CURRICULUM
FOR
B.SC.(HONOURS)
IN
MATHEMATICS

Under Choice Based Credit System

(CBCS)

Effective from the academic session 2016-2017

KAZI NAZRUL UNIVERSITY

ASANSOL-713 340

WEST BENGAL

Department of “Mathematics”, Kazi Nazrul University, Asansol

Curriculum for B.Sc. Honours in Mathematics [Choice Based Credit System]

Semester-I

Sr. No.	Name of the Subject	Nature	Code	Teaching Scheme in hour per week			credit
				L	T	P	
1	Unit 1: Classical Algebra Unit 2: Abstract Algebra I	Core Course-I		5	1	0	6
2	Unit 1: Real Analysis I Unit 2: Integral Calculus	Core Course-II		5	1	0	6
3	GE-I	GE					4/5
	GE-I Lab/Tutorial	GE					2/1
4	EVS	AECC		4			4
							Total Credit =22

Semester-II

Sr. No.	Name of the Subject	Nature	Code	Teaching Scheme in hour per week			credit
				L	T	P	
1	Unit 1: Linear Algebra Unit 2: Abstract Algebra II	Core Course III		5	1	0	6
2	Unit 1: Geometry of two-dimension Unit 2: Geometry of three-Dimension	Core Course-IV		5	1	0	6
3	GE-II	GE					4/5
	GE-II Lab/Tutorial	GE					2/1
4	MIL	AECC					2
							Total Credit =20

Semester-III

Sr. No.	Name of the Subject	Nature	Code	Teaching Scheme in hour per week			credit
				L	T	P	
1	Unit 1: Vector Analysis Unit 2: Tensor Calculus	Core Course-V		5	1	0	6
2	Unit 1: Real Analysis II Unit 2: Number Theory	Core Course-VI		5	1	0	6
3	Differential Equations	Core Course VII		5	1	0	6
4	GE-III	GE					4/5
	GE-III Lab/Tutorial	GE					2/1
5	SEC –I	AEEC-I					2
				Total Credit =26			

Semester-IV

Sr. No.	Name of the Subject	Nature	Code	Teaching Scheme in hour per week			credit
				L	T	P	
1	Real Analysis III	Core Course-VIII		5	1	0	6
2	Introduction to Operations Research	Core Course IX		5	1	0	6
3	Mechanics I (Dynamics of a Particle)	Core Course X		5	1	0	6
4	GE-IV	GE					4/5
	GE-IV Lab/Tutorial	GE					2/1
5	SEC –II	AEEC-II					2
				Total Credit = 26			

Semester-V

<table>
<tr><th rowspan="2">Sr. No.</th><th rowspan="2">Name of the Subject</th><th rowspan="2">Nature</th><th rowspan="2">Code</th><th colspan="3">Teaching Scheme in hour per week</th><th rowspan="2">credit</th></tr>
<tr><th>L</th><th>T</th><th>P</th></tr>
<tr><td>1</td><td>Unit 1: Metric Spaces
Unit 2: Elementary complex analysis</td><td>Core Course XI</td><td></td><td>5</td><td>1</td><td>0</td><td>6</td></tr>
<tr><td>2</td><td>Mechanics II
(Dynamics of a system of Particles, rigid body Dynamics and statics)</td><td>Core Course XII</td><td></td><td>5</td><td>1</td><td>0</td><td>6</td></tr>
<tr><td rowspan="2">3</td><td>DSE –I</td><td>DSE-I</td><td></td><td></td><td></td><td></td><td>4/5</td></tr>
<tr><td>DSE –I / Lab Tutorial</td><td>DSE-I</td><td></td><td></td><td></td><td></td><td>2/1</td></tr>
<tr><td rowspan="2">5</td><td>DSE –II</td><td>DSE-II</td><td></td><td></td><td></td><td></td><td>4/5</td></tr>
<tr><td>DSE –II Lab/ Lab Tutorial</td><td>DSE-II</td><td></td><td></td><td></td><td></td><td>2/1</td></tr>
<tr><td colspan="4"></td><td colspan="4">Total Credit = 24</td></tr>
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<u>Pool of DSE-I and DSE-II</u>

(Choose any two from the following)

Marks: 50 (Credits: Theory: 5, Tutorial: 1) for each topic

i) Element of Topology & Functional Analysis
ii) Linear Algebra
iii) Mathematical Modelling
iv) Integral Transforms.
v) Probability & Statistics

Semester-VI

Sr. No.	Name of the Subject	Nature	Code	Teaching Scheme in hour per week			credit
				L	T	P	
1	Numerical Analysis & Computer Programming	Core Course-XIII		5	1	0	6
2	Computer aided numerical Laboratory	Core Course-XIV		4	0	2	6
3	DSE –III	DSE-III					4/5
	DSE –III / Lab Tutorial	DSE-III					2/1
4	DSE –IV	DSE-IV					4/5
	DSE –IV Lab/ Lab Tutorial	DSE-IV					2/1
				Total Credit =24			

<u>Pool of DSE-III and DSE-IV</u>

(Choose any two from the following)

Marks: 50 (Credits: Theory: 5, Tutorial: 1) for each topic

i. Discrete Mathematics
ii. Special Theory of Relativity
iii. Optimization Techniques
iv. Programming in C with applications
v. Classical mechanics

<u>Total Credit: 142</u>

SEMESTER I

CORE COURSE-I

Unit-1: Classical Algebra, Unit-2: Abstract Algebra

Total Marks: 50 (10 marks reserved for internal assessment) Credit: 6

Unit I: Classical Algebra (30 Marks)

Inequalities: Arithmetic mean, geometric mean and harmonic mean; Schwarz inequality and Weierstrass's inequality. Simple continued fraction and its convergence, representation of real numbers.

Complex numbers: De Moivre's theorem, roots of unity, exponential function, Logarithmic function, Trigonometric function, hyperbolic function and inverse circular function.

Polynomial: polynomial equation, Fundamental theorem of algebra (statement only), multiple roots, statement of Rolle's theorem only and its application, equation with real coefficients, complex roots, Descarte's rule of sign, location of roots, Sturm's theorem, relation between roots and coefficients, transformation of equation, Reciprocal equations, special roots of unity, solution of cubic equations- Cardan's method, solution of biquadratic equation – Ferrari's method.

Well ordering principle for $\mathbb{N}$, division algorithm, Principle of mathematical induction and its simple applications, Prime and composite numbers, Fundamental theorem of arithmetic, greatest common divisor, relatively prime numbers, Euclid's algorithm, least common multiple.

Unit 2: Abstract Algebra I (20 Marks)

Surjective, injective and bijective mapping, composition of two mappings, inverse mapping, extension and restriction of mappings, equivalence relation.

Group: Definition, examples, subgroups, necessary and sufficient condition for a nonempty set to be a subgroup, generator of a group and a subgroup, order of a group and order of an element, Abelian group.

Permutation group, cycles, length of a cycle, transposition, even and odd permutation, alternating group, examples of S_3 and K_4 (Klein 4-group).

Cyclic subgroups of a group, cyclic groups and their properties, groups of prime order, coset, Lagrange's theorem.

Ring, Characteristic of a Ring, subring, integral domain, elementary properties, field, skew field, subfields, characteristic of a field or integral domain, finite integral domain, elementary properties.

References:

1. J. Gallian, *Contemporary Abstract Algebra*, Cengage Learning, 7th Edition, 2009.
2. I. N. Herstein, *Topics in Algebra*, John Wiley & Sons; 2nd Edition, 1975.
3. P. Mukhopadhyay, S. Ghosh and M. K. Sen, *Topics in Abstract Algebra*, University Press.
4. J. B. Fraleigh, *First Course in Abstract Algebra*, Pearson, 2002.
5. S. K. Mapa, *Higher Algebra (Classical)*, Sarat Book House, 8th Edition, 2013.
6. S. Barnard and J. M. Child, *Higher Algebra*, Macmillan and Company Limited,
7. Burnside & Panton, *The Theory of Equations*, Hodges Figgis And Company.
8. B. C. Chatterjee, *Abstract Algebra*, Vol. I, Das Gupta, 1957.
9. Barnard & Child: Higher Algebra, Macmillan and Company Limited, 1936.
10. Niven, Zuckerman and Montogomery, *An Introduction to the Theory of Numbers*, John Wiley & Sons, 5th Edn,1991.
11. David M. Burton, *Elementary Number Theory*, McGraw-Hill, 7th Edn, 2010.
12. G. A. Jones and J. M. Jones, *Elementary Number Theory*, Springer International Edition,

CORE COURSE-II

Unit-1: Real Analysis I, Unit-2: Integral Calculus

Total Marks: 50 (10 marks reserved for internal assessment) Credit: 6

Unit I: Real Analysis I (30 Marks)

A brief discussion on the real number system: Field structure of R, order relation, Archimedean properties, order completeness properties of R. Arithmetic continuum, geometric continuum, neighbourhood of a point, neighbourhood system, interior points, open sets, limit points, derived sets, closed sets, closure.

Sequence, limit of a sequence, bounded sequence, convergence, divergence, Oscillatory sequence, (only definitions and simple examples). Sandwich Theorem, Bounded functions, monotone functions. Limit of a function at a point. Sequential criterion on limit, Continuity of a function at a point and on an interval. Sequential criterion on continuity, Properties of continuous functions over a closed and bounded interval. Uniform continuity.

Derivative of a function. Successive differentiation, Leibnitz's theorem, Rolle's theorem, mean value theorems. Intermediate value property, Darboux theorem. Taylor's theorem, and Maclaurin's theorem with Lagrange's and Cauchy's forms of remainders. Taylor's series. Expansion of elementary functions such as $e^x, cosx, sinx, (1+x)^n, \log(1+x)$ etc.

Envelope, asymptote, curvature. Curve tracing: Astroid, cycloid, cardioids, folium of Descartes. Maxima, minima, concavity, convexity, singularity. Indeterminate forms. L'Hospital's theorem. Real valued Functions of several variables (two and three variables). Continuity and differentiability. Partial derivatives. Commutativity of the orders of partial derivatives. Schwarz's theorem, Young's theorem, Euler's theorem.

Unit 2: Integral Calculus (20 Marks)

Definite Integral – Definition of Definite Integral as the Limit of a Sum; Fundamental Theorem of Integral Calculus (statement only). General Properties of Definite Integral; Integration of Indefinite and Definite Integral by Successive Reduction.

Multiple Integral – Definition of Double Integral and Triple Integral as the Limit of a Sum; Evaluation of Double Integral and Triple Integral; Fubini's Theorem (statement and applications).

Applications of Integral Calculus – Quadrature and Rectification; Intrinsic Equations of Plane Curves; Evaluation of Lengths of Space Curves, Areas of Surfaces and Volumes of Solids of Revolution. Evaluation of Centre of Gravity of some Standard Symmetric Uniform Bodies: Rod; Rectangular Area, Rectangular Parallelepiped, Circular Arc, Circular Ring and Disc, Solid and Hollow Spheres, Right Circular Cylinder and Right Circular Cone.

References:

1. L. J. Goldstein, David Lay, N.I.Asmar, David I. Schneider, *Calculus and Its Applications*, Pearson, New International Edition, 2014
2. W. Rudin, *Principles of Mathematical Analysis*, TMH, Third Edition , Indian Edition
3. T. M. Apostal, *Mathematical Analysis*, Narosa Book Disributors Pvt. Ltd.
4. G. B. Folland, *Advanced Calculus*, University of Washington, Pearson.
5. R. R. Goldberg, *Methods* of *Real analysis*, Oxford and IBH Publishing Co. Pvt. Ltd.
6. R. G. Bartle and D. R. Sherbert, *Introduction to Real Analysis*, Wiley India Pvt. Ltd.
7. S. K. Mapa, *Introduction to Real Analysis*, Sarat Book Distributors.
8. Shantinarayan, P.K. Mittal, *Integral Calculus*, S. Chand Publishing.
9. Shantinarayan, *Mathematical Analysis*, S. Chand and Company Ltd.
10. J. Edwards, *Differential Calculus for Beginners*, MacMilan.
11. G. B. Thomas, M. D. Weir, J. R. Hass, *Thomas Calculus* , Pearson.
12. B. Williamson, An Elementary Treatise on the Integral Calculus, D. Appleton and Co.
13. S. C. Malik & S. Arora, *Mathematical Analysis*, New Age International Publishers.

SEMESTER II

C O R E   C O U R S E - I I I

Unit-1: Linear Algebra, Unit-2: Abstract Algebra II

Total Marks: 50 (10 marks reserved for internal assessment) **Credit: 6**

Unit 1: Linear Algebra (30 Marks)

Matrices of real and complex numbers: Algebra of matrices, symmetric and skew-symmetric matrices, Hermitian and skew-Hermitian matrices, orthogonal matrices.

Determinants: Definition, Basic properties of determinants, Minors and cofactors. Laplaces method. Vandermonde's determinant. Symmetric and skew symmetric determinants. (No proof of theorems).

Adjoint of a square matrix. Invertible matrix, Non-singular matrix. Inverse of an orthogonal Matrix.

Elementary operations on matrices. Echelon matrix. Rank of a matrix. Determination of rank of a matrix (relevant results are to be state only). Normal forms. Elementary matrices. Statements and application of results on elementary matrices. Congruence of matrices (relevant results are to be state only), normal form under congruence, signature and index of a real symmetric matrix.

Vector space: Definitions and examples, Subspace, Union and intersection of subspaces. Linear sum of two subspaces. Linear combination, independence and dependence. Linear span. Generators of vector space. Dimension of a vector space. Finite dimensional vector space. Examples of infinite dimensional vector spaces. Replacement Theorem, Extension theorem. Extraction of basis. Complement of a subspace.

Row space and column space of a matrix. Row rank and column rank of a matrix. Equality of row rank, column rank and rank of a matrix.

Linear homogeneous system of equations : Solution space. Necessary and sufficient condition for consistency of a linear non-homogeneous system of equations. Solution of system of equations (Matrix method). Linear Transformation on Vector Spaces: Definition of Linear Transformation, Null space, range space of an Linear Transformation, one-one, onto, invertible, linear transformation, Rank and Nullity, Rank-Nullity Theorem and related problems.

Unit 2: Abstract Algebra II (20 Marks)

Normal subgroups of groups and their properties, homomorphism between the two groups, isomorphism, kernel of a homomorphism, first isomorphism theorem, isomorphism of cyclic groups. Ideal of a Ring (definition, examples and simple properties).
Partial order relation, Poset, maximal and minimal elements, infimum and supremum of subsets, Lattices, definition of lattice in terms of meet and join, equivalence of two definitions.
Boolean algebra, Huntington postulates, examples, principle of duality, atom, Boolean function, conjunctive normal form, disjunctive normal form, switching circuits.

References:

1. J. Gallian, *Contemporary Abstract Algebra*, Cengage Learning.
2. M. Artin, *Abstract Algebra*, Pearson.
3. Otto Bretscher, *Linear Algebra with Applications*, Pearson.
4. Sen, Ghosh & Mukhopadhyay, *Topics in Abstract Algebra*, University Press,
5. Promode Kumar Saikia, *Linear Algebra with Applications*, Pearson.
6. J. B. Fraleigh, A First Course in Abstract Algebra, Pearson, 2002.
7. Birkhoff & Maclane, *Survey of Modern Algebra*, Macmillan, 3rd edition, 1965.
8. B. C. Chatterjee, *Abstract Algebra*, Vol. I, Das Gupta, 1957.
9. David C. Lay, *Linear Algebra and its Applications*, Pearson, Fourth Edition, 2011.
10. S. H. Friedberg, A. J. Insel and L. E. Spence, *Linear Algebra*, Prentice Hall of India.
11. K. M. Hoffman and R. Kunze, *Linear Algebra*, Prentice Hall if India
12. S. Kumaresan, *Linear Algebra: A Geometrical Approach*, Prentice Hall of India.
13. A. R. Rao and P. Bhimasankaram, *Linear Algebra*, Hindustan Book Agency.
14. S. K. Mapa, *Higher Algebra (Abstract and Linear)*, Sarat Book House.

CORE COURSE-IV

Unit-1: Geometry of two-dimension, Unit-2: Geometry of three-dimension

Total Marks: 50 (10 marks reserved for internal assessment) Credit: 6

Unit 1: Geometry of two-dimension (20 Marks)
Fundamental concepts of Geometry: Euclid's postulates. Cartesian Frame of reference.

Transformation of rectangular coordinate axes using matrix treatment: Translation, Rotation and their composition. Theory of invariants using matrix method. General equation of second order degree. Reduction to its normal form. Classification of conics. Pair of tangents. Chord of contacts. Pole and polar, Conjugate points and conjugate lines. Diameter and conjugate diameter.

Pair of straight lines. Homogeneous second degree equation. Angle between them. Bisectors of angles between pair of lines. Condition that an equation of second degree represents a pair of straight lines. Point of intersection. Pair of lines through the origin and the points of intersection of a line with a conic. Polar equation of a conic, tangent, normals, chord of contact.

Unit 2: Geometry of three-dimension (30 Marks)

Fundamental concepts. Orthogonal Cartesian Frame of reference. Coordinate system. Orthogonal projection. Direction cosines and ratios.

Transformations of rectangular coordinate axes using matrix treatment: Translation, Rotation and rigid motion. Theory of invariants using matrix method. General equation of second degree involving three variables. Reduction to its normal form. Classification of surfaces.

Plane. Various form of equations of planes. Pair of planes. Angle between them. Bisectors of angles of pair of lines. Condition that a second degree equation represents a pair of planes. Point of intersection. Condition of perpendicularity and parallelism of pair of planes.

Straight line. Symmetric and non-symmetric form of straight line and conversion of one into another form. Angle between two straight lines. Distance of a point from a line. Angle between a line and a plane. Coplanarity of two lines. Shortest distance between two lines and its equation. Position of a line relative to a plane. Lines intersecting a number of lines. Tetrahedron.

Sphere, Cone, Cylinder. Condition that a general equation of second degree represents these surfaces. Section of these surfaces by plane; Circle, Generators. Sphere through a circle. Radical plane. Tangent plane. Tangent line. Normal. Enveloping cone and cylinder. Reciprocal cone.

Surfaces of revolution. Ellipsoid. Hyperboloid of one and two sheets. Elliptic Paraboloid. Hyperbolic paraboloid. Normal forms. Tangent Plane. Normal line. Generating lines and some properties.

References:

1. P. R. Vittal, *Analytical Geometry 2D and 3D*, Pearson Education.
2. S. L. Loney, *The Elements of Coordinate Geometry*, Reem Publications Pvt. Ltd.
3. E. H. Askwith, *A Course of Pure Geometry*, Macmillan & Co. Ltd.
4. R. J. T. Bell, *An Elementary Treatise on Co-ordinate Geometry*, Macmillan & Co. Ltd.
5. M. C. Chaki, *A Text Book of Analytical Geometry*, Calcutta Publishers.
6. R. M. Khan, *Analytical Geometry of Two and Three Dimension and Vector Analysis*, New Central Book Agency.

SEMESTER III

CORE COURSE-V

Unit-1: Vector Analysis, Unit-2: Tensor Calculus

Total Marks: 50 (10 marks reserved for internal assessment) **Credit: 6**

Unit 1: Vector Analysis (30 Marks)

[**Prerequisites -** Vector Algebra: Addition of vectors, scalar and vector products of two vectors, representation of a vector in E3, components and resolved parts of vectors. Point of division of a line segment, signed distance of a point from a plane, vector equation of a straight line and a plane, shortest distance between two skew lines].

Product of vectors: Scalar and vector triple products, product of four vectors. Applications of vector algebra - (i) in geometrical and trigonometrical problems (ii) to find work done by a force, moment of a force about a point and about a line (iii) to calculate volume of a tetrahedron. Continuity and differentiability of vector-valued function of one variable. Velocity and acceleration. Space curve, arc length, tangent, normal. Integration of vector-valued function of one variable. Serret-Frenet Formula Vector-valued functions of two and three variables, gradient of scalar function, gradient vector as normal to a surface. Divergence and curl, their properties. Evaluation of line integral of the type

$$\int_C \varphi(x,y,z)d\vec{\gamma},\ \int_C \vec{F}.d\vec{\gamma},\ \int_C \vec{F}\times d\vec{\gamma}$$

Green's theorem in the plane. Gauss and Stokes theorems (Proof not required), Green's first and second identities. Evaluation of surface integrals of the type

$$\iint_S \varphi\,\overrightarrow{dS},\ \iint_S \vec{F}.\overrightarrow{dS},\ \iint_S \vec{n}\times\vec{F}\,\overrightarrow{dS}$$

Unit 2: Tensor Calculus (20 Marks)

Historical study of tensor. Concept of E^n . Tensor as a generalization of vector in E^2, E^3 and E^n. Einstein's Summation convention. Kronecker delta. Algebra of tensor: Invariant. Contravariant and covariant vectors. Contravariant, covariant and mixed tensors. Symmetric and skew-symmetric tensors. Addition, subtraction and scalar multiplication of tensors. Outer product, inner product and contraction. Quotient law. Calculus of tensor: Riemannian space. Line element. Metric tensor. Reciprocal metric tensor. Raising and lowering of indices. Associated tensor. Magnitude of vector. Angle between two vectors. Christoffel symbols of different kinds and laws of transformations. Covariant differentiation. Gradient, divergence, curl and Laplacian. Ricci's theorem. Riemann-Christoffel curvature tensor. Ricci tensor. Scalar curvature. Einstein's space (Definition only).

References:

1. B. Spain, *Vector Analysis*, D.Van Nostrand Company Ltd., 1965.
2. L. Brand, *Vector Analysis*, Dover Publications Inc., 2006.

3. Shanti Narayan, *A Text Book of Vector Analysis*, S.Chand publishing, 19th Edition, 2013.
4. P.K.Nayak, Vector Algebra & Analysis with Applications, University Press.
5. M. Spiegel, S. Lipschutz, D. Spellman, *Vector Analysis*, McGraw-Hill, 2nd Edition, 2009.
6. C. E. Weatherburn, *Elementary Vector Analysis*: *With Application to Geometry and Physics*, Bell, 1921.
7. E. W. Hobson, *A Treatise of Plane Trigonometry*, Cambridge, University Press, 3rd Edition, 1911.
8. D. E. Rutherford, *Vector Methods*, Oliver and Boyd, 1965.
9. I. S. Sokolnikoff, *Tensor Analysis: Theory and Applications*, John Wiley and Sons, Inc., New York, 1951.
10. M. C. Chaki, *A Text Book of Tensor Calculus*, Calcutta Publishers, 2000.
11. U. C. De, A. A. Shaikh and J. Sengupta, *Tensor Calculus*, Alpha Science International Ltd; 2nd Revised Edition, 2007.
12. B. Spain, *Tensor Calculus: A Concise Course*, Dover Publications, 2003.

CORE COURSE-VI

Unit-1: Real Analysis II, Unit-2: Number Theory

Total Marks: 50 (10 marks reserved for internal assessment) Credit: 6

Unit 1: Real Analysis II (30 Marks)

Definition of Riemann integration. Uniqueness. Darboux theory of Riemann integration. Equivalence of the two definitions. Darboux theorem (proof not required). Properties of Riemann integral. Riemann integrability of continuous function, monotone function and function having countable number of discontinuities, functions defined by the integral, their continuity and differentiability.

Fundamental theorem of integral calculus. Equivalence of Riemann integral and the anti derivative (i.e., integration as inverse process of differentiation) for continuous functions.

First and second mean value theorems of integral calculus integration by parts for Riemann integrals.

Improper integral and their convergence (for unbounded functions and for unbounded range of integration) Abel's and Dirichlet's test. Beta and Gamma functions. Evaluation of improper integrals:

$$\int_0^{\pi/2} logsinxdx; \int_0^{\infty} \frac{sinx}{x} dx; \int_0^{\infty} e^{-ax} \frac{sin\beta x}{x} dx, \qquad \alpha > 0;$$

and integrals dependent on them.

Unit 2: Number Theory (20 Marks)

Congruences: properties and algebra of congruences, Fermat's theorem, Wilson's theorem, Euler's theorem (generalization of Fermat's theorem), Linear congruence, system of linear congruence theorem. Chinese remainder theorem.

Number of divisors of a number and their sum, least number with given number of divisors. Eulers φ function, properties of φ function, arithmetic function, Mobius μ - function, relation between φ function and μ function. Diophantine equations of the form ax+by = c, a, b, c integers.

References:

1. L.J Goldstein, David Lay, N.I.Asmar, David I. Schneider, *Calculus and Its Applications*, Pearson.
2. W. Rudin, *Principles of Mathematical Analysis*, TMH.
3. T. M. Apostal, *Mathematical Analysis*, Narosa Book Disributors Pvt. Ltd.
4. G. B. Folland, *Advanced Calculus*, University of Washington, Pearson.
5. R. R. Goldberg, *Methods* of *Real analysis*, Oxford and IBH Publishing Co. Pvt. Ltd.
6. R. G. Bartle and D. R. Sherbert, *Introduction to Real Analysis*, Wiley India Pvt. Ltd
7. S. K. Mapa, *Introduction to Real Analysis*, Sarat Book Distributors.
8. Shantinarayan, P.K. Mittal, *Integral Calculus*, S. Chand Publishing.
9. Shantinarayan, *Mathematical Analysis*, S. Chand and Company Ltd.
10. J. Edwards, *Differential Calculus for Beginners*, MacMilan.
11. G. B. Thomas, M. D. Weir, J. R. Hass, *Thomas Calculus*, Pearson.
12. 12. B. Williamson, An Elementary Treatise on the Integral Calculus, D. Appleton and Co.,
13. S. C. Malik & S. Arora, *Mathematical Analysis*, New Age International Publishers.
14. S. K. Mapa, *Higher Algebra (Classical)*, Sarat Book House.
15. G. A. Jones and J. M. Jones, *Elementary Number Theory*, Springer International Edition.

CORE COURSE-VII

Differential Equations

Total Marks: 50 (10 marks reserved for internal assessment) Credit: 6

Ordinary Differential Equations (Marks - 40)

Picard's existence theorem (statement only) for $\frac{dy}{dx} = f(x, y)$ with $y = y_0$ at $x = x_0$. Exact differential equations, condition of integrability. Equation of first order and first degree-exact equations and those reducible to exact form. Equations of first order higher degree-equations solvable for $p = \frac{dy}{dx}$, equations solvable for y, equation solvable for x, singular solutions, Clairaut's form. Singular solution as envelope to family of general solution to the equation. Linear differential equations of second and higher order. Two linearly independent solutions of second order linear differential equation and Wronskian, general solution of second order linear differential equation, solution of linear differential equation of second order with constant coefficients. Particular integral for second order linear differential equation with constant coefficients for polynomial, sine, cosine, exponential function and for function as combination of them or involving them. Method of variation of parameters for P.I. of linear differential equation of second order. Homogeneous linear equation of n-th order with constant coefficients. Reduction of order of linear differential equation of second order when one solution is known. Simultaneous linear ordinary differential equation in two dependent variables. Solution of simultaneous equations of the form $dx/P = dy/Q = dz/R$. Equation of the form (Paffian form) Pdx +Qdy+Rdz = 0. Necessary and sufficient condition for existence of integrals of the above (Without proof).

Partial Differential Equations (Marks - 10)

Formulation of partial differential equation, Lagrange's Linear equation. General integral and complete integral. Integral surface passing through a given curve.

Reference:

1. D. A. Murray, *Introductory Course on Ordinary Differential Equations,* Longmans.
2. G. Birkhoff and G. C. Rota, *Ordinary Differential Equations*, Wiley.
3. E. A. Coddington, *An Introduction to Ordinary Differential Equations*, McGraw Hill,
4. R. Bronson, G. Costa, Schaum's Outline of Differential Equations, Mc- Graw Hill.
5. E. I. Ince, Ordinary *Differential Equations,* Dover Publication, 1956.
6. P. R. Ghosh & J. G. Chakraborty, *Differential Equations,* U. N. Dhur and Sons Pvt. Ltd.,
7. I. N. Sneddon, *Elements of Partial Differential Equations,* McGraw Hill. 1957
8. F. H. Miller, *Partial Differential Equations,* John Wiley, 1941.
9. P. Phoolan Prasad & R. Ravichandan , *Partial Differential Equations,* New Age Int.
10. T. Amarnath, *Partial Differential Equation,* Narosa Publishing House.

SKILL ENHANCEMENT COURSE-I

(Choose any one from the following)

1. **Mathematical study on local weather conditions. (Marks: 50, credit: 2)**
(Marks distribution: written submission: 35, viva: 15)

Students are required to collect data from the local weather office. Then the collected data have to be analysed by means of charts, graphs and other statistical tools to make a report on the local weather conditions. The report has to be submitted at the time of examination.

2. **Object oriented programming in C++. (Marks: 50, credit: 2)**
(Marks distribution: Written submission: 35, viva: 15)

Programming paradigms, characteristics of objected programming languages, brief history of C^{++}, structure of C^{++} program, differences between C and C^{++}, basic C^{++} operators, comments, working with variables, enumeration, arrays and pointer.

Objects, classes, constructor and destructors, friend function, inline function, encapsulation, data abstraction, inheritance, polymorphism, dynamic binding, operator overloading, method overloading, overloading arithmetic operator and comparison operators.

Template class in C^{++}, copy constructor, subscript and function call operator, concept of namespace and exception handling.

References:

1. A. R. Venugopal, Rajkumar and T. Ravishanker, Mastering C^{++}, TMH.
2. S.B. Lippman and J. Lajoie, C^{++} Primer, Addison Wesley.
3. D. Parasons, Object Oriented Programming with C^{++}, BPB pub.
4. E. Balaguruswami, Object Oriented Programming in C^{++}, Tata McGraHill.

SEMESTER IV

CORE COURSE-VIII

Real Analysis III

Total Marks: 50 (10 marks reserved for internal assessment) **Credit: 6**

Real Analysis III

Sequence of real numbers. Notion of convergence and limit. Monotone sequences subsequences and their convergence, upper and lower limits of a sequence, algebra of limit superior and limit inferior. Cauchy's general principle of convergence. Bolzano-Weierstrass theorem, Heine-Borel theorem.

Series of non negative terms. Test for convergence: Comparison test, Ratio test, Cauchy's root test, Raabe's test, Logarithmic test, Gauss's test, Cauchy's condensation test. Alternating series, Leibnitz's test.

Series of arbitrary numerical terms. Absolutely and conditionally convergent series, Riemann's rearrangement theorem (Proof not required)

Sequences and series of functions and their convergence. Uniform convergence. Cauchy's criterion of uniform convergence. Continuity of a limit function of a sequence of continuous functions. Continuity of the sum function of a uniformly convergent series of continuous functions. Term-by-term differentiation and integration of a uniformly convergent series of functions.

Fourier series of a function. Dirichlet's condition (statement only). Uniformly convergent trigonometric series as a Fourier series. Riemann-Lebesgue theorem on Fourier series. Series of odd and even functions. Convergence of Fourier series of piece-wise monotone functions (Proof not required)

Functions of several variables (two and three variables): Theory of maxima and minima, Lagrange's method of multiplier. Jacobian, Implicit function theorem (Proof not required). Inverse function theorem (statement only). Change of variables of multiple integrals.

Differentiation and integrals under the sign of integration, Leibnitz theorem, Integral as a function of parameter. Change of order of integration for repeated integrals.

References:

1. L.J Goldstein, David Lay, N.I.Asmar, David I. Schneider, *Calculus and Its Applications*, Pearson, New International Edition.
2. W. Rudin, *Principles of Mathematical Analysis*, TMH.
3. T. M. Apostal, *Mathematical Analysis*, Narosa Book Disributors Pvt. Ltd.
4. G. B. Folland, *Advanced Calculus*, University of Washington, Pearson.
5. R. R. Goldberg, *Methods* of *Real analysis*, Oxford and IBH Publishing Co. Pvt. Ltd.
6. R. G. Bartle and D. R. Sherbert, *Introduction to Real Analysis*, Wiley India Pvt. Ltd.
7. S. K. Mapa, *Introduction to Real Analysis*, Sarat Book Distributors.
8. Shantinarayan, P.K. Mittal, *Integral Calculus*, S. Chand Publishing, 10th Edition.
9. Shantinarayan, *Mathematical Analysis*, S. Chand and Company Ltd.
10. J. Edwards, *Differential Calculus for Beginners*, Pearson.
11. G. B. Thomas, M. D. Weir, J. R. Hass, *Thomas Calculus*, Pearson.
12. B. Williamson, An Elementary Treatise on the Integral Calculus, D. Appleton and Co.
13. S. C. Malik & S. Arora, *Mathematical Analysis*, New Age International Publishers.

CORE COURSE-IX

Introduction to Operations Research

Total Marks: 50 (10 marks reserved for internal assessment) **Credit: 6**

Introduction to Operations Research

[**Prerequisite:** General introduction to optimization problem, Definition of L.P.P., Mathematical formulation of the problem, Canonical & Standard form of L.P.P., Basic solutions, feasible, basic feasible & optimal solutions].

Reduction of a feasible solution to basic feasible solution.

Hyperplanes, Convex sets and their properties, Convex functions, Extreme points, Convex feasible region, Convex polyhedron, Polytope, Supporting hyperplane, Separating hyperplane.

Fundamental theorem of L.P.P., Replacement of a basis vector, Improved basic feasible solutions, Unbounded solution, Condition of optimality, Simplex method, Simplex algorithm, Artificial variable technique (Big M method, Two phase method), Inversion of a matrix by Simplex method, Solution of simultaneous equations by Simplex method.

Duality in L.P.P.: Concept of duality, Fundamental properties of duality, Fundamental theorem of duality, Duality & Simplex method, Dual simplex method and algorithm.

Transportation Problem (T.P.): Mathematical formulation, Existence of feasible solution, Loops and their properties, Initial basic feasible solutions (different methods, like North West corner, Row minima, Column minima, Matrix minima & Vogel's Approximation method), Optimal solutions, Degeneracy in T.P., Unbalanced T.P., Special cases in T.P.

Assignment Problem (A.P.): Mathematical formulation, Solution methods of A.P., Hungerian method, Restrictions on assignments, maximization problem, unbalanced assignment problem, Traveling salesman (salesperson) problem.

Theory of Games: Introduction, Two person zero-sum games, Minimax and Maximin principles, Minimax and Saddle point theorems, Pure and Mixed Strategies games without saddle points, Minimax (Maximin) criterion, Dominance rules, Solution methods of games without saddle point : Algebraic method, Graphical method and Linear Programming method, Symmetric game.

References:

1. G. Hadley, *Linear Programming*, Perason.
2. R. Bronson and G. Naadimuthu, *Schaum's Outline of Operations Research,* Schaum's Outline.
3. A. K. Bhunia and L. Sahoo, *Advanced Operations Research, Asian Books Pvt. Ltd.,*
4. J.G. Chakravorty and P.R. Ghosh, *Linear Programming and Game Theory*, Moulik Library.
5. J. K. Sharma, *Operations Research – Theory and Applications*, Macmillan.
6. H. A. Taha, *Operations Research – An Introduction,* Pearson.

CORE COURSE-X

Mechanics I

Total Marks: 50 (10 marks reserved for internal assessment) **Credit: 6**

Mechanics I (Dynamics of a Particle)

[**Prerequisite:** Basic concepts of Dynamics: Motion in a straight line with uniform acceleration, Vertical motion under gravity, Momentum of a body, Newton's laws of motion, Reaction on the lift when a body is carried on a lift moving with an acceleration, Work, Power and Energy, Impulse and Impulsive forces].

Rectilinear motion: Motion under repulsive force (i) proportional to distance (ii) inversely proportional to square of the distance, Motion under attractive force inversely proportional to square of the distance, Motion under gravitational acceleration.

Simple Harmonic Motion: Simple harmonic motion, Compounding of two simple harmonic motions of the same period, Elastic string and spiral string, Hook's law, Particle attached to a horizontal elastic string, Particle attached to a vertical elastic string, Forced vibrations, Damped harmonic oscillations, Damped forced oscillations.

Two dimensional motion: Angular velocity and angular acceleration, Relation between angular and linear velocity, Radial and transverse components of velocity and acceleration, Velocity and acceleration components referred to rotating axes, Tangential and normal components of velocity and acceleration, Motion of a projectile under gravity (supposed constant).

Central orbits: Motion in a plane under central forces, Central orbit in polar and pedal forms, Rate of description of sectorial area, Different forms of velocity at a point in a central orbit, Apse, apse line, apsidal distance, apsidal angle, Law of force when the centre of force and the central orbit are known, Differential equation and classifications of paths under central accelerations, Stability of circular orbits, Conditions for stability of circular orbits under central force (general case).

Planetary motion: Newton's law of gravitation, Kepler's laws of planetary motion, Modification of Kepler's third law, Escape velocity, Time to describe a given arc of an orbit.

Motion in a resisting medium & Constrained motion: Motion of a heavy particle on a smooth curve in a vertical plane, Motion under gravity with resistance proportional to some integral power of velocity, Motion of a projectile in a resisting medium,Terminal velocity, Motion of a particle in a plane under different laws of resistance, Motion on a smooth cycloid in a vertical plane, Motion of a particle along a rough curve (circle, cycloid).

Change of mass, Motion of a rocket.

References:

1. S. L. Loney, *An Elementary Treatise On the Dynamics of a Particle and a Rigid Body*, Cambridge at the University Press.
2. J. L. Synge and B. A. Griffith, *Principles of Mechanics*, McGraw-Hill, 1959.
3. A. S. Ramsey, *Dynamics (Part I & II),* Cambridge University Press, 1951.
4. F. Chorlton, *A Text Book of Dynamics*, E. Horwood, 1983.
5. S. Ganguly and S. Saha, *Analytical Dynamics of a Particle*, New Central Book Agency (P)
6. N. Dutta and R. N. Jana, *Dynamics of a Particle*, Shreedhar Prakashani.
7. M.D. Raisinghania, *Dynamics*, S. Chand & Company Ltd.

SKILL ENHANCEMENT COURSE-II

1. **Mathematical study on environmental pollutions. (Marks: 50, credit: 2)**

(Marks distribution: written submission: 35, viva: 15).

Students are required to collect data either by himself/herself or from the local bodies. Then the collected data have to be analysed by means of charts, graphs and other statistical tools to make a report on the local environmental pollution. The report has to be submitted at the time of examination.

2. **Use of Latex. (Marks: 50, credit: 2)**

(Marks distribution: written submission: 35, viva: 15)

Introduction: TEX, LATEX, Software installation, Latex compilation

Text, Symbols and Commands: Command names and arguments, Environments, Declarations, Lengths, Special characters, Character set and Fonts, Type size, Sectioning and Paragraphs

Document Layout and Organization: Document classes (article, report, book, letter, beamer, slides), Page style options, Parts of the document, Table of contents

Packages: Geometry, Hyperref, amsmath, amssymb, algorithms

Displayed Text: Changing font, Centering and indenting, Lists, Theorem like declarations, Tabular stops, Arrays, Boxes, Tables, Footnotes and marginal notes, Page numbering, Comments within text

Mathematical Formulas: Mathematical environments, Mathematical symbols, Single equations, Blocks of mathematical formula, Multiline equation, Mutiple equations, Spacing in Math mode, Theorem, Lemmas, Fine-tuning mathematics

Graphics Inclusion and color: The graphics packages, Adding color

User Customizations: Counters, Lengths, User defined commands and environments

Document management: Processing parts of a document, In-text references, Bibliographies, Indexing, Fancy headers, Keyword index

Application to: Trigonometric formulas, Statistical data chart, Mathematical formulas, writing articles/research papers etc.

References:

5. Leslie Lamport, *LATEX: A document preparation system*, Addison-Wesley Publishing Company, 1986.
6. Donald Knuth, *The TEXbook*, Addison-Wesley Publishing Company, 1984.
7. Helmut Kopka and Patrick W. Daly, *A Guide to LATEX and Electronic Publishing*, Wesley Publishing Company, 2004.

SEMESTER V

CORE COURSE-XI

Unit-1: Metric Spaces, Unit-2: Elementary complex analysis

Total Marks: 50 (10 marks reserved for internal assessment) **Credit: 6**

Unit 1: Metric Spaces (30 Marks)

Definition of Metric spaces, examples including the standard ones such as discrete metric space, the real line ℝ, the complex plane ℂ, Euclidian spaces $\mathbb{R}^n$, unitary spaces $\mathbb{C}^n$, $C(a,b)$ (with sup metric and integral metric), $l^p, 1 \leq p < \infty$.

Open ball, closed ball, metric topology, distance between a point and a set, distance between two sets, boundedness of a set, properties of open and closed sets, limit point, interior point, closure, interior, boundary of subsets and relation between them; dense subsets, nowhere dense subsets, basis, separable space, LindelÖf space, second countable space and relation between them; Hausdorff property, Cauchy sequence, Convergence of sequences, completeness and Cantor Intersection theorem.

Continuous functions and their basic properties, algebra of real/ complex valued continuous functions, uniformly continuous functions, uniform continuity of the distance function. Open covering and compactness, compactness and finite intersection property (FIP) of closed sets, closed subsets and compactness, continuity and compactness; relation between continuity, compactness and uniform continuity; equivalence of compactness, sequential and B-W compactness; boundedness, total boundedness and relation between them; relation between total boundedness, completeness and compactness; distance between disjoint closed sets one of which being compact, Heine Borel theorem concerning compact sets in R^n.

Unit 2: Elementary Complex Analysis (20 Marks)

Introduction of complex numbers, the complex plane ℂ and its basic geometric and topological aspects, Extended complex plane $\mathbb{C}_\infty$, stereographic projection and spherical representation of $\mathbb{C}_\infty$.

Limit, continuity and differentiability of complex valued functions, Cauchy-Riemann (C-R) equations, analytic functions, harmonic functions.

Power series, radius of convergence and Cauchy-Hadamard theorem, infinite differentiability of sum function of power series, introduction of exp (z), cos z, sin z, Log z and its branch-their elementary properties.

Bilinear transformations: The group of Mobius transformation and its generators-the inversion, dilations; fixed point and uniqueness of a Mobius transformation by its action at three distinct points; cross ratio, cross ratio and circle preserving property of Mobius transformation; orientation principle and construction of bijective analytic functions from one side of a circle onto one side of another circle in $\mathbb{C}_\infty$.

References:

1. John.B.Conway, *Functions of one complex variable*, Narosa Publishing House, 1987.
2. Edward B Saff and Arthur David Snider, *Fundamentals of Complex Analysis with Applications to Engineering and Science*, Pearson, 2003.
3. James Ward Brown and Ruel V.Churchill, *Complex variables and Applications*, McGraw Hill, 2013.
4. E.T.Copson, *Introduction to the theory of functions of a complex variable*, Clarendon press.
5. S. M. Shah and Subhas Chandra Saxena, *Introduction to Real variable theory*, PHI.
6. E. G. Philips, *Functions of a complex variable: with applications*, Interscience Publishers,
7. S. Kumaresan, *Topology of Metric spaces*, Narosa Publishing House, 2014.
8. A. K. Banerjee and A. Dey, *Metric space and complex Analysis*, New Age International Pvt.Ltd
9. M. N. Mukherjee, *Elements of Metric Spaces*, Academic Press, 2010.
10. S.N.Mukhopadhyay and A.K.Layek, *Mathematical Analysis*, U.N.Dhur and Sons,
11. Ajit Kumar and S.Kumaresan, *Real Analysis*, CRC Press (Taylor and Francis group),
12. Shanti Narayan, *Real Analysis*, S.Chand and Co.Ltd., 2001.
13. H,L.Royden and P.M Fitzpatrick, *Real Analysis*, PHI.
14. Lavs V.Ahlfos, *Complex Analysis*, McGraw Hill, 1979.
15. E. T. Copson, *Metric spaces*, Universal Book Stall, 1989.
16. S. Ganguly, *Elements of Complex Analysis*, Academic Publishers, 2011.
17. W.J.Thron, *Topological Structures*, New York[s.n.],1966.

CORE COURSE-XII

Mechanics-II

Total Marks: 50 (10 marks reserved for internal assessment) Credit: 6

Mechanics II (Classical Dynamics, Dynamics of a System of Particles and Rigid Body):

Physical foundation of classical dynamics: Interpretation of Newton’s laws of motion – body force and surface force with examples, inertial frames, law of superposition, closed systems, Galilean transformation – form invariance of Newton’s laws under Galilean transformation, limitations of direct applications of Newton’s laws in solving problems of mechanics.

Dynamics of a system of particles: Basic concepts, Centroid, linear momentum, angular momentum, kinetic energy, potential energy, work, power, conservative system of forces; Use of centroid – motion relative to the centroid, angular momentum and kinetic energy relative to the centroid; Conservation principles – linear momentum, angular momentum, total energy; Constraints – basic concepts with examples, D’Alembert Principle.

Introduction to rigid body dynamics: Moments and product of inertia – basic concepts, radius of gyration, parallel and perpendicular axis theorems, a few examples (rod, rectangular plate, circular plate, elliptic plate, sphere, cone, rectangular parallelepiped, cylinder, ellipsoid of revolution etc.); Motion about a point and about fixed axes – angular momentum, inertia matrix, principal axes, principal moments of inertia, kinetic energy, momental ellipsoid, equimomental surface, reaction of the axis of rotation, impulsive forces; General motion of rigid body – translational and rotational motion, kinetic energy and angular momentum (translational and rotational); Two-dimensional motion of rigid body - equation of motion, kinetic energy, angular momentum, problems illustrating laws of motion [motion of a uniform sphere (solid and hollow) along a perfectly rough plane, motion of a uniform heavy circular cylinder (solid and hollow) along a perfectly rough inclined plane, motion of a rod when released from a vertical position with one end resting upon a perfectly rough table or smooth table, motion of a uniform heavy solid sphere along an imperfectly rough inclined plane, motion of a uniform circular disc, projected with its plane vertical along an imperfectly rough horizontal plane with a velocity of translation and angular velocity about the centre].

References:

1. F. Chorton, *Text Book of Dynamics*, CBS Publishers and Distributors, Delhi, 1985.
2. S. L. Loney, *An Elementary Treatise on the Dynamics of a Particle and of Rigid Bodies*, Radha Publishing House, Calcutta, 1985.
3. S. L. Loney, *An Elementary Treatise on Statics,* Radha Publishing House
4. E. J. Routh, *A treatise on analytical statics with numerous examples,* Cambridge University press, Vol. I, Second Edition, 1985.
5. W. H. Besant and A. S. Ramsey, *A treatise on Hydromechanics*, CBS Publishers and Distributors, New Delhi, 1988.
6. A. S. Ramsey, *Dynamics, Part I & II*, CBS Publishers and Distributors, New Delhi, Second Edition, 1985.
7. A. S. Ramsey, *Statics*, CBS Publishers and Distributors, New Delhi.
8. J. M. Kar, *Hydrostatics*, K. P. Basu Publishing Co., Calcutta, 1994.
9. N. C. Rana and P. S. Joag, *Classical Mechanics*, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.

DSE-I AND DSE-II

(Choose any two of the following)

For each topic

Total Marks: 50 (10 marks reserved for internal assessment) Credit: 6

i) Elements of Topology & Functional Analysis

Topology-Introduction-Definition-Important Examples-Order topology-subspace topology-Metric Topology-Open base-open subbase-Elementary concepts-Closed Sets-Limit points-Properties-Closure operator-dense sets-examples-properties-Separable spaces-

Neighbourhood of a point-Neighbourhood system-Continuous functions and its properties-homeomorphisms-topology invariant-examples.
Countability Axioms-Local base-First Countable space examples-properties-Second Countable space-examples-properties. Separation Axioms-T1; T2 spaces-examples-Properties-Normal spaces-examples-elementary properties.
Connected spaces-examples-properties-separated set concept-connected subspaces of R-components-connectedness and continuity. Compact spaces-examples-properties-and concepts-FIP and compact spaces-Compactness and continuity-Limit point compactness-Lindelof spaces-examples-properties.

Normed Linear Spaces-examples-properties-Banach Spaces-Properties-Inner product spaces(Pre-Hilbert Spaces)-examples-properties-Cauchy schwartz' Inequality- Bessel's inequality-parallelogram law-polarization identity-bounded linear transformations- important discussions-Quotient spaces-Hilbert spaces-properties-orthogonal complements- orthonormal sets-Gram-schmidt orthonormalization process-examples.

References:

1. Goffman, C., Pedrick, G., First Course in Functional Analysis, PHI, New Delhi, 1987.
2. Bachman, G., Narici, L., Functional Analysis, Academic Press, 1966.
3. Taylor, A.E. Introduction to Functional Analysis, John Wiley and Sons, New York, 1958.
4. Simmons, G.F., Introduction to Topology and Modern analysis, McGraw-Hill, 1963.
5. Conway, J.B., A course in Functional Analysis, Springer Verlag, New York, 1990.
6. Kreyszig, E., Introductory Functional Analysis and its Applications, John Wiley and Sons, New York, 1978.
7. Munkers, J.R., Topology, A First Course, PHI, New Delhi, 2000.
8. Dugundji, J., Topology, Allyn and Bacon, 1966.

ii) Linear Algebra

Linear transformations**:** Linear transformations, Algebra of linear transformations, Isomorphism, Matrix representation of linear transformations, Linear functional, Double dual, Transpose of a linear transformation.

Inner product spaces**:** Norm, Normed linear spaces, Inner products, Real and complex inner product spaces, Orthogonality, Construction of orthogonal sets, Complements, Projections, Best approximation.

Canonical forms: Eigen values and eigen vectors, Eigen spaces, Similar and congruent matrices, Characteristic polynomial, Minimal polynomial, Annihilating polynomials, Diagonalization, Diagonalization of Hermitian matrices, Reduction of a matrix to normal form, Jordan Canonical form.

Bilinear forms**:** Matrix associated with a bilinear form, Quadratic form, Rank, Signature and index of a quadratic form, reduction of a quadratic form to normal form, Sylvester’s law of inertia, Simultaneous reduction of two quadratic forms, Applications to Geometry and Mechanics.

References:

1. S. H. Friedberg, A. J. Insel and L. E. Spence, Linear Algebra (4^{th} Edition), *Prentice-Hall of India Private Limited*, New Delhi (2012).
2. K. Hoffman and R. Kunze, Linear Algebra (Second Edition), *Prentice-Hall of India Private Limited*, New Delhi (1996).
3. S. Kumaresan, Linear Algebra: A Geometrical Approach, *Prentice-Hall of India Private Limited*, New Delhi (2000).
4. A. R. Rao and P. Bhimasankaram, Linear Algebra, *Hindustan Book Agency*, New Delhi, (2000).

iii) Mathematical Modeling

Introduction, Emergence of Mathematical Modeling on simple situations; Basic steps of Mathematical Modeling, its needs; Process / technique of Mathematical Modeling; Some characteristics of Mathematical Models; Classification of Mathematical Models ---- Deterministic and Stochastic models with illustrations; Limitations of Mathematical Modeling.

Elementary ideas of dynamical systems, autonomous dynamical systems; Equilibrium points and their characterization --- node, saddle point, focus, centre and limit cycle concepts with simple illustrations.

Mathematical Models in Physical Sciences: Formulation of some mathematical models and their analyses for (i) linear frictionless systems, (ii) linear system with friction, (iii) nonlinear frictionless systems and (iv) nonlinear systems with friction.

Mathematical Models in Biological Sciences: Deterministic single species population model, Exponential growth model---- formulation, solution, interpretation and limitations. Logistic growth model, Gompertz growth model together with their respective formulations, solutions, interpretations and limitations. Formation of stochastic single species population model, solution, interpretation and limitation. Population models for two interacting species, Predator-prey and competitive type of interactions. Lotka-Volterra prey-predator model, formulation, solution, interpretation and limitations. Lotka-Volterra model of two competitive species, formulation, solution, interpretation and limitations.Discrete time model for age-structured single species population.

Mathematical modeling of planetary motions; Mathematical modeling of circular motion and motion of satellites.

References:

1. Mathematics for Dynamic Modeling, E. Beltrami, Academic Press, Orlando, Florida.
2. Mathematical Models, R. Haberman, Prentice-Hall, Inc., New Jersey, 1977.
3. An Introduction to Mathematical Ecology, E. C. Pielou, John Wiley & Sons, 1969.
4. Mathematical Modeling, J N Kapur, New Age International (P) Ltd., 2003.
5. Differential Equations and Their Applications, M. Braun, Springer, New York, 1978.
6. Mathematical Modeling, Meerschaert, Mark M., Academic Press, New York, 1993.
7. Concept of Mathematical Modeling, W. Meyer, McGraw-Hill, New York, 1994.

iv) Integral Transforms

Fourier Transforms: Definition and properties of Fourier Transforms, Fourier Transforms of Derivatives, Fourier Transforms of some useful functions, Fourier sine and cosine transforms, Inversion formula of Fourier Transforms, Convolution Theorem, Parseval's relation, Application of Fourier transforms to Heat, Wave and Laplace equations.

Laplace Transforms: Definition and properties of Laplace transforms, Laplace Transform of some elementary functions, Laplace Transforms of the derivatives, Initial and final value theorems, Convolution theorems, Inverse of Laplace Transform, Application to Ordinary and Partial differential equations.

References :

1. I.N. Sneddon : The Uses of Integral Transforms.
2. C.J. Tranter : Integral Transforms.
3. I.N. Sneddon : fourier Transform.
4. Andrews & Shivamoggi : Integral transforms for Engineers.
5. L.Debnath & D.Bhatta : Integral Transforms and Their Applications.

v) Probability & Statistics

[**Prerequisite:** Concept of mathematical probility, addition and multiplication theorem of probability. Independent event, total probability, Bayes' theorem, Bernoulli trials, Binomial distribution].

Generalised addition and multiplication rule of probability continuity theory, Boole's inequality, Bonferroni's inequality; Poisson trials and Poisson law of probability, Multinomial law; Random variables, Discrete and continuous distribution functions: Poisson, Geometric, Negative Binomial, exponential, Hypergeometric, Uniforn, Normal, Gamma, Beta, Cauchy distributions.

Transformation of random variables; Discrete and continuous distribution in two dimension, Marginal distribution, Bivariate Uniform distribution, Bivariate Normal distribution, Transformation of two dimensional random variables, Conditional distribution, Mathematical expectation in one and two variables, Moments, Measures of skewness and kurtosis, Moment generating function, Characteristic function, Uniqueness of characteristic function (statement only) Conditional expectation, covariance, co-relation coefficient, Regression curves, and – distribution.

Convergence in probability, convergence in law, Tchebycheff's inequality, Bernoulli's limit theorem, Law of large numbers, Concept of asymptotically normal distribution, De-Moivre-Laplace limit theorem, Central limit theorem in case of equal components.

Statistics: Method of least square, curve fitting (straight line, parabola and exponential curves).
Sampling theory, simple random sampling, sampling distribution of the statistic χ^2, t and F-distribution of the statistic.
Theory of estimation, point estimation, unbiasedness, minimum variance, consistency, efficiency, sufficiently, maximum likelihood method; Interval estimation –confidence interval, approximate confidence interval. Testing of hypothesis, Neyman-Pearson lemma, Likelihood ratio testing, application to Normal(m, σ)-population, Pearsonian χ^2 -test for goodness of fit. Theory of errors.

References:

1. S. Ross – *First Course in Probability*, Pearson.
2. W.Feller – An *Introduction to Probability* Theory and its Applications, Vol –I , Wiley, Third Edition, 1968.
3. W.Feller – An *Introduction to Probability* Theory and its Applications, Vol –II , Wiley, Second Edition, 1971.
4. R. V. Hogg, J. W.Mekenard and A.T. Craig, *Introduction to Mathematical Statistics,* Pearson Education, 2005.
5. A.Gupta, *Groundwork of Mathematical Probability & Statistics,* Academic publishers, 1983.
6. Banerjee, De & Sen, *Mathematical Probability*, U. N. Dhur & Sons Pvt. Ltd., Revised 3rd Edition.

SEMESTER VI

CORE COURSE-XIII

Unit-1: Numerical Analysis, Unit-2: Computer Programming

Total Marks: 50 (10 marks reserved for internal assessment) **Credit: 6**

Unit-1: Numerical Analysis (Marks: 35)

Approximation of numbers, significant digits, Loss of significance, Algebraic manipulation for avoiding loss of significance.

Errors: Absolute, Relative and Percentage errors; Round off errors; propagation of round off errors in arithmetic operations; Inherent errors in numerical methods.

Polynomial Interpolations: Existence and uniqueness of interpolating polynomials, error in interpolation, Lagrange’s interpolating formula, Newton’s divided difference interpolating formula, properties of divided differences, forward and backward difference operators and their relations, Newton’s forward and backward difference interpolation formulae. Central difference and averaging operators, central interpolation formulae: Statement of Gauss, Stirling and Bessel's formulae and their applications. Concept of piece-wise polynomial interpolation, Idea of Inverse interpolation. Error in interpolation. Numerical differentiation based on equispaced argument values. Error in differentiation formulae.

Numerical solution of non-linear equations:
Solution of algebraic and transcendental equations (real roots only): (i) Method of Bisection, (ii) Regula Falsi Method (iii) Secant Method (iv) Newton – Raphson Method (v) Fixed point iteration method. Convergences and rate of convergence of these methods.

Solution of a system of linear algebraic equation:
Gauss' Elimination and Gauss Jordan methods, Pivoting methods, Jacobi and Gauss-Seidel methods with convergence criteria.

Numerical Integration: Concept of numerical quadrature, Newton-Cotes' formula trapezoidal rule, Simpson's one-third rule, composite formulae; Geometrical interpretation of the methods, Degree of precision.

Initial value problems: Solution of first-order ordinary differential equation: Picard's method, Euler's method (concept of Predictor-Corrector method) Modified Euler's method, Error estimate and convergence of Euler's method, Taylor's method, Runge-Kutta's method of second and fourth orders (derivation of second order formula only) and their significance.

Unit-2: Computer Programming (Marks: 15)

Computer Language: Concept of programming languages, Machine language, Assembly language, High-level language, Interpreter, Compiler, Source and Object programs.
Number Systems: Binary, decimal, octal and hexadecimal number systems and their conversions. Programming Language in Fortran: character, constants and their classifications, variables and their classifications. Assignment statement, Arithmetic statement, control statements: Logical IF, Block IF, Arithmetic IF, data statement, Input/Output statements, DO statement, computed GOTO statement, continue statement. Executable and non-executable statements. Rules for the usage of DO statement. Arithmetic statement function.
Subscripted variables: Concept of array variables in programming language. Simple programs. Sub-program: Concept of function sub-program, purpose of sub-program, subroutines, purpose of using subroutines. Format specifications. Simple programs.

References:

1. F. B. Hildebrand, *Introduction to Numerical Analysis*, McGraw-Hill, New York,
2. J. B. Scarborough, *Numerical Mathematical Analysis*, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 2003.
3. B. Bradie, *A Friendly Introduction to Numerical Analysis*, Pearson.
4. A. Gupta and S. C. Bose, *Introduction to Numerical Analysis*, Academic Publishers.
5. P.K. Nayak, Numerical Analysis: Theory & Applications, Asian Book Pub.
6. M. K. Jain, S. R. K. Iyenger and R. K. Jain, *Numerical Methods for scientific and Engineering computation*, New Age International Publishers, New Delhi, 2003.
7. N. Dutta and R.N. Jana, *Introductory Numerical Analysis*, Shreedhar Prakashni.
8. K. E. Atkinson, *Elementary Numerical Analysis*, John Wiley & Sons, New York.
9. C. Xavier, *FORTRAN 77and Numerical Methods*, New Age International Pvt. Ltd.
10. M.Pal, FORTRAN 77 with numerical and statistical analysis, Asian Book Pub.

CORE COURSE-XIV

Computer Aided Numerical Practical using FORTRAN 77 programming)

Total Marks: 50 **Credit: 6**

[Sessional (Algorithm, Flowchart and Program with output) : 10 marks
Problem – I: 20 marks (Algorithm-5, Program-10, Result-5)
Problem - II: 15 Marks (Program – 10, Result – 5) Viva-voce: 5 marks**]**

Problem-I: 1. Interpolation (taking at least six points) by
(a) Lagrange's interpolation formula,
(b) Newton's Forward Difference formula
(c) Numerical differentiation (2)
Problem-I: 2. Solution of a first-order ordinary differential equation by
(a) Modified Euler's method,
(b) Fourth-order Runge-Kutta method
Problem-I: 3. Solution of system of linear equations by
(a) Gauss elimination method (excluding pivotal condensation)
(b) Gauss Seidel iterative method.

Problem-II: 1. Finding a real root of an equation by
(a) Fixed point iteration method,
(b) Newton-Raphson's method

Problem-II: 2. Integration (taking at least 10 sub-intervals) by
(a) Trapezoidal rule,
(b) Simpson's 1/3 rd rule

References:

1. C. Xavier, *FORTRAN 77 and Numerical Methods*, New Age International Pvt. Ltd.,
2. M.Pal, FORTRAN 77 with numerical and statistical analysis, Asian Book Pub.
3. G. C. Layek, A. Samad and S. Pramanik, *Computer Fundamentals, Fortran77, Numerical Program*, Levant.

DSE-III AND DSE-IV

(Choose any two of the following)
For each topic
Total Marks: 50 (10 marks reserved for internal assessment) **Credit: 6**

i) Discrete Mathematics

Symbolic Logic: Propositional Logic --- Propositional language, truth (by tables), tautologies, contradictions, validity, adequacy of connectives. Axiom system, Deduction theorem, derivations, soundness and completeness theorems. Independence of axioms, consistency.

Graphs: Definitions and basic concepts, problems in which Graphs provide a mathematical model – Konigsberg Bridge problem, Connector problem, Utilities problem, Travelling salesman problem, shortest path problem. Vertex degree and incidence, first theorem of graph theory. Subgraphs, graph isomorphism, Paths and cycles. Connectedness and components. Matrix representation of graph.
Trees - definition and basic concepts. Spanning trees. Connector problem --- Kruskal's algorithm. Shortest path problem --- Breadth First Search algorithm, Depth First Search algorithm. Dijkstra's algorithm.

Combinatorics: The basic problem of combinatorics— counting, enumeration of permutations and combinations. Principle of inclusion and exclusion – examples only. The pigeon-hole principle – examples only. Recursions. Generating functions and recurrence relations. Solution of recurrence relation by generating function technique — problem solving.

Lattice: Partially ordered sets, lattices, chains and anti-chains — Dilworth's theorem. The necklace problem — Burnside's theorem. Polya's theorem and their applications, Booleam Algebra as a complemented distributive lattice.

References:

1. M. Huth, M. Ryan; *Logic in Computer Science*, 2nd edition, Cambridge University Press.

2. J. L. Mott, A. Kandel, T. P. Baker; *Discrete mathematics for Computer Scientists and Mathematicians* (2nd edition), Prentice-Hall (India), 1999.

3. B. Kolman, R. C. Busby, S. Ross; *Discrete mathematical structures*, (3rd edition), Prentice Hall, 1999.

4. E. Mendelson; *Introduction to Mathematical Logic*, 5th edition, N.Y., Van-Norstand.

5. I. M. Copi, C. Cohen; *Introduction to logic*, 9th edition, Prentice Hall (India), 1997.

6. J. P. Tremblay, R. Manohar; *Discrete Mathematical Structures with Applications to Computer Science*, McGraw Hill, 1997.

7. J. Kelley; *The essence of logic*, Prentice Hall (India), 1997.

8. J. H. Van Lint, R. M. Wilson; *A course in Combinatorics*, Cambridge University Press.

9. A. Margaris; *First order mathematical logic*, Dover Publications, N.Y., 1990.

10. M. O. Albertson, J. P. Hutchinson; *Discrete Mathematics with Algorithms*, John Wiley and Sons.

11. C. L. Liu; *Elements of Discrete Mathematics*, 2nd edition, McGraw Hill, Computer Science series.

12. N. Deo; *Graph theory with applications to Engineering and Computer Sciences*,PHI.

13. R. A. Brualdi; *Introductory Combinatorics*, Prentice Hall (India).

ii) Special Theory of Relativity

Review of Newtonian mechanics – inertial frames, Galilean transformation. Relative motion, Ideas of absolute space and time, Michelson-Morley's experiment. Postulates of Special Theory of Relativity, Lorentz transformation (LT).

Geometrical interpretation of LT, group property of LT, concepts of simultaneity. Relativistic kinematics – composition of parallel velocities, Length contraction, time dilation. Variation of mass with velocity, longitudinal and transversal mass. Equivalence of mass and energy, relativistic energy-momentum relation. General Lorentz transformation. Geometrical representation of space-time – four dimensional

Minkowskian space-time of special relativity. Time-like, light-like and space-like intervals. Null Cone, proper time, world line of a particle. Four vectors in Minkowskian space-time. Energy-momentum four vector, relativistic force and transformation equations for its components.

References:

1. J. L. Anderson – Principles of Relativity Physics.
2. P. G. Bergmann – Introduction to the Theory of Relativity.
3. R. Resnick – Introduction to Special Relativity.
4. S. Bannerjee and A. Bannerjee – Special Theory of Relativity.
5. Ray d'Inverno – Introducing Einstein's Relativity.

iii) Optimization Techniques

Operations Research: Introduction, Definition and Scope of Operations Research, Application of Operations research in different areas.

Revised simplex method: Standard forms of revised simplex method, Computational procedure, Comparison of simplex method and revised simplex method.

Parametric and post-optimal analysis: Change in the objective function. Change in the requirement vector, Addition of a variable, Addition of a constraint, Parametric analysis of constant and requirement vector.

Classical Optimization Techniques: Single variable optimization, Multivariate optimization (with no constraint, with equality constraints and with inequality constraints)
Search Methods: Fibonacci and golden section method.

Gradient Method: Method of conjugate directions for quadratic function, Streepest descent and Davodon-Fletcher-Powell method. Methods of feasible direction and cutting hyperplane method.

Integer Programming: Gomory's cutting plane algorithm, Gomory's mixed integer problem Algorithm, A branch and bound algorithm.

References:

1. Rabindram, Phillips, Solberg., Operations Research: Principles and Practice, Wiley.
2. A.M. Natarajan, P. Balasubramanie, A. Tamilarasi, Operations Research, Pearson.
3. Taha, H.A., Operations Research-An Introduction, Pearson.
4. Sarup, K., Gupta, P.K., and Mohan, Man, Operations Research, Sultan Chand & Sons.
5. Sharma, J.K., Opeartions Research, Mcmillan, India.
6. Sharma, S.D., Operation Research, Kedarnath & Ramnath, Meerut.

iv) Programming in C with applications

Introduction to C language:
Character set, Variables and Identifiers, Keywords, Built-in Data types, Variable definition, Arithmetic Operators and Expressions, Precedence of Operators, Constants and Literals, Simple Assignment Statement, Basic Input / Output Statements, Simple C Programs.
Conditional Statements and Loops:
Decision making within a program, Conditions, Relational Operators, Logical Connectives, IF Statement, IF- ELSE Statement; Loops: While Loop, Do While, For Loop, Nested Loops, Infinite Loops, Switch Statement, Structured Programming.
Arrays:
One Dimensional Arrays: Array Manipulation; Searching, Insertion, Deletion of an element from an Array; Finding the largest / smallest element in an Array; Two Dimensional Arrays: Addition and Multiplication of two matrices, Transpose of a square matrix, representation of Sparse matrices.
Functions:
Top-Down approach of problem solving, Modular programming and Functions, Standard Library of C Functions, Prototype of a Function, Return type, Function Call, Block Structure, Passing Arguments to a Function: Call by Reference, Call by Value, Recursive Functions, Arrays as Function Arguments. Local, Global, Static Variables.
Structures and Unions:
Structure variables, Initialization, Structure Assignment, Nested Structure, Structures and Functions, Structures and Arrays: Arrays of structures, Structures containing Arrays, Unions.
Pointers:
Address operators, Pointer Type Declaration, Pointer Assignment, Pointer Initialization, Pointer Arithmetic, Functions and Pointers, Arrays and Pointers, Pointer Arrays.
File Processing:
Concept of Files, File Opening in various modes and Closing of a File, Reading from a File, Writing onto a File.

References:

1. Programming in ANSI C, E. Balagurusami, Tata McGraw-Hill Education, 2002.
2. Programming in C, A Complete Introduction to the Programming Language, Stephan G
3. Kochan, Sams Publishing, Indiana, 2005.
4. Programming with ANSI and TURBO C, Ashok N. Kamthane, Pearson Education, 2016.
5. C in Depth, S. K. Srivastava and D. Srivastava, BPB Publication, 2009.

v) Mechanics III (Statics & Hydrostatics)

[**Prerequisite:** Basic concepts – concurrent forces, parallel forces, moment of a force, couple, resultant of a force and a couple].

Forces in three-dimension – reduction to force and couple, Pointsot's central axis, wrench, pitch, screw, conditions of equilibrium, invariants; Virtual work – concept of virtual displacement, principle of virtual work, simple examples; Stability of equilibrium – stable and unstable equilibrium, energy test of stability, determination of positions of equilibrium, stability of a heavy body resting on a fixed body with smooth surfaces, simple examples; Equilibrium of flexible string – general equations of equilibrium of a uniform flexible string under the action of given coplanar forces, common catenary, parabolic chain, suspension bridge, catenary of uniform strength.

Basic concepts – fluid pressure and its elementary properties (such as in equilibrium it is same in every direction), density, specific gravity, compressible and incompressible fluid, homogeneous and non-homogeneous fluid; Equilibrium of fluid in a given field of force – equation of pressure, conditions of equilibrium, pressure gradient, equipressure surface, equilibrium of fluid rotating uniformly about an axis; Pressure in a heavy homogeneous liquid – thrust on a plane surface, centre of pressure, determining the position of the centre of pressure, effects on increasing depth, thrust on a curved surface, buoyancy, Archimedes principle, resultant thrust, Equilibrium of floating bodies – conditions of equilibrium of a freely floating body, body floating under constraints, equilibrium of fluids revolving uniformly about an axis, stability of equilibrium, metacentre, conditions of stability; Gases – relation among pressure, volume and temperature, Boyle's law, Charle's law, ideal gas, isothermal and adiabatic changes, heat capacities, internal energy of a gas, reversible change, equilibrium of an isothermal atmosphere, convective equilibrium, total energy at rest.

References:

1. S. L. Loney, *An Elementary Treatise on Statics,* Radha Publishing House, Calcutta, 1985.
2. E. J. Routh, *A treatise on analytical statics with numerous examples,* Cambridge University press, Vol. I, Second Edition, 1985.
3. W. H. Besant and A. S. Ramsey, *A treatise on Hydromechanics*, CBS Publishers and Distributors, New Delhi, 1988.
4. A. S. Ramsey, *Dynamics, Part I & II*, CBS Publishers and Distributors, New Delhi, Second Edition, 1985.
5. A. S. Ramsey, *Statics,* CBS Publishers and Distributors, New Delhi, Second Edition, 1985.
6. J. M. Kar, *Hydrostatics*, K. P. Basu Publishing Co., Calcutta, 1994.
7. N. C. Rana and P. S. Joag, *Classical Mechanics,* Tata McGraw Hill Publishing

Syllabus for Generic Elective papers in Mathematics

Semester I

G E - I

Unit-1: Differential Calculus-I, Unit-2: Integral Calculus I & Ordinary Differential Equation I

Total Marks: 50 (10 marks reserved for internal assessment) Credit: 6

Unit I: Differential Calculus I (20 Marks)

Rational and Irrational numbers, Linear continuum, Functions, limit of functions, Algebra of limits, Continuous functions, Properties of continuous functions, Monotone functions, Inverse function.

Derivative and its applications, Successive differentiation, Leibnitz's theorem, Rolle's theorem, Mean value theorem of Lagrange and of Cauchy with geometrical interpretations. Taylor's theorem and Maclaurin's theorem with remainder in Lagrange's and Cauchy's form and application of mean value theorem, Darboux's theorem. Series expansion of $\sin x$, $\cos x, \log(1+x)$, $(1+x)^n$, a^x with domain of convergence.

Determination of maxima and minima, Indeterminate forms.

Unit 2: Integral Calculus I & Ordinary Differential Equation I (30 Marks)

Definite integral as limit of a sum, its geometrical interpretation, Fundamental theorem of integral calculus, Reduction formula, Evaluation of definite integral viz: $\int_0^{\pi/2} sin^n x dx, \int_0^{\pi/2} cos^n x dx, \int_0^{\pi/2} sin^m x cos^n x dx,$ (m, n being positive integers).

First order and first degree ordinary differential equation: Existence and uniqueness theorem of solution, Exact differential equation, Integrating factor, First order linear differential equation, Equation reducible to linear form. Trajectories, orthogonal trajectories.

References:

1. B.C. Das and B.N.Mukherjee, *Differential Calculus*, U. N. Dhur and Sons Pvt.Ltd.
2. B.C. Das and B.N.Mukherjee, *Integral Calculus*, U. N. Dhur and Sons Pvt.Ltd.
3. *Calculus: Differentiation and Integration*, ICFAI University Press, Pearson.
4. Richard R.Goldberg, *Methods of Real Analysis*, Oxford and IBH, 2012.
5. Shanti Naryayn and P. K. Mittal, *Differential Calculus*, S Chand.
6. Shanti Naryayn and P. K. Mittal, *Integral Calculus*, S Chand, 35th Revised Edition.
7. Daniel A.Murray, *Introductory Course in Differential Equations*, Orient Logman.
8. K.C.Maity and R.K.Ghosh, *Differential Calculus*, Books and Allied (P) Ltd.,.

9. K.C.Maity and R.K.Ghosh, *Integral Calculus*, Books and Allied (P) Ltd.
10. J.G.Chakraborty and P.R.Ghosh, *Differential Equation*, U. N. Dhur and Sons Pvt. Ltd.,
11. R.K.Ghosh and K.C.Maity, *An introduction to Differential Equation*, New Central Book Agency (P) Ltd.

Semester II

G E - I I

Unit-1: Differential Calculus-II, Unit-2: Integral Calculus II&Ordinary Differential Equation II

Total Marks: 50 (10 marks reserved for internal assessment) Credit: 6

Unit I: Differential Calculus II (20 Marks)

Sequence and its convergence, Cauchy's Criteria of convergence. Tests of convergence, Infinite series of constant terms, comparison test, D'Alembert's ratio test, Cauchy's root test, Raabe's test, Logarithmic test, Gauss' test. Alternating series, Leibnitz's test for alternating series (proofs are not required).

Functions of several variables, repeated and simultaneous limits, continuity, partial derivatives, total differentials, directional derivatives. Euler's theorem on homogeneous functions of two and three variables.

Rectilinear asymptotes, Envelopes, Curvature, Radius of curvature, tangent and normal, pedal equation of a curve.

Unit 2: Integral Calculus II & Ordinary Differential Equation II (30 Marks)

Idea of improper integrals and test of convergence of the following improper integrals (proofs are not required).

$$\int_0^1 \frac{dx}{x^\mu}, \int_a^\infty f(x)dx, \int_a^\infty \frac{f(x)dx}{(x-a)^\mu}$$

Beta and Gamma functions (only simple properties and examples). [12 hours lecture]

Quadratures, Rectification of curves, Volume and surface of solids of revolutions, Pappus theorem (statement only), Centre of gravity of simple bodies such as Rod; Rectangular Area, Rectangular Parallelepiped, Circular Arc, Circular Ring and Disc.

Equation of first order but not of first degree: Equations solvable for $p = \frac{dy}{dx}$, Equations solvable for x, Equations solvable for y, Clairaut's form of equation, singular solution, Equations reducible to Clairaut's form .

Higher order linear differential equations with constant coefficients: Both homogeneous and non-homogeneous forms.

Simultaneous differential equation of first order.

References:

1. B.C. Das and B.N.Mukherjee, *Differential Calculus*, U. N. Dhur and Sons Pvt.Ltd.
2. B.C. Das and B.N.Mukherjee, *Integral Calculus*, U. N. Dhur and Sons Pvt.Ltd.
3. *Calculus: Differentiation and Integration* , ICFAI University Press, Pearson.
4. Richard R.Goldberg, *Methods of Real Analysis*, Oxford and IBH , 2012.
5. Shanti Naryayn and P. K. Mittal, *Differential Calculus*, S Chand.
6. Shanti Naryayn and P. K. Mittal, *Integral Calculus*, S Chand.
7. Daniel A.Murray, *Introductory Course in Differential Equations*, Orient Logman.
8. K.C.Maity and R.K.Ghosh, *Differential Calculus*, Books and Allied (P) Ltd.
9. K.C.Maity and R.K.Ghosh, *Integral Calculus*, Books and Allied (P) Ltd..
10. S. N. Mukhopadhyay and A. Layek – *Mathematical Analysis – Vol-I* , U. N. Dhar & Sons Pvt. Ltd.
11. S. N. Mukhopadhyay and S. Mitra – *Mathematical Analysis – Vol-II*, (U. N. Dhar & Sons. Pvt. Ltd.
12. J.G.Chakraborty and P.R.Ghosh, *Differential Equation*, U. N. Dhur and Sons Pvt. Ltd.
13. R.K.Ghosh and K.C.Maity, *An introduction to Differential Equation*, New Central Book Agency (P) Ltd.

Semester III

G E - I I I

Unit-1: Classical Algebra, Unit-2: Abstract and Linear Algebra

Total Marks: 50 (10 marks reserved for internal assessment) Credit: 6

Unit 1: Classical Algebra (20 Marks)

Polynomials, Division Algorithm, Fundamental Theorem of Classical algebra (proof not required) and its consequences, Descarte's rule of signs – its applications, Relation between roots and co-efficients, symmetric functions of roots, transformation of polynomial equations, Cardan's solution of cubic equation. Complex numbers, De-Moivre's theorem, exponential, logarithm, sine and cosine of complex numbers.

Unit 2: Abstract & Linear Algebra (30 Marks)

Mapping – injective, surjective and bijective. Composition of two mappings, Inverse mapping. Binary composition, groupoids, semigroups, monoids, groups – simple examples, properties like uniqueness of identity and inverse element, law of cancellation and solution of the equation $ax = b$ and $ya = b$. Commutative property, subgroups, permutation, even and odd permutation, group of permutation, divisor of zeros, Rings, Integral domain, fields.

Solution of non-homogeneous system of three linear equations by matrix inversion method. Elementary row and column operations, rank of a matrix, row reduced echelon form and fully reduced normal form.

Vector spaces over reals, simple examples, Euclidean 3-space E^3, linear dependence and independence of a finite set of vectors, sub-spaces, definition and examples.

References:

1. S. K. Mapa, *Higher Algebra (Abstract and Linear),* Sarat Book House.
2. Promode Kumar Saikia, *Linear Algebra With Applications*, Pearson.
3. Burnside and Panton, *The Theory of Equations,* Hodges Figgis And Company.
4. U. M. Swamy & A. V. S. N. Murthy, *Algebra: Abstract and Modern,* Pearson.
5. Ghosh & Chakravorty, *Higher Algebra (Classical & Modern),* U. N. Dhur & Sons Pvt. Ltd.

Semester IV

GE-IV

Geometry & Vector Analysis

Total Marks: 50 (10 marks reserved for internal assessment) Credit: 6

Geometry (40 Marks) & Vector Analysis (10 Marks)

Geometry (2- Dimension) (Marks - 10)

Transformation of rectangular axes, Invariants, Pair of straight lines, General equation of second degree –reduction to standard forms and classification. Polar coordinates, polar equation of a straight line, circle and conic.

Geometry (3- Dimension) (Marks-30) Rectangular Cartesian coordinates. Transformation of axes.

Equations of a plane and a straight line, Shortest distance between two skew lines.

Sphere, Cone, Cylinder, Ellipsoid, Hyperboloid and Paraboloid referred to principal axes. Tangent planes and normals.

Vector Analysis (10 Marks)

Definition of vector, Resolution of vectors into components along three directions. Scalar and vector products of two and three vectors. Applications to geometry and mechanics**.**

Continuity and differentiability of vector-valued function of one variable. Velocity and acceleration. Vector-valued functions of two and three variables, Gradient of scalar function, Divergence, curl and their properties.

References:

1. Loney, *Co-ordinate Geometry*, Reem Publication Pvt. Ltd.
2. R. J. T. Bell, *An Elementary Treatise on Co-ordinate Geometry,* Macmillan & Co. Ltd.
3. N. Dutta & R. N. Jana, *Analytical Geometry and Vector Algebra*, Shreedhar Prakashani,
4. B. Spain, *Vector Analysis*, D.Van Nostrand Company Ltd.
5. L. Brand, *Vector Analysis*, Dover Publications Inc.
6. Shanti Narayan**,** *A Text Book of Vector Analysis*, 19th Edn, S.Chand publishing.
7. M. Spiegel, S.Lipschutz , D. Spellman, *Vector Analysis*, McGraw-Hill.