Academic Council Approval Date: May 30, 2024

PAPERS FOR VII AND VIII SEMESTERS IN MATHEMATICS UNDER UG(NEP2020) SYLLABUS, NEHU, SHILLONG.

Sl. No.	Course Name	Course Code	Credits
Semester - VII			
1	Research Methodology and Proposal Writing	MTH - 400	4
2	Analysis (Major)	MTH – 401	4
3	Linear Algebra and Algebra (Major)	MTH - 402	4
4	Ordinary Differential Equations (Major)	MTH - 403	4
5	Application of Mathematics in Environmental Studies (Minor)	MTH – 404	4
Semester - VIII			
6	Classical Mechanics (Major)	MTH – 450	4
7	C – Programming (Minor)	MTH – 451	4
8	Research Project (Major)	MTH – 452	12
9	Partial Differential Equations (Major)	MTH – 453	4
10	Topology (Major)	MTH – 454	4
11	Advanced Analysis (Major)	MTH - 455	4

Note: Students securing 75% or more in aggregate till the 6th semester are eligible to opt for Hons with research and are allowed to take MTH-452. All other students must opt for UG Hons with three advanced courses: MTH-453, MTH-454 and MTH-455.

Seventh Semester Credits:4

MTH-400: RESEARCH METHODOLOGY & PROPOSAL WRITING

LEARNING OBJECTIVES

The primary objective of this course is to let students understand the fundamental concepts of research, identify the criteria for good research and learn how to select a research problem effectively. They will know how to conduct a literature review and develop a structured research proposal. Further, they will gain proficiency in LaTeX/MS Word for writing academic and research documents.

UNIT I

Meaning of research, Objectives and types of research, Approaches, and significance of the research, research method versus methodology, research and scientific method, Criteria of good research, research problem, and selecting the research problem and techniques.
(Contact hours – 15)

UNIT II

Meaning of Research design, features of good research design and important concepts, exploratory research design, descriptive research design, experimental design, concepts of dependant and independent variables. (Contact hours – 15)

UNIT III

Well-ordering property of natural numbers, Principle of Mathematical Induction, Pigeonhole principle, recurrence relations, solution of recurrence relation by characteristic method, Inclusion-exclusion principle. (Contact hours – 15)

UNIT IV

Proposition, Algebra of Propositions, Logical connectives, Tautologies, contradiction and contingency, Logical implication, Argument, and Rules of inferences.
Review of literature: Writing a research proposal using Latex, Create Latex files, typesetting a Latex document, using graphics in Latex, and setting up a beamer document for presentation. (Contact hours – 15)

COURSE OUTCOME

Upon successful completion of the course, students will be able to formulate and analyze research problems effectively. They will also be able to use LaTeX and computational software for writing research papers and presentations and also improving their technical documentation skills.

Suggested readings:

1. C. R. Kothari, Research Methodology – Methods and techniques, New Age International publishers (2004).
2. Robert A. Beeler, How to count, An Introduction to Combinatorics and its applications, Springer (2005).
3. Introduction to Real Analysis (4th edition) – R. G. Bartle and D. R. Sherbert, John Wiley & Sons, Inc., New York, (2021).

4. Differential equations, dynamical systems and introduction to chaos - M. Hirsch, S. Smale & R.L. Devaney; Academic Press, Elsevier, (2013).
5. Paul Zimmerman, Computational Mathematics with Sagemath, Creative Commons (2018).
6. R. Nageswara Rao, Core Python Programming, Third edition, Dreamtech press (2021).
7. Donald Bindner and Martin Erickson, A student's guide to the study, practice and tools of Modern Mathematics, CRC Press (2011).
8. Richard Hammack, Book of Proof, Virginia Commonwealth Univ., Third Edition (2018).

Seventh Semester Credits:4

MTH-401: Analysis

LEARNING OBJECTIVES

By the end of this course, students will be able to understand the concepts in metric spaces such as sequences and their convergence, limits and continuity of functions, Riemann integration and integration of vector-valued functions, sequences and series of functions

UNIT I

Review of finite, infinite, countable and uncountable sets, Schröder-Bernstein theorem; the ordered real field, Archimedean property, density of rational numbers, existence of n^{th} root of positive real numbers, exponential and logarithm; metric spaces, open and closed sets, limit points, interior points, compact spaces; Nested interval theorem, Bolzano Weierstrass theorem, Heine-Borel theorem.

(Contact hours – 15)

UNIT II

Connected sets, connected subsets of real numbers, Sequences, Cauchy sequences, complete metric space, completeness property of R, construction of real numbers using Cauchy sequences, limit supremum and limit infimum; series, series of nonnegative terms, the number e, the root and ratio tests; summation by parts, absolute convergence, addition and multiplication of series, rearrangements.

(Contact hours – 15)

UNIT III

Limits of functions, continuous functions, uniform continuity, continuity and compactness, continuity and connectedness, intermediate value theorem; one-dimensional Brower fixed point theorem; discontinuities and their classifications, monotonic functions, infinite limits and limits at infinity; differentiation of real valued functions and mean value theorem, differentiation of vector-valued functions.

(Contact hours – 15)

UNIT-IV

Riemann integration: change of variable, fundamental theorem of calculus, integration of vector-valued functions; review of sequences and series of functions, pointwise and uniform convergence; nowhere differentiable functions; Statement of Stone-Weierstrass' theorem for a real and complex-valued functions on an interval. (Contact hours – 15)

COURSE OUTCOMES

Upon successful completion of the course, students will be able to develop a rigorous understanding of foundational real analysis concepts, understand the fundamental properties of functions, including continuity, differentiability, and integrability, in real and vector-valued settings and also comprehend the idea of series of functions

Suggested readings:

1. Principles of Mathematical Analysis (3rd edition) – W. Rudin, McGraw Hill Kogakusha Ltd., 2017.
2. Elementary Analysis (2nd Edition) - Kenneth A. Ross, Springer (2013).
3. Mathematical Analysis (5th edition) – T. Apostol, Addison-Wesley; Publishing Company, 2001.
4. Introduction to Real Analysis (4th edition) – R. G. Bartle and D. R. Sherbert, John Wiley & Sons, Inc., New York, 2021.
5. Introduction to Topology- Collin Adams and Franzosa, Pearson, Prentice Hall of India (2009).
6. Basic Real Analysis (2nd edition)– H.H. Sohrab, Birkhäuser (2014).

Seventh Semester Credits:4

MTH-402: LINEAR ALGEBRA & ALGEBRA

LEARNING OBJECTIVES

This course is aimed to help students comprehend the structure of vector spaces and their significance in linear algebra; learn to analyse conditions for diagonalizability of matrices and linear transformations.

This course is intended to help students to understand group actions and learn about Rings, Fields, Euclidean domains and unique factorization domains.

UNIT-I

Isomorphism between the algebra of linear transformations and that of matrices; similarity of matrices and linear transformations. Cayley-Hamilton theorem; diagonalizability, necessary and sufficient condition for diagonalizability; projections and their relation with direct sum decomposition of vector spaces; invariant subspaces.

(Contact hours – 15)

UNIT-II

Primary decomposition theorem, cyclic subspaces; companion matrices; triangulability; canonical forms of nilpotent transformations; Jordan canonical forms; inner product spaces; properties of inner products and norms; Cauchy-Schwarz inequality; orthogonality and orthogonal complements, orthonormal basis, Gram-Schmidt process.

(Contact hours – 15)

UNIT III

A brief review of groups, their elementary properties and examples, Group action; Cayley's theorem, group of symmetries, dihedral groups and their elementary properties; orbit decomposition; counting formula; class equation, consequences for p-groups; Sylow's theorems (proofs using group actions), applications of Sylow's theorems.

(Contact hours – 15)

UNIT IV

Direct product of groups; structure theorem for finite abelian groups; invariants of a finite abelian group; basic properties and examples of ring, domain, division ring and field; direct products of rings; characteristic of a domain; field of fractions of an integral domain; ring homomorphisms(always unitary); ideals; factor rings; prime and maximal ideals, principal ideal domain, Euclidean domain; unique factorization domain.

(Contact hours – 15)

COURSE OUTCOMES

After successfully completing the course, students will be able to demonstrate an understanding of the isomorphism between the algebra of linear transformations and matrices; determine conditions for diagonalizability. They will be able to use Sylow's theorems to classify finite groups and determine conjugacy classes and identify the distinction between the various classes of domains.

Suggested readings:

1. Linear Algebra, Stephen A. Friedberg, A.J. Insel and L.E.Spence, Pearson (2014).
2. Linear Algebra (2nd edition) – K. Hoffman and R. Kunze, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
3. Linear Algebra (2nd edition) – Promode Kumar Saikia, Pearson (second edition), 2014.
4. Topics in Algebra (4th edition) – I. N. Herstein, Wiley Eastern Limited, New Delhi, 2003.
5. First Course in Linear Algebra – P. B. Bhattacharya, S. K. Jain and S. R. Nagpal, Wiley Eastern Ltd., New Delhi, 2000.
6. Linear Algebra, A Geometric Approach – S. Kumaresan, Prentice-Hall of India Pvt. Ltd., New Delhi, 2001.
7. Abstract Algebra – D.S. Dummit, R.M. Foote, John Wiley&Sons (2003).

Seventh Semester Credits:4

MTH-403: ORDINARY DIFFERENTIAL EQUATIONS

LEARNING OBJECTIVES

The objectives of this course is to help students understand and solve first-order and higher-order linear differential equations with constant coefficients; utilize the Wronskian to determine linear independence of solutions; understand Lipschitz conditions and the convergence of successive approximations; solve Higher-Order Linear Differential Equations; analyze singular points, critical points and their stability properties in autonomous systems.

UNIT I

Linear equations of first order; linear equations with constant coefficients; the second and nth order homogeneous equation; initial value problems for second and nth order equations; existence theorem; uniqueness theorem; linear dependence and independence of solutions; the Wronskian and linear independence; a formula for the Wronskian; the non-homogeneous equation of second order and nth order. (Contact hours – 15)

UNIT II

Existence and uniqueness of solutions to the first order equation; equations with variable separated; exact equations, the method of successive approximations; Lipschitz condition; convergence of successive approximation (existence theorem); non-local existence of solutions; uniqueness of solutions; existence and uniqueness of solutions to systems and n-th order equations. (Contact hours – 15)

UNIT III

Linear equations with variable coefficients; initial value problems for the homogeneous equations; solutions of homogeneous equations; Wronskian and linear independence; reduction of the order of a homogeneous equation; non-homogeneous equations; homogeneous equations with analytic coefficients; the Legendre equation, justification of the power series method. (Contact hours – 15)

UNIT IV

Linear equations with regular singular points; the Euler equation; second order equations with regular singular points – example and the general case, a convergence proof, the exceptional cases; the Bessel equation; regular singular points at infinity; autonomous systems, the phase plane; critical point; types of critical points; stability; stable critical point; asymptotically stable; stability for linear systems; stability by Liapunov's direct method. (Contact hours – 15)

COURSE OUTCOMES

After successfully completing the course, students will be able to solve Linear Differential Equations and Initial Value Problems; apply Theoretical Concepts of Existence and Uniqueness; solve homogeneous and non-homogeneous equations with variable coefficients;

solve and analyze differential equations with singular points, including Euler and Bessel equations.

Suggested readings:

1. An Introduction to Ordinary Differential Equations – E. A. Coddington, Prentice-Hall of India Private Ltd., New Delhi, 2012.
2. Differential equations with applications and historical notes (2^{nd} edition) – G.F. Simmons, Tata MvGraw-Hill, New Delhi, 2016.
3. Elementary Differential Equations (3^{rd} Edition) – W. T. Martain and E. Relssner, Addison Wesley Publishing Company, inc., 1995.
4. Theory of Ordinary Differential Equations – E. A. Codington and N. Levinson, Tata McGraw hill Publishing co. Ltd. New Delhi, 1999.
5. Differential Equations, Dynamical Systems and an Introduction to Chaos – M.W. Hirsch, S. Smale, and R.L. Devaney, Elsevier (2004).
6. Spherical Harmonics – T. M. Mac Robert, Pergamon Press, 1967.

Seventh Semester Credits:4

MTH-404: APPLICATION OF MATHEMATICS IN ENVIRONMENTAL STUDIES

LEARNING OBJECTIVES

The course is designed to help students to explore applications of matrix methods in population modelling; apply linear programming techniques to real-world problems in ecology and the environment; explore mathematical models in medicine and their applications; apply discrete dynamical system concepts to logistic population models.

UNIT I

System of linear equations, matrix form, elementary row operations, row equivalence, row reduced, row reduced echelon matrices, elementary matrices and their roles in determining invertibility of square matrices, row rank, relation between row equivalence and row space of matrices, matrix population modelling. (Contact hours – 15)

UNIT-II

Linear programming problem – introduction, graphical solution method, some exceptional cases; general linear programming problem, duality, simplex method; problems related to ecology and environment. (Contact hours – 15)

UNIT III

Simple situations requiring mathematical modelling, techniques of mathematical modeling, Classifications, Characteristics and limitations of mathematical models, Some simple illustrations. Mathematical modelling in population dynamics, Mathematical modelling of epidemics through systems of ordinary differential equations of first order Mathematical Models in Medicine. (Contact hours – 15)

UNIT-IV

Discrete dynamical systems, orbit of a point, types of orbit; fixed point: sink, source and neutral fixed points; classification of fixed points of real-valued function of one real variable, dynamics of logistic population model.

(Contact hours – 15)

COURSE OUTCOMES

After successfully completing the course, students will be able to apply matrix techniques to model real-world problems, such as population dynamics; solve practical problems related to environmental and ecological systems; apply mathematical modelling techniques to problems in medicine; investigate the behaviour of logistic population models in dynamic systems.

Suggested readings:

1. Linear Algebra– K. Hoffman and R. Kunze, Prentice Hall of India Pvt. Ltd., New Delhi, (2nd edition) 2000.
2. Introduction to Applied Mathematics for Environmental Science – David F. Parkhurst, Springer (2006).
3. Operations Research (for Group B) – K. Swarup, P. K. Gupt and Man Mohan, Sultan Chand & Sons, New Delhi, 2000.
4. Mathematical Modelling- J. N. Kapur, New Age International, 1988.
5. Differential equations, dynamical systems and introduction to chaos - M. Hirsch, S. Smale & R.L. Devaney; Academic Press, 2013, Elsevier.
6. Linear Algebra and its application - Gilbert Strang, Brooks Cole, 4th edition (2006).
7. Rutherford, A. *Mathematical Modelling Techniques.* Courier Corporation, 2012.
8. Linear Algebra (2nd edition) – Promode Kumar Saikia, Pearson, 2009.

Eight Semester Credits:4

MTH-450: CLASSICAL MECHANICS

LEARNING OBJECTIVES

This course will enable students to comprehend Lagrangian Mechanics and Generalized Coordinates; derive Lagrange's equations from Hamilton's principle and extend it to non-conservative and non-holonomic systems; analyse Rigid Body Motion and Rotational Dynamics; understand Hamiltonian Mechanics and Canonical Transformations.

UNIT I

Generalized coordinates; holonomic & non-holonomic systems; D'Alembert's principle; Lagrange's equations; calculus of variations. (Contact hours – 15)

UNIT II

Hamilton's principle, Lagrange's equations from Hamilton's principle, extension of Hamilton's principle to non-conservative and non-holonomic systems, conservation theorems and symmetry properties. (Contact hours – 15)

UNIT III

Eulerian angles; Euler's theorem on the motion of a rigid body; infinitesimal rotations; rate of change of a vector; coriolis force; Euler's equations of motion; force free motion of a rigid body; heavy symmetrical top with one point fixed. (Contact hours – 15)

UNIT IV

Hamilton's equations of motion, conservation theorems and physical significance of Hamiltonian, Hamilton's equations from variational principle, principle of least action; equations of canonical transformation; integral invariants of Poincare'; Lagrange and Poisson brackets as canonical invariants, equations of motion in Poisson bracket notation; infinitesimal contact transformations; constants of motion and symmetry properties. (Contact hours – 15)

COURSE OUTCOMES

After successfully completing the course, students will be able to utilize generalized coordinates and D'Alembert's principle in formulating equations of motion; derive Conservation Laws from Symmetry Principles; solve problems involving Rigid Body Dynamics; apply the principle of least action and understand its significance in classical mechanics.

Suggested readings:

1. Classical Mechanics (3rd edition) – H. Goldstein, Addison Wesley Publications, Massachusetts, 2002.
2. Classical Mechanics – C. R. Mondal, Prentice-Hall of India, 2001.
3. Classical Mechanics (5th edition)– T. W. B. Kibble, Orient Longman, London, 2004.
4. Mechanics – L. D. Landau and E. M. Lipshitz, Pergamon Press, Oxford, 1976.
5. Lectures on Mechanics – J. E. Marsden, Cambridge University Press, 1992.

Eight Semester Credits:4

MTH-451: C-PROGRAMMING

LEARNING OBJECTIVES

This course is aimed to train students to write computer programming using C language. It will enable them to formulate algebraic problems which are in the form of an array, geometrical problems and also problems related to Number Theory.

UNIT I

Character sets for C; identifiers in C; arithmetic expressions in C; assignment statements in C; built-in functions; input and output statements in C; input and output formating, Indentation, comment statements; data types; operators – relational, logical, arithmetical and assignment operators. statement labels; elementary programs in C. Logical IF statements in C; break, continue and goto statements in C; problems using if and nested if - Roots (including complex roots) of quadratic equations: checking if a point is inside or outside a circle, checking if a Triangle is isosceles, equilateral, scalene, checking if a year is a leap year. (Contact hours – 15)

UNIT II

Loops- while, for, do-while loops in C. arrays- arrays of numbers – vectors and matrices; reading and writing arrays, operations on arrays; strings, standard string functions, operations on strings. Sum of digits and reversing a number, valuation of sum of series, binomial coefficients. Vectors and Matrices – dot product, angle between vectors, norm1, norm2, norm3, and norm infinity of a vector, finding unit vector along a vector. Input, output, addition, multiplication, trace, transpose for matrices. (Contact hours – 15)

UNIT III

Function definition, function prototypes, arguments, call by value, call by reference, automatic variables in C; scope– local and global variables; recursion vs iteration, file- file opening modes, file input/output using fprintf, fscanf. Recursion – evaluating n!, series, evaluating determinant of a matrix, 8 Queens problem. (Contact hours – 15)

UNIT IV

Number Theory applications– checking if a number is prime , factorising a number into prime factors, Sieve method, Euclidean Algorithm for gcd and Extended Euclidean Algorithm. Programming conjectures like Goldbach conjecture, Collatz conjecture. (Contact hours – 15)

COURSE OUTCOMES

By the end of this course, students will be able to understand the fundamental syntax and structure of the C programming language. They will be able to solve mathematical problems using logical constructs such as if, else, and nested conditions. They will be equipped to implement iterative processes using loops and perform operations on arrays, strings, vectors, and matrices, and apply programming skills to problems in number theory.

Textbooks:

1. The C Programming Language – B. W. Kernighan and D. M. Ritchie, Prentice Hall, India, 1995.
2. Programming in ANSI C – Balagurusamy, Tata McGraw-Hill, 2008.
3. Primes and Programming – An Introduction to Number Theory with Programming– P. Goblin, Cambridge University Press, 1993.

Eight Semester Credits:12

MTH-452: RESEARCH PROJECT / DISSERTATION

Eight Semester Credits:4

MTH-453: PARTIAL DIFFERENTIAL EQUATIONS

LEARNING OBJECTIVES

This course is aimed at making students understand the fundamentals of Partial Differential Equations (PDEs), initial and boundary conditions in PDEs; classify PDEs into hyperbolic, parabolic, and elliptic types; study the Heat Equation; study the basic properties of elliptic problems.

UNIT I

Meaning of a Partial Differential Equation (PDE), well-posed problems, initial conditions, boundary conditions, first-order PDE in two independent variables and the Cauchy Problem, semilinear and quasilinear equations, method of characteristics, examples of characteristics method, the existence and uniqueness theorem, non-linear PDE of first order, Charpit's method of solution. (Contact hours – 15)

UNIT II

Second order linear PDE**,** classification, canonical forms of hyperbolic, parabolic and elliptic equations, one-dimensional wave equation, canonical form and general solution, the Cauchy problem and d'Alembert's formula, domain of dependence and region of influence, the Cauchy problem for the non homogeneous wave equation. (Contact hours – 15)

UNIT III

Parabolic differential equations, heat equation, occurrence and importance of heat equation, fundamental solution of the heat equation, separation of variables for the heat equation, uniqueness using energy method for initial boundary value problem, applications of the heat equation. (Contact hours – 15)

UNIT IV

Elliptic equations, basic properties of elliptic problems, Laplace and Poisson equations, the maximum principle, applications of the maximum principle, Green's identities, separation of variables for elliptic problems. (Contact hours – 15)

COURSE OUTCOMES

After successfully completing the course, students will be able to identify different types of PDEs and their physical significance; classify PDEs based on their order and linearity; solve the wave equation using d'Alembert's method and understand its implications; solve Laplace and Poisson equations using the maximum principle.

Suggested readings:

1. An Introduction to Partial Differential Equations- Yehuda Pinchover and Jacob Rubinstein, Cambridge University Press, 2005.
2. Partial Differential Equations (Second Edition)- Phoolan Prasad and Renuka Ravindran, New Age International (P) limited Publishers, 2011.
3. Partial Differential Equations- Lawrence C. Evans, American Mathematical Society, Volume 19 of Graduate studies in mathematics, 2010.
4. Lectures on Partial Differential Equations- Vladimir I. Arnold, Springer-Verlag Berlin Heidelberg.
5. Partial Differential Equations: An Introduction – Walter A. Strauss, John Wiley and Sons, Ltd, 2007.

Eight Semester Credits:4

MTH-454: TOPOLOGY

LEARNING OBJECTIVES

This course is designed to help students understand fundamental concepts of Topology such as the topological spaces, closed sets, limit points, closure, and interior of sets; apply the concepts of product topology and quotient topology; study connectedness and path-connectedness; understand compact spaces, countability and Separation Axioms.

UNIT I

Order relations, dictionary order, well-ordered set, minimal uncountable well ordered set S_Ω; topological spaces; basis and sub basis; order topology; subspace topology; closed sets and limit points, closure and interior of a set, Hausdorff spaces, continuous functions and homeomorphisms, pasting lemma. (Contact hours– 15)

UNIT II

Product topology, quotient topology, connected spaces, path connected spaces, component, path component, locally connected and locally path-connected spaces. (Contact hours – 15)

UNIT III

Compact spaces; limit point compact and sequentially compact spaces; locally compact spaces; one-point compactification; finite product of compact spaces, statement of Tychonoff's theorem and its applications.

(Contact hours – 15)

UNIT IV

First and second countable spaces; Lindelof spaces and separable spaces; regular and normal spaces, Urysohn's lemma, completely regular space, Urysohn's metrization theorem and Tietze's extension theorem and applications.

(Contact hours – 15)

COURSE OUTCOMES

After successfully completing the course, students will be able to know different types of topological spaces and their properties; product topology and quotient topology to construct new topological spaces; classify spaces based on their connectedness and path-connectedness; apply compactness concepts to spaces; work with Separation Axioms and Metrization Theorems.

Suggested readings:

1. Topology, a first course – J. R. Munkres, Prentice-Hall of India Ltd., New Delhi, 2000.
2. General Topology – J. L. Kelley, Springer Verlag, New York, 1990.
3. An introduction to general topology (2^{nd} edition) – K. D. Joshi, Wiley Eastern Ltd., New Delhi, 2002.
4. General Topology – J. Dugundji, Universal Book Stall, New Delhi, 1990.
5. Foundations of General Topology – W. J. Pervin, Academic Press, New York, 1964.
6. General Topology – S. Willard, Addison-Wesley Publishing Company, Massachusetts, 1970.
7. Basic Topology – M.A. Armstrong, Springer International Ed., 2005.

Eight Semester Credits:4

MTH-455: ADVANCED ANALYSIS

This course is aimed at helping students to learn about Measure Theory and Measurable Functions; know Lebesgue Integration and its properties; understand the Riesz-Fischer theorem and its significance; compute directional derivatives and higher-order partial derivatives and their properties, including Schwarz's lemma; understand and apply advanced theorems such as the injective and surjective mapping theorems in Multivariable Calculus

UNIT I

Measure on the real line: Lebesgue outer measure and its properties, Lebesgue measurable sets, σ-algebra, σ-algebra of Lebesgue measurable sets, Borel sets, properties of measurable sets, characterization of measurable sets, an uncountable set of measure zero, a non-measurable set.

(Contact hours – 15)

UNIT-II

Measurable functions and their properties, Borel and Lebesgue measurability: a measurable non-Borel set; Integration of non-negative functions, general Lebesgue integral, Integration of series, properties of Lebesgue integral, rings, σ-rings, measures and outer measure, extension of a measure, measure spaces, property almost everywhere, integration with respect to a measure.

(Contact hours–15)

UNIT-III

Fatou's lemma, Lebesgue's monotone convergence theorem, Lebesgue's dominated convergence theorem. Comparison of Riemann and Lebesgue integral; integration of complex valued functions, L^p spaces, inequalities of Hölder and Minkowski, completion of L^p spaces.
(Contact hours – 15)

UNIT-IV

Injective mapping theorem, surjective mapping theorem, inverse function theorem and implicit function theorem of functions of two and three (for analogy) variables; extremum problems with and without constraints of functions of two and three (for analogy) variables.
(Contact hours – 15)

COURSE OUTCOMES

After successfully completing the course, students will be able to construct measurable spaces and functions; understand the notion of Lebesgue measure and outer measures; use the Riesz-Fischer theorem in function space analysis; use mapping theorems to analyse injective and surjective functions.

Suggested readings:

1. Measure theory and integration - De Barra, Gearoid, Horwood Publishing, 2003.
2. Principles of Mathematical Analysis (3rd edition) – W. Rudin, McGraw Hill Kogakusha Ltd., 2017.
3. Mathematical Analysis (5th edition) – T. Apostol, Addison-Wesley; Publishing Company, 2001.
4. The Elements of Real Analysis (3rd edition) – R. G. Bartle, Wiley International Edition, 1994.
5. Advanced Calculus (4th Edition) – R.C. Buck & E.F. Buck, McGraw Hill Book Company, 1999.
6. Introduction to Topology and Modern Analysis (4th edition) – G. F. Simmons, McGraw Hill Kogakusha Ltd., 2000.
7. Introduction to Real Analysis (4th edition) – R. G. Bartle and D. R. Sherbert, John Wiley & Sons, Inc., New York, 2021

****