Choice Based Credit System (CBCS)

RAYBURN COLLEGE

(Autonomous, Accredited B++ Grade, 2.96 CGPA out of 4 by NAAC 2023)
Affiliated to M.U: No. MU/1-65/98/CDC/136:07.08.2012.
Recognized by UGC under Section 2(f) & 12(B) of 1956 Act: No.8-29/2015(CPP-I/C):23/04/2015.

DEPARTMENT OF MATHEMATICS

UNDERGRADUATE PROGRAMME

(Courses effective from Academic Year 2024-25)

Discipline Specific Core Courses

Semester I

MMC-101: Calculus

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 6 Lectures (per week)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Unit 1: **Derivatives for Curve sketching** **(35 marks, 5 weeks)**

First and second derivative tests for Extreme Values of Functions, Concavity and Curve Sketching, Limits to infinity and infinite limits, Indeterminate Forms and L'Hôpital's Rule, Asymptotes, Higher order derivatives, Leibniz rule.

Unit 2: **Curve tracing in polar Co-ordinates** **(30 marks, 4 weeks)**

Parametric representation of curves, Polar Coordinates, Tracing of curves in Polar Coordinates, Graphing Polar Coordinate Equations, Areas and Lengths in Polar Coordinates, Classification of conics in Polar Coordinates.

Unit 3: **Vector Calculus and its applications** **(35 marks, 5 weeks)**

Vector valued functions and their graphs, Limits and continuity of vector functions, Differentiation and integration of vector functions, Projectile motion, Unit tangent, Normal and binormal vectors, Curvature, Kepler's Second Law (Equal Area Law).

References:

1. Thomas, Jr. George B., Weir, Maurice D., & Hass, Joel (2014). Thomas' Calculus (13^{th}ed.)Pearson Education, Delhi. Indian Reprint 2017.

2. B. C. Das, B. N. Mukherjee. Differential Calculus (55^{th} Edition), U.N.Dhur & Sons Private Ltd., Kolkata (2015).

MMC-102: Algebra

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 6 Lectures (per week),
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Unit 1: Theory of Equations **(35 marks, 5 weeks)**

Polynomial functions, Division algorithm, Synthetic division, Remainder Theorem, Factor Theorem, Polynomial equations, Relation between roots and Co-efficients of a polynomial equation, Symmetric function of the roots of an equation, sum of powers of the roots, Solution of cubic and biquadratic equations, De Moivre's Theorem for integer and fractional indices.

Unit2: Relation, functions and Basic Number Theory **(35 marks, 5 weeks)**

Binary relations, Partial order relation, Equivalence relations, Functions, Inverses and composition, One to one correspondence and Cardinality of a set, Division Algorithm, Divisibility and the Euclidean Algorithm, Prime Numbers, Congruences and applications, Principles of Mathematical induction.

Unit 3: Matrices **(30 marks, 4 weeks)**

Rank of a matrix, Rank and elementary operations, Row reduction and echelon forms, System of linear equations, Solution of the matrix equation AX=B, Solution sets of linear systems, linear independence, Eigenvectors and Eigen values, The Characteristic equation and Cayley- Hamilton Theorem.

References:

1. Goodaire, Edgar G &Parmentor, Michael M (2005); Discrete Mathematics with Graph Theory (3rd Ed.) Pearson Education Pvt. Ltd., Indian Reprint 2015
2. MK Singal, Asha Rani Singal, (2020); Algebra (31st Ed) R Chand &Co, New Delhi.
3. Chandrika Prasad, (1963). Text Book on Algebra and Theory of Equations PothishalaPvt. Ltd.

Additional Readings:

1. Kolman, Bernard, & Hill, David R. (2001). *Introductory Linear Algebra with Applications* (7th ed.). Pearson Education, Delhi. First Indian Reprint 2003.
2. Lay, David C., Lay, Steven R., & McDonald, Judi J. (2016). *Linear Algebra and its Applications* (5th ed.). Pearson Education.
3. Andrilli, Stephen, &Hecker, David (2016). *Elementary Linear Algebr*a (5th ed.). Academic Press, Elsevier India Private Limited.
4. Burton, David M. (2007). *Elementary Number Theory* (7th ed.). Tata Mc-Graw Hill Edition, Indian Reprint.

Semester II

MMC-203: Real Analysis

Total Marks: 100 (Theory: 75, Internal Assessment: 25)

Workload: 6 Lectures (per week),
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Unit 1: Real Number System ℝand its properties (30 Marks, 4 Weeks)

Algebraic and order properties ofℝ, Absolute value of a real number; Bounded above andbounded below sets, Supremum and infimum of a nonempty subset of ℝ, the completeness property of ℝ, Archimedean property, Density of rational numbers in ℝ;Definition and types of intervals, Nested intervals property; Neighbourhood of a point in ℝ,Open and closed sets in ℝ.

Unit 2: Sequences in ℝ (35 Marks, 5 Weeks)

Convergent sequence, Limit of a sequence, Bounded sequence, Limit theorems, Monotonesequences, Monotone convergence theorem, Subsequences, Bolzano-Weierstrass theorem forsequences, Limit superior and limit inferior for bounded sequence, Cauchy sequence, Cauchy'sconvergence criterion.

Unit 3: Infinite Series (35 Marks, 5 Weeks)

Convergence and divergence of infinite series of real numbers, Necessary condition forconvergence, Cauchy criterion for convergence; Tests for convergence of positive term series**:**Integral test, Basic comparison test, Limit comparison test, D'Alembert's ratio test, Cauchy'sn^{th}root test; Alternating series, Leibniz test, Absolute and conditional convergence.

References:

1. Bartle, Robert G., &Sherbert, Donald R. (2015). *Introduction to Real Analysis*(4th ed.). Wiley India Edition. New Delhi.
2. Ross, Kenneth A. (2013). *Elementary Analysis*: *The theory of calculus* (2nd ed.).Undergraduate Texts in Mathematics, Springer.Indian Reprint.
3. Denlinger, Charles G. (2011). *Elements of Real Analysis*.Jones and Bartlett India Pvt.Ltd. Student Edition.Reprinted 2015.

Additional Readings:

1.Bilodeau, Gerald G., Thie, Paul R., &Keough, G. E. (2010). *An Introduction toAnalysis* (2nd ed.). Jones and Bartlett India Pvt. Ltd. Student Edition.Reprinted 2015.

2.Thomson, Brian S., Bruckner, Andrew. M., & Bruckner, Judith B. (2001).*ElementaryReal Analysis.*Prentice Hall.

MMC-204: Differential Equations

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 6 Lectures (per week),
Duration: 14 Weeks (56 Hrs. Theory) **Examination:** 3 Hrs.

Unit 1: Differential Equations and Mathematical Modeling (35 marks, 5 weeks)

Differential equations and mathematical models, Order and degree of a differential equations, Integrals as general and particular solutions, Exact differential equations and integrating factors of first order differential equations, Separable Equations, Homogeneous Equations, Reduction to homogeneous equations, Linear equations and Bernoulli Equation, Clairaut's Equation, Existence and Uniqueness of solution of initial and boundary value problems of first order ODE, singular solution of first order ODE.

Unit 2: Second and higher order differential Equations (35 marks, 5 weeks)

General solution of homogeneous equation of second order, Principle of superposition for a homogeneous equation, Wronskian, its properties and applications, Linear homogeneous and non- homogeneous equations of higher order with constant coefficients, Euler's equation, Method of undetermined coefficients, Method of variation of parameters, Applications of second order differential equations to mechanical vibration.

Unit 3: Analysis of Mathematical Models (30 marks, 4 weeks)

Application of first order differential equations to acceleration-velocity model, Growth and Decay model. Introduction to compartmental models, Lake pollution model (with case study of Lake Burley Griffin), Drug Assimilation models, population models (with limited growth, exponential growth) Epidemic models.

References:

1. Barnes, Belinda &Fulford, Glenn R. (2015). *Mathematical Modelling with Case Studies, Using* Maple *and* MATLAB (3rd ed.). CRC Press, Taylor & Francis Group.
2. Edwards, C. Henry, Penney, David E., &Calvis, David T. (2015). *Differential Equation and Boundary Value Problems*: *Computing and Modeling*(5th ed.). Pearson Education.
3. Ross, Shepley L. (2004). *Differential Equations* (3rd ed.). John Wiley & Sons. India.

Semester III

MMC-305: Theory of Real Functions

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 6 Lectures (per week),
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Unit 1: Limits of Functions (20 Marks, 3 Weeks)

Limits of functions (□□□□□approach), Sequential criterion for limits, Divergence criteria, Limit theorems, One-sided limits, Infinite limits and limits at infinity.

Unit 2: Continuous Functions and their Properties (35 Marks, 5 Weeks)

Continuous functions, Sequential criterion for continuity and discontinuity, Algebra of continuous functions, Properties of continuous functions on closed and bounded intervals; Uniform continuity, Nonuniform continuity criteria, Uniform continuity theorem.

Unit 3: Derivability and its Applications (45 Marks, 6 Weeks)

Differentiability of a function, Algebra of differentiable functions, Carathéodory's theorem andchain rule; Relative extrema, Interior extremum theorem, Rolle's theorem, Mean- valuetheorem and its applications, Intermediate value property of derivatives - Darboux'stheorem,Taylor polynomial, Taylor's theorem with Lagrange form of remainder, Application ofTaylor's theorem in error estimation; Relative extrema, and to establish a criterion for convexity;Taylor's series expansions of , sin *x* and cos*x*

Reference:

1. Bartle, Robert G., &Sherbert, Donald R. (2015). *Introduction to Real Analysis* (4th ed.).Wiley India Edition. New Delhi.

Additional Readings:

1. Ghorpade, Sudhir R. &Limaye, B. V. (2006). *A Course in Calculus and Real Analysis*.Undergraduate Texts in Mathematics, Springer (SIE).First Indian reprint.
2. Mattuck, Arthur. (1999). *Introduction to Analysis*, Prentice Hall.
3. Ross, Kenneth A. (2013). *Elementary Analysis*: *The theory of calculus* (2nd ed.).Undergraduate Texts in Mathematics, Springer.Indian Reprint.

MMC-306: Group Theory

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 6 Lectures (per week),
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Unit 1: **Groups and elementary properties** **(35 Marks, 5 Weeks)**

Symmetries of a Square, Dihedral groups, Definition and examples of groups including permutation groups and quaternion groups, cycle notation of permutations, properties of permutations, Elementary properties of groups,Permutations, Even and odd permutations.

Unit 2: **Subgroups** **(35 Marks, 5 Weeks)**

Subgroups and examples of subgroups, Centralizer, Normalizer, Center of a group, Cosets of a Group, Lagrange's theorem and consequences including Fermat's Little theorem, cyclic groups, Classification of subgroups of cyclic groups, Normal subgroups, Quotient Groups,alternatinggroups.

Unit 3: **Group Homomorphisms** **(30 Marks, 4 Weeks)**

Group homomorphisms, Properties of homomorphisms, Group isomorphisms, Properties of isomorphisms, First, Second and Third isomorphism theorems for groups, Cayley's theorem **Reference**

1. Gallian, Joseph. A. (2013). Contemporary Abstract Algebra (8th ed.). Cengage Learning IndiaPrivate Limited, Delhi. Fourth impression, 2015.
2. I.N. Herstein,(2006).Topics in Algebra (2ndEdn).Wiley India Pvt. Ltd.

Additional Reading:

1. V.K.Khanna, SK Bhambri (2017). A course in Abstract Algebra (5thEdn).Vikas Pub. House Pvt Ltd.

2. Rotman, Joseph J. (1995). *An Introduction to The Theory of Groups* (4th ed.). Springer Verlag, NY.

MMC-307: Multivariate Calculus

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 6 Lectures (per week),
Duration: 14 Weeks (70 Hrs. Theory) **Examination:** 3 Hrs.

Course Objectives: To understand the extension of the studies of single variable differential and integral calculus to functions of two or more independent variables. Also, the emphasis will be on the use of Computer Algebra Systems by which these concepts may be analyzed and visualized to have a better understanding.

Course Learning Outcomes: This course will enable the students to learn:
i) The conceptual variations when advancing in calculus from one variable to multivariable discussions. ii) Inter-relationship amongst the line integral, double and triple integral formulations.
iii) Applications of multi variable calculus tools in physics, economics, optimization, and understanding the architecture of curves and surfaces in plane and space etc.

Unit 1: Calculus of Functions of Several Variables and Properties of Vector Field- (40 Marks, 6 weeks)

Functions of several variables, Level curves and surfaces, Limits and continuity, Partial differentiation, Higher order partial derivative, Tangent planes, Total differential and differentiability, Chain rule, Directional derivatives, The gradient, Maximal and normal property of the gradient, Tangent planes and normal lines, Extrema of functions of two variables, Method of Lagrange multipliers, Constrained optimization problems; Definition of vector field, Divergence and curl.

Unit 2: Double and Triple Integrals – (30 Marks, 4 Weeks)

Double integration over rectangular and nonrectangular regions, Double integrals in polar co-ordinates, Triple integral over a parallelepiped and solid regions, Volume by triple integrals, triple integration in cylindrical and spherical coordinates,Jacobians (Without Proof), Change of variables in double and triple integrals.

Unit 3: Green's, Stokes' and Gauss Divergence Theorem – (30 Marks, 4 Weeks)

Line integrals, Applications of line integrals**:** Mass and Work, Fundamental theorem for line integrals, Conservative vector fields, Green's theorem, Area as a line integral; Surface integrals, Stokes' theorem, The Gauss divergence theorem.

References:

1. Strauss, Monty J., Bradley, Gerald L., & Smith, Karl J. (2007). *Calculus* (3rd ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Indian Reprint 2011.

2. Marsden, J. E., Tromba, A., & Weinstein, A. (2004). *Basic Multivariable Calculus*.Springer (SIE).First Indian Reprint.

Semester IV

MMC-408: Partial Differential Equations

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 6 Lectures (per week),
Duration: 14 Weeks (56 Hrs. Theory) **Examination:** 3 Hrs.

Unit 1. First order PDE and Methods of Characteristics (30 Marks, 4 Weeks)

Definitions & Basic concepts, Formation of PDE, classification and geometrical interpretation of first order partial differential equations (PDE), Method of characteristics and general solution of first order PDE, Lagrange and Charpit method, Cauchy's problems for first order PDE, Canonical form of first order PDE, Method of separation of variables for first order PDE

Unit 2.Classification of second order Linear PDE an Wave equations (35 Marks, 5 Weeks)

Classification of second order PDE, Reduction to canonical forms, Equations with constant coefficients, General solutions, Cauchy's Problem for second order PDE, Mathematical Modeling of vibrating string, vibrating membrane, Homogeneous wave equation, Initial boundary value problems, Non-homogenous boundary conditions, Finite string with fixed ends, Non- homogeneous wave equation.

Unit 3. Methods of separation of Variables (35 Marks, 5 Weeks)

Methods of separation of Variables for second order PDE, vibrating string problems, Existence and uniqueness of solution of vibrating string problems, Heat conduction problem, Existence and uniqueness of solution of Heat conduction problems, General solution of higher order PDE with constant coefficient, Non-homogeneous Problems.

References:

1. Myint-U, Tyn and Debnath, Lokenath. (2007). Linear Partial Differential Equation for Scientists and Engineers (4^{th}ed). Springer, Third Indian Reprint.

Additional Readings:

1. Sneddon, I. N. (2006). *Elements of Partial Differential Equations*, Dover Publications.Indian Reprint.
2. Stavroulakis, Ioannis P &Tersian, Stepan A. (2004). *Partial Differential Equations*: *An Introduction with Mathematica and MAPLE* (2nd ed.). World Scientific.

MMC-409: Riemann Integration

Total Marks: 100 (Theory: 70 and Internal Assessment: 30)
Workload: 6 Lectures (per week),
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Unit 1: Riemann Integration (35 Marks, 5 Weeks)

Definition of Riemann integration,(Algebraic and order properties of Riemann Integrals) Boundedness theorem, Riemann integrability, Cauchy's criterion, Squeeze Theorem, Riemann integrability of step, continuous, and monotone functions, Additivity theorem, Fundamental theorems (First and Second forms), substitution theorem, Lebesgue's integrability criteria, composition theorem, product theorem,
Integration by parts, Darboux sums, Darboux integrals, Darboux integrability criteria, equivalence of Riemann integral and Darboux integral.

Unit 2: Sequence and Series of Functions (35 Marks, 5 Weeks)

Pointwise and uniform convergence of sequence of functions, Theorem on the continuity of the limit function of a sequence of functions, Theorems on the interchange of the limit and derivative, and the interchange of the limit and integrability of a sequence of functions. Pointwise and uniform convergence of series of functions, Theorems on the continuity, Derivability and integrability of the sum function of a series of functions, Cauchy criterion and the Weierstrass M-Test for uniform convergence.

Unit 3: Improper Integral and Power Series (30 Marks, 4 weeks)

Improper integrals of Type-I, Type-II and mixed type, Convergence of Beta and Gamma functions, and their properties.
Definition of a power series, Radius of convergence, Absolute convergence (Cauchy-Hadamard theorem), Uniform convergence, Differentiation and integration of power series, Abel's Theorem.

References:

1. Bartle, Robert G., & Sherbert, Donald R. (2015). *Introduction to Real Analysis* (4th ed.). Wiley India Edition. Delhi.
2. Denlinger, Charles G. (2011). *Elements of Real Analysis*. Jones and Bartlett (Student Edition).First Indian Edition. Reprinted 2015.
3. Ghorpade, Sudhir R. &Limaye, B. V. (2006). *A Course in Calculus and Real Analysis*. Undergraduate Texts in Mathematics, Springer (SIE).First Indian reprint.
4. Ross, Kenneth A. (2013). *Elementary Analysis*: *The Theory of Calculus* (2nd ed.). Undergraduate Texts in Mathematics, Springer.

MMC-410 : Numerical Analysis

Total Marks: 100 (Theory: 75 + Internal Assessment: 25)
Workload: 6 Lectures (per week),
Duration: 14 Weeks (70 hrs) **Examination:** 3 Hrs.

Unit 1: Methods for solving Algebraic and Transcendental Equations (30 Marks, 4 weeks)

Rate of Convergence, Methods of iteration, Bisection method, Newton-Raphson method, Fixed point iteration method, Solution of systems of linear algebraic equations using Gauss elimination and GaussSeidel method.

Unit 2: Interpolation (35 Marks, 5 weeks)

Finite difference, relation between the operators, ordinary and divided differences, Newton's forward and Backward interpolation formulae, Newton's divided difference formulae and their properties, Lagrange, Hermite and Spline interpolation, Least square polynomial approximation.

Unit 3: Numerical Differentiation and Integration (35 Marks, 5 weeks)

First order and higher order approximation for first derivative, Approximation for second derivative.

Numerical integration by Newton-Cotes formula, Trapezoidal rule, Simpson's rule and its error analysis. Methods to solve ODE's, Picard's method, Euler's and Euler's modified method and Runge-Kutta methods of 2^{nd} and 4^{th} order.

Solution of boundary value problems of ordinary differential equations using Finite Difference method.

References:

1. Bradie, Brian. (2006). *A Friendly Introduction to Numerical Analysis*. Pearson Education, India. Dorling Kindersley (India) Pvt. Ltd. Third impression 2011.

Additional Readings:

1. Jain, M. K., Iyengar, S. R. K., & Jain, R. K. (2012). *Numerical Methods for Scientific and Engineering Computation*. (6th ed.). New Age International Publisher, India, 2016.

2. Gerald, C. F., & Wheatley, P. O. (2008). *Applied Numerical Analysis* (7th ed.). Pearson Education. India.

Semester-V

MMC-511: Metric Spaces

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures (per week), 1 Tutorial (per week)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs,

Unit 1: **Basic Concepts** **(30 marks, 4 weeks)**

Metric spaces: Definition and examples, Open and closed ball, Neighbourhood, Open set, Interior, exterior, frontier and boundary points of a set, limit point of a set, derived set, closed set, closure of a set, diameter of a set, Dense set, Subspace of a metric space.

Unit 2: **Complete Metric Spaces and Continuous Functions** **(35 marks, 5 weeks)**

Sequences in metric spaces, Cauchy and convergent sequences, Completeness of a metric space, Continuous mappings, Criteria for Continuity, Uniform Continuity, Homeomorphism, Lipschitz Conditions, Contraction mapping, Banach fixed point theorem.

Unit 3: **Connectedness and Compactness** **(35 marks, 5 weeks)**

Connectedness, Components, Connected subsets of R, Connectedness and continuity, Compactness,

Compactness and Continuity, Sequential compactness, Compactness and finite intersection property, Bolzano-Weierstrass property, Heine-Borel theorem, Totally bounded sets, Compact Subsets of Function Spaces.

References:

1. E. T. Copson (1988). *Metric Spaces*. Cambridge University Press.
2. S. Kumaresan (2014). *Topology of Metric Spaces* (2nd ed.). Narosa Publishing House. New Delhi. 3. G.F. Simmons (2004). *Introduction to Topology and Modern Analysis*. Tata McGraw Hill. New Delhi.
4. Satish Shirali & Harikishan L. Vasudeva (2006). *Metric Spaces*. Springer-Verlag.
5. Micheál O'Searcoid (2009). *Metric Spaces*. Springer-Verlag.

Additional reading

1. P. K. Jain & Khalil Ahmad (2019). *Metric Spaces*. Narosa Publishing House. New Delhi.

MMC-512 : Mechanics

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures (per week), 1 Tutorial (per week)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs,

Unit 1: Dynamics **(35 marks, 5 weeks)**

Components of velocities and accelerations along, radial and transverse, along tangential and normal, Simple Harmonic motions, Dynamics of a particle, Motion on smooth and rough plane curves, Motion in resisting medium including projectile, Motion of varying mass, Central orbits and Kepler's Law, Acceleration in different Coordinate system

Unit 2: Statics **(35 marks, 5 weeks)**

Equilibrium condition of coplanner forces, Equilibrium of strings, common catenary, catenary of uniform strength, Force in 3-dimension, Poinsots Central axis, Wrenches Null lines and planes, stable and unstable equilibrium

Unit 3: Dynamics of Rigid Bodies **(30marks, 4 weeks)**

Moments and products of inertia, Momental Ellipsoid, Equimomental systems, Principal Axis, D'Alembert's Principle, Equations of motion of rigid bodies, Motion of centre of inertia, Motion relative to centre of inertia, Motion about a fixed axis, Compound Pendulum, Motion in 2 dimension under finite and impulsive forces, Conservation of momentum and Energy. Euler's dynamical equations for the motion of a rigid body about an axis, Theory of small oscillations.

References:

1 S.L. Loney (1988): *An elementary treatise on dynamics of particle and of rigid bodies*. Cambridge University Press 1956, reprinted by S.Chand & Company (P) Ltd.
2 Das & Mukherjee (2010): *Dynamics* published by S. Chand & company (p) Ltd.ISBN-81-85624-96-8.
3 Das & Mukherjee (2010): *Statics* published by S.Chand & company (p) Ltd., ISBN-81-85624-18-6.

4 S.L. Loney (2004): *An Elementary treatise on Statics* published by A.I.T.B.S., New Delhi, 2004 ISBN-81-7473-123-7.
5 A.S. Ramsey (2009): *Statics*, Cambridge University Press

Additional reading

1 M. Ray and G.C. Sharma (2008): *A Textbook of dynamics* published by S. Chand & company (p) Ltd., (Chapter 1,2,6,8,9,11,12), ISBN-81-219-0342-4.
2 R.S. Verma: *A Text Book on Statics*, Pothishala Pvt Ltd., Allahabad. 3 A.S. Ramsey (2009): *Dynamics* , Cambridge University Press
4 P. L. Srivatava (1964). *Elementary Dynamics*. Ram Narin Lal, Beni Prasad Publishers Allahabad.
5 J. L. Synge & B. A. Griffith (1949). *Principles of Mechanics*. McGraw-Hill

Semester VI

MMC-613: Complex Analysis

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures (per week), 1 Tutorials (per week) **Duration:**
14 Weeks (70 Hrs. Theory) **Examination:** 3 Hrs.

Unit 1: Analytic Functions and Cauchy-Riemann Equations (35 marks, 5 weeks)
Functions of complex variables, Limits, Theorems on limits, Limits involving the point at infinity, Continuity, Derivatives, Differentiability, Cauchy-Riemann equations, Sufficient conditions for differentiability; Polar forms of Cauchy-Riemann equations, Analytic functions, Trigonometric function, Multivalued Functions and its branches, Logarithmic functions, Complex exponents.

Unit 2: Complex Integrals (30 marks, 4 weeks)
Definite integrals of complex functions over a real interval, Contours, Contour integrals, Antiderivatives, Proof of antiderivative theorem, Cauchy-Goursat theorem, Cauchy integral formula; An extension of Cauchy integral formula, Extension of Cauchy integral formula, Cauchy's inequality, Liouville's theorem and the fundamental theorem of algebra.

Unit 3: Series and Residues (35 marks, 5 weeks)
Convergence of sequences and series, Taylor series and its examples; Laurent series and its examples, Absolute and uniform convergence of power series, Uniqueness of series representations, Singular points, Isolated singular points, Residues, Cauchy's residue theorem, residue at infinity; Types of isolated singular points, Residues at poles and its examples.

References:

1. H.S. Kasana. (2015). *Complex Variables, Theory and Applications*, (2nd ed.). Printice Hall of India Learning Private Limited.
2. Brown, James Ward, & Churchill, Ruel V. (2014). *Complex Variables and Applications* (9th ed.). McGraw-Hill Education. New York

Additional Readings:

1. Bak, Joseph & Newman, Donald J. (2010). *Complex analysis* (3rd ed.). Undergraduate Texts in Mathematics, Springer. New York.

2. Zills, Dennis G., & Shanahan, Patrick D. (2003). *A First Course in Complex Analysis with Applications*. Jones & Bartlett Publishers, Inc.
3. Mathews, John H., & Howell, Rusell W. (2012). *Complex Analysis for Mathematics and Engineering* (6th ed.). Jones & Bartlett Learning. Narosa, Delhi. Indian Edition.

MMC-614: Ring Theory & Linear Algebra

Total Marks: 100 (Theory: 75 and Internal Assessment: 25)
Workload: 5 Lectures (per week), 1 Tutorial (per week) **Duration:**
14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Unit 1: Rings : (35 marks,5 weeks)

Definition and examples of rings, properties of rings, Subrings, Integral Domains & Fields, Characteristics of a ring, Ideals, Ideal generated by a subset of ring, Factor rings, Operations on ideals, Prime Ideal, Principal Ideal and Maximal Ideals, Homomorphism and Isomorphism of Rings, Kernal of a homomorphism; First, Second and Third Isomorphism Theorems, Field of quotients, Polynomial ring over commutative ring, Division algorithm and consequences, Principal ideal domains, Reducibility and Irreducibility tests, Einstein's Irreducibility criterions, Unique factorisation in Z[x], Irreducibles, primes, Unique Factorization Domain(UFD), Euclidean domain,

Unit 2 : Vector Spaces : **(25 marks, 3 weeks)**

Concept of vector space over a Field K, Subspaces, Necessary and sufficient condition for being a Subspace, Algebra of subspaces, Coset of subspace, Quotient Space, Linear combination of vectors, Linear Span, Subspace generated by a subset, Linear dependence & Linear independence, Basis and Dimension with related theorems, Finite Dimensional Vector Space, Dimension of Subspaces, Lagrange Interpolation formula.

Unit 3: Linear Transformations & Inner Product Space: **(40 marks, 6 weeks)**

Linear Transformation, Null space, Ranges, Rank and Nullity of a Linear Transformation Kernal of Linear Transformation, Representation of Linear Transformation as matrices, Algebra of Linear Transformation, Isomorphism and Isomorphism theorem, Dual Space, Double dual, Dual basis, Transpose of a linear transformation and its matrix in the dual basis, Annihilator of a Subspace, Eigenvalues, Eigenvectors, Eigenspaces and Characteristic polynomial of a linear operator, Caley Hamilton theorem, The minimal polynomial for a linear operator.

Inner product spaces and Norms, Orthonormal basis , Gram-Schmidt Orthogonalization process Orthogonal Complements, Bessel's Inequality for Finite Dimensional Vector Spaces, S

References:

1. **Gallian, Joseph. A.** (2013). Contemporary Abstract Algebra (8^{th} ed.). Cengage Learning India Private Limited. Delhi
2. **Friedberg, Stephen H, Insel, Arnold J, & Spence Lawrence E.** (2003). *Linear Algebra* (4^{th} ed.) Prentice-Hall of India Pvt. Ltd. New Delhi.

Additional Readings:

1. **Herstein I.N.** (2006). *Topics in Algebra* (2^{nd} ed.). Wiley Student Edition. India
2. **Hoffman, Kenneth, Kunze, Ray Alden** (1978). *Linear Algebra* (2^{nd} ed.). Prentice-Hall of India Pvt. Ltd. New Delhi. Pearson Education India Reprint, 2015
3. **V.K.Khanna** & **S.K.Bhambri**: *A Course in Abstract Algebra*, Vikash Publishing House Pvt Ltd, New Delhi

Skill Enhancement Paper

Semester I

MMSE-101 A : La*TeX*

Total Marks: 100 (Theory: 37.5, Internal Assessment: 12.5 and Practical: 50)
Workload: 2 Lectures (per week), 4 Practicals (per week per student)
Duration: 14 Weeks (28 Hrs. Theory + 56 Hrs. Practical) **Examination:** 2 Hrs.

Unit 1: Getting Started with La*TeX*(15 marks, 4 weeks)

Introduction to *TeX* and La*TeX*, Typesetting a simple document, Adding basic information to a document, Environments, Footnotes, Sectioning and displayed material.

Unit 2: Mathematical Typesetting with La*TeX*(20 marks, 6 weeks)

Accents and symbols, Mathematical Typesetting (Elementary and Advanced)**:** Subscript/ Superscript, Fractions, Roots, Ellipsis, Mathematical Symbols, Arrays, Delimiters, Multiline formulas, Spacing and changing style in math mode.

Unit 3: Graphics and Beamer Presentation in La*TeX*(15 marks, 4 weeks)

Graphics in LaTeX, Simple pictures using PS Tricks, Plotting of functions, Beamer presentation.

References:

1. Bindner, Donald & Erickson, Martin. (2011). *A Student's Guide to the Study, Practice, and Tools of Modern Mathematics*.CRC Press, Taylor & Francis Group, LLC.

2. Lamport, Leslie (1994). *LaTeX*: *A Document Preparation System*, User's Guide and Reference Manual (2nd ed.). Pearson Education.Indian Reprint.

Practical/Lab work to be performed in Computer Lab.

Practicals:

[1] Chapter 9 (Exercises 4 to 10), Chapter 10 (Exercises 1 to 4 and 6 to 9), Chapter 11 (Exercises 1, 3, 4, and 5), and Chapter 15 (Exercises 5, 6 and 8 to 11).

MMSE-101 B : Computational Mathematics Laboratory

Total Marks: 100 (Theory: 37.5, Internal Assessment: 12.5 and Practical: 50)
Workload: 2 Lectures (per week), 4 Practicals (per week per student)
Duration: 14 Weeks (28 Hrs. Theory + 56 Hrs. Practical) **Examination:** 2 Hrs.

Unit-1: PowerPoint Presentation (10 marks, 3 weeks)

Navigate the PowerPoint interface, creating new presentation from scratch – or by using beautiful templets, Add text, Pictures, Sound, Movies and Charts. Designing slides using themes, colours and special effects, Animate objects on slides, work with Master slides to make presentation easy.

Unit -2: Spreadsheets (15 marks, 4 weeks)

Examine spreadsheet concepts and explore the Microsoft Office Excel environment, Create, Open and View a workbook. Save and print workbooks. Enter and Edit data. Modify a worksheet and workbook. Work with cell references. Learn to use functions and formulas. Create and edit charts and Graphics. Filter and sort table data. Work with pivot tables and charts. Import and Export data.

Unit -3: Mathematica (25 marks, 7 weeks)

Getting Acquainted with the notation and convention, the Kernel and the Front End, Built- functions. Basic operations, Assignment and Replacement. Logical Relations, Sum and Products, Loops.

Two Dimensional Graphics – plotting functions of a single variable, Additional Graphics Commands, Animations.

Three Dimensional Graphics – plotting functions of two variables, Special three dimensional plots.

Equation(s) solving commands, Matrix operations – vectors and matrices operations, eigenvalues and eigenvectors, trace, adjoint, inverse, diagonalization etc.

References:

1. Binder, Donald & Erickson, Martin (2011). A student's guide to the Study, Practice, and Tools of Modern Mathematics. CRC Press, Taylor & Francis Group, LLC.

2. Hillier and Hillier (2003). Introduction to Management Science: A Modeling and Case Studies Approach with Spreadsheet, Second Edition, McGraw-Hill.

3. Eugene Don, Ph. D., Schaum's Outlines Mathematica, Mc-Graw Hill (2009).

List of Practical to be performed at the Laboratory:

a) **PowerPoint Presentation**:
   1. Change the fonts, colour of text on a slide
   2. Add bullets or numbers to text
   3. Format text as superscript or subscript
   4. Insert a picture that is save on your local drive or an internal server
   5. Insert a picture from the web
   6. Insert shapes in your slide

b) **Spreadshee**t:
   1. Format, enhance, and insert formulas in spreadsheet.
   2. Move data within and between workbooks.

3. Maintain a workbook and create a chart in a spreadsheet.
4. Create, modify and manage a database table and query.
5. Create relationships between tables in a database.
6. Import and export data among word processing software, a spreadsheet and a database.
7. Merge data in a database with a word processing document.

c) **Mathematica**:

1. In an expression containing x, y, z replace all x, y, z by and .
2. Find the sum of i) _ _ __ , ii) __ __
3. Solve the equation i) for , ii) Solve:
4. Plot the graph of and together, where
6. Plot the graph of the function , where and

Semester II

MMSE-202 A : Python Programming

Total Marks: 100 (Theory: 37.5, Internal Assessment: 12.5 and Practical: 50)
Workload: 2 Lectures (per week), 4 Practicals (per week per student)
Duration: 14 Weeks (28 Hrs. Theory + 56 Hrs. Practical) **Examination**: 2 Hrs.

Unit 1Introduction to Programming using Python (20 marks, 6 weeks)

Structure of a Python Program, Functions, Interpreter shell, Indentation.Identifiers and keywords, Literals, Strings, Basic operators (Arithmetic operator, Relational operator, Logical or Boolean operator, Assignment Operator, Bit wise operator). Building blocks of Python: Standard libraries in Python, notion of class, object and method.

Unit 2 Creating Python Programs (15 marks, 4 weeks)

Input and Output Statements, Control statements:-branching, looping, Exit function, break, continue and pass, mutable and immutable structures. Testing and debugging a program.

Unit 3 Visualization using 2D and 3D graphics and data structures (15 marks, 4 weeks)

Visualization using graphical objects like Point, Line, Histogram, Sine and Cosine Curve, 3D objects, Built-in data structures: Strings, lists, Sets, Tuples and Dictionary and associated operations. Basic searching and sorting methods using iteration and recursion.

References:

1. Downey, A.B., (2015),*Think Python–How to think like a Computer Scientist*, 3rd edition. O'Reilly Media.
2. Taneja, S. &Kumar,N., (2017),*Python Programming-A Modular Approach*. Pearson Education.

Additional Reading:

1. Brown, M. C. (2001).TheComplete Reference:Python, McGraw Hill Education.
2. Dromey, R. G. (2006),How to Solve it by Computer, Pearson Education.

3. Guttag, J.V.(2016),Introduction to computation and programming using Python. MIT Press.

4.Liang,Y.D. (2013),Introduction to programming using Python. PearsonEducation.

Practical

1. Execution of expressions involving arithmetic, relational, logical, and bitwise operators in the shell window of Python IDLE.
2. Write a Python function to produce the outputs such as: a)

```
*
```

```
  *    * *
*    * * * *
  *    * *
  *    (b)
```

```
1
232
34543
4567654
567898765
```

3. Write a Python program to illustrate the various functions of the "Math"module.
4. Write a function that takes the lengths of three sides:**side1**, **side2** and **side3** of the triangle as the input from the user using **input** function and return the area of the triangle as the output. Also, assert that sum of the length of any two sides is greater than the third side.
5. Consider a showroom of electronic products, where there are various salesmen. Each salesman is given a commission of 5%, depending on the sales made per month. In case the sale done is less than 50000, then the sales man is not given any commission. Write a function to calculate total sales of a salesman in a month, commission and remarks forthe salesman. Sales done by each salesman per week is to be provided as input. Assign remarks according to the following criteria**:** Excellent: Sales >=80000
   Good: Sales>=60000 and <80000
   Average: Sales>=40000 and <60000
   Work Hard: Sales <40000
6. Write a Python function that takes a number as an input from the user and computes its factorial.
7. Write a Python function to return nth terms of Fibonacci sequence
8. Write a function that takes a number with two or more digits as an input and finds its reverse and computes the sum of its digits.
9. Write a function that takes two numbers as input parameters and returns their least common multiple and highest common factor.
10. Write a function that takes a number as an input and determine whether it is prime or not.
11. Write a function that finds the sum of then terms of the following series:

a) 1 – x2 /2! +x4 /4! –x6 /6! +… xn /n!

b) 1 +x2 /2! +x4 /4! +x6 /6! +… xn /n!

12. Write a Python function that takes two strings as an input from the user and counts the number of matching characters in the given pair of strings.
13. Write a Python function that takes a string as an input from the user and displays itsreverse.

14. Write a Python function that takes a string as an input from the user and determines whether it is palindrome or not.
15. Write a Python function to calculate the sum and product of two compatible matrices
16. Write a function that takes a list of numbers as input from the user and produces the corresponding cumulative list where each element in the list present at index i is the sum of elements at index j <=i.
17. Write a function that takes **n** as an input and creates a list of n lists such that i^{th} list contains first five multiples of i.
18. Write a function that takes a sentence as input from the user and calculates the frequency of each letter. Use a variable of dictionary type to maintain the count.
19. Write a Python function that takes a dictionary of *word***:** *meaning* pairs as an input from the user and creates an inverted dictionary of the form meaning: list-of-words.
20. Usage of Python debugger tool-pydbandPython Tutor.
21. Implementation of Linear and binary search techniques
22. Implementation of selection sort, insertion sort, and bubble sort techniques
23. Write a menu-driven program to create mathematical 3D objects Curve, Sphere, Cone, Arrow, Ring, and Cylinder.
24. Write a program that makes use of a function to accept a list of n integers and displays a histogram.
25. Write a program that makes use of a function to display sine, cosine, polynomial and exponential curves.
26. Write a program that makes use of a function to plot a graph of people with pulse rate p vs. height h. The values of p and hare to be entered by the user.
27. Write a function that reads a file **file1** and displays the number of words and the number of vowels in the file.
28. Write a Python function that copies the content of one file to another.
29. Write a function that reads a file **file1** and copies only alternative lines to another file **file2**. Alternative lines copied should be the odd numbered lines.

MMSE-202 B: Computer Algebra Systems and Related Software

Total Marks: 100 (Theory: 37.5, Internal Assessment: 12.5 and Practical: 50)
Workload: 2 Lectures (per week), 4 Practicals (per week per student)
Duration: 14 Weeks (28 Hrs. Theory + 56 Hrs. Practical) **Examination**: 2 Hrs.

Unit 1: Introduction to CAS and Applications (15 marks, 4 weeks)

Computer Algebra System (CAS), Use of a CAS as a calculator, Computing and plotting functions in 2D, Plotting functions of two variables using Plot3D and ContourPlot, Plotting parametric curves surfaces, Customizing plots, Animating plots, Producing tables of values, working with piecewise defined functions, Combining graphics.

Unit 2: Working with Matrices(15 marks, 4 weeks)

Simple programming in a CAS, Working with matrices, Performing Gauss elimination, operations (transpose, determinant, inverse), Minors and cofactors, Working with large matrices, Solving system of linear equations, Rank and nullity of a matrix, Eigenvalue, eigenvector and diagonalization.

Unit 3: R - The Statistical Programming Language (20 marks, 6 weeks)

R as a calculator, Explore data and relationships in **R.** Reading and getting data into **R:** Combine and scan commands, Types and structure of data items with their properties. Manipulating vectors, Data frames, Matrices and lists. Viewing objects within objects. Constructing data objects and conversions, Summary commands**:** Summary statistics for vectors, Data frames, Matrices and lists. Summary tables. Stem and leaf plot, Histograms. Plotting in **R:** Box-whisker plots, Scatter plots, Pairs plots, Line charts, Pie charts, Cleveland dot charts and bar charts. Copy and save graphics to other applications.

References:

1. Bindner, Donald & Erickson, Martin. (2011). *A Student's Guide to the Study, Practice, and Tools of Modern Mathematics*.CRC Press, Taylor & Francis Group, LLC.

2. Torrence, Bruce F., &Torrence, Eve A. (2009). *The Student's Introduction to Mathematica®: A Handbook for Precalculus, Calculus, and Linear Algebra* (2nd ed.). Cambridge University Press.

3. Gardener, M. (2012). *Beginning R*: *The Statistical Programming Language*, Wiley.

Note: Theoretical and Practical demonstration should be carried out only in **one** of the CAS: Mathematica/MATLAB/Maxima/Scilab or any other.

Practical/Lab work to be performed in Computer Lab.

Practicals:

[1] Chapter 12 (Exercises 1 to 4 and 8 to 12), Chapter 14 (Exercises 1 to 3)
[2] Chapter 3 [Exercises 3.2 (1 and 2), 3.3 (1, 2 and 4), 3.4 (1 and 2), 3.5 (1 to 4), 3.6 (2 and 3)].
[2] Chapter 6 (Exercises 6.2 and 6.3).
[2] Chapter 7 [Exercises 7.1 (1), 7.2, 7.3 (2), 7.4 (1) and 7.6].

Note: Relevant exercises of [3] Chapters 2 to 5 and 7 (The practical may be done on the database to be downloaded from http://data.gov.in/).

Generic Elective (GE) Course -Mathematics
Semester-III

MMGE-301: QUANTITATIVE APTITUDE

Total Marks: 100 (Theory: 70, Internal Assessment: 30)
Workload: 6 Lectures, (per week)
Duration: 14 Weeks (70 Hrs.) **Examination**: 3 Hrs.

Unit-1: Arithmetic Ability I **(30 marks, 4 weeks)**

Chain Rule –Time and Work – Pipes and Cisterns
Time and Distance – Problems on Trains – Boats and Streams

Unit-2: **Arithmetic Ability II** **(30 marks, 4 weeks)**

Simple Interest – Compound Interest – Stocks and Shares. (Chapters 17, 18 & 19) Clocks – Area (Chapters 24, 25)

Unit-3: **Arithmetic Ability III** **(40 marks, 6 weeks)**

Volume and Surface Area. (Chapters 28)
Permutations and Combinations. (Chapters 30 & 31)

Text Book:

1. Scope and treatment as in "Quantitative Aptitude", S. Chand and Company Ltd. Ram Nagar, New Delhi (2007).

Semester-IV

MMGE-402 : BASIC TOOLS OF MATHEMATICS

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 6 Lectures(per week)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

UNIT-1: Geometry and Vectors: **(40 marks, 6 weeks)**

Geometry
Three Dimensional space, Rectangular Cartesian Coordinates, Polar Coordinates, Cylindrical Coordinates, Spherical coordinates. Change of origin, Section of a line joining two given points.

Vectors
Addition of two or more vectors, Negative of a vector, , Subtraction of two vectors, Multiplication of a vector by a scalar, Vector equations, Collinear vectors, Position vector of a point, Section Ratio of a point, Linear combination of a set of vectors, Coordinates of two and three dimensional vectors. Product of two or three vectors.

UNIT-2: Algebra and Calculus **(40 marks, 6 weeks)**

Algebra
Geometric Mean, Arithmetic Mean, Harmonic Mean and related Inequalities, Arithmetic and Geometric Progression, Polynomial, Equation, Linear Equation, Quadratic Equation, Roots and Coefficients, Fundamental Theorem of Algebra, Binomial Theorem, Permutation, and Combination, Mathematical Induction, Determinants, Matrices, Solution of equations by matrix method.

Differential Calculus
Mappings, Inverse Mapping and Composite Mappings.
Limit, Continuity, Differentiation, Maxima and Minima, Tangent and normal, Partial Differentiation.

Integral Calculus
Definition, Properties, Methods of Integration, Definite integrals, Infinite Integrals.

UNIT-3: Probability **(20 marks, 2 weeks)**

Probability

Definition, Random variable (discrete and continuous), Probability Distribution (mass function, density function, distribution function), Expectations, Some Standard Probability Distributions (Distributions: Binomial, Poisson, Negative Binomial, Geometric, Hyper-geometric, Normal, Exponent, Uniform, Gamma, Beta, etc.)

Recommended books

1. B.S.Vatssa: Discrete Mathematics ch.1, 2e, WishwaPrakashan (A Division of Wiley Eastern Ltd.)
2. Chandrika Prasad: Algebra and Theory of Equations, Pothisala Pvt. Ltd.
3. Das and Mukherjee: Differential Calculus, UN Dhur& Sons Pvt. Ltd.
4. Das and Mukherjee: Integral Calculus, UN Dhur& Sons Pvt. Ltd.
5. Ghosh&Maity: Vector Analysis, New Central Book Agency, Kolkata
6. S.C. Gupta and V.K. Kapoor: Fundamentals of Mathematical Statistics, Sultan Chand & Sons.
7. Chakraborty&Ghosh: Analytical Geometry and Vector Analysis, UN.Dhur& Sons, Kolkata
8. Chakraborty&Ghosh: Advanced Analytical Geometry , UN.Dhur& Sons, Kolkata

Semester - V

MMGE –503 : RECREATIONAL MATHEMATICS

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures (per week), 1Tutorial (per week) **Duration:**
14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Unit-1: Basic Set Theory and Fundamentals (30 marks, 4 weeks)

Notations, Venn Diagram, Union, Intersection, Complement, Comparable, sets of Numbers, Line Diagram of the Number System, Intervals, Algebra of Sets.

Order Relation, Absolute Value, Summation Notation, Indexed Summation, Product Notation, Well Ordering Principle.

Recursion, Handshake Problem, Tower of Brahma, Binomial Theorem, Pascal's Identity, Pascal's Triangle, Magic Squares, Geometrical Patterns.

Polygonal, Triangular, Square, Pentagonal, Hexagonal, Pyramidal. Triangular Pyramidal, Square Pyramidal, Pentagonal Pyramidal, Hexagonal Pyramidal numbers.

Unit 2: Congruences (35 marks, 5 weeks)

Basic properties of congruences, congruence classes, linear congruence, solutions, Chinese Remainder Theorem, Some special theorems, Fermat's little theorem, Euler's theorem, Wilson's theorem, Application of congruence; Divisibility test, check digits.

Detection of error in an ISBN, ISSN, product code(UPC), credit card check digit, application of congruences in sports, setting time table for tournaments.

Unit 3: Some applications and Biography of some Mathematicians (35 marks, 5 weeks)

Palindromic number, Taxicab number (Hardy-Ramanujan Number).

Pythagorean Triples, Pythagorean triples and the unit circle.

Fibonacci Numbers, Fibonacci sequence, Fibonacci Problem, Dynamical Growth of rabbit population and Fibonacci sequence, Some Fascinating Numbers of Lucas, Examples of Mathematics in Nature, Geometric shapes, Symmetry, Fibonacci Spiral, Golden Ratio, Fractals.

Historical Notes on S. Ramanujan, G. Hardy, Paul Erdos, Aryabhata, Brahmagupta, Bhaskara.

References:

1. Seymour Lipschutz, Set Theory and Related Topics, Schaum's Outline Series, TMH/McGraw Hill
2. Thomas Koshy (2007): Elementary Number Theory with Applications, (Second Edn.), Elsevier.
3. Joseph H. Silverman (2014): A Friendly Introduction to Number Theory, (Fourth Edn), Pearson IN.
4. Neville Robbins: Beginning Number Theory, (Second Edn.), Jones & Barlett Learning.
5. M.K.Sen, B.C.Chakraborty (2002): Introduction to Discrete Mathematics, NCBA Publishers. 6. Wikepedia

Semester - VI

MMGE-604: Discrete Mathematics

Total Marks: 100 (Theory: 75, Internal Assessment: 25) **Workload:**
5 Lectures, 1 Tutorial (per week)
Duration: 14 Weeks (70 Hrs.) **Examination**: 3 Hrs.

Unit 1: Logical Mathematics (30 marks, 4 weeks)

Compound statements (and, or, implication, negation, contrapositive, quantifiers), Proofs in Mathematics, Truth tables, Basic logical equivalences and its consequences, Logical arguments, Binary relations, Types of binary relations, Equivalence relations, Partial and total ordering (Hasse diagram, Lexicographic order, Isomorphism, extremal elements).

Unit 2: Lattices and its Properties (35 marks, 5 weeks)

Lattices, Duality principle, Lattices as ordered sets, Lattices as algebraic structures, Sublattices, Products and homomorphisms, Distributive lattices, Boolean algebras, Boolean polynomials, Minimal forms of Boolean polynomials, Quinn−McCluskey method, Karnaugh diagrams, Switching circuits and applications of switching circuits.

Unit 3: Applications of Numbers (35 marks, 5 weeks)

Properties of integers, Division algorithm, Divisibility and Euclidean algorithm, GCD, LCM, Relatively prime, Prime numbers, Statement of fundamental theorem of arithmetic, Fermat primes, Recursively defined sequences, Recursive relations and its solution (characteristics polynomial and generating function), Principles of counting (Inclusion/Exclusion, Addition and Multiplication rule, Pigeon-Hole).

References:

1. Bernard Kolman, Robert C Busby, Sharon C Ross (2004). *Discrete Mathematical Structures.* (Fifth Edition) Pearson Education, Inc..
2. Goodaire, Edgar G., & Parmenter, Michael M. (2005). *Discrete Mathematics with Graph Theory* (3rd ed.). Pearson Education (Singapore) Pvt. Ltd. Indian Reprint.
3. Lidl, Rudolf & Pilz, Günter. (1998). *Applied Abstract Algebra* (2nd ed.). Undergraduate Texts in Mathematics. Springer (SIE). Indian Reprint 2004.

Additional Reading:

1. Rosen, Kenneth H. (2012) *Discrete Mathematics and its Applications* (7th ed.). McGraw-Hill Education (India) Pvt. Ltd.

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE) MME : 501 [SEMESTER – V]

ANY ONE OF THE FOLLOWING
ADVANCED GROUP THEORY/ MATHEMATICAL MODELING/INTEGRAL TRANSFORM

Total Marks: 100 (Theory: 75 and Internal Assessment: 25)
Workload: 5 Lectures (per week), 1 Tutorial (per week) **Duration:**
14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

MME-501 A : Advanced Group Theory

Unit 1: Automorphisms and External and Internal Direct Products (35 marks, 5 weeks)

Automorphism, inner automorphism, Automorphism groups, Automorphism groups of finite and infinite cyclic groups, Characteristic subgroups, Commutator subgroup and its properties; Applications of factor groups to automorphism groups.

External direct products of groups and its properties, The group of units modulo *n* as an external direct product, Applications to data security and electric circuits; Internal direct products, Fundamental theorem of finite Abelian groups and its isomorphism classes.

Unit 2: Group Action (30 marks, 4 weeks)

Group actions and permutation representations; Stabilizers, orbits and kernels of group actions; Groups acting on themselves by left multiplication and consequences; Conjugacy in S_n, Conjugacy classes, The class equation, *p*-groups.

Unit 3: Sylow Theorems and applications (35 marks, 5 weeks)

The Sylow theorems and consequences, Applications of Sylow theorems; Classification of groups of order p^2, where *p* is a prime, Classification of groups of pq where p, q are distinct primes; Finite simple groups, Non simplicity tests; Generalized Cayley's theorem, Index theorem, Embedding theorem and applications. Simplicity of A_5.

References:

1. Dummit, David S., & Foote, Richard M. (2016). *Abstract Algebra* (3rd ed.). Student Edition. Wiley India.

2. Gallian, Joseph. A. (2013). *Contemporary Abstract Algebra* (8th ed.). Cengage Learning India Private Limited. Delhi.

3. Herstein, I. N. (2006.) *Topics in Algebra* (2nd Edition). Wiley India.

4. Michael Artin (2014). *Algebra* (2nd Edition). Pearson.

5. Bhattacharya, P.B., Jain, S.K. and Nagpaul, S.R. (2003). *Basic Abstract Algebra* (2nd Edition). Cambridge University Press.

Additional Reading:

1. Rotman, Joseph J. (1995). *An Introduction to The Theory of Groups* (4th Edn.) Springer-Verlag, New York.

2. Khanna, Vijay K, Bhambri, S K (2017). *A Course in Abstract Algebra*(5th edition). Vikas Publishing House.

MME – 501 B : Mathematical Modeling

Unit 1: Power Series Solutions **(30 marks, 4 weeks)** Power series solution of a differential equation about an ordinary point, Solution about a regular singular point, the method of Frobenius. Legendre's and Bessel's equation.

Unit 2: Monte Carlo Simulation **(35 marks, 5 weeks)**

Monte Carlo Simulation Modeling**:** Simulating deterministic behavior (area under a curve, volume under a surface); Generating Random Numbers**:** Middle square method, Linear congruence; Queuing Models**:** Harbor system, Morning rush hour. Overview of optimization modeling; Linear Programming Model: Geometric solution, Algebraic solution, Simplex method, Sensitivity analysis.

Unit 3: Graph Theory **(35 marks, 5 weeks)**

Graphs, Diagraphs, Networks and subgraphs, Vertex degree, Paths and cycles, Regular and bipartite graphs, Four cube problem, Social networks, Exploring and traveling, Eulerian and Hamiltonian graphs, Applications to dominoes, Diagram tracing puzzles, Knight's tour problem, Gray codes.

References:

1. Aldous, Joan M., & Wilson, Robin J. (2007). *Graphs and Applications*: *An Introductory Approach*. Springer. Indian Reprint.
2. Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015). *Differential Equation and Boundary Value Problems*: *Computing and Modeling* (5th ed.). Pearson.
3. Giordano, Frank R., Fox, William P., & Horton, Steven B. (2014). *A First Course in Mathematical Modeling* (5th ed.). Brooks/Cole, Cengage Learning.

MME-501 C : Integral Transforms

Unit 1: Fourier Series **(25 marks, 3 weeks)**

Fourier series, Euler's formulae, Dirichlet's conditions for Fourier series, Fourier sine and cosine series, Convergence of Fourier series, Fourier series for even and odd functions, Half-Range Fourier series, HalfRange expansions, Bessel's inequality, The complex form of Fourier series.

Unit 2: Laplace Transforms **(40 marks, 6 weeks)**

Integral transform, Kernel of an integral transform, Laplace transform, Existence theorem, Linearity property, Shifting theorems, Change of scale property, Laplace transforms of derivatives and integrals, Laplace transforms of periodic functions, Integral equations, Dirac's delta function.

Further properties of Laplace transforms: Multiplication by positive integral power of t, Division by t, Inverse Laplace transform, Lerch's theorem, Linearity property of inverse Laplace transform, Inverse transform of derivatives, Convolution theorem, Integral equations, Applications of Laplace transform in obtaining solutions of ordinary differential equations and integral equations.

Unit 3: Fourier Transforms **(35 marks, 5 weeks)**

Fourier and inverse Fourier transforms, Fourier sine and cosine transforms, Inverse Fourier sine and cosine transforms, Relation between Fourier and Laplace transforms, Linearity property, Change of scale property, Shifting property, Modulation theorem, Solution of integral equation by Fourier sine and cosine transforms, Convolution theorem for Fourier transform, Parseval's identity for Fourier transform, Plancherel's theorem, Fourier transform of derivatives, Applications of infinite Fourier transforms to boundary value problems, Finite Fourier transform, Inversion formula for finite Fourier transforms.

References:

1. James Ward Brown & Ruel V. Churchill (2011), *Fourier Series and Boundary Value Problems.* McGraw-Hill Education.
2. Dr. S. Sreenadh, S. Ranganathan, Dr. M. V. S. S. N. Prasad & Dr. V. Ramesh Babu, *Fourier series & Integral transforms* (Reprint 2020),S Chand.
3. MD Raisinghania (2022), *Advanced Differential Equations* (20th edition*),* S Chand and Company Ltd., New Delhi.

Additional Reading:

1. Erwin Kreyszig (2011). *Advanced Engineering Mathematics* (10th edition). Wiley
2. A. Zygmund (2002). Trigonometric Series (3rd edition). Cambridge University Press.
3. Phil Dyke (2014). *An Introduction to Laplace Transform and Fourier.* Springer.
4. Rajendra Bhatia. *Fourier Series* (2nd edition). Hindustan Book Agency (India), New Delhi.
5. H K Dass (2018). *Advanced Engineering Mathematics* (22nd edition). S Chand and Company Ltd., New Delhi.

.MME : 602 [SEMESTER – VI]

ANY ONE OF THE FOLLOWING

MME 602 A : Special Theory of Relativity & Tensors

Total Marks: 100 (Theory: 75, Internal Assessment: 25)
Workload: 5 Lectures (per week), 1 Tutorial (per week) **Duration:**
14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Unit 1: Newtonian Mechanics and Relativistic Kinematics **(35 marks, 5 weeks)** Inertial frames, Galilean transformation, Michelson-Morley experiment, Lorentz-Fitzgerald contraction hypothesis, Relativistic concept of space and time, Postulates of special theory of relativity.
Lorentz transformation equations and its geometrical equations, Group properties and its geometrical equations, consequences of Lorentz transformation equations like Relativity of Simultaneity, Einstein's time dilation, length contraction and related problems, transformation equations for components of velocity and acceleration of a particle.

Unit 2: Relativistic Mechanics **(35 marks, 5 weeks)**
Variation of mass with velocity, Equivalence of mass and energy and its consequences, Transformation equations for mass, momentum, energy and force. Relation between momentum and energy. Energy momentum four vector.
Four dimensional Minkowskian spacetime of special relativity, time-like, light-like and space like intervals, Null cone, proper time, world line of a particle, Four tensors in Minskownian space-time.

Unit 3: Tensors **(30 Marks, 4 weeks)**

Space of N-dimension, Transformation of co-ordinates, contravariant and covariant vectors (Tensor of first order), Tensor of second order (or of rank two), Tensors of higher rank (or higher orders), Mixed tensors, Kronecker delta symbol, Invariant or scalar, Algebraic operations with tensors, Addition & subtraction of tensors, contraction, product of tensors, Inner Product, symmetric and Skew symmetric tensor.

References:

1. **Farook Rahaman (2014):** The Special Theory of Relativity, A Mathematical Approach, Springer
2. **Robert Resnick (2007)**: Introduction to Special Relativity, John Wiley
3. **James L Anderson (1973):** Introduction to the Theory of Relativity, DoverPublications

Additional Reading:

1. **M. Ray**: Special Theory of Relativity, S Chand and Co
2. **A. Das (1993)**: The Special Theory of Relativity, Springer
3. **Banerjee and Banerjee (2012)**: The Special Theory of Relativity, PHI, New Delhi.
4. **Dirac** : General Theory of Relativity, Prentice Hall of India, New Delhi.
5. **S.K. Bose**: General Theory of Relativity, Wiley Eastern Ltd.

MME – 602 B : Linear Programming and its Applications

Total Marks: 100 (Theory: 75 and Internal Assessment: 25)
Workload: 5 Lectures (per week), 1 Tutorial (per week) **Duration:**
14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Unit 1: Introduction to Linear Programming (30 marks, 4 weeks)
The Linear Programming Problem**:** Standard, Canonical and matrix forms, Graphical solution. Convex and polyhedral sets, Hyperplanes, Extreme points. Basic solutions; Basic Feasible Solutions; Reduction of any feasible solution to a basic feasible solution; Correspondence between basic feasible solutions and extreme points.

Unit 2: Methods of Solving Linear Programming Problem and dual problem (40 marks, 6 weeks)
Simplex Method**:** Algebra of Simplex method, Optimal solution, Termination criteria for optimal solution of the Linear Programming Problem, Unique and alternate optimal solutions, Unboundedness; Simplex Algorithm and its Tableau Format; Artificial variables, Two-phase method, Big-M method.
Motivation and Formulation of Dual problem; Primal-Dual relationships; Fundamental Theorem of Duality; Complimentary Slackness.

Unit 3: Applications (30 marks, 4 weeks)
*Transportation Problem***:** Definition and formulation; Methods of finding initial basic feasible solutions; North West corner rule. Least cost method; Vogel's Approximation method; Algorithm for solving Transportation Problem.
*Assignment Problem***:** Mathematical formulation and Hungarian method of solving.
*Game Theory***:** Basic concept, Formulation and solution of two-person zero-sum games, Games with mixed strategies, Linear Programming method of solving a game.

References:

1. Bazaraa, Mokhtar S., Jarvis, John J., & Sherali, Hanif D. (2010). *Linear Programming and Network Flows* (4th ed.). John Wiley and Sons.
2. Hadley, G. (1997). *Linear Programming*. Narosa Publishing House. New Delhi.
3. Taha, Hamdy A. (2010). *Operations Research*: *An Introduction* (9th ed.). Pearson.

Additional Readings:

1. Hillier, F. S. & Lieberman, G. J. (2010). *Introduction to Operations Research- Concepts and Cases* (9th ed.). Tata McGraw Hill.
2. Thie, Paul R., & Keough, G. E. (2014). *An Introduction to Linear Programming and Game Theory*. (3rd ed.). Wiley India Pvt. Ltd.

MME-602 C : Probability Theory and Statistics

Total Marks: 100 (Theory: 75 + Internal Assessment: 25)
Workload: 5 Lectures (per week), 1 Tutorial (per week)
Duration: 14 Weeks (70 Hrs.) **Examination:** 3 Hrs.

Unit 1: Probability Functions and Moment Generating Function (30 marks, 4 weeks)
Sample space, Probability set function, Real random variables – Discrete and continuous, Cumulative distribution function, Probability mass/density functions, Transformations, Mathematical expectation, Moments, Moment generating function, Characteristic function.

Unit 2: Univariate Discrete, Continuous Distributions and Bivariate distributions

(35 marks, 5 weeks)

Discrete distributions: Uniform, Bernoulli, Binomial, Negative binomial, Geometric and Poisson; **Continuous distributions:** Uniform, Gamma, Exponential, Chi-square, Beta and Normal; Normal approximation to the binomial distribution.

Bivariate Distribution: Joint cumulative distribution function and its properties, Joint probability density function, Marginal distributions, Expectation of function of two random variables, Joint moment generating function, Conditional distributions and expectations.

Unit 3: Correlation, Regression and Central Limit Theorem **(35 marks, 5 weeks)** The Correlation coefficient, Covariance, Calculation of covariance from joint moment generating function, Independent random variables, Linear regression for two variables, The method of least squares, Bivariate normal distribution, Chebyshev's theorem, Strong law of large numbers, Central limit theorem and weak law of large numbers.

References:

1. Hogg, Robert V., McKean, Joseph W., & Craig, Allen T. (2013). *Introduction to Mathematical Statistics*(7th ed.). Pearson Education, Inc.

2. Miller, Irwin & Miller, Marylees. (2014). John E. Freund's *Mathematical Statistics with Applications* (8th ed.). Pearson. Dorling Kindersley (India).

Additional Reading:

1. Ross, Sheldon M. (2014). *Introduction to Probability Models* (11th ed.). Elsevier Inc.AP.
2. Mood, A.M., Graybill, F.A. & Boes, D.C. (1974). *Introduction to the Theory of Statistics* (3rd ed.). McGraw-Hill Education Pvt. Ltd. Indian edition (2017).