binary trees. Planar graphs, Euler formula, Multi graphs and Euler Circuits, Hamiltonian graphs, Chromatic numbers, Four Color Problem.

Unit -IV **14 Marks**

Boolean Algebras: Introduction, Boolean algebra, Boolean functions, Switching mechanisms,Minimization of Boolean functions.

Unit- V **14 Marks**

Network flows: Graphs as models of flow of commodities, flows, Maximal flows

and minimalcuts, Max-flow Min-cut theorem, Applications.

Book Recommended:

J. L. Mott, A. Kandel and T. P. Baker: Discrete Mathematics for Computer

Scientists andMathematician, 2nd Edition, Prentice-Hall of India Ltd.

Unit-I: CHAPTER-3

Unit-II: CHAPTER-4(4.1-4.7)

Unit-III: CHAPTER-5

Unit-IV: CHAPTER-6(6.1-6.5)

Unit-V: CHAPTER-7

Book for References:

Kenneth H Rosen: Discrete Mathematics and Its Applications, 7th Edition,

McGraw HillEducation Pvt. Ltd., 2016.

COURSE OUTCOMES

CO-1: Learn about the Relation, Digraphs, Lattice, Path and applications.

CO-2: Know about the Directed graphs, special properties of Binary relations, Order relations, Lattices and Operations on relations.

CO-3: Understand the basic concepts of Graph; Associate adjacency matrix to a graph; define andexplain Planar, Eulerian and Hamiltonian graphs; define the properties of Bipartite graphs and understand the four Color problem; define Trees and obtain Spanning trees.

CO-4: Learn basic operations in Boolean algebra; relate Boolean operations to equivalent truth tables; simplify Boolean functions by using the basic Boolean properties.; minimize Boolean functions using Karnaugh maps.

CO-5: Model flow of commodities as graphs and apply Flow techniques to the design of Network optimization problems.

HARD CORE-303 (PROGRAMMING WITH PYTHON)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Mid Term From Part-A

(Record -10, Viva-15, Experiment-45 (Part B-15 Marks, Part C-15 Marks, Part D-15 Marks)

Part A

Computer System Overview, Data Representation, Boolean Logic, Introduction to Problem Solving, Getting Started with Python, Python Fundamentals, Data Handling, Flow of Control.

Part B

1. Program that reads 3 numbers (integers) and prints them in ascending order.

2. Program to calculate and print roots of a quadratic equation:

$$ax^2 + bx + c = 0 \ (a \neq 0).$$

3. Program to calculate the factorial of a number.

4. Program to calculate and print the sum of even and odd integers of the first n natural numbers.

5. Program to implement 'guess the number' game. Python generates a number randomly in the range [10,50]. The user is given five chances to guess a number in the range $10 \leq$ number ≤ 50.

6. Program to input some numbers repeatedly and print their sum. The program ends when the users say no more to enter (normal termination) or program aborts when the number entered is less than zero.

7. Program to input a number and test if it is a prime number.

Part C

1. Write a program to input three numbers and display the largest/smallest number.

2. Write a program to input a 6-digit number and divide it into three 2-digit numbers.

3. Write a program to input a number and then print its first and last digit raised to the length of the number (the number of digits in the number is the length of the number).

4. Write a program to find the lowest and second lowest number from the 10 numbers input.

5. Write a Python script to print 'Fibonacci series' first 20 elements.

6. Write a Python script to read an integer > 1000 and reverse the number.

7. Write a Python script to generate divisors of a number.

Part D

1. Write a program to check if a given number is a perfect number or not.

2. Write a program to check if a given number is an Armstrong number or Not.

3. Write a program to check if a given number is a Palindrome number or not.

4. Write a program to calculate BMI of a person after inputting its weight in kgs and height in meters and then print the Nutritional status as per the following table.

Nutritional Status	WHO Criteria BMI Cutt-off
Underweight	<18.5
Normal	18.5 – 24.9
Overweight	25 – 29.9
Obese	≥30

5. Write a program to implement a simple calculator for two input numbers. Offer choices through a menu.

6. Write a Python script to input two numbers and print their lcm (least common multiple) and gcd (greatest common divisor).

7. Write a program to input the value of x and n and print the sum of the series.

$$- x + \frac{x^2}{2!} - \frac{x^3}{3!} + \frac{x^4}{4!} - \ldots + (-1)^n \frac{x^n}{n!}$$

Books Recommended:

1. Python Programming using Problem Solving Approach by Reema Thareja, Oxford University Press.

2. Introduction to Computing and Problem Solving using Python by E. Balagurusamy, McGraw Hill Education (India) Private Limited.

CORE ELECTIVE-II (OPERATIONS RESEARCH)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: The main objective of this paper is to make student aware of some numerical techniques of operations research.

Learning Outcomes: After finishing this course, the student will be able to

2. Understand the solution procedures of about Integer programming problems and Goal programming problems.

3. Know how to solve sequencing problems and dynamic programming problems.

4. Learn advanced techniques of solving linear programming problem.

5. Know different types of Poisson queues and solution of problems based on this theory.

Unit I **14 Marks**

Integer Programming Problem

Unit II **14 Marks**

Sequencing Problems

Unit III **14 Marks**

Dynamic Programming

Unit IV **14 Marks**

Linear Programming Problem-Advanced Techniques.

Unit V **14 Marks**

Queuing Theory-Introduction to Poisson Queuing Systems.

Book Recommended:

Kanti Swarup, P. K. Gupta and Man Mohan: Operations Research, Sultan Chand & Sons, NewDelhi, 2020.

Unit-I Chapter-7,

Unit-II Chapter-12(12.1-12.6)

Unit-III Chapter-13

Unit-IV Chapter-9(9.1-9.4)

Unit-V Chapter-21(21.1-21.9) (Upto Model IV)

COURSE OUTCOMES

CO-1: Understand the solution procedures of about Integer programming problems and Goalprogramming problems.

CO-2: Know how to solve sequencing problems and dynamic programming problems.

CO-3: Learn advanced techniques of solving linear programming problem.

CO-4: Know different types of Poisson queues and solution of problems based on this theory.

CO-5: Development of skills in Operation research.

CORE ELECTIVE-II (MATHEMATICALS MODELLING)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: Its main aim learn about Mathematical Model and its Application in Real World Field.

Learning Outcomes: Students will able to know model such as Mathematical Modelling for Need, Technique and its application, student learn to develop models using first order differential Equations, Partial differential Equations, Graph Theory and Linear Programming.

Unit – I **14 Marks**

Mathematical Modeling: Need, Techniques, Classifications and sample illustrations.

Unit – II **14 Marks**

Mathematical Modeling through Ordinary Differential Equations of First Order.

Unit – III **14 Marks**

Mathematical Modeling through Partial Differential Equations

Unit – IV **14 Marks**

Mathematical Modeling through Graphs

Unit – V **14 Marks**

Mathematical Modeling through Mathematical Programming, Maximum principle and Maximum Entropy Principle.

BOOK RECOMNDED

1. Mathematical Modelling, 2nd Edition, J N Kapur New Age International Publishers.

Unit -I: Chapter -1

Unit -II: Chapter -2

Unit -III: Chapter -6

Unit -IV: Chapter -7

Unit -V: Chapter -10

COURSE OUTCOMES

CO1: able to know models such as Mathematical Modelling for Need, Technique and its application

CO2: learn to develop models using first order Ordinary differential Equations

CO3: learn to develop models using Partial differential Equations

CO4: Know mathematical modeling through Graphs

CO-5: Learn mathematical modeling through Mathematical programming and Maximum principle

CORE ELECTIVE-II (OPERATOR THEORY)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: To study linear operators on function space beginning with differential operators and integral operators. The operators may be presented abstractly by their characteristics such as bounded linear operators, closed operators and consideration may be given to nonlinear operators. The study which depends heavily on the topology of function space is branch of functional analysis.

Learning Outcomes: Prove the continuity of concrete linear operators between topological vector space. Given a linear operator understand whether or not it is compact. Find the essential spectra of linear operators. Find the maximal spectra of concrete commutative branch algebra.

Unit – I **14 Marks**

Introduction to complex homomorphism.

Unit – II **14 Marks**

Basic properties of spectrum, Symbolic calculus

Unit – III **14 Marks**

Differentiation, The group of invertible elements, Commutative branch algebra

Unit – IV **14 Marks**

Ideals and homomorphism, Gelfand transform

Unit – V **14 Marks**

Involution to non-commutative algebra, positive functionals.

Book Recommended:

Functional analysis, Walter Ruddin, TMH (Chapter 10&11)

COURSE OUTCOMES

CO-1: Understand the basic concepts Complex homomorphism.

CO-2: Learn spectrum, Symbolic calculus.

CO-3: Understand the concept of Differentiation, The group of invertible elements, Commutative branch algebra**.**

CO-4:. Learn Ideals and homomorphism.

CO-5: Development of skills in Operator theory.

CORE ELECTIVE-III

Numerical Solution of ordinary Differential Equations

Full Marks: 100 (Mid Semester-30, End Semester-70)

Course Objectives: In view of wide application of numerical solution of differential equations in tackling physical problems occurring in science and technology, there is a need to build the foundation of the students in this topic.

Learning Outcomes: At the end of the course, the students will be able to

1. Know different techniques of numerical solution of ordinary differential equation such as: Euler method, Backward Euler method and their error analysis.

2. Understand different methods for solving initial value problems (IVPs) using Taylor'smethod, Runge-Kutta methods and Collocation methods.

3. Understand error analysis, stability and convergence of multistep methods such as Adams-Bashforth methods and Adams–Moulton methods.

4. Know how to solve boundary value problems (BVPs) using finite difference methods,Shooting methods and Collocation methods.

Unit-I **20 Marks**

Ordinary Differential Equations (ODE): Solutions of Initial value problems by Euler's method, Error analysis of Euler's method, Asymptotic error analysis, Numerical stability; Backward Euler method and the Trapezoidal method.

Unit-II **20 Marks**

Ordinary Differential Equations (ODE): Solutions of Initial value problems by Taylor methods; Runge–Kutta methods, A general framework for explicit Runge– Kutta methods, Convergence, Stability and Asymptotic error, Error prediction and control, Implicit Runge–Kutta methods, Two-point Collocation methods.

Unit-III **20 Marks**

Multistep Methods: Adams–Bashforth methods, Adams–Moulton methods,Truncation error, Convergence, A general error analysis, Stability theory, Convergence theory, Relative stability and weak stability.

Unit-IV **20 Marks**

Two-point Boundary Value Problems: A finite-difference method, Convergence, Numerical examples, Boundary conditions involving the derivative;

Unit- V

Nonlinear two point boundary value problems, Finite difference methods, Shooting methods, Collocation methods.

Book Recommended:

Kendall E. Atkinson, Weimin Han and David E. Stewart: Numerical Solution of Ordinary Differential Equations, Wiley, 2009.

Unit – I : Chapter – 2, 4

Unit – II : Chapte 5 (5.1 – 5.3, 5.6)

Unit – III : Chapter 6 (6.1, 6.2); Chapter – 7

Unit –IV : Chapter 11 (11.1)

Unit – V : Chapter – 11 (11.2, 11.2.2, 11.2.3

Book for References:

1. Kendall E. Atkinson: An Introduction to Numerical Analysis, 2nd Edition, Wiley.

2. S. S. Sastry: Introductory methods of Numerical Analysis, 5th Edition, PHI.

COURSE OUTCOMES

CO1: able to know models such as Mathematical Modelling for Need, Technique and its application

CO2: learn to develop models using first order Ordinary differential Equations

CO3: learn to develop models using Partial differential Equations

CO4: Know mathematical modelling through Graphs

CO-5: Learn mathematical modelling through Mathematical programming and Maximum principle.

CORE ELECTIVE-III (OPTIMIZATION THEORY)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: The main objective of this course is to make the student aware of different types of optimizations and its application through case study.

Learning Outcomes: After the end of this course, students are able to

1. Solve problems on one-dimentional optimization using different methods.
2. Solve problems on unconstrained gradient based optimization.
3. Solve linear programming using duality and dual simplex method.
4. Know about constrained optimization methods.

Unit – I **14 Marks**

One dimensional optimization : Introduction, Function Comparison Methods, Polynomial Interprolation methods, Interative methods.

Unit – II **14 Marks**

Unconstrained Gradient based Optimizatonm Methods : Gradient and Conjugate Gradient Type Algorithms, Newton Type Methods, Quasi Newton Methods.

Unit – III **14 Marks**

Linear Programming : Convex Analysis, Simplex Method, Fidning initital solution, Duality, Dual Simplex Method.

Unit – IV **14 Marks**

Constrained Optimization Methods : Lagrange Multipliers, Kuhn-Tucker Conditions, Transformation Methods

Unit – V **14 Marks**

Convex Optimization, Lineratization methods, Direction Generation Methods.

Book Recommended:

M.C. Joshi and K.M. Moudgalya : Optimization Theory and practice, Narosa Publishing House, 2015.

UNIT-I: CHAPTER -2

UNIT-II: CHAPTER -3

UNIT-III: CHAPTER -4

UNIT-IV & V : CHAPTER -5

Book for References:

J.A. Snyman : Practical Mathematical Optimization, Springer Sciences, 2005

CORE ELECTIVE-IV
(PROBABILITY & STATISTICAL INFERENCE)
Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: The aim of the course is to pay a special attention to role of random variables in the probability theory, concept of Probability distributions and its properties, understanding Weak Law of Large Numbers, Strong Law of Large Numbers and Central Limit Theorem with their applications, Theory of Estimation and Testing of Hypothesis.

Learning Outcomes: After successful completion of this course, student will be able to

1. Understand the concepts of random variables, probability distributions and independence ofrandom variables related to measurable functions.
2. Learn the concepts of weak and strong laws of large numbers and central limit theorem.
3. Apply various estimation methods and testing procedures to deal with real life problems. 4.Understand Neyman-Pearson fundamental lemma, UMP test, Interval estimation and confidence interval.

Unit – I **14 Marks**

Random Variables: Discrete random variables, Continuous random variables, Functions of random variables, Joint Distributions: Discrete random variables, Continuous random variables, independent random variables, Conditional Distributions, Functions of Jointly Distributed random variables, Expected Values: Expected value of a random variable, Variance and Standarddeviation, Covariance and Correlation, Conditional expectation, moment generating function.

Unit II **14 Marks**

Limit Theorems: Law of Large numbers, convergence in distribution, central limit theorem**,** Distributions derived from normal distribution**:** chi-square, T and F distributions, Sample mean and variance, Survey Sampling: Population parameters, Simple random sampling, Estimation of a ratio.

Unit III **14 Marks**

Estimation of Parameters: Parameter Estimation, method of moments, The method of Maximum likelihood, Efficiency and the Cramer Rao Lower bound, Sufficiency, Factorization Theorem, The Rao-Blackwell theorem.

Unit IV **14 Marks**

Testing of Hypothesis: The Neyman-Pearson Paradigm, Optimal Tests, The Neyman-Pearson Lemma,

Unit V **14 Marks**

The duality of Confidence Intervals and Hypothesis Tests, The Generalized Likelihood Ratio tests, Likelihood Ratio for Multinomial distribution, Test for Normality.

Book Recommended:

John A. Rice: Mathematical Statistics and Data Analysis, Cengage Learning.
UNIT-I: CHAPTER (2 3 4)

UNIT-II: CHAPTER (5 6 7)

UNIT-III: CHAPTER (8)

UNIT-IV: CHAPTER (9.1 -9.3)

UNIT-V: CHAPTER (9.3-9.9)

Book for References:

Larry Wasserman: All of Statistics-A Concise Course in Statistical Inference, Springer.

COURSE OUTCOMES

CO-1: Understand the concepts of random variables, probability distributions and independence of random variables related to measurable functions.

CO-2: Learn the concepts of weak and strong laws of large numbers and central limit theorem.

CO-3: Apply various estimation methods and testing procedures to deal with real life problems.

CO-4: Understand Neyman-Pearson fundamental lemma, UMP test, Interval estimation and confidence interval

CO-5: Know about the duality of Confidence intervals and Hypothesis tests.

SEMESTER-IV

CORE-401 (NUMERICAL ANALYSIS)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: Numerical analysis is an integral part of scientific computation. A strong background of mathematical analysis is required for developing efficient numerical methods. Therefore, this course in numerical analysis consists of both theoretical and computational aspects. Thus, the main objective is to prepare the students for future research in this area.

Learning Outcomes: On successful completion of the course, the students will be able to

1. Learn different types of approximation of functions.

2. Know the methods of solution of system of linear equations and their analysis.

3. Understand the numerical methods of solving ordinary differential equations and theiranalysis.

4. Understand the eigen value location, error and stability of results.

Unit – I **14 Marks**

Approximation of Functions: Weierstrass theorem and Taylor's theorem, Minimax approximation problem, Least square approximation problem, Orthogonal polynomials, Least square approximation problem (Continued).

Unit – II **14 Marks**

Numerical Solution of Systems of Linear Equations: Gaussian Elimination, pivoting and scaling in Gaussian Elimination, Variants of Gaussian Elimination, Error analysis, Residual correction method, Iteration methods, Error prediction and acceleration.

Unit – III **14 Marks**

Numerical Methods for Ordinary Differential Equations: Existence, uniqueness and stability theory, Euler's method, Multistep methods, Midpoint methods, Trapezoidal method,

Unit-IV **14 Marks**

Low- order predictor-corrector algorithm, Derivation of higher order multistepmethods, Convergence and Stability for multistep methods.

Unit - V **14 Marks**

Eigen value location, error and stability results; Hermite Interpolation, Piecewisepolynomial interpolation (Cubic Spline Interpolation, B-Spline curves).

Book Recommended:

Kendall E. Atkinson: An introduction to Numerical Analysis, 2nd Edition, Wiley.

Unit-I Chapter-4(4.1-4.5)

Unit-II Chapter-8(8.1-8.7)

Unit-III Chapter-6(6.1-6.5)

Unit-IV Chapter -6(6.6-6.8)

Unit-V Chapter-3(3.6, 3.7), Chapter-9(9.1)

COURSE OUTCOMES

CO-1: Learn different types of Approximation of functions.

CO-2: Know the methods of solution of System of linear equations and their analysis.

CO-3: Understand the numerical methods of solving Ordinary differential equations and their analysis.

CO-4: Understand the Low-order Predicators-Correctors, derivation of Higher order Multistep function.

CO-5: Understand the Eigen value location, error and stability of results.

HARD CORE-402 (ADVANCED PROGRAMMING WITH PYTHON

AND LATEX)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Mid Term From Part-A & Part B

(Record -10, Viva-15, Experiment-45

(Part C-15 Marks, Part D-15 Marks, Part E-15 Marks)

Part A

Fundamentals of Python, String Manipulation, List Manipulation, Tuples and Dictionaries.

Part B

Fundamentals of LATEX- Introduction, Text, Symbols and Commands, Document Layout and Organization, Displayed Text Mathematical Formulas.

Part C

1. Write a program that reads a line and prints its statistics like: Number of uppercase letters, Number of alphabets, Number of symbols, Number of lowercase letters and number of digits.

2. Write a program that reads a line and a substring. It should then display the number of occurrences of the given substring in the line.

3. Write a program that inputs the individual words of your college motto and joins them to make a string. It should also input day, month and year of your college's foundation date and print the complete date.

4. Write a program that takes a string with multiple words and then capitalizes the first letter of each word and then forms a new string out of it.

5. Write a program that reads a string and checks whether it is a palindrome string or not without using string slice.

6. Write a program that reads a string and then prints a string that capitalizes every other letter in the string, e.g., 'passion' becomes 'pAsSiOn'.

7. Write a program that asks the user for a string s and a character c; and then it prints out the location of each character c in the string s.

Part D

1. Write a program that asks the user for a string and creates a new string that doubles each character of the original string. For instance: if the user enters 'sipo', the output should be 'ssiippoo'.

2. Write a program that inputs a line of text and prints its each word in a separate line. Also print the count of words in the line.

3. Write a program to input a string and print number of uppercase and lowercase letters in it.

4. Write a program to input a string and check if it contains a digit or not.

5. Write a program that inputs a list, replicates it twice and then prints the sorted list in ascending and descending order.

6. Write a program to find the minimum element from a list of elements along with its index in the list.

7. Write a program to calculate the Mean of a given list of numbers.

Part E

1. Write a program to search for an element in a given list of numbers.

2. Write a program to count the frequency of a given element in a list of numbers.

3. Write a program to find frequencies of all elements of a list. Also print the list of unique elements in the list and duplicate elements in the given list.

4. Write a program to check if the maximum element of the list lies in the first half of the list or in the second half.

5. Write a program to input 2 lists and display the maximum element from the elements of both the lists combined along with its index in its list.

6. Write a program to input a list of numbers and swap elements at the even location with the elements at the odd location.

7. Write a program to read a list of n integers (positive as well as negative). Create two new lists, one having all positive numbers and the other having all negative numbers from the given list. Print all three lists.

Books Recommended:

1. Python Programming using Problem Solving Approach by Reema Thareja, Oxford University Press.

2. Introduction to Computing and Programming using Python by John V. Guttag, PHI Learning Private Limited.

3. A Guide to LATEX and Electronic Publishing by Helmut Kopka & Patrick W. Daly, Addison Wesley.

4. LATEX Beginners Guide, Stephan Kotturitz, PACKT Publishing Open Source.

CORE ELECTIVE-IV (FLUID DYNAMICS)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: The course on fluid mechanics is devised to introduce fundamental concepts and notions used in fluid dynamics; apply concepts of conservation of mass, momentum and energy to the fluid flows; understand the role of governing non-dimensional parameters in flow dynamics; and study analytical solutions to variety of simplified problems.

Learning Outcomes: On successful completion of the course, the students will be able to Understand the types of flows, the fundamental properties of fluids and the stress-strain relationship in fluids.

1. Derive the equations of continuity, momentum, and energy applied to fluid motions.

2. Apply dimensional analysis to predict physical parameters that influence the fluid flow.4.Solve the governing equations of a fluid motion with simplified Navier-Stokes equation.

Unit – I 14 Marks

Basic Concepts.

Unit – II 14 Marks

Fundamental Equations of the Flow of Viscous Fluids.

Unit – III 14 Marks

Dynamical Similarity and Inspection & Dimensional Analysis.

Unit – IV 14 Marks

Exact Solutions of the Navier-Stokes' Equations.

Unit – V 14 Marks

Theory of Laminar Boundary Layers.

Book Recommended:

J. L. Bansal: Viscous Fluid Dynamics, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.

Unit-I Chapter -1

Unit-II Chapter –2

Unit-III Chapter -3(3.1-3.4, 3.8, 3.9)

Unit-IV Chapter –4(4.1-4.6)

Unit-V Chapter -6 (6.1-6.4)

COURSE OUTCOMES

CO-1: Understand the types of flows, the fundamental properties of fluids and the stress-strain relationship in fluids.

CO-2: Derive the equations of continuity, momentum, and energy applied to fluid motions.

CO-3: Apply dimensional analysis to predict physical parameters that influence the fluid flow.

CO-4: Solve the governing equations of a fluid motion with simplified Navier-Stokes equation.

CO-5: Know about the theory of Laminar boundary layers.

CORE ELECTIVE-IV (THEORY OF COMPUTATION)

Full Marks: 100 (Mid Semester:30, End Semester:70)

Course Objectives: To understand the concept of machine, finite automata, pushdown automata, linear bounded automata and Turing machine. To understand formal language and grammar, context free grammar and context free language. To understand the relation between formal language, grammar and machine, concept of algorithm and complexity of problems.

Learning Outcomes: Demonstrate advanced knowledge of formal computation and its relationship to languages. Distinguish different computing languages and classify their respective types. Recognize the comprehend formal reasoning about languages. Show a competent understanding of the basic concept of complexity theory.

Unit-I **14 Marks**

Introduction to automata and computability theory, mathematical preliminaries.

Unit-II **14 Marks**

Finite automata and non-determinism.

Unit-III **14 Marks**

Regular expressions, Pumping lemma for regular languages.

Unit-IV **14 Marks**

Context Free Grammars and Pumping lemma for context free languages.

Unit-V **14 Marks**

Pushdown automata.

Book Recommended:

1. Introduction to theory of computation, Michel Sipser, PWS Publishing Company.
2. Introduction to automata theory, Language & Computation, J E Hopcroft, Rajiv Motwani, J D Ulman, Pearson Education.
3. An Introduction to Formal Language & Automata by Peter Linz, Narosa Publishing House.

COURSE OUTCOMES

CO-1: Demonstrate advanced knowledge of formal computation and its relationship to languages.
CO-2: Distinguish different computing languages and classify their respective types.
CO-3: Recognize the comprehend formal reasoning about languages.
CO-4: Show a competent understanding of the basic concept of complexity theory.
CO-5: Discussion on Pushdown automata.

CORE ELECTIVE-IV

(NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS)

Full Marks: 100 (Mid Semester-30, End Semester-70)

Course Objectives: Most of the models in fluid dynamics ultimately reduce to partial differential equations(PDEs). So, there is a need for the students to make themselves aware of solving numerically PDEs to enable themselves for future research in this area.

Learning Outcomes: On successful completion of the course, the students will be able to

1. Solve numerically PDEs using finite difference method.

2. Know Jacobi's iteration method, Gauss-Seidel iteration method, Successive Over-Relaxation or SOR method and ADI method for solving Laplace's equation and Poisson's equation.

3. Use Blender-Schmidt's, Crank-Nicolson and DuFort-Frankel methods for Parabolic PDEs.

4. Solve hyperbolic PDEs using finite difference methods and also know consistency, stability and convergence of the methods used.

Unit – I **14 Marks**

Partial Differential Equations (PDE): Classification of PDEs, Finite difference approximations to PDEs. Numerical solutions of Elliptic, Parabolic and Hyperbolic PDEs.

Unit – II **14 Marks**

Solution of Laplace's equation by Liberman's iteration procedure, Jacobi's iteration method, Gauss-Seidel iteration method, Successive Over-Relaxation or SOR method, ADI method, Poisson's equation.

Unit – III **14 Marks**

Explicit formula for Parabolic PDE; Solution of parabolic equation by BlenderSchmidt's, Crank-Nicolson, DuFort-Frankel methods for Parabolic PDE.

Unit – IV **14 Marks**

Explicit formula for Hyperbolic PDE; Solution by method of finite difference,

Unit – V **14 Marks**

Explicit formula for Hyperbolic PDE. Consistency, Stability and Convergence aspects of these methods.

Books Recommended:

1. S.S.Sastry: Introductory methods of Numerical Analysis, 5th Edition, PHI.

2. G. D. Smith: Numerical Solution of Partial Differential Equations, 3rd

Edition, Oxford University Press

COURSE OUTCOMES

CO-1: Know different techniques of numerical solution of ordinary differential equation such as: Euler method, Backward Euler method and their error analysis.

CO-2: Understand different methods for solving initial value problems (IVPs) using Taylor's method, Runge-Kutta methods and Collocation methods.

CO-3: Understand error analysis, stability and convergence of multistep methods such as Adams-Bashforth methods and Adams–Moulton methods.

CO-4: Know how to solve boundary value problems (BVPs) using finite difference methods, Shooting methods and Collocation methods.

CO-5: Know solving Nonlinear two-point boundary value problems.