PROPOSED CURRICULUM AND CREDIT FRAMEWORK FOR FOUR YEAR UNDERGRADUATE PROGRAMME

Department of Mathematics
Nagaland University

2025

Major Course (Core papers)

Paper Code	Course Code	Title of the paper		Total Credit
FIRST SEMESTER				
C-1	MAT/C1	Calculus		4
C-2	MAT/C2	Classical Algebra		4
SECOND SEMESTER				
C-3	MAT/C3	Ordinary Differential Equations		4
C-4	MAT/C4	Real Analysis		4
THIRD SEMESTER				
C-5	MAT/C5	Group Theory		4
C-6	MAT/C6	Partial Differential Equations		4
FOURTH SEMESTER				
C-7	MAT/C7	Numerical Methods		4
C-8	MAT/C8	Theory of Real Functions		4
FIFTH SEMESTER				
C- 9	MAT/C9	Riemann Integration and Series of Functions		4
C-10	MAT/C10	Ring Theory		4
C-11	MAT/C11	Mechanics		4
SIXTH SEMESTER				
C-12	MAT/C12	Probability and Statistics		4
C-13	MAT/C13	Complex Analysis-I		4
C-14	MAT/C14	Linear Algebra - I		4
C-15	MAT/C15	Elementary Number Theory		4
SEVENTH SEMESTER				
C-16	MAT/C16	Analysis on Metric Spaces		4
C-17	MAT/C17	Complex Analysis - II		4
C-18	MAT/C18	Linear Algebra - II		4
C-19	MAT/C19	Research Methodology		4
EIGHTH SEMESTER				
C-20	MAT/C20	Point Set Topology		4
C-21	MAT/C21	Several Variable Calculus	For Honors with Research MAT/C24: Research Project for 12 credits	4
C-22	MAT/C22	Abstract Algebra		4
C-23	MAT/C23	Measure Theory - I		4

Skill Enhancement Courses

Course Title	Course Code	Semester	Total Credit
Logic and Sets	MAT/SEC1	III	3
Computer Graphics	MAT/SEC2		
Introduction to Numerical Methods	MAT/SEC3		
Graph Theory	MAT/SEC4	IV	3
Operating System: LINUX	MAT/SEC5		
Introduction to Number Theory	MAT/SEC6		

These two courses **may be** offered by Mathematics departments in respective colleges. Students having Major in Mathematics can opt for any SEC paper from the common pool offered by the college. Colleges can select the courses for SEC from the common pool made by the university**.**

Syllabus

MAT/C1: Calculus

UNIT 1

Statements, Statements with quantifiers, Compound statements, Implications, Proofs in Mathematics,Sets, Operations on sets, Families of sets, Power sets, Cartesian product of sets.

UNIT 2

Functions. One-one functions, onto functions and bijections. Composition of functions. Inverse of a function. Image of subsets under functions. Inverse image of subsets under functions.

UNIT 3

Derivatives. Tangent lines and rates of change. The derivative function. Techniques of differentiation. Product rule. Quotient rule. Chain rule. Implicit differentiation. Local Linear Approximation. Differentials. Increase, and decreasing functions. Second derivative and concavity. Maxima and minima.

UNIT 4

Integration. Indefinite Integrals. Integration by substitution. Definition of area as a limit. Sigma Notation. Definite Integrals. The Fundamental Theorem of Calculus. Area between two curves, Volumes by slicing. Disks and washers. Volumes by cylindrical shells. Length of a Plane Curve. Area of a Surface of Revolution.

Recommended Books:

1. Ajit Kumar, S. Kumaresan andBhaba Kumar Sarma, A Foundation Course in Mathematics, Narosa Publishing House, 2018.
2. H. Anton, I. Bivens, S. Davis – Calculus, 10 Edition, Wiley, 2012.
3. Shobha Bagai, Amber Habib and Geetha Venkataraman, *A Bridge to Mathematics*, SAGE, 2017.
4. James Stewart, *Essential Calculus: Early Transcendentals*, Metric Version, Cengage, 2014.
5. George B. Thomas, Jr. and Ross L. Finney, *Calculus and Analytic Geometry*, 9th edition, Pearson Education India, 2010.
6. David Guichard, *Single Variable Calculus*. https://www.whitman.edu/mathematics/calculus/

MAT/C2: Classical Algebra

UNIT 1

Polar representation of complex numbers. nth roots of unity. De Moivre's theorem for rational indices and its applications. Polynomial Equations. Relations between the roots and the coefficients of polynomial equations. Symmetric function of roots, Descartes Rule of sign, Solutions of cubic and biquadratic equations.

UNIT 2

Systems of linear equations. Solutions and elementary operations. Gaussian elimination Homogeneous equations. Matrix algebra: addition, scalar multiplication and transposition. Matrix-vector multiplication. Matrix multiplication. Inverses. Elementary matrices. Linear transformations.

UNIT 3

Determinants. Determinant via cofactors. Determinants and row operations. Determinant and matrix product. Determinant and volume. Determinant and matrix inverse. Cramer's rule. Eigenvalues and eigenvectors, Characteristic polynomial. Diagonalization.

UNIT 4

Vector space structure of R^n. Subspaces of Euclidean space. Spanning sets. Linear independence. Equivalence of invertibility of a matrix to independence of its rows and columns. Basis and dimension. Rank of a matrix. Rank-nullity theorem. Similarity and diagonalization.

Recommended Books:

1. S. Barnard and J.M. Child, Higher Algebra, Macmillan, 1959.
2. W.S. Burnside & A.W. Panton – The Theory of Equations, Dublin University Press.
3. W. Keith Nicholson, Linear Algebra with Applications, Open edition, Lyryx Learning, https://collection.bccampus.ca/textbooks/linear-algebra-with-applications-2023-a-d-vretta-lyryx-inc-446/
4. David C. Lay -Linear Algebra and its Applications, Pearson.

MAT/C3: Ordinary Differential Equations

UNIT 1

Differential equations. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form.

UNIT 2

Differential equations of the first order and first degree - Equation reducible to homogenous form. Bernoulli's equation. Exact differential equations. Differential equation of the first order but not of the first degree. Equations solvable for p,x,y. General and singular solutions. Clairaut's equation. Linear differential equations of higher order with constant coefficients. Complementary function and particular integrals.

UNIT 3

General solutions of homogenous equation of second order, principle of super position for homogenousequation, Wronskian: its properties and applications. Linear homogenous and non - homogenous equations of higher order with constant coefficients.

UNIT 4

Linear equation of second order. Standard form. Complete solution. Complementary function. Particular integral. Reduction to normal form. Transformation by changing the independent variable. Method of variation of parameters. Solution by operators.Simultaneous equations of the form dx/P = dy/Q = dz/R. Solution. Geometrical interpretation. Total differential equations. Solution by inspection.

Recommended Books:

1. G.F. Simmons – Differential Equations with Applications and Historical Notes, CRC Press.
2. S.L. Ross -- Differential Equations, Wiley.
3. B. Barnes, G.R. Fulford -- Mathematical Modeling with Case studies: A Differential Equation Approach using Maple and Matlab, CRC Press/ Chapman and Hall.
4. C.H. Edwards, D.E. Penny, D. Calvis -- Differential Equations and Boundary Value Problems: Computing and Modeling, Pearson.

MAT/C4: Real Analysis

UNIT 1

Review of Algebraic and Order Properties of $\mathbb{R}$,ε - neighbourhood of a point in$\mathbb{R}$. Idea of countable sets and uncountable sets. Bounded above sets, Bounded below sets, Bounded sets. Maximum and minimum of sets. Supremum and Infimum. The Completeness Property of $\mathbb{R}$. The Archimedean Property. Density of Rational (and Irrational) numbers in $\mathbb{R}$.

UNIT 2

Interior points. Interior of sets. Limit points. Derived set. Closure of sets. Isolated points. Illustrations of Bolzano - Weierstrass theorem for sets. Open and closed sets. Compact sets. Heine - Borel theorem.

UNIT 3

Sequences, Bounded sequence, Convergent sequence, Limit of a sequence, Theorems on limits, Monotone Sequences, Monotone Convergence Theorem. Subsequence, Monotone Subsequence Theorem. Bolzano - Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy Convergence Criterion. Incompleteness of rationals. Completeness of reals.

UNIT 4

Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's nth root test, Integral test, Alternating series, Leibniz test, Absolute and Conditional convergence.

Recommended Books:

1. R.G. Bartle and D.R. Sherbert- Introduction to Real Analysis, Wiley
2. A. Kumar and S.Kumaresan- A Basic Course in Real Analysis, CRC Press.
3. W. Rudin - Principles of Mathematical Analysis, McGraw Hill Education.
4. T.M. Apostol -- Mathematical Analysis ,Narosa.

MAT/C5: Group Theory

UNIT 1

Division algorithm, congruence operations, Group. Definition. Examples. Abelian Group. Order of a group. Elementary properties of groups using definition. Integral power of an element of a group.

UNIT 2

Subgroups and examples of subgroups, Cosets, properties of cosets. Normal subgroups. Cyclic group, centralizer, normalizer, centre of a group, product of two subgroups. Properties of cyclic groups, classification of subgroups of cyclic groups.

UNIT 3

Permutations. Symmetric groups and permutation groups. Cyclic notation for permutations, properties of permutations, even and odd permutations, alternating group. Lagrange's theorem and consequences including Fermat's Little theorem. Normal subgroups, factor groups.

UNIT 4

Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms, First, Second and Third isomorphism theorems. Cauchy's theorem for finite abelian groups.

Recommended Books:

1. J.B. Fraleigh-- A First Course in Abstract Algebra, Pearson.
2. M. Artin-- Abstract Algebra, Pearson.
3. I.N. Herstein -- Topics in Algebra, Wiley.
4. J.A. Gallian – Contemporary Abstract Algebra

MAT/C6: Partial Differential Equations

UNIT 1

Partial Differential equations- basic concepts and definitions. First order equations.Lagrange's method ofsolving first order partial differential equations (Lagrange'sequation). Working rule for solving Lagrange's equation – Type 1, 2,3 and 4.

UNIT 2

Classification of first order partial differential equations into linear, semi-linear, quasi-linear and non-linearequations with examples. Cauchy's problem for first order partial differential equations. Charpit's method.Jacobi's method.

UNIT 3

Canonical forms of first-order linear equations. Method of separation of variables for solving first orderpartial differential equations. Wave equation and Laplace equation. Classification of second order linearequations to canonical forms.

UNIT 4

The Cauchy problem of an infinite string, Initial Boundary Value Problem, Semi-Infinite string with a fixedend, semi-infinite string with a free end, equations with non-homogeneous boundary conditions. Non-homogeneous wave equation. Method of separation of variables. Solving the vibrating string problem.Solving the heat conduction problem.

Recommended Books:

1. Advanced Differential Equations—M.D. Raisinghania (S.Chand)
2. Elements of Partial Differential Equation- Ian Sneddon, Dover
3. Partial Differential Equations – K.S. Bhamra (PHI Learning)
4. An elementary course in Partial Differential Equations – T. Amaranath (Narosa Publishing House)

MAT/C7: Numerical Methods

Use of Scientific Calculator is allowed.

UNIT 1

Finite differences. The operatorsΔ, $\nabla$and E. Properties. Central difference operators μ and δ. Gauss's central difference formula.

UNIT 2

Transcendental and Polynomial equations. Bisection method, Newton's method. Secant method. Rate of convergence of these methods.

UNIT 3

System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis.

UNIT 4

Interpolation. Lagrange and Newton's methods. Error bounds. Gregory forward and backward difference interpolation.Numerical Integration: Trapezoidal rule, Simpson's $3/8^{th}$ rule, Boole's Rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson's rule.

Recommended Books:

1. B.Bradie -- A Friendly Introduction to Numerical Analysis, Pearson.
2. M.K. Jain, S.R.K. Iyengar, R.K. Jain -- Numerical Methods for Scientific and Engineering Computation, New age International Publisher.
3. J.B. Scarborough – Numerical Mathematical Analysis, Oxford and IBH Publishers.
4. S.S. Sastry – Introductory Methods of Numerical Analysis, Prentice Hall India.

MAT/C8: Theory of Real Functions

UNIT 1

Limits of functions (approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits and limits at infinity. Continuous functions, sequential criterion for continuity and discontinuity. Algebra of continuous fractions.

UNIT 2

Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non - uniform continuity criteria, uniform continuity theorem.

UNIT 3

Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions. Relative extrema, interior extremum. Rolle's theorem, Mean value theorem, intermediate value property of derivatives.

UNIT 4

Darboux's theorem. Applications of mean value theorem to inequalities and approximation of polynomials, Taylor's theorem to inequalities. Cauchy's mean value theorem. Taylor's theorem with Lagrange's form of remainder.

Recommended Books:

1. R. Bartle, D.R. Sherbert -- Introduction to Real Analysis, Wiley.
2. K.A. Ross -- Elementary Analysis: The Theory of Calculus, Springer.
3. A. Mattuck-- Introduction to Analysis, Prentice Hall.
4. S.R. Ghorpade, B.V. Limaye --A Course in Calculus and Real Analysis, Springer.

MAT/C9: Riemann Integration and Series of Functions

UNIT 1

Riemann integration; inequalities of upper and lower sums; Riemann conditions of integrability. Riemann sum and definition of Riemann integral through Riemann sums; equivalence of two definitions; Riemann integrability of monotone and continuous functions.

UNIT 2

Properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals; Fundamental theorems of Calculus. Integration by parts.

UNIT 3

Pointwise and uniform convergence of sequence of functions. Theorems oncontinuity , derivability and integrability of the limit function of a sequence of functions.

UNIT 4

Series of functions; Theorems on the continuity and derivability of the sum function of a series of a functions; Cauchy criterion for uniform convergence and Weierstrass M - Test.Limit superior and Limit inferior. Power series, radius of convergence, Cauchy Hadamard Theorem. Differentiation and integration of power series ; Abel's Theorem; Weierstrass Approximation Theorem.

Recommended Books:

1. K.A. Ross -- Elementary Analysis: The Theory of Calculus, UTM, Springer.
2. R.G. Bartle, D.R. Sherbert -- Introduction to Real Analysis, Wiley.
3. W. Rudin – Principles of Mathematical Analysis, McGraw Hill Education.
4. A. Kumar, S. Kumaresan – A Basic Course in Real Analysis, CRC Press.

MAT/C10: Ring Theory

UNIT 1

Definition and examples of rings, properties of rings, subrings, zero divisors, integral domains – definition and examples. Fields – definitions and examples. Properties of fields, relationship between fields and integral domains. Characteristic of a ring. Characteristic of a field.

UNIT 2

Ideals – definitions and examples. Ideals generated by a subset of a ring. Factor rings. Operations on ideals. Prime ideal and maximal ideal.

UNIT 3

Ring homomorphisms, properties of ring homomorphisms, Isomorphism theorems I,II and III, field of quotients of an integral domain.

UNIT 4

Euclidean domain, ideals in Euclidean domain, gcd of elements in a commutative ring, , Principal ideal domain,ideals in PID, unique factorization domain, associates in an integral domain, relationships between ED,PID and UFD.

Recommended Books:

1. I.N. Herstein -- Topics in Algebra, Wiley.
2. J.A. Gallian -- Contemporary Abstract Algebra, Cengage Learning.
3. D.S. Dummit& R.M. Foote – Abstract Algebra, Wiley.
4. N.S. Gopalakrishnan – University Algebra, New Age International Publishers.

MAT/C11: Mechanics

UNIT 1

Coplanar forces. Moment of a system of coplanar forces. Equation of line of action of the resultant of a system of coplanar forces. Necessary and sufficient condition for the equilibrium of a system of coplanar forces acting on a rigid body. Astatic equilibrium. Equilibrium of a rigid body under three forces. (m,n) theorem.

UNIT 2

Work. Work done by a system of concurrent forces. Virtual work. Principle of virtual work for a system of coplanar forces acting on a particle. Omission of forces. Stability of equilibrium. Stable, unstable and neutral equilibrium. Work function test for the nature of stability of equilibrium. Energy test for equilibrium.

UNIT 3

Centre of gravity. Definition and general formulation. Centre of gravity of arc, plane area, area bounded by curve, solid of revolution, surface of revolution. Centre of gravity bounded area in polar coordinates. The theorem of Pappus, Friction, Statical, dynamical and limiting friction. Laws of friction. Limiting equilibrium. Coefficient of Friction. Angle of friction. Cone of friction. Equilibrium of a body on a rough inclined plane.

UNIT 4

Fundamental definitions and principles. Motion in a straight line. Simple harmonic motion. Motion under earth's attraction. Uniplanar motion where the accelerations parallel to fixed axes are given. Composition of simple harmonic motion.Tangential and normal accelerations. Constrained motion. Conservation of energy. The simple pendulum. Motion on a rough curve. Motion in a resisting medium. Motion where the mass moving varies.

Recommended Books:

1. M.M. Rahman -- Statics,New Central Book Agency.
2. M.M. Rahman – Rigid Dynamics, New Central Book Agency.
3. I.H. Shames, G.K.M. Rao -- Engineering Mechanics: Statics and Dynamics, Pearson.
4. R.C. Hibbeler, A. Gupta -- Engineering Mechanics: Statics and Dynamics, Pearson.
5. P.N. Chatterji -- Dynamics, Educational Publishers.

MAT/C12: Probability and Statistics

UNIT 1

Basic definitions of probability, probability axioms, real random variables, probability distribution of a random variable, discrete and continuous random variables, functions of a random variable, probability density functions.

UNIT 2

Skewness, moments and kurtosis. Moments of a distribution function, moment generating function, discrete distributions, uniform, binomial, Poisson, negative binomial. Continuous distributions- normal, gamma, Cauchy.

UNIT 3

Mathematical expectation, Expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution.

UNIT 4

Correlation – definition and types. Correlation coefficient. Linear regression for two variables. Line of regression. Regression coefficients. Properties of regression coefficients. Chebyshev's inequality.

Recommended Books:

1. An Introduction to Probability -Theory and Applications- William Feller(Wiley).
2. An introduction to Probability and statistics- Vijay K. Rohatgi, A.K. Md. Ehsanes Saleh (Wiley).
3. A first course in Probability – Sheldon Ross (Pearson)
4. Mathematical Statistics – J.N Kapur, H.C. Saxena (S. Chand)
5. Simplified course in statistics – H.C. Saxena, H.K.Dass. M.D. Raisinghania (S. Chand).

MAT/C13: Complex Analysis- I

UNIT 1

Complex numbers, modulus and argument, rectangular and polar representations, regions on the complex plane, De Moivre's theorem: statement and proof, Euler's formula, exponential and logarithmic functions of complex variables, branch cut, principal branch, trigonometric functions expressed in terms of exponential functions, inverse trigonometric functions, hyperbolic functions.

UNIT 2

Functions of complex variable, continuity, differentiability, analytic functions, Cauchy-Riemann equations, necessary and sufficient conditions for function to be analytic, polar form of Cauchy-Riemann equations, construction of analytic functions: problems.

UNIT 3

Power series, some special tests for convergence of power series, absolute convergence, radius of convergence of power series, sum function of a power series, Cauchy-Hadamard theorem: problems. Differentiability of analytic functions, common examples- complex exponential, trigonometric, logarithmic function.

UNIT 4

Complex integration: elementary definitions, contour integrals and its examples, basic properties of contour integration, ML-inequality, Cauchy- Goursat theorem, Cauchy integral formula, Cauchy's inequality, Liouville's theorem, Morera's theorem and fundamental theorem of algebra.

Recommended Books:

1. Complex Function Theory - Donald Sarason (Hindustan Book Aegncy)
2. Foundations of complex analysis – S. Ponnusamy (Narosa)
3. Introduction to complex Analysis—H.A. Priestley (Oxford University Press)

MAT/C14: Linear Algebra-I

UNIT 1

Vector spaces – definition and examples. Subspaces, algebra of subspaces. Linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces. Theorems and examples.

UNIT 2

Linear transformations –definition and examples. Null space (kernel), range, rank and nullity of a linear transformation. Rank-nullity theorem. Algebra of linear transformations. Vector space L(V, W) of linear transformations from V to W. Dimension of L(V, W). Non-singular linear transformation. Isomorphism – definition and examples. Necessary and sufficient conditions for vector spaces to be isomorphic. Isomorphism theorems.

UNIT 3

Matrix representation of a linear transformation. Examples. Matrix representation of thesum, product and composition of linear transformations. Matrix representation of the inverse of linear transformation. Matrix representation of a linear transformation with respect to different bases.

UNIT 4

Dual space. Dual basis. Dimension of dual space. Linear functional. Annihilator. Dimension of annihilator of a subspace. Double dual. Characteristic vector and root. Characteristic polynomial. Eigen space. Algebraic and geometric multiplicities. Minimal Polynomial. Cayley-Hamilton theorem. Diagonalizability of linear operators.

Recommended Books:

1. K. Hoffman & R. Kunze – Linear Algebra, Pearson.
2. S. Kumaresan -- Linear Algebra: A Geometric Approach, Prentice Hall of India.
3. S. Axler – Linear Algebra Done Right, Springer.
4. S. Friedberg & L. Spence – Linear Algebra, Pearson.

MAT/C15: Elementary Number Theory

UNIT 1

Divisibility. GCD & LCM. Euclidean Algorithm.Linear Diophantine equation. Primes. Co-primes. Prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues.

UNIT 2

Chinese Remainder theorem. Fermat's Little theorem. Wilson's theorem. Number theoretic functions, sum and number of divisors, totally multiplicative functions. Greatest integer function. De Polygnac's Theorem

UNIT 3

Euler's phi-function. Euler's theorem, reduced set of residues, some properties of Euler's phi-function.Definition and properties of the Dirichlet product. The Mobius Inversion formula.

UNIT 4

Order of an integer modulo n, primitive roots for primes, composite numbers having primitive roots, Euler's criterion, the Legendre symbol and its properties.Quadritic Residues. Quadratic reciprocity, quadratic congruences with composite moduli. The Jacobi symbol.

Recommended Books:

1. D.M. Burton -- Elementary Number Theory, McGraw-Hill.
2. N. Robbins -- Beginning Number Theory, Jones & Bartlett Publishers.
3. I. Niven, H.S. Zuckerman, H.L. Montgomery – An Introduction to the Theory of Numbers, Wiley.
4. T. M. Apostol – Introduction to Number Theory, Springer.

MAT/C16: Analysis on Metric Spaces

UNIT 1

Metric spaces: definition and examples. Open and closed balls. Neighbourhoods, interior point, open set, interior of a set. Limit point of a set, closed set, closure of set, Subspaces.

UNIT 2

Sequences in a metric space, Cauchy sequences. Complete Metric Spaces. Convergence in a metric space, dense sets. Limits, limits involving the point at infinity. Continuous functions on metric spaces equivalent characterizations of continuity, Generalization of the definition of continuity by inverse image of open sets and closed sets.

UNIT 3

Uniform continuity, compact metric space: definition and examples. Sequentially compact, limit point compact and their equivalence. Theorems on compact spaces, continuous functions on compact metric spaces, Inverse of continuous functions defined on compact domain. compact sets in Euclidean spaces. Heine- Borel theorem.

UNIT 4

Connected metric space: definition and examples. Theorems on connected spaces. Path connected metric spaces: definition and examples. Relationship between connectedness and path connectedness.

Recommended Books:

1. Principles of Mathematical analysis, W. Rudin, McGraw Hill Education, 2013.
2. Introduction to topology and modern analysis, G.F. Simmons, 2016.
3. Topology of metric spaces – S. Kumaresan, McGraw Hill Education (Narosa),2005
4. Mathematical Analysis, T.M. Apostol, Narosa,2002.
5. T. Tao Analysis II, Hindustan Book Agency.

MAT/C17: Complex Analysis-II

UNIT 1

Conformal representation: transformation, Jacobian of transformation, conformal transformations, some general transformations, bilinear transformation, critical points, fixed points, cross ratio, perseverance of cross ratio, fixed points of bilinear transformation—theorems and problems.

UNIT 2

Singularities: zero of a function, singular point, different types of singularities, limiting point of zeroes and poles, theorems and problems on singularities. Residue Theorem, Taylor's series, Laurent series.

UNIT 3

Calculus of residues: Residue at a pole, residue at infinity, Cauchy's residue theorem, computation of residue at a finite pole, Jordan's lemma, integration round unit circle, evaluation of integrals $\int_{-\infty}^{\infty} f(z)dz$ when f(z) has no poles on the real line, evaluation of integrals $\int_{-\infty}^{\infty} f(z)dz$ when f(z) has poles on real line, Argument Principle.

UNIT 4

Meromorphic and entire functions: definition, Mittag Lefler's expansion theorem, number of poles and zeroes of a meromorphic function, principle of argument, Rouche's theorem, fundamental theorem of algebra: problems, Maximum Modulus Theorem.

Recommended Books:

1. Foundations of complex analysis – S. Ponnuswamy (Narosa)
2. Complex Function Theory – Donald Sarason (Hindustan Book Agency)
3. Introduction to complex Analysis—H.A. Priestley (Oxford University Press)
4. Complex Variables and Applications- S. Ponnusamy, H.Silverman, Birkhauser.

MAT/C18: Linear Algebra – II

UNIT 1

Diagonal matrix, diagonalization of linear operators. Characterizations of diagonalizable operators via multiplicities of eigen values, minimal polynomial and direct decomposition of vector spaces into eigen spaces, diagonalization of square matrices and Eigen Value Decomposition.

UNIT 2

Triangular matrix, triangulization of linear operators, characterization of triangulizable operators, canonical form of nilpotent operator, Jordan canonical form, Jordan basis, existence of Jordan basis, similarity of square matrix to its Jordan form, rational canonical form.

UNIT 3

Inner product spaces, properties of inner products and norms, Cauchy-Schwarz inequality; orthogonality and orthonormality of vectors, orthonormal basis, orthogonal complement, Projection theorem, projection operators and their properties, Gram-Schmidt orthonalization process.

UNIT 4

Adjoint of linear transformation, existence and uniqueness of adjoint operator, properties of adjoint operator. Operators on inner product spaces: Hermitian, unitary, normal and positive operators and their properties, matrix representation of these operators wrt orthonormal bases. Spectral theorems for diagonalizability of operators.

Recommended Books:

1. Linear Algebra (2^{nd} edition) – K. Hoffman and R. Kunze, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
2. Topics in Algebra (4^{th} edition) – I. N. Herstein, Wiley EasternLimited, NewDelhi, 2013.
3. Linear Algebra, A Geometric Approach – S. Kumaresan , Prentice-Hall of India Pvt. Ltd., New Delhi, 2001.
4. First Course in Linear Algebra – P. B. Bhattacharya , S. K. Jain and S. R. Nagpal, Wiley Eastern Ltd., New Delhi, 2000.
5. Finite Dimensional Vector Spaces – P. R. Halmos, Van Nostrand Inc., 1965.

MAT/C19 : RESEARCH METHODOLOGY

Objective: The objective of this course is to introduce students to the fundamentals of research methodology, emphasizing the processes, techniques, and tools required to conduct high-quality research. Students will learn about the various types of research, including qualitative, quantitative, and experimental approaches, and the importance of designing research with clear objectives, hypotheses, and problem statements. The course will cover the practical aspects of research design, data collection, and sampling techniques. Students will also explore the process of data analysis using statistical methods and software, along with ethical considerations and report writing standards, including the use of referencing styles and plagiarism detection tools.

Unit 1: Research Methodology (15 Lectures)

Objectives and motivations in research; Characteristics and limitations of research; Components of research work; Criteria of good research, Research process; Types of Research; Fundamental, Pure or Theoretical Research, Applied Research, Descriptive Research, Evaluation Research, Experimental Research, Survey Research, Qualitative Research, Quantitative Research.

UNIT 2: Research Design Formulation (15 Lectures)

Research Design – definition – essentials and types of research design – errors and types of errors in research design. Research problem: Selecting and analyzing the research problem – problem statement formulation – formulation of hypothesis. Variables in Research – Measurement and scaling, Different scales, Construction of instrument, Validity and Reliability of instrument.

UNIT 3: Research Publication Ethics (15 Lectures)

Publication Ethics: Definition, Introduction and Importance, Conflicts of Interest, Best practices/standards initiatives, and guidelines: COPE, EAME, etc. Plagiarism, Self-Plagiarism, Software for detection of Plagiarism. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice-versa, types, complaints and appeals.

UNIT 4: Code of Ethics in Research (15 Lectures)

Ethical issues in research: Code of Ethics in Research, Violation of publication ethics, authorship and contributorship, Intellectual Property Rights, Ethics related to Participants and Researchers: Copyright; Royality, Patent Law, Citation, Acknowledgment. Predatory publishers and journals.

MAT/C20: Point Set Topology

UNIT 1

Definition and examples of topological spaces; basis and sub basis; definition of open set; dictionary order, order topology; subspace topology; product topology on the cartesian product of finite topological spaces, relation of different topologies.

UNIT 2

Limit point, T1 space, Hausdorff Space, closed set definition, continuous function and its properties, product topology on the cartesian product of infinite topological spaces, metric topology.

UNIT 3

Connected spaces, properties of connected sets, component, path compnent, local connectedness, local path-connectedness.

UNIT 4

Compact spaces; limit point compact and sequentially compact spaces; locally compact spaces; finite product of compact spaces, properties of compact spaces, Countability and separation axioms; Lindelof spaces and separable spaces, Urysohn's lemma; Tietze's extension theorem; statement of Urysohnmetrization theorem.

Recommended Books:

1. Topology, a first course – J. R. Munkres, Prentice- Hall of India Ltd., New Delhi, 2000.
2. General Topology – J. L. Kelley, Springer Verlag, N ew York, 1990.
3. An introduction to general topology (2^{nd} edition) – K. D. Joshi, Wiley Eastern Ltd., New Delhi, 2002.
4. Introduction to Topology & Modern Analysis – G. F. Simmons, Tata McGraw Hill.
5. General Topology – J. Dugundji, Universal Book Stal l, New Delhi, 1990.

MAT/C21: Several Variable Calculus

UNIT 1

Functions from $\mathbb{R}^n$ into $\mathbb{R}^m$, Limits and continuity, Partial derivative, Directional derivative, Continuously differentiable functions, Derivative, Uniqueness of derivative, Chain rule, Sufficient condition for a function to be differentiable, Jacobian matrix of the derivative.

UNIT 2

Critical points – maxima, minima and saddle point, discriminant test to determine the nature of critical points, Hessian matrix and its application to determine the nature of the critical points, Gradient and its relationship with directional derivative, Partial derivatives of higher order, Schwarz's Theorem, Inverse Function Theorem, Implicit Function Theorem.

UNIT 3

Riemann integration on $\mathbb{R}^n$ and its properties, Integration on non-rectangular regions, Multiple integral, Fubini's Theorem, Partitions of unity, Change of variables, Line integral and surface integral. Exercises on evaluation of surface area and volume using double and triple integrals.

UNIT 4

Line integral and surface integral, geometric interpretation, curl and divergence of vector-valued functions, Green's theorem, Stokes' theorem and Gauss' Divergence theorem: statements and proofs. Exercises on Green's theorem, Stokes' theorem and Gauss' Divergence theorem.

Recommended Books:

1. Functions of several variables – Wendell Fleming, Springer-Verlag, New York Inc,, 1977.
2. Calculus on manifolds: A modern approach to classical theorems of advanced calculus – Michael Spivak, CRC Press, 2018.
3. Principles of mathematical analysis – Walter Rudin, McGraw Hill Education, 2013.
4. Analysis -II , Terrence Tao, HBA 5. Advanced calculus – GB Folland, Pearson, 2002.

MAT/C-22: Abstract Algebra

UNIT 1

Permutation groups, permutations as products of cycles, even and odd permutations, normal subgroups, quotient groups; isomorphism theorems, correspondence theorem. Direct product, Group action; Cayley's theorem, group of symmetries, dihedral groups and their elementary properties; orbit decomposition; counting formula; class equation, consequences for p-groups.

UNIT 2

Sylow's theorems (proofs using group actions), Applications of Sylow's theorems, conjugacy classes in S_n and A_n, simplicity of A_n. ; structure theorem for finite abelian groups; invariants of a finite abelian group (Statements only).

UNIT 3

Polynomial Rings, Division algorithm and its consequences, Factorisation of polynomials, Euclidean Domain, Principal Ideal Domain, Unique Factorisation Domain - definition, example and properties.

UNIT 4

Reducible and irreducible polynomials and various methods to check irreducibility of polynomials over **Z** and **Q**, Gauss' theorem for reducibility of f(x) in **Z**[x], Eisenstein's criterion for irreducibility of f(x) in **Z[**x] over **Q**, roots of polynomials, finite fields of order 4, 8, 9 and 27 using irreducible polynomials over $\mathbf{Z}_2$ and $\mathbf{Z}_3$.

Recommended Books:

1. Topics in Algebra (4^{th} edition) – I. N. Herstein, Wiley Eastern Limited, New Delhi, 2003.
2. A First Course in Abstract Algebra (4^{th} edition) – J. B. Fraleigh, Narosa Publishing House, New Delhi, 2002.
3. Abstract Algebra – D.S. Dummit, R.M. Foote, John Wiley&Sons (2003).
4. Basic Abstract Algebra (3^{rd} edition) – P.B. Bhattacharya, S. K. Jain and S. R. Nagpal, Cambridge University Press, 2000.
5. Contemporary Abstract Algebra (4^{th} edition) – J. A. Gallian, Narosa Publishing House, New Delhi, 1999.

MAT/C23: Measure Theory- I

Unit-I:
Outer measure of a subset of IR^n and its properties, computation of outer measure of a set in IR^n, outer measure is non- additive.

Unit-II:
Measureable set and its properties in IR^n, countable property, sigma algebra property, Borel property. Measureable function, characterisation of Measureable functions, contruction of new measureable functions from the given measureable functions on IR^n.

Unit-III
Simple fuctions on IR^n, lebesque integral of simple functions, basic properties of lebesque integration of non-negative simple function, integration of non-negative measureable function in IR^n, properties of lebesque integral on non-ve measureable function on IR^n, lebesque Monotone convergence theorem, Fatou's lemma on IR^n.

Unit-IV:
Integration of absolutely integrable function on IRn, definition of lebesque integral of absolutely integrable function on IRn and its properties, lebesque Dominated Convergence Theorem on IRn, relation between Riemann integral and lebesque integral, Fubini's Theorem.

Textbooks:
1. Analysis-II, Terrence Tao, HBA.
2. Measure Theory and Integration, G De Barra, New Age International Publishers.