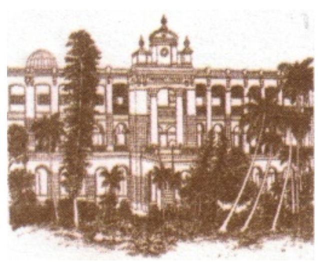
PRESIDENCY UNIVERSITY

DEPARTMENT OF MATHEMATICS

Syllabus for B.Sc. (Hons.) Mathematics
under Choice Based Credit System (CBCS)
(effective from Academic Year 2018-19)

EXCELLENCE SINCE 1817
PRESIDENCY
UNIVERSITY
KOLKATA



Department of Mathematics
(Faculty of Natural and Mathematical Sciences)
Presidency University
Hindoo College (1817-1855), Presidency College (1855-2010)
86/1, College Street, Kolkata - 700 073
West Bengal, India

Department of Mathematics
Presidency University

Course Structure for B.Sc. (Hons.) Mathematics under CBCS

Semester	Core Course (14)	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective (DSE) (4)	General Elective (GE) (4)
I	**MATH 01C1** Calculus and Geometry	**AECC-1** English Language			**MATH 01GE1** Calculus I
	MATH 01C2 Algebra				
II	**MATH 02C3** Real Analysis I	**AECC-2** Environmental Science			**MATH 02GE2** Calculus II
	MATH 02C4 Groups and Rings I				
III	**MATH 03C5** Real Analysis II		**MATH 03SEC1** Computer Programming		**MATH 03GE3** Algebra
	MATH 03C6 Linear Algebra I				
	MATH 03C7 Ordinary Differential Equations				
IV	**MATH 04C8** Sequence and Series of Functions and Metric Spaces		**MATH 04SEC2** LaTeX		**MATH 04GE4** Analytical Geometry
	MATH 04C9 Multivariate Calculus				
	MATH 04C10 Partial Differential Equations				
V	**MATH 05C11** Numerical Methods			**MATH 05DSE1**	
	MATH 05C12 Groups and Rings II			**MATH 05DSE2**	
VI	**MATH 06C13** Complex Analysis and Fourier Series			**MATH 06DSE3**	
	MATH 06C14 Probability Theory			**MATH 06DSE4**	

Details of the Credit Structure of Courses:

Sl. No.	Course	Credit	Theory	Tutorial/Practical	Marks*
1	Core Course	6×14	$5 \times 13 + 4 \times 1$	$1 \times 13 + 2 \times 1$	$100 \times 14 = 1400$
2	DSE	6×4	5×4 $(5 \times 3 + 4 \times 1)$	1×4 $(1 \times 3 + 2 \times 1)$	$100 \times 4 = 400$
3	GE	6×4	5×4	1×4	$100 \times 4 = 400$
4	SEC	4×2	4×2		$100 \times 2 = 200$
5	AECC	4×2	4×2		$100 \times 2 = 200$
	Total	**148**	**125**	**23**	**2600**

* For the core course `MATH 05C11` and the DSE course `MATH 05DSE2-B`, division of marks would be 100=70(end semester exam.)+30(practical exam.) and for all the other courses the division of marks would be 100=80(end semester exam.)+20(internal assessment).

Discipline Specific Electives (DSE):

1. **Choices for MATH 05DSE1**
   (a) MATH 05DSE1-A: Linear Programming and Game Theory
   (b) MATH 05DSE1-B: Number Theory
2. **Choices for MATH 05DSE2**
   (a) MATH 05DSE2-A: Theory of Ordinary Differential Equations (ODE)
   (b) MATH 05DSE2-B: Mathematical Modelling
3. **Choices for MATH 06DSE3**
   (a) MATH 06DSE3-A: Linear Algebra II and Field Theory
   (b) MATH 06DSE3-B: Industrial Mathematics
4. **Choices for MATH 06DSE4**
   (a) MATH 06DSE4-A: Mechanics
   (b) MATH 06DSE4-B: Differential Geometry

Detailed Syllabi of the Courses

Core 1: Calculus and Geometry
Subject Code: MATH 01C1
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Calculus: Hyperbolic functions, higher order derivatives, Leibniz rule and its applications to problems of type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n\sin x$, $(ax+b)^n\cos x$, concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications in business, economics and life sciences.

Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin nx dx$, $\int \cos nx dx$, $\int \tan nx dx$, $\int \sec nx dx$, $\int (\log x)^n dx$, $\int \sin^n x \sin^m x dx$, volumes by slicing, disks and washers methods, volumes by cylindrical shells, parametric equations, parametrizing a curve, arc length, arc length of parametric curves.

Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration, modeling ballistics and planetary motion, Kepler's second law.

Geometry: Techniques for sketching parabola, ellipse and hyperbola. Properties of parabola, ellipse and hyperbola, polar equations of conics, classification of conics using the discriminant.

Equation of a plane, signed distance of a point from a plane, planes passing through the intersection of two planes, angle between two intersecting planes and their bisectors. Parallelism and perpendicularity of two planes. Equations of a line in space, rays or half lines, direction cosines of a line, angle between two lines, distance of a point from a line, condition for coplanarity of two lines, skew-lines, shortest distance. Spheres, cylindrical surfaces, cone, ellipsoid, surface of revolution.

Books Recommended:

1. G.B. Thomas and R.L. Finney, Calculus, Pearson.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, Pearson.
3. H. Anton, I. Bivens and S. Davis, Calculus, John Wiley.
4. R. Courant and F. John, Introduction to Calculus and Analysis, I & II, Springer.
5. T. Apostol, Calculus, I & II, John Wiley.
6. S.L. Loney, The Elements of Coordinate Geometry, McMillan.
7. J.T. Bell, Elementary Treatise on Coordinate Geometry of Three Dimensions, McMillan.

Core 2: Algebra
Subject Code: MATH 01C2
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Quick review of algebra of complex numbers, modulus and amplitude (principal and general values) of a complex number, polar representation, De-Moivre's Theorem and its applications: nth roots of unity.

Polynomials with real coefficients and their graphical representation. Relationship between roots and coefficients: Descarte's rule of signs, symmetric functions of the roots, transformation of equations. Solutions of the cubic and bi-quadratic equations. Statement of the fundamental theorem of Algebra. Inequality: The inequality involving AM$\geq$GM$\geq$HM, Cauchy-Schwartz inequality.

Equivalence relations and partitions, partial order, statement of Zorn's lemma. Mappings and functions, injective, surjective and bijective mappings, composition of mappings, invertible mappings. Cardinality of a set, countable and uncountable sets, bijection from the unit interval to unit square using Schroeder-Bernstein theorem, well ordering principle. Divisibility and Euclidean algorithm, congruence relation between integers. Principle of mathematical induction. Statement of the fundamental theorem of arithmetic.

Elementary row operations: row reductions, elementary matrices, echelon forms of a matrix, rank of a matrix, characterization of invertible matrices using rank. Solution of systems of linear equations $A\mathbf{x} = \mathbf{b}$: Gaussian elimination method and matrix inversion method.

Elements of $\mathbb{R}^n$ as vectors, linear combination and span of vectors in $\mathbb{R}^n$, linear independence and basis, vector subspaces of $\mathbb{R}^n$, dimension of subspaces of $\mathbb{R}^n$. Linear transformations on $\mathbb{R}^n$ as structure preserving maps, invertible linear transformations, matrix of a linear transformation, change of basis matrix. Adjoint, determinant and inverse of a matrix.

Definitions and examples: (i) groups, subgroups, cosets, normal subgroups, homo-morphisms. (ii) rings, subrings, integral domains, fields, characteristic of a ring, ideals, ring homomorphisms.

Books Recommended:

1. Bernard and Child, Higher Algebra, Macmillan.
2. S. K. Mapa, Classical Algebra, Levant.
3. T. Andreescu and D. Andrica, Complex Numbers from A to Z, Birkhauser.
4. D. C. Lay, Linear Algebra and its Applications, Pearson.
5. C. Curtis, Linear Algebra, Springer.
6. J. B. Fraleigh, A First Course in Abstract Algebra, Pearson.
7. Ghosh, Mukhopadhyay and Sen, Topics in Abstract Algebra, University Press.

Core 3: Real Analysis I
Subject Code: MATH 02C3
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Review of Algebraic and Order Properties of $\mathbb{R}$, δ-neighbourhood of a point in $\mathbb{R}$, countability of $\mathbb{Q}$ and uncountability of $\mathbb{R}$. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Supremum and Infimum, The Completeness Property of $\mathbb{R}$, The Archimedean Property, Density of Rational (and Irrational) numbers in $\mathbb{R}$, Intervals. Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets.

Sequences, Bounded sequence, Convergent sequence, Limit of a sequence, Limit superior and Limit inferior, Limit Theorems, Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano-Weierstrass Theorem for Sequences. Cauchy sequence, Cauchys Convergence Criterion. Construction of $\mathbb{R}$ from $\mathbb{Q}$ by Dedekind's cut or by equivalent Cauchy sequences.

Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's root test, integral test, Alternating series, Leibniz test, Absolute and Conditional convergence, Cauchy product, Rearrangements of terms, Riemann's theorem on rearrangement of series (statement only).

Limits of functions (ϵ-δ 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 functions. 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.

Books Recommended:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, J. Wiley.
2. Terence Tao, Analysis I, HBA.
3. Walter Rudin, Principles of Mathematical Analysis, McGraw-Hill.
4. Tom Apostol, Mathematical Analysis, Narosa.
5. S.K. Berberian, A First Course in Real Analysis, Springer Verlag

Core 4: Groups & Rings I
Subject Code: MATH 02C4
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Groups: Groups as symmetries, examples: S_n, D_n, $GL(n,\mathbb{R})$, $SL(n,\mathbb{R})$, $O(n,\mathbb{R})$, $SO(n,\mathbb{R})$ etc., elementary properties of groups, abelian groups.

Subgroups and cosets: examples of subgroups including centralizer, normalizer and center of a group, product subgroups; cosets and Lagrange's theorem with applications. Cyclic groups and its properties, classification of subgroups of cyclic groups. Normal subgroups: properties and examples, conjugacy classes of elements, properties of homomorphisms and kernels, quotient groups and their examples. Presentation of a group in terms of generators and relations.

Properties of S_n, cycle notation for permutations, even and odd permutations, cycle decompositions of permutations in S_n, alternating group A_n, Cayley's theorem. Isomorphism theorems: proofs and applications, isomorphism classes of finite groups of lower order. Cauchy's theorem for finite abelian groups, statements of Cauchy's and Sylow's theorem and applications.

Rings: Examples and basic properties of rings, subrings and integral domains. Ideals, algebra of ideals, quotient rings, chinese remainder theorem. Prime and maximal ideals, quotient of rings by prime and maximal ideals, ring homomorphisms and their properties, isomorphism theorems, field of fractions.

Books Recommended:

1. Herstein, Topics in Algebra, John Wiley.
2. Fraleigh, A First Course in Abstract Algebra, Pearson.
3. M. Artin, Algebra, Pearson.
4. Bhattacharya, Jain and Nagpaul, Basic Abstract Algebra, Cambridge Univ. Press.
5. Gallian, Contemporary Abstract Algebra, Narosa.
6. Rotman, An Introduction to the Theory of Groups, Springer.
7. Dummit and Foote, Abstract Algebra, John Wiley.
8. Hungerford, Algebra, Springer.

Core 5: Real Analysis II
Subject Code: MATH 03C5
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Differentiability of a function at a point and in an interval, Carathéodory's theorem, Algebra of differentiable functions, Chain rule, Relative extrema, interior extremum theorem. Rolle's theorem, Mean value theorem, intermediate value property of derivatives - Darboux's theorem. Cauchy's mean value theorem. Applications of mean value theorems to inequalities and approximation of polynomials. Proof of L'Hôpital's rule.

Taylor's theorem with Lagrange's form of remainder and Cauchy's form of remainder, application of Taylor's theorem to convex functions. Taylor's series and Maclaurin's series expansions of exponential, trigonometric and other functions.

Riemann integration. upper and lower sums, Riemann's conditions of integrability. Riemann sum and definition of Riemann integral through Riemann sums. Equivalence of the two definitions. Riemann integrability of monotone and continuous and piecewise continuous functions. Properties of the Riemann integral. Intermediate Value theorem for integrals. Fundamental theorems of Calculus and its consequences. Functions of bounded variation and their properties.

Improper integrals; Proof of integral test for series, Convergence of Beta and Gamma functions, Bohr-Mollerup theorem and its consequences.

Books Recommended:

1. R.G. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley.
2. Terence Tao, Analysis I & II, HBA.
3. Tom Apostol, Mathematical Analysis, Narosa.
4. Tom Apolstol, Calculus I, Wiley.
5. W. Rudin, Principles of Mathematical Analysis, McGraw-Hill.
6. C. G. Denlinger, Elements of Real Analysis, Jones & Bartlett.
7. K.A. Ross, Elementary Analysis, The Theory of Calculus, Springer (UTM).
8. Royden, Real Analysis, Pearson.

Core 6: Linear Algebra I
Subject Code: MATH 03C6
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Vector spaces, linear combination of vectors, linear span, linear independence, basis and dimension. Subspaces, algebra of subspaces, dimension of subspaces, quotient spaces.

Linear transformations, matrix representation of a linear transformation, null-space and range, rank and nullity of a linear transform, Sylvester's (rank-nullity) theorem and application. Algebra of linear transformations, isomorphisms and isomorphism theorems, change of coordinate matrix.

Row space and column space of a matrix, row rank, column rank and rank of a matrix, equality of these ranks, rank of product of two matrices, rank factorisation.

Linear functionals, dual spaces, dual basis, double dual, transpose of a linear transform and its matrix in the dual basis, annihilators.

Characteristic polynomial; eigen values, eigen vectors and eigen space of a linear transform, diagonalizability of a matrix, invariant subspaces and Cayley-Hamilton theorem. Minimal polynomial for a linear operator, diagonalizability in connection with minimal polynomial, canonical forms.

Inner products and norms; inner products spaces, Cauchy-Schwarz inequality, orthogonal and orthonormal basis, orthogonal projections, orthogonal complements, Gram-Schmidt orthogonalisation process, Bessel's inequality.

Definitions of real symmetric, orthogonal, Hermitian, normal, unitary matrices; spectral theorems for real symmetric matrices.

Books Recommended:

1. K. Hoffman, R. A. Kunze, Linear Algebra, PHI.
2. S. Lang, Introduction to Linear Algebra, Springer.
3. Gilbert Strang, Linear Algebra and its Applications, Academic.
4. S. Kumaresan, Linear Algebra: A Geometric Approach, PHI.
5. P.R. Halmos, Finite Dimensional Vector Spaces, Springer.
6. A. R. Rao and P. Bhimasankaram, Linear Algebra, HBA.
7. Friedberg, Insel and Spence, Linear Algebra, Pearson.
8. C. Curtis, Linear Algebra: An Introductory Approach, Springer (UTM).

Core 7: Ordinary Differential Equations
Subject Code: MATH 03C7
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Formation of ordinary differential equations, geometric interpretation, general solution, particular solution.

First order equations: Lipschitz condition, linear first-order equations, exact equations and integrating factors, separable equations, linear and Bernoulli forms. Higher degree equations: general solution and singular solution, Clairut's form, singular solution.

Higher order equations: second order equations, general theory and solution of a homogeneous equation, Wronskian (properties and applications), general solution of a non-homogeneous equation, Euler-Cauchy forms, method of undermined coefficients, normal form, variation of parameters, use of f(D) operator, solution of both homogeneous and inhomogeneous higher order equations (order greater than two).

Strum-Liouville problem, eigenvalues and eigenfunctions.

Systems of linear differential equations: basic theory, normal form, homogeneous linear systems with constant coefficients.

Power series solution: solution about regular singular point, applications: hypergeometric and Legendre differential equations, properties of both functions.

Books Recommended:

1. Murray: Introductory Course on Differential Equations.
2. S. L. Ross: Differential Equations.
3. H.T.H. Piaggio: Differential Equations.
4. G.F. Simmons: Differential Equation with Applications and Historical Notes.
5. A.C. King, J. Billingham and S.R. Otto: Differential Equations: Linear, Nonlinear, Ordinary, Partial.
6. Edwards and Penny: Differential equations and boundary value problems: Computing and Modelling.

Core 8: Sequence & Series of Functions and Metric Spaces
Subject Code: MATH 04C8
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Sequence & series of functions: Point-wise and uniform convergence of sequence of functions. Theorems on convergence of a sequence of functions and continuity, differentiability and integrability of the corresponding limit function. Series of functions; Theorems on the continuity and differentiability of the sum function of a series of functions. Cauchy criterion for uniform convergence and Weierstrass' M-Test, construction of nowhere differentiable continuous maps on $\mathbb{R}$.

Power series, radius of convergence, Cauchy-Hadamard Theorem, Differentiation and integration of power series; Abel's Theorem; Weierstrass' Approximation Theorem.

Metric spaces: definition and examples. $\mathbb{R}^n$ as a metric space. Elementary topological notions for metric spaces: Open and closed balls, Neighbourhood of a point, Interior of a set, Limit point of a set, Open and Closed sets in a metric space, Dense subsets of a metric space. Separable spaces. Discrete metric space.

Sequences in metric spaces and Cauchy sequences, Completeness, Completion of a general metric space. The Baire Category Theorem.

Compact metric spaces, Compact subsets of $\mathbb{R}^n$, The Bolzano-Weierstrass theorem, Cantor's theorem, Supremum and Infimum on compact sets, Total boundedness, equivalence of sequential compactness with compactness for metric spaces. Connectedness, Connected subsets of $\mathbb{R}$. Continuity and connectedness, Continuous and uniformly continuous functions on a metric space. Sequential criterion of continuity. Homeomorphisms.

Contraction mappings, Banach contraction principle. C(X) as a metric space. Arzelá-Ascoli Theorem. Stone-Weierstrass Theorem (statement only).

Books Recommended:

1. Terence Tao, Analysis II, HBA (TRIM Series).
2. Tom Apostol, Mathematical Analysis, Narosa.
3. W. Rudin, Principles of Mathematical Analysis, McGraw-Hill.
4. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill.
5. S. Kumaresan, Topology of Metric Spaces, Narosa.
6. Irving Kaplansky, Set Theory and Metric Spaces, AMS Chelsea Publishing.
7. S. Shirali and H. L. Vasudeva, Metric Spaces, Springer.
8. J. Munkres, Topology, Pearson.

Core 9: Multivariate Calculus
Subject Code: MATH 04C9
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Functions of several variables, limit and continuity, partial derivatives, differentiability and total derivatives as matrices, sufficient condition for differentiability, chain rule; gradient vector, directional derivatives, the Jacobian theorem; inverse and implicit function theorems; higher derivatives and Taylor's theorem.

Maxima and minima, constrained optimisation problems, Lagrange's multipliers.

Tangent spaces, definition of a vector field, divergence and curl of a vector field, identities involving gradient, curl and divergence; maximality and normality properties of the gradient vector field.

Double integrals, double integrals: (i) over Rectangular region, (ii) over non-rectangular regions, (iii) in polar co-ordinates; triple integrals, triple integrals over: (i) a parallelepiped, (ii) solid regions; computing volume by triple integrals, in cylindrical and spherical co-ordinates; change of variables in double integrals and triple integrals.

Line integrals, applications of line integrals: mass and work, fundamental theorem for line integrals, conservative vector fields, independence of path. Green's theorem, Surface integrals, Stoke's theorem, The Divergence theorem.

Books Recommended:

1. Terence Tao, Analysis II, HBA (TRIM Series).
2. Tom Apostol, Mathematical Analysis, Narosa.
3. W. Rudin, Principles of Mathematical Analysis, McGraw-Hill.
4. Tom Apostol, Calculus II, John Wiley.
5. M. Spivak, Calculus on Manifold.
6. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer.
7. J. Stewart, Multivariable Calculus, Concepts and Contexts; Thomson.

Core 10: Partial Differential Equations
Subject Code: MATH 04C10
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Partial differential equations: basic concepts and definitions, mathematical problems. first- order equations: classification, construction and geometrical interpretation; method of characteristics for obtaining general solution of quasi linear equations, canonical forms of first-order linear equations. method of separation of variables for solving first order partial differential equations.

Derivation of heat equation, wave equation and Laplace equation; classification of second order linear equations as hyperbolic, parabolic or elliptic; reduction of second order linear equations to canonical forms.

The Cauchy problem, the Cauchy-Kovalevskaya theorem, Cauchy problem of an infinite string, initial boundary value problems, semi-infinite string with a fixed end, 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.

Laplace transforms: introduction and properties with derivations; existence, simple problems, inverse Laplace transform, convolution, solving ODEs and PDEs using Laplace transform.

Books Recommended:

1. I. N. Sneddon: Elements of Partial Differential equations.
2. E. T. Copson: Partial Differential Equations.
3. T. Amarnath, An elementary course in partial differential equations, Narosa.
4. T. Myint-U and L. Debnath, Linear Partial Differential Equations for Scientists and Engineers, Springer.

Core 11: Numerical Methods
Subject Code: MATH 05C11
Credits: 6 (Theory-4, Practical-2)
Contact Hours per Week: 8 (4 Theory lectures + 4 Practical classes)

Errors (Absolute, relative, round off, truncation).

Solution of transcendental and non linear equations: bisection method, secant and Regula-Falsi methods, iterative methods, Newton's methods, convergence and errors of these methods.

Interpolation: Lagrange's and Newton's divided difference methods, Newton's forward and backward difference methods, Gregory's forward and backward difference interpolation; error bounds of these methods.

Solution of a system of linear algebraic equations: Gaussian elimination method, Gauss-Jordan, Gauss-Jacobi and Gauss-Siedel methods and their convergence analysis.

Numerical integration: trapezoidal rule, Simpson's rule, composite trapezoidal and Simpson's rule, Bolle's rule, midpoint rule, Simpson's 3/8-th rule, error analysis of these methods.

Ordinary differential equations: modified Euler's method and Runge-Kutta method of second and fourth orders.

List of Practicals (Using any software):

1. Root finding using bisection, Newton-Raphson, secant and Regula-Falsi method.
2. LU decomposition.
3. Gauss-Jacobi method.
4. Gauss-Siedel method.
5. Interpolation using Lagrange's and Newton's divided differences.
6. Integration using Simpson's Rule.
7. Differentiation using Runge-Kutta method.

Books Recommended

1. K. Atkinson: Introduction to Numerical Analysis.
2. Sastry: Introductory Methods of Numerical Analysis.
3. W. Press, S. Teukolsky, W. Vettering, B. Flannery: Numerical Recipes in C.
4. U. Ascher and C. Greif: A First Course in Numerical Methods, PHI.
5. J. Mathews and K. Fink: Numerical Methods using Matlab, PHI.
6. Jain, Iyengar, Jain: Numerical Methods for Scientific & Engineering Computation, New age.

Core 12: Groups & Rings II
Subject Code: MATH 05C12
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Groups: Group actions, stabilisers and kernels, orbit-stabiliser theorem and applications, permutation representation associated to a group action, Cayleys theorem via group action, groups acting on themselves by conjugation, class equation and consequences, conjugacy in S_n, p-groups, proof of Cauchy's theorem and Sylows theorems and consequences.

Automorphisms of a group, inner automorphisms, group of automorphisms and their computations (in particular for finite and infinite cyclic groups), characteristic subgroups, commutator subgroup and its properties.

Direct product of groups, properties of external direct products, $\mathbb{Z}_n$ as external direct product, internal direct products, fundamental theorem of finite abelian groups, fundamental theorem of finitely generated Abelian groups (statement only) and its applications.

Rings: Polynomial rings over commutative rings, division algorithm and consequences, factorisation of polynomials, reducibility tests, irreducibility tests, Eisenstein's criterion. Principal Ideal Domains (PID), unique factorisation in $\mathbb{Z}[x]$, divisibility in integral domains, irreducibles and primes, Unique Factorisation Domains (UFD), Euclidean Domains (ED).

Books Recommended:

1. Gallian, Contemporary Abstract Algebra, Narosa.
2. Fraleigh, A First Course in Abstract Algebra, Pearson.
3. M. Artin, Abstract Algebra, Pearson.
4. Hungerford, Algebra, Springer.
5. Dummit and Foote, Abstract Algebra, John Wiley.
6. Bhattacharya, Jain and Nagpaul, Basic Abstract Algebra, CUP.
7. Rotman, An Introduction to the Theory of Groups, Springer.
8. Musili, Rings and Modules, Narosa.

Core 13: Complex Analysis and Fourier Series
Subject Code: MATH 06C13
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Complex Analysis: Complex numbers, field structure of complex numbers, geometric interpretation, stereographic projection.

Functions of complex variable, mappings. Derivatives, Holomorphic functions, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.

Analytic functions and power series, analytic functions are holomorphic, absolute and uniform convergence of power series, examples of analytic functions, exponential function, trigonometric function, complex logarithm.

Rectifiable paths, Riemann-Steieltjes integral of a function over an interval, Definition of complex integration of functions over a rectifiable path. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy-Goursat theorem, Cauchy's integral formula, equivalence of analyticity and holomorphicity.

Liouville's theorem and the fundamental theorem of algebra. Zeros of analytic functions and identity principle. Morera's theorem. Convergence of sequences and series of analytic functions.

Poles, removable and essential singularity, Riemann's theorem on removable singularities, residue formula, Casorati-Weierstrass theorem, meromorphic functions. The argument principle, The open mapping property of holomorphic functions, maximum modulus principle, Schwarz lemma, conformality, Möbius transformations and the cross ratio, winding number, Laurent series.

Fourier series: Complex valued periodic functions on $\mathbb{R}$, inner products on periodic functions, trigonometric polynomials, Fourier series and coefficients, periodic convolutions, Weierstrass' approximation theorem for trigonometric polynomials, Fourier's theorem on mean square convergence, Bessel's inequality, Riemann-Lebesgue lemma, Parseval's identity, Dirichlet's theorem on convergence of Fourier series (proof can be done if time permits).

Books Recommended:

1. Brown and Churchill, Complex Variables and Applications, McGraw-Hill.
2. J.B. Conway, Functions of One Complex Variable, Springer.
3. Stein and Shakarchi, Complex Analysis, Princeton Univ. Press.
4. Gamelin: Complex Analysis, Springer.
5. W. Rudin, Principles of Mathematical Analysis, McGraw-Hill.
6. T. Tao, Analysis II, HBA.
7. T. Apostol, Mathematical Analysis, Narosa.

Core 14: Probability Theory
Subject Code: MATH 06C14
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Classical theory and its limitations: random experiment and events, event space; classical definition of probability and its drawback, statistical regularity, frequentist probability.

Probability axioms: basics from measure theory (sets, collections of sets, generators, the monotone class theorem, probability measure, probability space, the Borel sets on $\mathbb{R}$), continuity theorem in probability, exclusion-inclusion formula, conditional probability and Bayes' rule, Boole's inequality, independence of events, Bernoulii trials and binomial law, Poisson trials, probability on finite sample spaces, geometric probability.

Random variables and their probability distributions: random variables, probability distribution of a random variable, discrete and continuous random variable, some discrete and continuous distributions on $\mathbb{R}$: Bernoulli, binomial and Poisson; uniform, normal, Gamma, Cauchy and χ^2-distributions; functions of a random variable and their probability distributions.

Characteristics and generating functions: expectation, moments, measures of central tendency, measures of dispersion, measures of skewness and Curtois, Markov, Chebycheff's inequality, probability generating function, moment generating function, characteristic function.

Probability distributions on $\mathbb{R}^n$: random vectors, probability distribution of a random vector, functions of random vectors and their probability distributions, moments, generating functions, correlation coefficient, conditional expectation, the principle of least squares, regression.

Convergence and limit theorems: sequence of random variables, convergence in distribution, convergence in probability, almost sure convergence, convergence in rth mean, weak and strong law of large numbers, Borel-Cantelli lemma, limiting characteristic functions, central limit theorem.

Introduction to stochastic processes, discrete time Markov chains, random Walk, continuous time Markov processes, Poisson process (if time permits).

Books Recommended:

1. W. Feller, An introduction to probability theory and its applications I, J. Wiley.
2. Stirzaker and Grimmett: Probability and Random Processes.
3. Rohatgi and Saleh: An introduction to probability and statistics, John Wiley.
4. Durett: Probability Theory & Examples.
5. Allan Gut: Probability-A Graduate Course, Springer.

Discipline Specific Elective Courses:

DSE 1: A. Linear Programming and Game Theory
Subject Code: MATH 05DSE1-A
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Linear Programming: General form of linear programming problems: basic formulation and geometric interpretation, standard and canonical forms.

Basic solutions, examples, feasible solutions, degenerate solutions, reduction of a feasible solution to a basic feasible solution; convex set of feasible solutions of a system of linear equations and linear in-equations; extreme points, extreme directions, and boundary points of a convex set, describing convex polyhedral sets in terms of their extreme points and extreme directions: Caratheodory's representation theorem; correspondence between basic feasible solution of a system of linear equations and extreme point of the corresponding convex set of feasible solutions.

Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, complexity of the simplex method; artificial variables: two-phase method, Big-M method and their comparison; polynomial time algorithms: ellipsoidal and Karmarkar's methods.

Duality, formulation of the dual problem, primaldual relationships, economic interpretation of the dual.

Transportation problem: mathematical formulation, north-west-corner method, least cost method, and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem. Assignment problem: mathematical formulation, Hungarian method for solving assignment problem.

Network and graph problems: minimal spanning trees, shortest path, flows in networks, perfect matching problem; Gale-Shapley algorithm for stable marriage.

Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games.

Books Recommended:

1. Hadley: Linear Programming, Narosa.
2. H. Karloff: Linear Programming, Modern Birkhuser Classic.
3. David Luenberger: Linear and nonlinear programming.
4. M. Osborne and A. Rubinstein: A Course in Game Theory.
5. R. Myerson: Game Theory.
6. S.R. Chakravarty, M. Mitra and P. Sarkar: A Course in Cooperative Game Theory.

DSE 1: B. Discrete Mathematics and Number Theory
Subject Code: MATH 05DSE1-B
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Combinatorics: Basic counting principles: multinomial theorem, principle of inclusion exclusion; recurrence relations and classification.

Graph Theory: Graphs and digraphs, complement, isomorphism, connectedness and reachability, adjacency matrix. Eulerian and Hamiltonian paths and circuits in graphs. Trees, rooted trees and binary trees; planar graphs, Euler's formula, statement of Kuratowski's theorem; independence number and clique number, chromatic number, statement of Havel-Hakimi Theorem and Four-color theorem.

Number Theory: Divisibility, primes and unique factorisation; GCD and Euclidean algorithm and its extension for computing multiplicative inverses; Arithmetic functions or number theoretic functions: sum and number of divisors, (totally) multiplicative functions, the greatest integer function, Euler's phi-function, Mobius function; definition and properties of the Dirichlet product; some properties of the Euler's phi-function, statement of the prime number theorem.

Linear Diophantine equations, congruences and complete residue systems; quadratic residues, quadratic reciprocity and the law of quadratic reciprocity, Euler's criterion, Legendre symbol and Jacobi symbol, Euler-Fermat theorem, Wilson's theorem, Chinese remainder theorem.

Applications: Public-key encryption, Miller-Rabin primality testing algorithm, idea of hardness of factoring and discrete logarithm problem; basics of Diffie-Hellman key agreement and RSA encryption and decryption.

Books Recommended:

1. Fred Roberts: Applied Combinatorics.
2. T. Andreescu and Z. Feng: A Path to Combinatorics for Undergraduates: Counting Strategies, Birkhauser.
3. D. B. West: Introduction to Graph Theory, PHI.
4. F. Harary: Graph Theory, Narosa.
5. D. M. Burton: Elementary Number Theory, TMH.
6. G. A. Jones and J. M. Jones: Elementary Number Theory, Springer.
7. N. Koblitz: A course in number theory and cryptography, Springer.
8. Niven, Zuckerman and Montgomery: An Introduction to the Theory of Numbers, John Wiley.

DSE 2: A. Theory of ODEs
Subject Code: MATH 05DSE2-A
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Fundamental theorem for existence and uniqueness, Gronwall's inequality, Dependence on initial conditions and parameters, maximal interval of existence, Global existence of solutions, vector fields and flows, Topological conjugacy and equivalence.

Linear flows on $\mathbb{R}^n$, The matrix exponential, linear first order autonomous systems, Jordan canonical forms, invariant subspaces, stability theory, classification of linear flows, fundamental matrix solution, non-homogeneous linear systems, periodic linear systems and Floquet theory.

α & ω Limit sets of an orbit, attractors, periodic orbits and limit cycles.

Local structure of critical points (the local stable manifold theorem, the Hartman-Grobman theorem, the center manifold theorem), the normal form theory, Lyapunov function, local structure of periodic orbits (Poincaré map and Floquet theory), the Poincaré-Benedixson theorem. Benedixson's criterion, Liénard systems.

Books Recommended:

1. C. Chicone: Ordinary differential Equations with applications.
2. L.D. Perko: Differential Equations and Dynamical Systems.
3. E. A. Coddington and N. Levinson: Theory of Ordinary Differential Equations.

DSE 2: B. Mathematical Modelling
Subject Code: MATH 05DSE2-B
Credits: 6 (Theory-4, Tutorial-2)
Contact Hours per Week: 8 (4 Theory lectures + 4 Practical classes)

Power series solution of a differential equation about an ordinary point, solution about a regular singular point, Bessel's equation and Legendre's equation, Laplace transform and inverse transform, application to initial value problem up to second order.

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.

List of Practicals (using any software)

1. Plotting of Legendre polynomial for $n = 1$ to 5 in the interval [0,1]. Verifying graphically that all the roots of $P_n(x)$ lie in the interval [0,1].
2. Automatic computation of coefficients in the series solution near ordinary points.
3. Plotting of the Bessels function of first kind of order 0 to 3.
4. Automating the Frobenius Series Method.
5. Random number generation and then use it for one of the following (a) Simulate area under a curve (b) Simulate volume under a surface.
6. Programming of either one of the queuing model (a) Single server queue (e.g. Harbor system) (b) Multiple server queue (e.g. Rush hour).
7. Programming of the Simplex method.

Books Recommended

1. T. Myint-U and L. Debnath, Linear Partial Differential Equation for Scientists and Engineers, Springer.
2. F. R. Giordano, M. D. Weir and W. P. Fox, A First Course in Mathematical Modeling, Thomson Learning.

DSE 3: A. Linear Algebra II and Field Theory
Subject Code: MATH 06DSE3-A
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Linear Algebra: Quadratic forms, positive and negative definite matrices; extrema of positive definite quadratic forms. Canonical forms: rational form and Jordan form of a matrix.

Formulae of determinant and inverse of a partitioned matrix, idempotent matrices, left inverse and right inverse of full-rank rectangular matrices, generalized inverse.

Proof of spectral theorem for complex Hermitian and real symmetric matrices, singular value decomposition, polar decomposition, simultaneous diagonalization of commuting Hermitian/real symmetric matrices.

Field theory: Examples: 1) field of fractions of an integral domain, 2) field of rational polynomials. 3) field of Meromorphic functions.

Field extensions, finite and algebraic extensions, algebraic closure of a field, splitting fields; normal extensions, separable extensions, inseparable and purely inseparable extensions, simple extensions; solvability by radicals, radical extensions, ruler and compass constructions.

Finite fields: structure of finite fields, existence and uniqueness theorems; primitive elements, minimal polynomials of elements, irreducible and primitive polynomials.

Books Recommended:

1. Hoffman and Kunze, Linear Algebra, PHI.

2. Gilbert Strang, Linear Algebra and its Applications, Academic.

3. Halmos, Finite Dimensional Vector Spaces, Springer.

4. Friedberg, Insel and Spence, Linear Algebra, Pearson.

5. Dummit and Foote, Abstract Algebra, John Wiley.

6. Hungerford, Algebra, Springer.

7. Morandi, Field and Galois Theory, Springer.

8. J. Howie, Fields and Galois Theory, Springer (UMS).

DSE 3: B. Industrial Mathematics
Subject Code: MATH 06DSE3-B
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Medical imaging and inverse problems: the content is based on mathematics of X-ray and CT-scan based on the knowledge of calculus, elementary differential equations, complex numbers and matrices.

Introduction to inverse problems: "Why should we teach Inverse Problems?"
Illustration of inverse problems through problems taught in pre-calculus, calculus, matrices and differential equations, geological anomalies in earth's interior from measurements at its surface (inverse problems for natural disaster) and (T)omography.

X-ray: introduction, X-ray behavior and Beer's Law (the fundament question of image construction), lines in the place.

Radon Transform: definition and examples, linearity, phantom (Shepp-Logan phantom: mathematical phantoms).

Back Projection: definition, properties and examples.

CT Scan: revision of properties of Fourier and inverse Fourier transforms and applications of their properties in image reconstruction; algorithms of CT-scan machine, algebraic reconstruction techniques (abbreviated as ART) with application to CT-scan.

Books Recommended:

1. T. G. Feeman, The Mathematics of Medical Imaging, A Beginners Guide, Springer.
2. C.W. Groetsch, Inverse Problems, Activities for Undergraduates, MAA.
3. A. Kirsch, An Introduction to the Mathematical Theory of Inverse Problems.

DSE 4: A. Mechanics
Subject Code: MATH 06DSE4-A
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Statics: coplanar forces, astatic equilibrium, friction, principle of virtual work, stable and unstable equilibrium, centre of gravity for different bodies, general conditions of equilibrium, central forces and forces in three dimensions.

Particle dynamics: Newton's equation of motion of a particle, simple illustrations: simple harmonic motion, particle in a central field; central orbits and Kepler's laws, constrained motion, oscillatory motion, motion of simple pendulum.

Rigid-body dynamics: moments and products of inertia, D'Alembert's principle of motion, compound pendulum, motion in two dimensions, conservation of linear and angular momentum, conservation of energy; derivation of Lagrange's equation for conservative holonomic system from D'Alembert's principle and from variational principle; solution of problems by Lagrange's equation.

Books Recommended:

1. S. L. Loney: Elements of Statics and Dynamics 1 and 2.
2. S. L. Loney: An Elementary treatise on Dynamics of particle and rigid bodies.
3. F. Chorlton: Textbook of Dynamics.
4. N. Rana and P. Joag: Classiscal Mechanics, McGraw-Hill.
5. H. Goldstein: Classical Mechanics, Pearson.

DSE 4: B. Differential Geometry
Subject Code: MATH 06DSE4-B
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Review of multivariate calculus: directional and total derivatives, inverse & implicit function thms.

Theory of curves: parametrized curves, regular curves and arc lengths, reparametrization of regular curves, planer curves, curvature as an invariant of a planar curve; spatial curves, torsion of a spatial curves, Serret-Frenet formulae; Isoperimetric inequality, the four vertex theorem.

Theory of surfaces: definition of smooth parametrized surfaces in $\mathbb{R}^3$; examples: (regular) level surfaces, quadric surfaces, ruled surfaces, surfaces of revolution; smooth functions on a surface, smooth curves on a surface, tangent planes (in particular of level surfaces in $\mathbb{R}^3$), derivative of a smooth map and Jacobian matrix, gradient vectors, smooth vector fields on surfaces in $\mathbb{R}^3$, tangent vector fields and integral curves, first fundamental forms and length of curves, isometries of surfaces, conformal mappings of surfaces, normal vectors and orientation of a surface.

Geometry of surfaces: Geodesics - definition and example (in particular, geodesics on a surface of revolution), second fundamental form, Gauss and Weingarten maps and their properties, normal and geodesic curvatures, parallel transport and covariant derivative, Christoffel symbols, Gaussian and mean curvature, principal curvatures of a surface, flat surfaces, surfaces of constant mean curvature, Gaussian curvature of compact surfaces (in $\mathbb{R}^3$). Basic properties of geodesics and geodesic coordinates. The Gauss' equation and Codazzi-Mainardi equations, Gauss' Theorema Egregium, surfaces of constant Gaussian curvature.

Differential forms in $\mathbb{R}^3$, exterior product and exterior derivative of forms, closed and exact forms, Poincaré lemma. Forms on surfaces, integration on surfaces, Stoke's theorem, Gauss-Bonnet theorem for compact surfaces.

Books Recommended

1. Thorpe: Elementary Topics in Differential Geometry, Springer.
2. do Carmo: Differential Geometry of Curves and Surfaces, Dover.
3. Pressley: Elementary Differential Geometry, Springer (UMS).
4. do Carmo: Differential Forms and Applications, Springer (Universitext).

Skill Enhancement Courses:

SEC 1: Computer Programming
Subject Code: MATH 03SEC1
Credits: 4 (Theory-2, Tutorial-2)
Contact Hours per Week: 4 (2 Theory lectures + 2 Tutorials)

Introduction to programming in the C language: arrays, pointers, functions, recursive pro- gramming and linked lists; notion of algorithms and their complexity, order notation; lists, stacks, queues and trees; searching and sorting algorithms; object-oriented programming and introduction to C++

Books Recommended

1. B. Kernighan & D. Ritchie, The C programming Language.
2. E. Horowitz and S. Sahani, Fundamentals of Data Structure.

SEC 2: Latex
Subject Code: MATH 04SEC2
Credits: 4 (Theory-2, Tutorial-2)
Contact Hours per Week: 4 (2 Theory lectures + 2 Tutorials)

Latex: Introduction to Latex; Document structure; Typesetting text, math formulas and expressions; Tables; Figures; Equations; Bibtex; Beamer presentation.

Books Recommended:

1. H. Kopka & P.W. Daly, Guide to Latex.
2. S. Kottwitz, Latex Beginner's Guide.

General Elective Courses (to be offered to the students of other departments):

GE 1: Calculus - I
Subject Code: MATH 01GE1
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Real Numbers: Axiomatic defnition. Intuitive idea of completeness.

Real-valued functions defined on an interval : Limit of a function (Cauchy's defnition). Algebra of limits. Continuity of a function at a point and in an interval. Acquaintance with the important properties of continuous functions on closed intervals.

Derivative its geometrical and physical interpretation. Sign of derivative Monotonic increasing and decreasing functions. Relation between continuity and differentiability.

Successive derivative (Leibnitz's Theorem and its application).

Mean Value Theorems and expansion of functions like e^x; $\sin x$; $\cos x$; $(1 + x)^n$; $\ln(1 + x)$ (with validity of regions).

Applications of Differential Calculus : Maxima and Minima, Tangents and Normals, Pedal equation of a curve. De
nition and examples of singular points (viz. Node, Cusp, Isolated point).

Indeterminate Forms : L'Hospital's Rule.

Sequence of real numbers: convergence, Cauchy criteria and other elementary properties. Series of real number, Absolute and conditional convergence of series.

Books Recommended:

1. S. Bartle, Introduction to Real Analysis.
2. T.M.Apostol, Calculus (Vol. I).
3. D. Widder, Advanced Calculus.
4. Shanti Narayan, Differential Calculus.

GE 2: Calculus - II
Subject Code: MATH 02GE2
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Integration of the form $\int \frac{dx}{a+b\cos x}$, $\int \frac{l\sin x + p\cos x}{m\sin x + n\cos x}dx$ and integration of rational functions.

2. Evaluation of definite integrals.

Integration as the limit of a sum (with equally spaced as well as unequally spaced intervals)

Reduction formulae of $\int \sin^m x\cos^n x dx$; $\int \tan^n x dx$ and $\int \frac{\sin^m x}{\cos^n x}dx$ and associated problems (m and n are non-negative integers).

Definition of Improper Integrals : Statements of (i) μ-test, (ii) Comparison test. Use of Beta and Gamma functions.

Applications: rectification, quadrature, finding c.g. of regular objects, volume and surface areas of solids formed by revolution of plane curve and areas.

Order and solution of an ordinary differential equation (ODE) in presence of arbitrary constants. Formation of ODE.

First order differential equations : (i) Variables separable. (ii) Homogeneous equations and equations reducible to homogeneous forms. (iii) Exact equations and those reducible to such equation. (iv) Euler's and Bernoulli's equations (Linear). (v) Clairaut's Equations : General and Singular solutions.

Orthogonal Trajectories.

Second order linear equations : Second order linear differential equations with constant coefficients. Euler's Homogeneous equations.

Books Recommended

1. Shanti Narayan, Integral Calculus.

2. T.M.Apostol, Calculus (Vol. I).

3. G.F. Simmons, Differential Equations with Applications and Historical Notes.

GE 3: Algebra
Subject Code: MATH 03GE3
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Complex Numbers: De Moivre's Theorem and its applications. Exponential, Sine, Cosine and Logarithm of a complex number. Definition of e^z, Inverse circular and Hyperbolic functions.

Theory of Equations: Fundamental Theorem of Algebra. Polynomials with real coefficients: Descarte's Rule of sign and its applications. Relation between roots and coefficients. Symmetric functions of roots, Transformations of equations. Solution of a cubic and biquadratic.

Introduction of Group Theory: Definition and examples. Elementary properties using definition of Group. Subgroup, Quotient group, Normal subgroup, Homomorphism and isomorphism.

Rings and Integral Domains: Definition and examples. Subrings and ideals. Quotient ring. Homomorphism ans isomorphism of rings.

Fields: Defnition and examples.

Vector (Linear) space over a field. Subspaces. Linear combinations. Linear dependence and independence of a set of vectors. Linear span. Basis. Dimension. Replacement Theorem. Extension theorem. Deletion theorem.

Row Space and Column Space of a Matrix. Rank of a matrix. Rank(AB) $\leq$ min(Rank A; Rank B).

System of Linear homogeneous equations: Solution space of a homogeneous system and its dimension. System of linear non-homogeneous equations: Necessary and sufficient condition for the consistency of the system. Method of solution of the system of equations.

Linear Transformation (L.T.) on Vector Spaces: Null space. Range space. Rank and Nullity, Sylvester's law of Nullity. Inverse of Linear Transformation. Non-singular Linear Transformation. Change of basis by Linear Transformation. Vector spaces of Linear Transformation.

Characteristic equation of a square matrix. Eigen-value and Eigen-vector. Invariant subspace. Cayley- Hamilton Theorem. Simple properties of Eigen value and Eigen vector.

Books Recommended

1. S. Kumaresan, Linear Algebra: A Geometric Approach, PHI.
2. Rao, Bhimashankaran: Linear Algebra, HBA (TRIM)
3. J.B. Fraleigh, First Course in Abstract Algebra, Narosa.

GE 4: Analytical Geometry
Subject Code: MATH 04GE4
Credits: 6 (Theory-5, Tutorial-1)
Contact Hours per Week: 6 (5 Theory lectures + 1 Tutorial)

Analytical Geometry of two dimensions: Transformations of Rectangular axes: Translation, Rotation and their combinations. Invariants.

General equation of second degree: Reduction to canonical forms and Classification.

Pair of straight lines: Condition that the general equation of 2nd degree may represent two straight lines. Points of intersection of two intersecting straight lines. Angle between two lines. Equation of bisectors of angles. Equation of two lines joining the origin to the points in which a line meets a second degree curve.

Equations of pair of tangents from an external point, chord of contact, poles and polars in case of general conic : Particular cases for Parabola, Ellipse, Circle and Hyperbola.

Polar equation of straight lines and circles. Polar equation of a conic referred to a focus as pole. Equation of chord joining two points. Equations of tangent and normal.

Analytical Geometry of three dimensions: Rectangular Cartesian co-ordinates: Distance between two points. Division of a line segment in a given ratio. Direction cosines and direction ratios of a straight line. Projection of a line segment on another line. Angle between two straight lines.

Equation of a Plane: General form. Intercept and Normal form. Angle between two planes. Signed distance of a point from a plane. Bisectors of angles between two intersecting planes.

Equations of Straight line: General and symmetric form. Distance of a point from a line. Shortest distance between two skew-lines. Coplanarity of two straight lines.

Sphere and its tangent plane.

Right circular cone and right circular cylinder. Familiarity with conicoids. Spherical and cylindrical coordinates.

Books Recommended:

1. S.L. Loney, The Elements of Coordinate Geometry, McMillan.

2. J.T. Bell, Elementary Treatise on Coordinate Geometry of Three Dimensions, McMillan.