DEPARTMENT OF MATHEMATICS
ACHARYA NAGARJUNA UNIVERSITY
NAGARJUNA NAGAR – 522 510

VISION

To create an academically sound environment that nurtures motivates and inspires excellence in research and teaching in Mathematics along with concern for society.

MISSION

To develop logical, analytical and Mathematical thinking power in the minds of students in order to cater the Mathematical needs of the society.

Programme Outcomes, Programme Specific Outcomes and Course Outcomes of M.Sc Mathematics

Programme Outcomes (PO's):

Programme outcomes describe what students are expected to know or be able to do by the time of Post graduation.

On completion of M.Sc. Mathematics programme student will be able to:

PO1: Mathematical Knowledge

Various branches of Mathematics are so selected and designed for M.Sc Mathematics course aiming at mathematical reasoning, sophistication in thing and acquaintance with enough number of subjects including application oriented ones to suit the present needs of various allied branches in Engineering and Science as well as provision of opportunities to pursue research in higher mathematics.

PO2: Problem Solving Skills

This programme also offers training in problem solving skills.

PO3: Analytical & Logical thinking

The student will be able to develop logical reasoning techniques and Techniques foranalyzing the situation.

PO4: Advanced Algebra

The students shall appreciate the necessity of various Algebraic structures with binary operations such as Group, Ring, Non-commutative ring that lead to new ideas in algebra for their future research in advanced topics of algebra.

PO5: Analysis:

The student shall get an insight in the behavior of curves defined on a closed and bounded interval and some important properties of continuous, monotonic, and differentiable functions defined on a closed and bounded interval and also their metric space analogues.

PO6: Numerical Techniques

The student will be able to learn some useful approximation and interpolation techniques in Mathematics.

PO7: Advanced Discrete Mathematics

The student will learn concepts like finite state machine, Boolean algebra, lattice which develop more useful logic in the development of theories of electronic computers, networks, switching circuits that are applicable in Physics.

PO8: Learning Number theoretical concepts

Student will learn some important concepts in Number theory that are useful in Cryptography related to the advanced area of research namely Network security.

PO9: Understanding Ability

Student will develop ability for generation of mathematical model to a given real life situation as well as learning new areas of mathematics in future either for teaching or for research.

PO10: Getting Abilities

Demonstrate the ability to conduct research independently and pursue higher studies towards Ph.D. degree in mathematics.

PO11: Evaluating capability

The student shall acquire capability to evaluate hypothesis, methods and evidence within their proper contexts in any situation.

PO12: Application of knowledge

The student shall able to apply the knowledge acquired in mathematics in Science, technology as well as research and its extensions.

Programme Specific Outcomes

- Understanding of the fundamental axioms in mathematics and capability of developing ideas based on them.

- Inculcate mathematical reasoning.
- To develop ones own learning capacity.
- Prepare and motivate students for research studies in mathematics and related fields.
- Develop abstract mathematical thinking.
- Assimilate complex mathematical ideas and arguments.

M.SC MATHEMATICS COURSE STRUCTURE & SYLLABUS

S.No	SEM. No.	Title of the Paper	Course code	Total Marks	I. A text	SEM end exam	Teaching Hours	Credits
1	I	ALGEBRA	M101	100	30	70	90	5
2		REAL ANALYSIS-I	M102	100	30	70	90	5
3		DIFFERENTIAL EQUATIONS	M103	100	30	70	90	5
4		TOPOLOGY	M104	100	30	70	90	5
5		ADVANCED DISCRETE MATHEMATICS	M105	100	30	70	90	5
6	II	GALOIS THEORY	M201	100	30	70	90	5
7		REAL ANALYSIS -II	M202	100	30	70	90	5
8		MEASURE AND INTEGRATION	M203	100	30	70	90	5
9		COMPUTER ORIENTED NUMERICAL METHODS	M204	100	30	70	90	5
10		GRAPH THEORY	M205	100	30	70	90	5
11	III	RINGS AND MODULES	M301	100	30	70	90	5
12		COMPLEX ANALYSIS	M302	100	30	70	90	5
13		FUNCTIONAL ANALYSIS	M303	100	30	70	90	5
14	ELECTIVE PAPERS	FUZZY SETS AND THEIR APPLICATIONS	M304(A)	100	30	70	90	5
		SEMI GROUPS	M304(B)	100	30	70	90	5
		NUMBER THEORY	M304(C)	100	30	70	90	5
15	ELECTIVE PAPER	LINEAR PROGRAMMING	M305	100	30	70	90	5
16	IV	NON-COMMUTATIVE RINGS	M401	100	30	70	90	5
17		PARTIAL DIFFERENTIAL EQUATIONS	M402	100	30	70	90	5
18		NEAR RINGS	M403	100	30	70	90	5
19	ELECTIVE PAPERS	ALGEBRAIC CODING THEORY	M404(A)	100	30	70	90	5
		LATTICE THEORY	M404(B)	100	30	70	90	5
		OPERATOR THEORY	M404(C)	100	30	70	90	5
20	ELECTIVE PAPER	OPERATIONS RESEARCH	M405B	100	30	70	90	5

M.Sc. MATHEMATICS I SEMESTER
M101: ALGEBRA

Subject Code :	M101	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives: To introduce the concepts Groups, Permutation groups, Direct product of groups, Rings, Euclidean Rings, Polynomial Rings and some related theories and to develop working knowledge of these concepts and also skills for applying them in number theory and construction of certain fields.

Unit-I: Group Theory: Definition of a Group, Some Examples of Groups, Some Preliminary Lemmas, Subgroups, A Counting Principle, Normal Subgroups and Quotient Groups, Homomorphisms, Automorphisms, Cayley's theorem, Permutation groups. (2.1 to 2.10 of the prescribed book [1]).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the concept of Groups, Normal groups and Quotients groups and permutation Groups.

Unit-II: Group Theory Continued: Another counting principle, Sylow's theorems, direct products, finite abelian groups (2.11 to 2.14 of the prescribed book [1]).

Learning outcomes: Upon completion of this unit, the student will be able to: Analyse counting principle and Sylow's theorems and apply them for describing structures of finite groups.

Unit-III: Ring Theory: Definition and Examples of Rings, Some special classes of Rings, Homomorphisms, Ideals and quotient Rings, More Ideals and quotient Rings, The field of quotients of an Integral domain, Euclidean rings, A particular Euclidean ring (3.1 to 3.8 of the prescribed book[l]).

Learning outcomes: Upon completion of this unit, the student will be able to: Demonstrate the knowledge of Rings, ideals of Rings and Quotient rings, Field of Quotients of an integral domain.

Unit-IV : Ring Theory Continued: Polynomial Rings, Polynomials over the rational field, Polynomial Rings over Commutative Rings (3.9 to 3.11 of the Prescribed book [l]). **Vector Spaces**: Elementary Basic Concepts - Linear Independence and Bases - Dual spaces (4.1 to 4.3 of the prescribed book [1]).

Learning outcomes: Upon completion of this unit, the student will be able to: Describe polynomial Rings and other forms of polynomial rings, base and Dimension of a Vector Space.

PRESCRIBED BOOK: [1] Topics in Algebra, I.N. HERSTEIN, Second Edition, Wiley Eastern Limited, New Delhi, 1988.
REFERENCE BOOK: "Basic Abstract Algebra",BHATTACHARYA P.B., JAIN S.K., NAGPAUL S.R., Second Edition, Cambridge Press.

Course Outcome: Acquaintance with the fundamental algebraic structures, namely Groups, Rings, Fields and Vector spaces, essential for further study of Algebra.

M.Sc. MATHEMATICS I SEMESTER
M102: REAL ANALYSIS-I

Subject Code :	M102	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives: The course objective is to develop problem solving skills and to acquire knowledge on some of the basic concepts in limits, continuity, derivatives, the Riemann Stieltjes – integrals and sequences of functions.

UNIT-I : Continuity: Limits of functions, continuous functions, Continuity and Compactness, continuity and connectedness. Discontinuities, Monotonic functions, Infinite limits and limits at infinity. (4.1 to 4.34 of chapter 4).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the concepts of limit and continuity of functions and discuss types of Discontinuities.

UNIT-II: Differentiation: Derivative of a real function, Mean value theorems, The continuity of derivatives, L'Hospital's rule, Derivatives of higher Order, Taylor' s theorem, Differentiation of vector valued functions. (5.1to 5.19 of chapter 5).

Learning outcomes: Upon completion of this unit, the student will be able to: Get introduced to the study of another equally important concept namely differentiation that is essential in the study of velocity and acceleration of continuous paths.

UNIT-III: Riemann Stieltjes Integral: Definition and Existence of the Integral, Properties of the Integral , Integration and Differentiation, Integration of vector valued functions. Rectifiable curves. (6.1 to 6.27 of chapter 6).

Learning outcomes: Upon completion of this unit, the student will be able to:
Determine the Riemann-Stieltjes integrability of a bonded function and prove a selection of theorems concerning integration.

UNIT-IV: Sequences and series of functions: Discussion of main problem, Uniform convergence, Uniform convergence and Continuity, Uniform convergence and Integration, Uniform Convergence and Differentiation. (7.1 to 7.18 of chapter7).

Learning outcomes: Upon completion of this unit, the student will be able to: Recognize the difference between point wise and uniform convergence of sequences of functions and illustrate the effect of uniform convergence on the limit function with respect to continuity, differentiability, and integrability.

PRESCRIBED BOOK: "Principles of Mathematical Analysis", Third Edition, WALTER RUDIN, Tata Mc Graw Hill**.**

Course Outcomes:
After completing this course, the student gets adequate knowledge about the behavior of a function in the vicinity of a point, learns about discontinuities at a point, analytical study of the movement of particle in the plane as well as the areas of the region bounded by a curve and the axes. Finally the students learn about the uniform behavior of sequences of plane curves.

M.Sc. MATHEMATICS I SEMESTER
M103: DIFFERENTIAL EQUATIONS

Subject Code :	M103	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives: To provide some standard methods for solving first-order, second-order and higher-order homogeneous and nonhomogeneous ordinary differential equations with constant and variable coefficients, linear equation with regular singular points, and to study the method of successive approximations, Lipshitz condition and non-local existence of solutions.

UNIT-I: Linear equations of the first order: Linear equations of the first order – The equation $Y^1 + ay = 0$ – The equation $y^1 + ay = b(x)$ - The general linear equation of the first order. (Chapter 1 of Coddington).
Linear Equations with constant co-efficients: Introduction - The second order Homogeneous equation – Initial value problems for the second order equations – Linear dependence and independence – A formula for the Wronskian – The non-homogeneous equation of order two – The homogeneous equation of order n – Initial value problems for n-th order equations. (Sections 1 to 8 in Chapter 2 Reference Book).

Learning outcomes: Upon completion of this unit, the student will be able to: Obtain the solutions of second order homogeneous and nonhomogeneous linear differential equations with constant coefficients and understand the utility of Wronskian, linear independence and independence of solutions.

UNIT – II: Linear Equations with Variable Co-efficients: Introduction – Initial value problems for the homogeneous equation – Solutions of the homogeneous equation – The Wronskian and linear independence – Reduction of the order of a homogeneous equation – The non-homogeneous equation – Homogeneous equations with analytic coefficients. (Sections 1 to 7 in Chapter 3 Reference Book).

Learning outcomes: Upon completion of this unit, the student will be able to: learn how to solve homogeneous and nonhomogeneous differential equations with variable coefficients and homogenious equation with analytic co-efficients.

UNIT – III : Linear Equations with Regular Singular Points: Introduction – The Euler equation – Second ordre equations with regular singular points –Second order equations with regular singular points – A convergence proof - The exceptional cases – The Bessel equation. (Sections 1 to 7 in Chapter 4 Reference Book).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the concepts regular singular points and solve the Euler equation and the Bessel equation.

UNIT- IV: Existence and Uniqueness of Solutions to First Order Equations: Introduction – Equation with variables separated – Exact equations – The method of successive approximations – The Lipschitz condition – Convergence of the successive approximations – Non-local existence of soltutions.(Sections 1 to 7 in Chapter 5 Reference Book).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the concepts of successive approximations, The Lipschitz condition and prove local and Non-local existence theorems.

Text Book : An introduction to Ordinary Differential Equations by Earl A. Coddington, Prentice-hall of Indial Private Limited, NEW DELHI, 1974.

Course outcomes: The students shall receive good introduction to the study of solutions of equations in higher order derivatives of a variable function with variable coefficients in general and constant coefficients as well as the student also learns technique of finding solutions of some special types of equations. Finally the student learns how to establish existence and uniqueness of $y^1 = f(x, y)$ when f satisfies the Lipschitz condition.

M.Sc. MATHEMATICS I SEMESTER
M104: TOPOLOGY

Subject Code :	M104	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives : To generalize the concept of distance, open sets, closed sets and related theorems in real line and to learn basic concepts in Metric Spaces, Topological Spaces, compact spaces and connected spaces.

UNIT-I
Metric Spaces: The Definition and some examples, Open sets, Closed sets, Convergence, Completeness and Baire's theorem, Continuous mappings. (Sections 9 to 13 of chapter 2).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the basic concepts of metric spaces, open sets, closed sets and continuous functions on metric spaces.

UNIT-II
Topological spaces : The Definition and some examples, Elementary concepts, Open bases and Open subbases, Weak topologies.(Sections 16 to 19 of chapter 3).

Learning outcomes: Upon completion of this unit, the student will be able to: Define and illustrate the concept of topology and prove a selection of theorems concerning Topological spaces, continuous functions and product topologies.

UNIT-III
Compactness: Compact spaces, Products of spaces, Tychonoff's theorem and locallyCompact spaces , Compactness for Metric Spaces, Ascoli's theorem.(Sections 21 to 25 of chapter 4).

Learning outcomes: Upon completion of this unit, the student will be able to: Characterize compact spaces using the Heiene-Borel theorem.

UNIT-IV
Separation: T_1 spaces and Hausdorff spaces , Completely regular spaces and normal spaces, Urysohn's Lemma and the Tietze extension theorem. Urysohn imbedding theorem. connected spaces, The components of a space (Sections 26 to 29 of Ch. 5 and sections 31 to 32 of chapter 6).

Learning outcomes: Upon completion of this unit, the student will be able to: Define and illustrate the concepts of the separation axioms and appreciate the beauty of deep mathematical results like Urysohn's lemma, Urysohn imbedding theorem and understand the dynamics of the proof techniques. Characterize connected spaces, components of a space.

PRESCRIBED BOOK: "Introduction to Topology and Modern Analysis", G.F. SIMMONS, Mc. Graw Hill Book Company , New York International student edition.

Course outcomes: The student shall be able to appreciate generalization of the properties of intervals on R and ideas of continuity on the real line in a more general context. The student shall also be able to appreciate the generalization of Heiene- Borel to compactness in topological spaces.

M.Sc. MATHEMATICS I SEMESTER
M105: ADVANCED DISCRETE MATHEMATICS

Subject Code :	M105	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives : To develop skills and to acquire knowledge on some of the basic concepts in Truth tables, Tautology and contradiction, Tautological implication, variables and quantifiers, Logic, Finite Machines, Fundamental concepts and basic results of Boolean Algebra, Lattices and their Applications, and applications of switching circuits, Gatting Network, Karnag diagrams..

UNIT –I: Propositional Calculus: Statements and Notations- Connectives and Truth Tables – Tautology and Contradiction – Equivalence of Statement / Formulas – Duality Law and Tautological Implication – Normal Forms – The theory of Inference for Statement Calculus – Consistency of Premises and Indirect Method of Proof. (Chapter – I of the reference [3]). Predicate Calculus: Predicate Logic – Statement Functions, Variables and Quantifiers – Free and Bound Variable – Inference Theory for the Predicate Calculus (Chapter – 2 of the reference [3]).

Learning outcomes: Upon completion of this unit, the student will be able to: Formulate statements from common language to formal logic, apply truth tables and the rules of propositional and predicate calculus.

UNIT –II: Finite Machines : Introduction, state tables and state diagrams, simple properties , Dynamics and Behavior. (refer Chapter 5 of the reference book [1]).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the concept of finite machines and study their applications like minimization, and realization.

UNIT – III: Properties and Examples of Lattices, Distributive Lattices, Boolean polynomials. (Sections 1 to 4 of Chapter 1 of [2]).

Learning outcomes: Upon completion of this unit, the student will be able to: be familiar with the notions of ordered algebraic structures, including lattices and Boolean algebras.

UNIT –IV: Ideals , filters and equations, Minimal forms of Boolean polynomials, Application of Lattices: Application of switching circuits, (Sections 5,6 of Chapter -1 and sections 7 and 8 of Chapter 2of [2]).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the concept of Boolean polynomials, ideals, filters and calculate the minimal forms of Boolean polynomials. Demonstrate switching circuits and applications of switching circuits.

Note: For units –III and IV the material of pages 1 to 66 of [2] is to be covered.

REFERENCE BOOKS:

[1] "Application oriented Algebra" JAMES L FISHER , IEP, Dun- Downplay pub.1977.
[2] " Applied abstract algebra", Second Edition, R.LIDL AND G. PILZ, Springer,1998.
[3] " Bhavanari Satyanarayana, Tumurukota Venkata Pradeep Kumar and Shaik Mohnddin Shaw, "Mathematical Foundation of Computer Science" BS Publications (A unit of BSP Book Pvt Ltd), Hyderabad, India 2016. (ISBN. 978-93-83635-81-8).
[4] Rm. Somasundaram "Discrete Mathematical Structures" Prentice Hall of India, 2003.

[5] Bhavanari Satyanarayana & Kuncham Syam Prasad, "Discrete Mathematics and Graph theory" (For B.Tech/B.Sc./M.Sc (Maths)), Printice Hall of India, New Delhi, April 2014.

Course Outcomes: After competing this course, the student will be able to: Receive meaningful introduction to discrete mathematics and its applications.

M.Sc. MATHEMATICS II SEMESTER
M201: GALOIS THEORY

Subject Code :	M201	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives: To develop skills and to acquire knowledge on some of the basic concepts in Modules, Algebraic Extensions, Splitting fields, Polynomials solvable by radicals.

UNIT-I : Algebraic extensions of fields: Irreducible polynomials and Eisenstein's criterion, Adjunction of roots, Algebraic extensions, Algebraically closed fields.(Chapter15 of prescribed text book).

Learning outcomes: Upon completion of this unit, the student will be able to: Derive and apply Gauss Lemma, and Eisenstein criterion for irreducibility of Polynomials.

UNIT-II : Normal and separable extensions: Splitting fields, Normal extensions, multiple roots, Finite fields, Separable extensions.(Chapter16 of prescribed text book).

Learning outcomes: Upon completion of this unit, the student will be able to: Demonstrate Field extensions and characterization of finite normal extensions as splitting fields and study prime fields.

UNIT-III: Galois Theory : Automorphism groups and fixed fields; Fundamental theorem of Galois theory; Fundamental theorem of Algebra (Chapter 17 of prescribed text book).

Learning outcome: Upon completion of this unit, the student will be able to: Learn Fundamental theorem of Galois theory, fundamental theorem of Algebra and related results, appreciate genius in proving strong important theorems at early age.

UNIT-IV: Applications of Galois theory to classical problems: Roots of unity and cyclotomic polynomials; Cyclic extensions; Polynomials solvable by radicals; symmetric. (Chapter 18 of prescribed text book).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand cyclotomis polynomials, cyclic extensions, Radical field extensions and Ruler & Compass constructions. Know the important applications of Galois Theory.

TEXT BOOK: [1]. "Basic Abstract Algebra" , Second Edition, BHATTACHARYA P.B., JAIN S.K., NAGPAUL S.R., Cambridge Press.

Course Outcomes: When one completes an introductory course on Galois theory one will be able to visualize and appreciate the necessity of acquiring deep mathematical thought to be able to solve certain seemingly simple questions such as insolvability of quintic by radicals. The course provides an opportunity to the student to learn highly sophisticated and deep concepts in algebra such as Algebraically closed fields, splitting fields, normal and separable extensions.

M.Sc. MATHEMATICS II SEMESTER
M202: REAL ANALYSIS-II

Subject Code :	M202	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives: To introduce the concept of equi continuous family of functions, power series, linear transformations, contraction principle, derivatives of higher order, differentiation of integrals and integration of differential forms and to prove the inverse function theorem and implicit functions theorem.

UNIT-I : Equi continuous family of functions , Stone Weierstrass theorem and Stone's generalization, Power series.(7.19 to 7.33 of Chapter 7 & 8.1 to 8.5 of Chapter 8).

Learning outcomes: Upon completion of this unit, the student will be able to: Study the Stone – Weierstrass theorem and its applications . Understand the properties of power series. Exponential, Trigonometric and Logarithmic functions.

UNIT-II: Exponential and logarithmic functions, Trigonometric functions, Linear Transformations, Differentiation, Contraction Principle. (Sections 8.6, 8.7 of Chapter 8 & 9.1 to 9.23 of Chapter 9).

Learning outcomes: Upon completion of this unit, the student will be able to: Compute derivatives and integrals of real valued and vector valued functions of several variables.

UNIT-III: Inverse function theorem , Implicit function theorem, determinants, derivatives of higher order and differentiation of integrals. (Sections 9.24 to 9.29 & 9.33 to 9.43 of Chapter 9).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand and apply the inverse function theorem, implicit function theorem , derivatives of higher order and differentiation of integrals.

UNIT-IV: Integration of differential forms: Integration, Primitive mappings, partitions of unity, change of variables , differential forms.(10.1 to 10.25 of Chapter10).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the concept of integration of differential forms.

TEXT BOOK: "Principles of Mathematical Analysis", Third Edition, WALTER RUDIN, Tata Mc Graw Hill.

Course outcomes: After completing this course, the student will be able to: learn that Weierstrass approximation theorem provides techniques to approximate a continuous function on a compact interval with a polynomial while Stones generalization explains method for extension of this concept in the context of algebras. The student shall be able to appreciate the role of fixed point theorem in the inverse function theorem. The student is further introduced to the way in which the inverse function theorem is involved while proving the famous implicate function.

M.Sc. MATHEMATICS II SEMESTER
M203: MEASURE THEORY

Subject Code :	M203	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives: To develop skills and to acquire knowledge on basic concepts of Lebesgue Measure, The Lebesgue Integral, Measurable Functions, L^p- spaces, Minkowski inequalities, Holder inequalities, Convergence and completeness.

Unit-I : Lebesgue Measure: Introduction, Outer measure , Measurable sets and Lebesgue measure, A non measurable set, Measurable functions, Littlewood's three principles (Chapter 3).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the concept of measure and properties of Lebesgue measure.

Unit-II: The Lebesgue Integral: The 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, Convergence in measure. (Chapter 4).

Learning outcomes: Upon completion of this unit, the student will be able to: Study the properties of Lebesgue integral and compare it with Riemann integral.

Unit-III: Differentiation and Integration: Differentiation of monotone functions, Functions of bounded variation, Differentiation of an Integral, Absolute continuity, Convex function. (Chapter 5).

Learning outcomes: Upon completion of this unit, the student will be able to: To establish the derivative of the indefinite integral of an integrable function is equal to the integral a.e. To establish the equivalent condition an indefinite integral is absolutely continuous. Jenson inequality becomes a generalization of the inequality between the arithmetic and geometric mean.

Unit-IV: The Classical Banach Spaces: The L^p-spaces, The Minkowski and Holder inequalitites, convergence and completeness, Approximation in L^p, Bounded linear functional on the L^{p-} spaces. (Chapter 6).

Learning outcomes: Upon completion of this unit, the student will be able to: To establishes several inequalities involving the $\|.\|_p$ in the L^p spaces. To find a representation for bounded linear functions.

TEXT BOOK: Real Analysis, Third Edition, H.L.Royden, Pearson Publication.

Course outcomes: After completing this course, the student shall realize the need of broader concepts of length and continuity for extending the notion of integral to widen the class of functions for which derivative and integral are inverse process to each other. Further the student gets a taste of duality theory through the classical Banach spaces.

M.Sc. MATHEMATICS II SEMESTER

M204: COMPUTER ORIENTED NUMERICAL METHODS

Subject Code :	M204	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives:

The objective of this course includes:

The comprehensive study of the C Programming Language, The study of numerical methods for Interpolation of polynomials and Approximation roots of functions and also Integration, The study of numerical methods for solving Linear system of equations and Ordinary differential equations with given initial conditions.

UNIT – I

C Programming

C – Character set, Identifiers and key words, declaration statement data types ,Variables, Constants, Structure of C program, (1.4, 1.5, 1.6, 1.7, 1.11 & 1.12 of Ajay Mittal). Expressions, simple expressions and compound expressions, classification of operations, (2.2, 2.3 &2.4 of Ajay Mittal). Statements, classification of statements. (3.2 & 3.3 of Ajay Mittal). Single dimensional arrays, Multidimensional arrays (4.3 & 4.6 of Ajay Mittal). Functions, classification of functions (5.2 & 5.3 of Ajay Mittal).

Learning outcomes: Upon completion of this unit, the student will be able to: Use different data types in a Computer program and Design programs involving Decision structures, Loops and Functions.

UNIT-II: Interpolation and Approximation: Introduction, Lagrange and Newton Interpolations, Finite difference Operators, Interpolating polynomials using finite differences, Hermite Interpolations. (Section 4.1 to 4.5 of chapter 4 of [2]).

Learning outcomes: Upon completion of this unit, the student will be able to: Apply various Mathematical operations and tasks, such as Interpolation of Polynomials.

UNIT-III: Numerical Differentiation and Integration: Introduction, Numerical integration, Methods based on Interpolation, Methods based on Undetermined Coefficients, Composite Integration Methods. (Sections 5.1, 5.6, 5.7, 5.8, 5.9 of chapter 5 of [2]).

Learning outcomes: Upon completion of this unit, the student will be able to: Ability to solve the Problems based on Numerical Integration.

UNIT-IV: Ordinary Differential Equations: Introduction Numerical methods, Single step methods, Multi step methods (sections 6.1 to 6.4 of [2]).

Learning outcomes: Upon completion of this unit, the student will be able to: find Numerical solution of ordinary differential equations such as Runga-Kutta methods.

TEXT BOOKS:

[1] " C Programming a practical approach", AJAY MITTAL, Pearson.

[2] "Numerical Methods for Scientific and Engineering Computation", M.K.JAIN,S.R.K.

IYANGAR AND R.K. JAIN Third edition, New Age International (p) Limited, New Delhi, 1997.

Course outcomes: After going through this course one finds the advantage of numerical methods in solving certain analytical problems and enjoys the application of computer methods effectively for several useful numerical methods

M.Sc. MATHEMATICS II SEMESTER

M205: GRAPH THEORY

Subject Code :	M205	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives: The main objective of this course is to introduce students with the fundamental concepts in graph Theory, with a sense of some its modern applications and it helps students to solve live problems that can be modelled by graphs.

UNIT-I: Paths and circuits: Isomorphism, Subgraphs , a puzzle with multi colored cubes. walks, Paths and Circuits, connected graphs, Disconnected graphs, Components, Euler graphs , Operations on graphs, More on Euler graphs, Hamiltonian paths and circuits, Travelling – Salesman Problem. (Chapters 2 of reference book).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the basic concepts of Graphs and Euler and Hamiltonian graphs and obtain a solution for Travelling salesman problems.

UNIT-II: Trees and Fundamental Circuits: Trees , some properties of trees , pendant Vertices in a tree, distances and centers in a tree, rooted and binary trees, on Counting trees, spanning trees, fundamental circuits, finding all spanning trees of a graph , spanning trees in a weighted Graphs. (Chapter 3 of reference book).

Learning outcomes: Upon completion of this unit, the student will be able to: Study the properties of trees and able to find a minimal spanning tree for a given weighted graph.

UNIT-III: Cut sets and Cut –vertices: Cut sets, All cut sets in a graph, Fundamental circuits and cut sets, connectivity and separability, network flows, 1-isomorphism, 2- isomorphism's. (Chapter 4 of reference book).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the purpose of introduction of concepts like cut-set, cut-vertex, Connectivity and separability.

UNIT-IV: Planar and dual graphs: Combinatorial Vs Geometric graphs , Planer graphs, Kuratowski's two graphs , Different representations of a planar graph , Detection of planarity, Geometric dual. (Sections 1 to 6 of Chapter 5).
Vector spaces of a graph: Sets with one operation, Sets with two operations, Modular arithmetic and Galois field, Vectors and Vector spaces, Vector space associated with a graph , Basis vectors of graph. (Sections 1 to 6 of Chapter 6).
Learning outcomes: Upon completion of this unit, the student will be able to: Understand the utility planar, dual graphs and vector spaces of a graph.

Course Outcomes: After completing this course, the student will be able to: Understand the basic concepts of graphs , directed graphs, weighted graphs, trees, minimal spanning trees for a given graphs, Eulerian graphs, Hamiltonian graphs and apply the shortest path algorithm to solve some real life problems.

TEXT BOOK:

[1]. " Graph theory with applications to Engineering and Computer Science", NARSINGH DEO, Prentice Hall of India Pvt., New Delhi,1993.

M.Sc. MATHEMATICS III SEMESTER
M301: RINGS AND MODULES

Subject Code :	M301	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives: To develop skills and to acquire knowledge on some advanced concepts of Modern Algebra i.e. different algebraic structures, Modules, Prime ideals, prime radical, Jacobson radical in commutative rings, complete ring of quotients, Prime ideal spaces.

UNIT-I: Rings and related Algebraic systems, Subrings, Homomorphisms, Ideals.
(Sections 1.1, 1.2 of chapter 1).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the concepts of commutative ring theory and special structures like Boolean algebras and Boolean rings. Know the relations between ring, Boolean algebra and lattice.

UNIT-II : Modules, Direct products and Direct sums, Classical Isomorphism Theorems. (Sections 1.3, 1.4 of chapter 1).

Learning outcomes: Upon completion of this unit, the student will be able to study: Classical isomorphism theorems and some properties of direct sum, product of rings and modules.

UNIT-III: Prime ideals in Commutative Rings, Prime ideals in Special Commutative Rings.
(Sections 2.1, 2.2 of Chapter 2).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the concept of Prime ideals, maximal ideals of commutative rings, Prime radical and Jacobson radical.

UNIT-IV: The Complete Ring of Quotients of a Commutative Ring, Ring of quotients of Commutative Semi Prime Rings, prime ideal spaces. (Sections 2.3, 2.4, 2.5 of Chapter 2).

Learning outcomes: Upon completion of this unit, the student will be able to: Study the Wedderburn –Artin theorem and its applications and Prime ideal spaces.

TEXT BOOK: "Lectures on Rings and Modules", J. Lambek, Blaisdell Publications.

Course outcome: The student attains more mathematical sophistication extending the concepts of rings introduced in the introductory course 101.

M.Sc. MATHEMATICS III SEMESTER
MA302: COMPLEX ANALYSIS

Subject Code :	M302	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives :

The objective of this course includes:

To introduce and develop the fundamental concepts of complex analysis such as analytic functions, Cauchy-Riemann relations and harmonic functions etc., To study Cauchy integral formula, general form of Cauchy theorem, the Fundamental theorem of Algebra, Maximum module Principle., To enable students to acquire skills of contour integration to evaluate definite integrals involving sins and cosines via residue calculus.

UNIT-I: Sums and products, basic algebraic properties, further properties, vectors and moduli complex conjugates, exponential form, products and powers in exponential form, arguments of products and quotients – roots of complex numbers- examples-Regions in the complex plane. (Sections 1 to 11 of Text Book) (Questions not to be given in sections 1 to 11).
Functions of complex variable, mappings, mappings by the exponential function, limit, Theorems on limits – limits involving the point at infinity continuity, derivatives, differentiation formulas – Cauchy Riemann equations, sufficient conditions for differentiability, polar co-ordinates. Analytic functions, Harmonic functions, Uniquely determined Analytical functions, Reflection principle. (Sections 12 to 28 of Text book).

Learning outcomes: Upon completion of this unit, the student will be able to: Represent Complex numbers algebraically and geometrically and understand Analytic functions, Cauchy-Riemann equations and verify Complex functions for analycity.

UNIT-II : The exponential function, the logarithmic functions, branches and derivatives of logarithms. Contours, contour integrals, Some examples – Examples with branch cuts-upper bounds for moduli of contour integrals, anti-derivatives, proof of the theorem (45), Cauchy-Goursat theorems, proof of the theorem (47), simply connected domains, multiply connected domains, Cauchy integral formula, An extension of the Cauchy integral formula – Some consequences of The extension. (Sections 29 to 31 & 39 to 52 of Text Book).

Learning outcomes: Upon completion of this unit, the student will be able to: Evaluate Complex integrals by applying Cauchy integral formula.

UNIT-III: Liouvelli's theorem and the fundamental theorem of Algebra, maximum modulus principle convergence of sequences, convergence of series, Taylor series, Laurent series, absolute and uniform convergence of power series, continuity of sums of power series, integration and differentiation of power series, uniqueness of series representations. **(Sections 53 – 66 of text book).**

Learning outcomes: Upon completion of this unit, the student will be able to: Differentiate the Taylor's series and Laurent series.

UNIT-IV: Isolated singular points, Residues, Cauchy residue theorem, residue at infinity – The three types of isolated singular points, Residues at poles, Examples, zeros of analytic functions, zeros and poles, behavior of a function near isolated singular points. Evaluation of improper integrals, Example

– improper integrals from Fourier analysis, Jordan's Lemma, definite integrals involving sinces and cosines, argument principle, Rouches's theorem. (sections 68 to 81 and 85 to 87 of text book).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand Residue theorem, the argument principle and Rouche's theorem, and Compute integrals using residues.

TEXT BOOK: "**Complex Variables and Applications"**, James Ward Brown Ruel V. Churchill, Mc Graw Hill, Eighth Edition, 2009.

REFERENCE BOOKS:

1. **Complex Variables, H. Silvermen.**
2. Complex Variables by H.S.Kasana, Prentice Hall of India.
3. Complex Variables by Murrey Rspiegel, Scheam's Outline series.

Course outcomes: Upon completion of this course, the student will be able to: define and analyze limits and continuity for functions of complex variables, Cauchy-Riemann equations, analytic functions, and entire functions. Evaluate complex contour integrals, the Cauchy integral formula and represent functions as Taylor and Laurent series, classify singularities and poles, find residues and evaluate complex integrals using the residue theorem.

M.Sc. MATHEMATICS III SEMESTER
MA303: FUNCTIONAL ANALYSIS

Subject Code :	M303	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives : To introduce basic concepts of Functional Analysis namely normed spaces, bounded linear functionals, and study their applications and also to introduce fundamental results in Functional Analysis namely Hahn-Banach Theorem, open mapping theorem and closed graph theorem and study their applications.

UNIT-I
Review of Properties of Metric spaces (Chapter-1), Normed spaces Examples, Basic properties – Finite dimensional normed spaces – compactness and finite Dimensions. (2.1 to 2.5 of Chapter 2).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand basic properties of finite dimensional normed spaces.

UNIT-II
Linear Operators, Bounded linear functional finite dimensional case – Duality Banach's finxed point theorem – Applications to linear equations and differential equations
(2.6 to 2.10 of Chapter 2 and 5.1 to 5.3 of Chapter 5).

Learning outcomes: Upon completion of this unit, the student will be able to: Analyse bounded linear functionals of finite dimensional normed spaces and apply them to linear and differential equations.

UNIT –III
Hann Banach theorem – Applications to bounded linear functional of C[a, b] adjoint reflexivity. (Sections: 4.1 to 4.6 of Chapter 4).

Learning outcomes: Upon completion of this unit, the student will be able to: Demonstrate the knowledge of continuous linear transformations and the Hahn-Banach theorem.

UNIT – IV
Uniform boundedness principles – convergence of sequences of operators and functional – open mapping theorem – closed graph theorem (4.7, 4.8, 4.9, 4.12 and 4.13 of Chapter 4).

Learning outcomes: Upon completion of this unit, the student will be able to: Describe uniform boundedness principle, open mapping theorem and closed graph theorem.

TEXT BOOK: "Introductory Functional analysis with Applications", **Erwin Kreyszig, John Wiley & Sons.**

Course outcomes: After completing this course, the student gets introduced to the basics that are required for analysis of continuous linear functions on Banach space. The student also learns the famous Hahn-Banach, Open mapping, Closed Graph theorem and Uniform boundedness principles.

M.Sc. MATHEMATICS III SEMESTER
M304(A): FUZZY SETS AND APPLICATIONS

Subject Code :	M304(A)	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives: The objective of this course is to teach the students the need of fuzzy sets , operations on fuzzy sets, arithmetic operations on fuzzy sets and fuzzy relations.

UNIT-1: From Classical (Crisp) sets to Fuzzy sets: **Introduction, Crisp Sets:** An overview, Fuzzyset: Basic types, Fuzzy sets: Basic Concepts, Characteristics and significance of the paradigm shift. (Chapter -1 of text book)
Fuzzy sets versus Crisp sets: Additional Properties of α-cuts, Representations of Fuzzy sets, Extension principle for Fuzzy sets (Chapters 2 of Text book).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the basic concepts of fuzzy sets, properties of α-cut sets and extension principle of fuzzy sets.

UNIT – II: Operations on Fuzzy sets: Types of Operations, Fuzzy Compliments, Fuzzy Intersections: t-Norms, Fuzzy unions: t-Conorms, Combinations of operations, Agreegation Operations (Chapter-3 of Text book).

Learning outcomes: Upon completion of this unit, the student will be able to: Describe fuzzy compliments, fuzzy intersections and fuzzy unions.

UNIT- III: Fuzzy Arithmetic: Fuzzy Numbers, Linguistic Variables, Arithmetic Operations on Intervals, Arithmetic Operations on Fuzzy numbers, Lattice of fuzzy numbers, Fuzzy equations (Chapter 4 of Text book).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the concept of fuzzy arithmetic.

UNIT-IV: Fuzzy Relations: Crisp versus fuzzy relations, Projections and Cylindric Extensions, Binary Fuzzy Relations, Binary Relations on a Single set, Fuzzy Equivalence Relations, Fuzzy Compatibility Relations, Fuzzy Ordering Relations, Fuzzy Morphisms, Sup – i Compositions of Fuzzy Relations, Inf- ω_i Compositions of fuzzy Relations.(Chapter 5 of Text book).

Learning outcomes: Upon completion of this unit, the student will be able to: Determine the difference between crisp relations, fuzzy relations and understand the concepts of fuzzy compatibility relations, fuzzy ordering relations and fuzzy morphisms.

PRESCRIBED BOOK: "Fuzzy sets and Fuzzy Logic, Theory and Applications",
G.J.Klir & B.YUAN, Prentice - Hall of India Pvt. Ltd., New Delhi., 2001.

Course outcomes: After completing this course, the student shall be able to: Understand the basic concepts of fuzzy sets, fuzzy arithmetic and fuzzy relations. Construct the appropriate fuzzy numbers corresponding to uncertain and imprecise collected data and also determine the concepts of fuzzy compatibility relations, fuzzy ordering relations and fuzzy morphisms.

M.Sc. MATHEMATICS III SEMESTER
M304(B): SEMI GROUPS

Subject Code :	M304(B)	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives: To introduce the Concepts of Semigroups, Homogenic Semigroups, Free Semigroups, Ideals, Regular Semigroups, Simple and Q-Simple Semigroups, and their related theories to develop working knowledge on these concepts.

UNIT – I
Basic Definitions, Monogenic Semigroups, Ordered Sets, Semilattices and Lattices, Binary Relations, Equivalences, Congruences. (Sections 1 to 5 of Chapter- I).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand basic definitions of Semigroups, Semilattices and Lattices, and their basic Results.

UNIT – II
Free Semigroups, Ideals and Rees Congruences, Lattices of Equivalences And Congruences equivalences, The structure of D. Classes – Regular Semigroups.. (Sections 5 to 8 of Ch. I).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand Free Semigroups, Ideals and Green's equivalences, and also find Structure of D.Classes.

UNIT - III
Simple and Q – Simple Semigroups, Principle Factors, Rees's Theorem, Primitive Idempotents. (Sections 1 to 3 of Chapter III).

Learning outcomes: Upon completion of this unit, the student will be able to: Analyze Simple and Q-Simple Semigroups, and Rees's Theorem.

UNIT –IV
Congruences on Completely 0 – Simple semigroups, The Lattice of Congruences on a Completely 0 – Simple Semigroup, Finite Congruence- Free Semigroups. (Sections 4 to 6 of Chapter III).

Learning outcomes: Upon completion of this unit, the student will be able to: Describe Congruences on Completely O-Simple Semigroups and Finite Congruences.

TEXT BOOK: "An Introduction to Semigroup Theory", J.M. Howie, Academic Press.

Course outcomes: The student realizes the richness of properties enjoied by Semigroups, an algebraic structure with fewer facilities than Groups.

M.Sc. MATHEMATICS III SEMESTER
M304(C): NUMBER THEORY

Subject Code :	M304(C)	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives : To develop problem solving skills and to acquire knowledge on basic concepts of Arithmetical Functions, Dirichlet Multiplication, Averages of Arithmetical Functions and Congruences.

UNIT-I

ARITHMETICAL FUNCTIONS AND DIRICHLET MULTIPLICATION: Introduction, The Mobius function $\mu(n)$, The Euler Totient function $\varphi(n)$, A relation connecting φ and μ, A product formula for $\varphi(n)$, The Dirichlet product of arithmetical functions, Dirichlet inverses and Mobius inversion formula, The Mangoldt function $\Lambda(n)$, Multiplicative functions, Multiplicative functions and Dirichlet multiplication, The inverse of a completely multiplicative function, Liouville's function $\lambda(n)$, The divisor function $\sigma_z(n)$. Generalised convolutions.

Learning outcomes: Upon completion of this unit, the student will be able to: Define and interpret the concepts of divisibility, congruence, Dirichlet product, multiplicative functions.

UNIT-II

AVERAGES OF ARITHMETICAL FUNCTIONS:
Introduction, The big oh notation Asymptotic equality of functions, Euler's summation formula, Some elementary asymptotic formulas, The average order of d(n), The average order of divisor functions $\sigma_z(n)$, The average order of $\varphi(n)$, An application to the distribution of lattice points visible from the origin, The average order of $\mu(n)$ and $\Lambda(n)$, The partial sums of a Dirichlet product, Applications to $\mu(n)$ and $\Lambda(n)$, Another identity for the partial sums of a Dirichlet product.

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the concepts of averages of arithmetical functions, prove and apply properties of multiplicative functions such as the Euler's phi function and of residues modulo n.

UNIT-III

SOME ELEMENTARY THEOREMS ON THE DISTRIBUTION OF PRIME NUMBERS:
Introduction, Chebyshev's functions $\psi(x)$and $\mathbf{I}(x)$. Relations connecting $\psi(x)$ and $\mathbf{I}(x)$, Some equivalent forms of the prime number theorem, Inequalities of $\pi(n)$ and p_n, Shapiro's Tauberian theorem, Application of Shapiro's theorem, An asymptotic formulae for the partial sums $\sum(1/p)$.

Learning outcomes: Upon completion of this unit, the student will be able to: Understand Chebyshev's functions $\psi(x)$and I(x) and the Relations connecting I(x) and $\pi(x)$, Some equivalent forms of the prime number theorem, Inequalities of $\pi(n)$ and pn, to study some applications of Shapiro's Tauberian theorem.

UNIT-IV

CONGRUENCES: Definition and basic properties of congruences, Residue classes and complete residue systems, Linear congruences, Reduced residue systems and Euler - Fermat theorem, Polynomial congruences modulo p, Lagrange's theorem, Simultaneous linear congruences, The Chinese remainder theorem, Applications of the Chinese remainder theorem, Polynomial congruences with prime power moduli.

Learning outcomes: Upon completion of this unit, the student will be able to: Solve congruences of various types and use the theory of congruences in applications.

PRESCRIBED BOOK: "**Introduction to Analytic Number Theory",** Tom M.Apostol, Narosa Publishing House, New Delhi.

Course outcomes: After completing this course the student able to: Understand the properties of divisibility and prime numbers, compute the greatest common divisor and least common multiples, operations with congruences and use the Lagrane theorem, Fermat's theorem, Chinese remainder theorem.

M.Sc. MATHEMATICS III SEMESTER

M305 LINEAR PROGRAMMING

Subject Code :	M305	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives : To develop problem solving skills and to acquire knowledge on basic concepts of in linear programming problems, Transportation problems, Assignment problems and Job sequencing.

UNIT – I Mathematical Background : Lines and hyperplanes: Convex sets, Convex sets and hyperplanes, Convex cones. [Sections 2.19 to 2.22 of Chapter 2of [1]].
Theory of the simplex method : Restatement of the problem, Slack and surplus Variables , Reduction of any feasible solution to a basic feasible solution, Some definitions and notations , Improving a basic feasible solution, Unbounded solutions, Optimality conditions, Alternative optima, Extreme points and basic feasible solutions.[Sections 3.1, 3.2, 3.4 to 3.10 of Chapter 3 of [1]].

Learning outcomes: Upon completion of this unit, the student will be able to: Formulate and solve a linear programming problem.

UNIT –II
Detailed development and Computational aspects of the simplex method:The Simplex method, Selection of the vector to enter the basis, degeneracy and breaking ties, Further development of the transportation formulas, The initial basic feasible solution –artificial variables, Tableau format for simplex computations, Use of the tableau format, conversion of a minimization problem to a maximization problem, Review of the simplex method , Illustrative examples. [Sections 4.1 to 4.5, 4.7 to 4.11 of Chapter 4 of [1]].

Learning outcomes: Upon completion of this unit, the student will be able to: Convert standard business problems into linear programming problems and can solve using simplex algorithm.

UNIT –III
Transportation problem: Introduction, properties of the matrix **A**, The Simplex Method and transportation problems, Simplifications resulting from all $y_{ij}^{\alpha\beta} = \pm 1$ or 0, The Transportation Problem Tableau, Bases in the transportation Tableau, The Stepping-Stone algorithm, Determination of an initial basic feasible solution, Alternative procedure for computing $z_{ij} - c_{ij}$; duality. [Sections 9.1 to 9.7 & 9.10, 9.11 of Chapter 9 of [1]].

Learning outcomes: Upon completion of this unit, the student will be able to: Formulate and solve transportation problems.

UNIT –IV
The Assignment problem : Introduction, Description and Mathematical statement of the problem, Solution using the Hungarian method, The relationship between Transportation and Assignment problems, Further treatment of the Assignment problem, The Bottleneck Assignment problem. (6.1 TO 6.6 OF Chapter 6 of [2]).

Learning outcomes: Upon completion of this unit, the student will be able to: Formulate and solve the Assignment problem.

PRESCRIBED BOOKS:

[1] " **Linear programming**", G.Hadley, Addison Wesley Publishing Company.

[2] " **Introduction to Mathematical Programming**", Benjamin Lev and Howard J. Weiss, Edward Arnold Pub, London, 1982.

Course outcomes: After completing this course, the student acquaints him (her) self in the mathematical methods for solving transportation problem and assignment problem.

M.Sc. MATHEMATICS IV SEMESTER
M401:NON COMMUTATIVE RINGS

Subject Code :	M401	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives: To acquire knowledge on advanced algebraic concepts of noncommutative rings i.e., radical theory, prime and primitive rings, completely reducible rings and completely reducible modules, Injective and Projective modules, Tensor products of modules..

UNIT I
Primitive Rings, Radicals, Completely reducible modules. [Sections 3.1, 3.2, 3.3 of Chapter 3].

Learning outcomes: Upon completion of this unit, the student will be able to: Characterize primitive rings and completely reducible modules.

UNIT II
Completely reducible rings, Artinian and Noetherian rings, On lifting idempotents, Local and Semi perfect rings. [Sections 3.4, 3.5, 3.6, 3.7 of Chapter 3].

Learning outcomes: Upon completion of this unit, the student will be able to: Decide whether a given ring or module, or a class of rings or modules, is Noetherian artinian/semisimple, by applying the characterizations discussed in the course.

UNIT III
Projective modules, Injective modules, The complete ring of quotients, Rings of endomorphism's of Injective modules. [Sections 4.1, 4.2, 4.3, 4.4 of Chapter 4].

Learning outcomes: Upon completion of this unit, the student will be able to: Identify local rings, semi-perfect rings, Characterize Injective and Projective modules. Know the relations between different types of modules. endomorphisms of injective modules

UNIT IV
Tensor products of modules, Hom and functors, exact sequences. (5.1, 5.2, 5.3 of Chapter 5).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the concepts of tensor products of modules, Hom and functors, exact sequences.

TEXT BOOK: "Lectures on Rings and Modules", J.Lambek**,** Blaisdell book in Pure and Applied Mathematics.Publications.

Course outcomes: After completing this course, the student will be able to: introduce a much deeper algebraic structure called Non-commutative ring and some salient properties of Radicals, Complete Reducibility, Artinian and Noetherian Rings, Modules and Tensor products.

M.Sc. MATHEMATICS IV SEMESTER
M402: PARTIAL DIFFERENTIAL EQUATIONS

Subject Code :	M402	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives : To introduce first and second order partial differential equations and their classifications and methods of finding solutions of these partial differential equations.

UNIT-I
First Order Partial Differential equations: Curves and Surfaces, Genesis of first order partial differential equations , Classification of Integrals, Linear equations of the first order, Pfaffian Differential equations, Compatible systems, Charpit's method, Jacobi's Method, Integral surfaces through a given curve. (Sections 1.1 to 1.9 of Chapter 1 of [1]).

Learning outcomes: Upon completion of this unit, the student will be able to: Classify first order partial differential equations and their solutions and solve them using different methods.

UNIT-II
Second order Partial differential Equations: Genesis of Second Order Partial Differential Equations. Classification of Second Order Partial differential equations One Dimensional Waves equation, Vibrations of an infinite string, Vibrations of a semi infinite string. Vibrations of a string of Finite Length, Riemann's Method, Vibrations of a string of finite length (Method of separation of variables.)(Sections 2.1 to 2.3.5 of Chapter 2 of [1]).

Learning outcomes: Upon completion of this unit, the student will be able to: Classify second order partial differential equations and solve one dimensional wave equations using different analytic methods.

UNIT-III
Laplace's Equation: Boundary value problems, Maximum and Minimum principles, The Cauchy problem, The Dirichlet problem for the upper Half plane, The Neumann problem for the upper Half plane, The Dirichlet Interior problem for a circle, The Dirichlet Exterior problem for a circle, The Dirichlet problem for a Rectangle Harnacks theorem.
(Sections 2.4.1 to 2.4.10 of Chapter 2 of [1]).

Learning outcomes: Upon completion of this unit, the student will be able to: Solve Laplace equations using various analytical methods demonstrate uniqueness of solutions of certain kinds of these equations.

UNIT-IV
Laplaces Equation – Green's Function. The Dirichlet problem for a Half plane, The Dirichlet problem for a circle, Heat conduction- Infinite Rod case, Heat conduction – Finite Rod case, Duhamel's principle, Wave equation, Heat Conduction Equation.
(Sections 2.4.11 to 2.4.13, 2.5.1 to 2.5.2, 2.6.1 to 2.6.2 of Chapter 2 of [1]).

Learning outcomes: Upon completion of this unit, the student will be able to: Compute solutions of heat equations using certain analytic methods and verify uniqueness of solutions of some types of these equations.

PRESCRIBED BOOK:

[1]. An Elementary course in Partial Differential Equations, T.AMARANATH, Second Edition, Narosa Publishing House, 2003.

Course outcomes: After completing this course, the student will be able to: learns some useful methods of solving first and second order Partial Differential Equations that frequently occur in Engineering and Physics.

M.Sc. MATHEMATICS IV SEMESTER
M403: NEAR RINGS

Subject Code :	M403	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives:

To introduce Near-Rings, a non-linear algebraic system, with its natural examples and with its ideals and modules and homomorphisms, direct products and direct sums, prime ideals, primitive ideals and related theories and to develop working knowledge on these concepts forgetting structures of near-rings.

UNIT-I

The Elementary Theory of Near-Rings: (a) Fundamental definitions and properties: Near-rings, N-groups, Substructures, Homomorphisms and Ideal-like concepts, Annihilators, Generated objects. (b) Constructions: Products, Direct sums & Subdirect products.
(c) Embeddings: Embedding in M(□), Mœ beds.

Learning outcomes: Upon completion of this unit, the student will be able to: Understand elementary and basic concepts of near-rings and its natural examples and homomorphisms and its ideal-like concepts.

UNIT-II

Ideal Theory:(a) Sums: (1) Sums and direct sums (2) Distributive sums. (b) Chain conditions, (c) Decomposition theorems, (d) Prime ideals (1) Products of subsets (2) Prime ideals (3) Semiprime ideals, (e) Nil and nil potent.

Learning outcomes: Upon completion of this unit, the student will be able to: Analyse ideal theory of near-rings and demonstrate the concepts of prime ideal, nil ideal and nilpotent ideal of a near-ring.

UNIT-III

Elements of the structure theory : (a) Types of N-groups, (b) Change of the near-ring
(c) Modularity, (d) Quasi-regularity, (e) Idempotents.

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the structure theory of near-rings and apply it for a given near-ring.

UNIT-IV

Primitive Near-Rings:
(a) General (1) Definitions and elementary results (2) The centralizer (3) Independence and density, (b) 0-Primitive near-rings, (c) 1-Primitive near-rings, (d) 2-Primitive near-rings
(1) 2-Primitive near-rings, (2) 2-primitive near-rings with identity.

Learning outcomes: Upon completion of this unit, the student will be able to: Describe different types of primitive near-rings and their structures.

TEXTBOOK: "**Near-Rings: The Theory and its Applications",** Gunter Pilz, Revised Edition 1983, North-Holland Publishing Company, AMSTERDAM.

Course outcomes: After completing this course, the student shall be able to: Understand the concepts of near-rings, ideal theory of near-rings, nil ideal and nilpotent ideal of a near-ring and describe different types of primitive near=rings and their structures.

M.Sc. MATHEMATICS IV SEMESTER
M404(A): ALGEBRAIC CODING THEORY

Subject Code :	M404(A)	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives: To detect errors in transmission of messages and to introduce the basic concepts of Coding theory such as linear codes, perfect and Related codes, and Cyclic Linear codes.

UNIT –I

Introduction to Coding Theory: Introduction, Basic assumptions, Correcting and Detecting error patterns, Information Rate, The Effects of error Correction and Detection, Finding the most likely codeword transmitted, Some basic algebra, Weight and Distance, Maximum likelihood decoding, Reliability of MLD, Error- detecting Codes, Error – correcting Codes. (Chapter 1).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand the Effects of error correction and Detection and the concept of Maximum-Likelihood Decoding and Reliability of MLD.

UNIT – II

Linear Codes : Linear Codes , Two important subspaces , Independence, Basis, Dimension, Matrices, Bases for C= <S> and $C^{\perp}$, Generating Matrices and Encoding , Parity – Check Matrices, Equivalent Codes, Distance of a Linear Code, Cosets, MLD for Linear Codes, Reliability of IMLD for Linear Codes. (Chapter.2).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand Generating Matrices and Encoding, Parity-Check Matrices, solving problems On linear codes.

UNIT –III

Perfect and Related Codes: Some bounds for Code, Perfect Codes, Hamming Codes , Extended Codes, The extended Golay Code, Decoding the extended Golay Code, The Golay code, Reed – Mullar Codes, Fast decoding for RM (1,m).(Chapter 3).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand and implement codes and source of information.

UNIT –IV

Cyclic Linear Codes : Polynomials and Words , Introduction to Cyclic codes, Polynomials encoding and decoding, Finding Cyclic Codes, Dual Cyclic Codes.(Chapter 4).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand Cyclic codes.

PRESCRIBED BOOK: "CODING THEORY- THE ESSENTIALS" , D.G. Hoffman, D.A. Lanonard , C.C. Lindner, K. T. Phelps,C. A. Rodger, J.R.Wall, Marcel Dekker Inc.
REFERENCE BOOK: "**Introduction to coding Theory",** J.H. Van Lint**,** Springer Verlag.

Course outcomes: After completing this course, the student will be able to: learn some algebraic properties of certain types of codes that at widely used in Engineering.

M.Sc. MATHEMATICS III SEMESTER

M404(B): LATTICE THEORY

Subject Code :	M404(B)	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives : To develop skills and knowledge of standard concepts in Hasse diagrams, complete lattices, distributive lattices, Boolean algebras and Boolean ring.

UNIT –I

Partly Ordered Sets:

Set Theoretical Notations, Relations, Partly Ordered Sets, Diagrams, Special Subsets of a Partly Ordered Set, Length, Lower and Upper Bounds, The Jordan–Dedekind Chain Condition, Dimension Functions.

Learning outcomes: Upon completion of this unit, the student will be able to: Understand partially ordered sets and Jordan Dedekind chain conditions.

UNIT – II

Algebras, Lattices, The Lattice Theoretical Duality Principle, Semi Lattices, Lattices as Partly Ordered Sets, Diagrams of Lattices, Sub Lattices, Ideals, Bound Elements of a Lattice, Atoms and Dual Atoms, Complements, Relative Complements, Semi Complements, Irreducible Prime Elements of a Lattice, The Homomorphism of a Lattice, Axiom Systems of Lattices.

Learning outcomes: Upon completion of this unit, the student will be able to: Analyze the relationship between posets and lattices, acquire knowledge of fundamental notions from lattice theory.

UNIT – III

Complete Lattices, Complete Sub Lattices of a Complete Lattice, Conditionally Complete Lattices, Compact Elements and Compactly Generated Lattices, SubAlgebra Lattice of an Algebra, Closure Operations, Galois Connections, Dedekind Cuts, Partly Ordered Sets as Topological Spaces.

Learning outcomes: Upon completion of this unit, the student will be able to: Define and understand basic properties of complete lattices and conditionally complete lattices, closure operations and their applications.

UNIT – IV

Distributive Lattices, Infinitely Distributive and Completely Distributive Lattices, Modular Lattices, Characterization of Modular and Distributive Lattices by their Sublattices, Distributive Sub lattices of Modular Lattices, The Isomorphism Theorem of Modular Lattices, Covering Conditions, Meet Representation in Modular and Distributive Lattices. Boolean Algebras, De Morgan Formulae, Complete Boolean Algebras, Boolean Algebras and Boolean Rings.

Learning outcomes: Upon completion of this unit, the student will be able to: Characterize modular and distributive lattices using the Birkhoff and Dedekind criterions, Understand Boolean algebras, Boolean rings.

PRESCRIBED BOOK: "Introduction to Lattice Theory", Gabor Szasz, Acadamic press.
REFERENCE BOOK: "Lattice Theory", G. Birkhoff, Amer. Math.Soc**.**

Course outcomes: After completing this course, the student shall be able to: attain some knowledge of basic concepts of structures with order relation, importance's of lattice and the relationship between Boolean algebras and Boolean Rings with unity.

M.Sc. MATHEMATICS IV SEMESTER

M404(C): OPERATOR THEORY

Subject Code :	M404(c)	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives: To develop skills and to acquire knowledge on advanced concepts in Hilbert spaces, Representation of functional on Hilbert spaces, Category theorem, Open mapping theorem, Closed Graph theorem, Banach's theorem and it's applications, Spectral theory etc.

UNIT- I

Hilbert Spaces, Orthogonality, total orthonormal sets, Legendre, Hermite and Laguerres polynomials – Representation of functionals on Hilbert Spaces (Sections 3.1 to 3.9 of Chapter 3).

Learning outcomes: Upon completion of this unit, the student will be able to: Characterize the category of normed spaces using Category theorem and differentiate weak and pointwise convergence of linear operators.

UNIT –II

Spectral theory in finite dimensional normed spaces, Properties of resolvent and Spectrum. (Sections 7.1 to 7.4 of Chapter -7).

Learning outcomes: Upon completion of this unit, the student will be able to: Demonstrate Spectral properties of Bounded Linear Operators.

UNIT –III

Resolvent and spectrum of an element in Banach algebras, Compact linear operations on Normed spaces and their properties. (Sections: 7.6 to 7.7 of Chapter 7 and Sections 8.1 ,8.2 & 8.3 of Chapter -8).

Learning outcomes: Upon completion of this unit, the student will be able to: Understand Banach algebras, Demonstrate spectral properties of compact linear operators.

UNIT –IV

Spectral properties of Compact linear operations on normed spaces, Fredholm type Operators, Fredholm alternative. (Sections: 8.4 to 8.7 of Chapter -8).

Learning outcomes: Upon completion of this unit, the student will be able to: Study Operator equations involving Compact linear operators.

TEXT BOOK: INTRODUCTORY FUNCTIONAL ANALYSIS WITH APPLICATIONS: Erwin Kreyszig, John Wiley & Sons.

Course outcomes: After completing this course, the student gets a meaningful introduction to the study of Bounded linear operators and Spectral theory.

M.Sc MATHEMATICS, FOURTH SEMESTER.
M405(B): OPERATIONS RESEARCH

Subject Code :	M405(B)	I A Marks	30
No. of Lecture / Seminar/ Tutorial for week	06L + 01 S/T	End Exam Marks	70
		Total Marks	100

Course Objectives: To develop problem solving skills of linear programming problems using Two-Phase method, Duality theory, The Revised Simplex method, Game theory and integer Programming.

UNIT –I

Further Discussion of the Simplex Method: The two phase Method for Artificial variables, phase-I, Phase-II, Numerical examples of the two phase method. (Sections 5.1 to 5.4 of Chapter -5 of [1]].

Learning outcome: Upon completion of this unit, the student will be able to: Solve the LPP using the two phase method.

UNIT –II

Duality theory and its Ramifications: Alternative formulations of linear programming problems, Dual linear programming problems, Fundamental properties of dual problems, Other formulations of dual problems, Unbounded solution in the primal, The dual simplex algorithm –an example. Post optimality problems, Changing the price vector, Changing the requirements vector, Adding variables or constraints (Sections 8.1 to 8.7 & 8.10 Chapter 8 and 11.2 TO 11.5 OF Chapter 11 of [1]).

Learning outcome: Upon completion of this unit, the student will be able to: Find the dual of an LPP and solve the Problem.

UNIT –III`

The Revised simplex method: Introduction, Revised simplex method: Standard form I, Computational procedure for standard form I, Revised simplex method: Standard form II, Computational procedure for standard form II, Initial identity matrix for phase –I , Comparison of the simplex method and Revised simplex method. (Sections 7.1 to 7.6 &7.8 of Chapter 7 of [1])).

Learning outcome: Upon completion of this unit, the student will be able to: Solve a linear programming problem using Revised Simplex Method.

UNIT –IV

Game theory: Game theory and Linear programming, Introduction, Reduction of a game to a linear programming problem, Conversion of a linear programming problem to a game problem. (Sections 11.12 to 11.14 of Chapter 11 of [1] and Section 10.3 of Chapter10 of [2]) **Integer programming:** Introduction, Gomory's cut, Balas Implicit Enumeration technique.Goal programming. (Sections 11.2 to 11.14 of Chapter 11 of [1], Sections 7.1, 7.2 and 7.4 of Chapter 7 of [2] and 10.3 of Chapter10 of [2]).

Learning outcome: Upon completion of this unit, the student will be able to: Solve integer programming problems and game theory problems.

PRESCRIBED BOOKS:

[1]. " Linear programming**", G.Hadley, Addison Wesley Publishing Company.**
[2]. " **Introduction to Mathematical Programming**", Benjamin Lev and Howard J. Weiss, Edward Arnold Pub, London, 1982.

Course outcomes: After completing this course, the student shall learn in detail, about the Simplex method, Revised simplex method and the relation between Game theory and linear programming.