Syllabus for B.Sc. Course (NEP) in Mathematics

2024

Department of Mathematics

DIAMOND HARBOUR WOMEN`S UNIVERSITY

Diamond Harbour Women's University
Faculty of Sciences
Department of Mathematics

Course Code Structure

Year	Sem	Code for DSC	Code for Minor	Code for Multi-Disciplinary	Code For Ability Enhance ment Course	Code For Skill Enhancement Course	Code For Value Added Course	Code For Voca-tional course	Code For Internship	Code For Disser-tation (Research With honours)	Total Credits	Marks
1	1	C1101: Classical and Abstract Algebra Group-A:(Classical Algebra) Group-B:(Abstract Algebra) C1102: Analytical Geometry of Two and Three Dimensions	G1103: Algebra and Geometry-I Group A-Classical Algebra Group B-Analytical Geometry(2D) Group C-Vector Algebra	MD-1: Basic Algebra	AEC-1 : Bengali	SEC-1: : C language with Mathematical Applications	VAC 1 ENVS				22	350
	2	C1201: Real Analysis-I C1202: Linear Algebra-I	G1203: Calculus and Diffrential Equation-I Group A- Differential Calculus-I Group B-Integral Calculus-I Group C-Differential Equation-I	MD-2: Mathematical Logic and Optimization	AEC-2 : English	SEC-2: Introduction to LATEX	VAC	VOC-1			28	400
2	3	C2101: Vector Algebra and Vector Analysis C2102: Calculus of Several Variables	G2103: Algebra and Geometry-II Group A-Modern Algebra Group B-Analytical Geometry (3D)	MD-3: Financial Mathematics and Vector Algebra	AEC-3 : Bengali	SEC-3: Introduction to Python Programming					20	300

	4	C2201: Real Analysis-II C2202: Linear Programming Problems and Game Theory C2203: Differential Equation (ODE)-I C2204: : Particle Dynamics and Statics-I Group-A: Particle Dynamics Group-B: Statics-I	G2205: Calculus and Diffrential Equation-II Group A- Differential Calculus-II Group B-Integral Calculus-II Group C-Differential Equation-II		AEC-4 : English			VOC-2			28	350
3	5	C3101: Metric Space C3102: Group Theory C3103: Differential Equation-II and Integral Transforms Group-A: Partial Differential Equation Group-B: Integral Transforms C3104: Statics –II , Rigid Dynamics and Hydrostatics Group –A Statics -II, Group-B : Rigid Dynamics Group-C : Hydrostatics	G3105: - Numerical methods and Linear Programming Group A- Numerical methods Group B-Linear Programming						INT		23	300
	6	C3201: Complex Analysis –I , Tensor Algebra and Tensor Calculus Group –A: Complex Analysis -I Group-B: Tensor Algebra and Tensor Calculus C3202: Numerical analysis C3203: Probability & Statistics C3204: Numerical Analysis (Practical)	G3205: Analytical Dynamics								20	250
4	7	C4101: Real Analysis-III C4102: Complex Analysis-II C4103: Ring Theory	G4105: Calculus							DIS Part 1	24	300

		C4104: Classical Mechanics								(4 Credit)		
	Without Research	C4101: Real Analysis-III C4102: Complex Analysis-II C4103: Ring Theory C4104: Classical Mechanics C4106: **Topology-I**	G4105: : Calculus									
	8 Without Research	C4201: Functional Analysis C4202: Differential Equation-III and Integral Equations Group-A: Differential Equation (ODE)-II Group-B: Integral Equations	G4203: Discrete Mathematics							DIS Part 2 (8 Credit)	20	250
		C4201: Functional Analysis C4202: Differential Equation-III and Integral Equation Group-A: Differential Equation (ODE)-II Group-B: Integral Equation C4204: **Optional -I:** Linear Algebra-II /Operation Research C4205: **Optional-II**: Topology-II/Fluid Mechanics	G4203: : Discrete Mathematics									
											185	**2500**

DSC Paper= 4 Credit; Minor = 4 credit; MD= 3 Credit; AEC=2Credit; SEC=3 Credit; VAC=2 Credit; VOC= 6 Credit; INT = 3 Credit

DSC

SEMESTER-1

C1101

Classical and Abstract Algebra (50 Marks)

Group-A: Classical Algebra (25 Marks, 2 Credits)

Complex numbers, De Moivre's theorem for rational indices and its applications. Theory of equations: Relation between roots and coefficients, the transformation of the equation, Descartes's rule of signs, cubic and biquadratic equation. Well-ordering property of positive integers, division algorithm,divisibility and Euclidean algorithm, prime number, and Fundamental Theoremof Arithmetic. Inequality: The inequality involving AM≥ GM≥ HM, Cauchy-Schwartz inequality.

Group-B: Abstract Algebra (25 Marks, 2 Credits)

Mapping, Binary Composition, Groupoid, semi Group, Groups, Sub Group,Cyclic Group, Normal Subgroup, Quotient Group, Group Homomorphism, Isomorphism Theorems of Groups, Ring, Subring, Integral domain, Field, Subfield.

References:

1. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed, Narosa Publishing House, 1999.
2. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed, Pearson, 2002.
3. M. Artin, Abstract Algebra, 2nd Ed, Pearson, 2011.
4. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra.
5. David S. Dummit and Richard M. Foot, Abstract Algebra, 3rd Ed, John Willey and Sons (Asia) Pvt. Ltd, Singapore, 2004.

C1102

Analytical Geometry of Two and Three Dimensions (50 Marks)

Analytical geometry of two dimensions. Transformation of rectangular axes. General equation of second degree and its reduction to normal form. Systems of conies. Polar equation of a conic. Tangent and Normals.
Direction cosines. Straight line. Plane. Sphere. Cone. Cylinder. Central conicoid, paraboloids,. Generating lines. Reduction of second-degree equations to normal form; classification of quadrics.

References:

Loney, S. L., Elements of Coordinate Geometry.
Shanti Narayan, Analytical Geometry of Three Dimensions.
Bell, R- J. T., Elementary Treatise on Coordinate Geometry.
Chaki, M. C, A Textbook of Analytical Geometry, Calcutta Publishers.

SEMESTER-2

C1201

Real Analysis-I (50 Marks)

Review of algebraic and order properties of R, ε-neighborhood of a point in R. Idea of countable sets, uncountable sets and uncountability of R. bounded sets, unbounded sets. Suprema and infima. Construction of Reals from Rationals, Cantor's nested interval Theorem, Completeness property of R and its equivalent properties. The Archimedean property.
Sequences, bounded sequence, convergent sequence, limit of a sequence, lim inf, lim sup. Limit theorems. Monotone sequences, monotone convergence theorem. Subsequences, divergence criteria. Monotone subsequence theorem (statement only), Bolzano Weierstrass theorem for sequences. Cauchy sequence, Cauchy's convergence criterion.
Infinite series, convergence and divergence of infinite series, Cauchy criterion, tests for convergence: comparison test, limit comparison test, D'Alembert's test, Raabe's test, Cauchy's nth root test, Gauss test, Logarithmic test, Integral test. Alternating series, Leibniz test. Absolute and conditional convergence, Rearrangement of series.
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 closed and bounded interval, intermediate value theorem. Uniform continuity,
Differentiability of a function at a point and in an interval, algebra of differentiable functions, Rolle's theorem. Mean value theorem: Lagrange's mean value theorem, Cauchy's mean value theorem, Darboux's theorem on derivatives. Applications of mean value theorem to inequalities and approximation of polynomials.

Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder and Young's form of remainder, application of Taylor's theorem to convex functions, Jensen's inequality, relative extrema. Taylor's series and Maclaurin's series expansions of exponential and trigonometric functions, ln (1 + x), 1/(ax + b) and(x+1)n . Application of Taylor's theorem to inequalities. L'Hospital's rule.

References:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2010.
3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.

C1202

Linear Algebra-I (50 Marks)

Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces (with special emphesis on R^n over R).

Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, Eigen values, Eigen vectors and characteristic equation of a matrix. Cayley-Hamilton theorem. Algebra of linear transformations. Isomorphisms. Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.

References:

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.
4. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa Publishing House, New Delhi, 1999.
5. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.
6. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007.
7. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India,1999.

8. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra, 2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
9. D.A.R. Wallace, Groups, Rings and Fields, Springer Verlag London Ltd., 1998.
10. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4^{th} Ed, Prentice-Hall of India Pvt Ltd, New Delhi, 2004.
11. S.Lang, Introduction to Linear Algebra, 2^{nd} Ed, Springer, 2005.
12. S.Kumaresan, Liner Algebra- A geometric Approach, Prentice-Hall of India, 1999.
13. Kenneth Hoffmann, Ray Alden Kunze, Linear Algebra, 2^{nd} Ed, Prentice-Hall of India Pvt Ltd, 1971.
14. S.H. Friedberg, A.L.Insel and L.E.Spence, Liner Algebra, Prentice-Hall of India Pvt Ltd, 2004.

SEMESTER-3

C2101

Vector Algebra and Vector Analysis (50 Marks)

Algebric Operations with vectors. Scalar and vector product of three vectors. Product of four vectors. Reciprocal vectors. Scalar, vector functions. Vector function of a scalar variable: Curves and Paths. Vector fields. Vector differentiation. Directional derivatives, the tangent plane, total differential, gradient, divergence, and curl. Vector integration: Path, line, surface, and volume integrals. Line integrals of linear differential forms, integration of total differentials, conditions for line integrals to depend only on the endpoints, the fundamental theorem on exact differentials. Serret-Frenet Formulas. Application of Vector analysis: Gauss Divergence theorem ,Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem.

References:

1. M.R. Speigel, Schaum's outline of Vector Analysis.
2. Marsden, J., and Tromba, Vector Calculus.
3. Kreyszig, Advanced Engineering Mathematics

C2102

Calculus of Several Variables (50 Marks)

Functions of several variables, limit and continuity of functions of two or more variables. Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes, Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems

Double integration over rectangular region, double integration over non-rectangular region, Double integrals in polar co-ordinates, Triple integrals, triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates. Change of variables in double integrals and triple integrals.

References:

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.

2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.

3. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE), Indian reprint, 2005.

4. James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.

5. M.R. Speigel, Schaum's outline of Vector Analysis.

SEMESTER-4

C2201

Real Analysis-II (50 Marks)

Riemann integration: inequalities of upper and lower sums, Darboux integration, Darboux theorem, Riemann conditions of integrability, Riemann sum and definition of Riemann integral through Riemann sums, equivalence of two definitions. Riemann integrability of monotone and continuous functions, properties of the Riemann integral; Integrability of functions with infinitely many discontinuities having finitely many limit points, Definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals; Fundamental theorem of Integral Calculus. Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions. Series of functions,Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test, Weierstrass approximation theorem. Power series.

References:

1. K.A. Ross, Elementary Analysis, The Theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
2. R.G. Bartle D.R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
3. Charles G. Denlinger, Elements of Real Analysis, Jones & Bartlett (Student Edition), 2011
4. S. Goldberg, Calculus and mathematical analysis.
5. T. M. Apostol, Calculus I, II.

C2202

Linear Programming Problems and Game Theory (50 Marks)

Definition of L.P.P. Formation of L.P.P. from daily life involving inequations. Graphical solution of L.P.P. Basic solutions and Basic Feasible Solution (BFS) with reference to L.P.P. Matrix formulation of L.P.P. Degenerate and Non-degenerate B.F.S.

Hyperplane, Convex set, Cone, extreme points, convex hull and convex polyhedron. Supporting and Separatinghyperplane. The collection of all feasible solutions of an L.P.P. constitutes a convex set. The extreme points of the convex set of feasible solutions correspond to its B.F.S. and conversely. The objective function has its optimal value at an extreme point of the convex polyhedron generated by the set of feasible solutions. (the convex polyhedron may also be unbounded). In the absence of degeneracy, if the L.P.P. admits of an optimal solution then at least one B.F.S. must be optimal. Reduction of a F.S. to a B.F.S.

Slack and surplus variables. Standard from of L.P.P. theory of simplex method. Feasibility and optimality conditions.

The algorithm. Two phase method. Degeneracy in L.P.P. and its resolution.

Duality theory : The dual of the dual is the primal. Relation between the objective values of dual and the primal problems. Relation between their optimal values. Complementary slackness, Duality and simplex method and their applications.

Transportation and Assignment problems. Mathematical justification for optimality criterion. Hungarian method. Traveling Salesman problem.

Concept of Game problem. Rectangular games. Pure strategy and Mixed strategy. Saddle point and its existence. Optimal strategy and value of the game. Necessary and sufficient condition for a given strategy to be optimal in a game. Concept of Dominance. Fundamental Theorem of Rectangular games. Algebraic method. Graphical method and Dominance method of solving Rectangular games. Inter-relation between the theory of Games and L.P.P.

References:

1. Linear Programming : Method and Application – S. I. Gass.
2. Linear Programming – G. Hadley.
3. An Introduction to Linear Programming & Theory of Games – S. Vajda.

4. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.

5. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.

6. Hamdy A. Taha, Operations Research, An Introduction, 8th Ed., Prentice-Hall India, 2006.

7. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002. 8. Churchman, Ackoff, Arnoff, Introduction to Operations Research, John Wiley and Sons Inc., 1957.

9. Billy, E. Gillet, Introduction to Operations Research: A Computer Oriented Algorithmatic Approach, TMH Edition, 1979.

10. Swarup K., Gupta P.K., Man Mohan, Operations Research, Sultan Chand and Sons, 2020.

11. Chakraborty J. G. and Ghosh, P.R., Linear Programming and Game Theory, Moulik Library, 1979

C2203

Differential Equation (ODE)-I (50 Marks)

First order differential equations : The existence and uniqueness theorem of Picard (Statement only), exact differential equations and integrating factors, special integrating factors and transformations, linear equations and Bernoulli equations.
Linear equations and equations reducible to linear form. First order higher degree equations solvable for x, y and p. Clairaut's equations and singular solution.
Linear differential equations of second order, Wronskian : its properties and applications, Euler equation, method of undetermined coefficients, method of variation of parameters.
System of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients.
Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions. Eigen value and Eigen functions.

References:

1. Codington ,E.A and Levinson , N ., Theory of ordinary differential equation , Mcgraw Hill .
2. Estham , Ordinary differential equation .
3. Hartman , P , Ordinary differential equation , John wiley and sons
4. Reid , W.T . Ordinary differential equation , John wiley and sons .
5. Burkhill , J .C ., Theory of ordinary differential equation
6. Ince , E .L . Ordinary differential equation , Dover

C2204

Particle Dynamics and Statics-I (50 Marks)

Group-A: Particle Dynamics (35 Marks, 3 Credits)

Recapitulations of Newton's laws. Applications of Newton's laws to elementary problems of simple harmonic motion, inverse square law and composition of two simple harmonic motions.

Tangent and normal accelerations. Circular motion. Radial and cross-radial accelerations. Damped harmonic oscillator. Motion under gravity with resistance proportional to some integral power of velocity. Terminal velocity. Simple cases of a constrained motion of a particle. Motion of a particle in a plane under different laws of resistance. Motion of a projectile in a resisting medium in which the resistance varies as the velocity. Trajectories in a resisting medium where resistance varies as some integral power of the velocity.

Central forces and central orbits. Typical features of central orbits. Stability of nearly circular orbits.

Planetary motion and Kepler's laws. Time of describing an arc of the orbit. Orbital energy. Relationship between period and semi-major axis. Motion of an artificial satellite.

Motion of a smooth cure under resistance. Motion of a rough curve under gravity e.g., circle, parabola, ellipse, cycloid etc.

Varying mass problems. Examples of falling raindrops and projected rockets.

Group-B: Statics-I (15 Marks, 1 Credits)

Friction : Law of Friction, Angle of friction, Cone of friction, To find the positions of equilibrium of a particle lying on a (i) rough plane curve, (ii) rough surface under the action of any given forces.

Astatic Equilibrium, Astatic Centre, Positions of equilibrium of a particle lying on a smooth plane curve under action of given force. Action at a joint in a frame work.

Centre of Gravity: General formula for the determination of C.G. Determination of position of C.G. of any arc, area of solid of known shape by method of integration.

References:

An Elementary Treatise on the Dynamics of a Particle & of Rigid bodies – S. L. Loney (Macmillan).

Dynamics of Particle and of Rigid Bodies – S. L. Loney.

SEMESTER-5

C3101

Metric Space (50 Marks)

Metric spaces Definition and examples. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, subspaces, dense sets, separable spaces. Sequences in metric spaces, Cauchy sequences. Complete metric spaces, Cantor's theorem. Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Connectedness, connected subsets of R. Compactness: Sequential compactness, Heine-Borel property, totally bounded spaces, finite intersection property, and continuous functions on compact sets. Contraction mappings. Banach fixed point theorem and its application to ordinary differential equation.

References:

1. SatishShirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006.
2. S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.

C3102

Group Theory (50 Marks)

Automorphism, inner automorphism, automorphism groups of finite and infinite cyclic groups, application of factor groups to automorphism groups, characteristic subgroup, commutator subgroup, and its properties.

External direct product and its properties, the group of units modulo n as an external direct product, internal direct product, the converse of Lagrange's theorem for finite abelian group, Cauchy's theorem for finite abelian group, Fundamental theorem of finite abelian groups. Class equation,Sylow theorem, Simple group.

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References:

1. Joseph A. Gallian, Contemporary Abstract Algebra, 4th Ed, Narosa Publishing House, 1999.
2. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed, Pearson, 2002.
3. M. Artin, Abstract Algebra, 2nd Ed, Pearson, 2011.
4. D.S. Malik, John M. Mordeson and M.K. Sen, Fundamentals of Abstract Algebra.
5. David S. Dummit and Richard M. Foot, Abstract Algebra, 3rd Ed, John Willey and Sons (Asia) Pvt. Ltd, Singapore, 2004.

C3103

Differential Equation-II & Integral Transformations (50 Marks)

Group A :Partial Differential Equation (25 Marks, 2 Credits)

Partial differential equations of the first order, non linear first order partial differential equations, Charpit's general method of solution, some special types of equations which can be solved easily by methods other than the general method, Lagrange's solution.
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.
Initial boundary value problems. Semi-infinite string with a fixed end, semi-infinite string with a free end. The Cauchy problem, Cauchy-Kowalewskaya theorem, Cauchy problem of finite and infinite string. Equations with non-homogeneous boundary conditions. Greens Function.
Non-homogeneous wave equation. Method of separation of variables, solving the vibrating string problem. Solving the heat conduction problem.

Group B: Integral Transformations (25 Marks, 2 Credits)

1. Fourier Transforms: Fourier integral Theorem. Definition and properties. Fourier transform of the derivative. Derivative of Fourier transform. Fourier transforms of some useful functions. Fourier cosine and sine transforms. Inverse of Fourier transforms. Convolution. Properties of convolution function. Convolution theorem. Applications.
2. Laplace transforms: Definition and properties. Sufficient conditions for the existence of Laplace Transform. Laplace Transform of some elementary functions. Laplace transform of the derivatives. Inverse of Laplace transform. Bromwich Integral Theorem. Initial and final value theorems. Convolution theorem. Applications.

References:

1. Elements of Partial Differential Equations – Ian N. Sneddon (McGraw Hill).
2. An Elementary Course in Partial Differential Equations – T. Amarnath (Narosa).
3. Partial Differential Equations, Graduate Series in Mathematics, Vol.19 L. C. Evans (1998, AMS)
4. Partial Differential Equations Miller.
5. Partial Differential Equations – F. John
6. Phoolan Prasad, RenukaRavindran: Partial Differential Equations.
7. John David Logan: Applied Partial Differential Equations.
8. Emmanuele Di Benedetto: Partial Differential Equations.

9. Andrei DmitrievichPolianin, VadimFedorovichZaitsev, Alan Moussiaux: Handbook of first Order Partial Differential Equations.
10. TynMyint U., LokenathDebnath: Linear Partial Differential Equations for Scientists and Engineers.
11 . I.N. Sneddon Use of Integral transform (McGraw Hill).
12. I.N. Sneddon Fourier Transforms (McGraw Hill).

C3104

Statics-II , Rigid Dynamics and Hydrostatics (50 Marks)

Group-A: Statics-II (10 Marks, 1 Credit)

Virtual work: Principle of virtual work for a single particle. Deduction of the conditions of equilibrium of a particle under coplanar forces from the principle of virtual work. The principle of virtual work for a rigid body. Forces which do not appear in the equation of virtual work. Forces which appear in the equation of virtual work. The principle of virtual work for any system of coplanar forces acting

Forces in the three dimensions. Moment of a force about a line. Axis of a couple. Resultant of any two couples acting on a body. Resultant of any number of couples acting on a rigid body. Reduction of a system of forces acting on a rigid body. Resultant force is an invariant of the system but the resultant couple is not an invariant. Conditions of equilibrium of a system of forces acting on a body. Deductions of the conditions of equilibrium of a system of forces acting on a rigid body from the principle of virtual work. Poisnot's central axis. A given system of forces can have only one central axis. Wrench, Pitch, Intensity and Screw. Condition that a given system of forces may have a single resultant. Invariants of a given system of forces. Equation of the central axis of a given system of forces.

Group-B: Rigid Dynamics(20 Marks, 2 Credits)

Centre of mass. Basic kinematic quantities : momentum, angular momentum and kinetic energy. Principle of energy and momentum. Work and poser. Simple examples on their applications. Impact of elastic bodies. Direct and oblique impact of elastic spheres. Losses of kinetic energy. Angle of deflection.Momental ellipsoid, Equimomental system. Principal axis. D'Alembert's principle. D'Alembert's equations of motion. Principles of moments. Principles of conservations of linear and angular momentum. Equation of motion of a rigid body about a fixed axis. Expression for kinetic energy and moment of momentum of a rigid body moving about a fixed axis. Compound pendulum. Interchangeability of the points of a suspension and centre of oscillation. Minimum time of oscillation. Equations of motion of a rigid body moving in two dimensions. Expression for kinetic energy and angular momentum about the origin of rigid body moving in two dimensions. Necessary and sufficient condition for pure rolling. Two dimensional motion of a solid of revolution moving on a rough horizontal plane.

Group-C: Hydrostatics(20 Marks, 1 Credit)

Definition of Fluid. Perfect Fluid, Pressure. To prove that the pressure at a point in fluid in equilibrium is the same in every direction. Transmissibility of liquid pressure. Pressure of heavy fluids. To prove (i) In a fluid at rest under gravity the pressure is the same at all points in the same horizontal plane. (ii) In a homogeneous fluid at rest under gravity the difference between the pressures at two points is proportional to the difference of their depths. (iii) In a fluid at rest under gravity horizontal planes re surfaces of equal density. (iv) When two fluids of different densities at rest under gravity do not mix, their surface of separation is a horizontal plane. Pressure in heavy homogeneous liquid. Thrust of heavy homogeneous liquid on plane surface.

Equilibrium of fluids in given fields of force : Definition of field of force, line of force. Pressure derivative in terms of force. Surface of equi-pressure. To find the necessary and sufficient conditions of equilibrium of a fluid under the action of a force whose components are X, Y, Z along the co-ordinate axes. To prove (i) that surfaces of equal pressure are the surfaces intersecting orthogonally the lines of force, (ii) when the force system is conservative, the surfaces of equal pressure are equi-potential surfaces and are also surfaces of equal density. To find the differential equations of the surfaces of equal pressure and density.

Pressure of gases. The atmosphere. Relation between pressure, density and temperature. Pressure in an isothermal atmosphere. Atmosphere in convective equilibrium.

References:

1. Hydrostatics – A. S. Ramsay.
2. Analytical Statics – S. L. Loney
3. Dynamics of Particle and of Rigid Bodies – S. L. Loney.

<u>SEMESTER-6</u>

C3201

Complex Analysis-I ,TensorAlgebra and Tensor Calculus (50 Marks)

Group-A: Complex Analysis-I (35 Marks, 3 Credits)

Complex Numbers:
Complex Plane, Lines, and Half Planes in the complex plane, Extended plane, and its Spherical Representation, Stereographic Projection.
Complex Differentiation:
Derivative of a complex function, Comparison between differentiability in the real and complex senses, Cauchy-Riemann equations, Necessary and Sufficient Criterion for complex differentiability, Analytic functions, Entire functions, Harmonic functions, and Harmonic conjugates.
Complex Functions and Conformality:
Polynomial functions, Rational functions, Power series, Exponential, Logarithmic, Trigonometric and Hyperbolic functions, Branches of a logarithm, Analytic functions as mappings,
Conformal maps, Möbius Transformations.

Group-B : Tensor Algebra, Tensor Calculus (15 Marks, 1 Credit)

Summation convention and indicial notation, Coordinate transformation and Jacobian, Contra-variant and Covariant vectors, Tensors of different types, Algebra of tensors and contraction, Metric tensor and 3-index Christoffel symbols, Parallel propagation of vectors, Covariant and intrinsic derivatives, Curvature tensor and its properties,

References:

1. T.J. Willmore, An Introduction to Differential Geometry, Dover Publications, 2012.

2. B. O'Neill, Elementary Differential Geometry, 2nd Ed., Academic Press, 2006.

3. C.E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press 2003.

4. D.J. Struik, Lectures on Classical Differential Geometry, Dover Publications, 1988.

5. S. Lang, Fundamentals of Differential Geometry, Springer, 1999.

6. E.Kreyszig, Differential Geometry, Dover Publications, New York, 1991.

7. B. Spain, Tensor Calculus: A Concise Course, Dover Publications, 2003.

8. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw – Hill International Edition, 2009.

9. Joseph Bak and Donald J. Newman, Complex Analysis, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., NewYork, 1997.

C3202

Numerical Analysis (50 Marks)

Representations of numbers: Roundoff error, truncation error, significant error, error in numerical computations.

Solution of transcendental and algebraic equations: Bisection, secant, RegulaFalsi, fixed-point, Newton-Raphson, Graffe's methods.

Interpolation: Difference schemes, and interpolation formulas using differences. La-grange and Newton interpolation.Hermiteinterpolation.Divided differences.

Numerical differentiation: Methods based on interpolations. Methods based on finite differences.

Numerical integration: Trapezoidal, Simpson's, and Weddle's rules. Gauss Quadrature Formulas.

Solution of linear equations: Direct methods - Gauss elimination, Gauss-Jordan elimination, LU decomposition. Iterative methods - Jacobi, Gauss-Siedel.

The algebraic eigenvalue problem: Jacobi's method, Given's method, House-holder's method, Power method.

Ordinary differential equations: Euler's method, Single-step methods, Runge-Kutta's method, multi-step methods.

Approximation: Different types of approximation, least square polynomial approximation.

References:

1. F. B. Hildebrand – Introduction to Numerical Analysis
2. Demidovitch and Maron – Computational Mathematics

3. F. Scheid – Computers and Programming (Schaum's series)
4. G. D. Smith – Numerical Solution of Partial Differential Equations (Oxford)
5. Jain, Iyengar and Jain – Numerical Methods for Scientific and Engineering Computation
6. A. Gupta and S. C. Basu – Numerical Analysis
7. Scarborough – Numerical Analysis
8. Atkinson – Numerical Analysis
9. A. Ralston A First Couse in Numerical Analysis, McGrawHill,N.Y.(1965)
10. Mullish, Henry, and Herbert, L., *Spirit of C: An Introduction to Modern Programming,* Jaico publishers**.**

11. Deitel, H. N., and Deitel, P. J., *C How to Program,* Prentice Hall

12. Xevier, C, *C Language and Numerical Methods,* New Age International.

C3203

Probability & Statistics (50 Marks)

Group A: Probability (35 Marks, 3 Credits)

Mathematical Theory of Probability : Random experiments. Simple and compound events. Event space. Classical and frequency definitions of probability and their drawbacks. Axioms of Probability. Statistical regularity. Multiplication rule of probabilities. Bayes' theorem. Independent events. Independent random experiments. Independent trials. Bernouli trials and binomial law. Poisson trials.

Random variables. Probability distribution. distribution function. Discrete and continuous distributions. Binomial, Poisson, Gamma, Uniform and Normal distribution. Poisson Process (only definition). Transformation of random variables. Two dimensional probability distributions. Discrete and continuous distributions in two dimensions. Uniform distribution and two dimensional normal distribution. Conditional distributions. transformation of random variables in two dimensions.

Mathematical expectation. Mean, variance, moments, central moments. Measures of location, dispersion, skewness and kurtosis. Median, mode, quartiles. Momentgenerating function. Characteristic function. Two-dimensional expectation. Covariance, Correlation co-efficient, Joint characteristic function. Multiplication rule for expectations. Conditional expectation. Regression curves, least square regression lines and parabolas. Chi-square and t-distributions and their important properties (Statements only). Tchebycheff's inequality. Convergence in probability. Statements of : Bernoulli's limit theorem. Law of large numbers. Poissons's approximation to binomial distribution and normal approximation to binomial distribution. Concepts of asymptotically normal distribution.

Statement of central limit theorem in the case of equal components and of limit theorem for characteristic functions (Stress should be more on the distribution function theory than on combinatorial problems. Difficult combinatorial problems should be avoided).

Group B:Statistics (15 Marks, 1 Credit)

Random sample. Concept of sampling and various types of sampling. Sample and population. Collection, tabulation and graphical representation. Grouping of data. Sample characteristic and their computation. Sampling distribution of a statistic.

Estimates of a population characteristic or parameter. Unbiased and consistent estimates. Sample characteristics as estimates of the corresponding population characteristics. Sampling distributions of the sample mean and variance. Exact sampling distributions for the normal populations.

Bivariate samples. Scatter diagram. Sample correlation co-efficient. Least square regression lines and parabolas. Estimation of parameters. Method of maximum likelihood. Applications to binomial, Poisson and normal population. Confidence intervals. Interval estimation for parameters of normal population. Statistical hypothesis. Simple and composite hypothesis. Best critical region of a test. Neyman-Pearson theorem (Statement only) and its application to normal population. Likelihood ratio testing and its application to normal population. Simple applications of hypothesis testing.

References:

1. The elements of probability theory and some of its applications - H. Cramer.
2. An introduction to probability theory and its applications (Vol. 1) – W. Feller.
3. Mathematical methods of statistics – H. Cramer.
4 Theory of probability – B. V. Gnedenko.
6. Mathematical probability – J. V. Uspensky.

C3204

Numerical Analysis (Practical) (50 Marks)

Numerical Methods Practical (Lab) using C programming

Numerical Methods Lab. Programming in C of the following set of problems:

- Bisection method.
- RegulaFalsi method.
- Newton-Raphson method.
- Lagrange interpolation.
- Newton's forward and backward interpolation.
- Trapezoidal and Simpson one-third rules.
- Gauss elimination method.
- Gauss-Siedel method.
- Power method (eigenvalue).
- Euler's method.
- Runge-Kutta's method.

References:

1. F. B. Hildebrand – Introduction to Numerical Analysis
2. Demidovitch and Maron – Computational Mathematics
3. F. Scheid – Computers and Programming (Schaum's series)
4. G. D. Smith – Numerical Solution of Partial Differential Equations (Oxford)
5. Jain, Iyengar and Jain – Numerical Methods for Scientific and Engineering Computation
6. A. Gupta and S. C. Basu – Numerical Analysis
7. Scarborough – Numerical Analysis
8. Atkinson – Numerical Analysis
9. A. Ralston A First Couse in Numerical Analysis, McGrawHill,N.Y.(1965)
10. Mullish, Henry, and Herbert, L., *Spirit of C: An Introduction to Modern Programming,* Jaico publishers**.**

11. Deitel, H. N., and Deitel, P. J., *C How to Program,* Prentice Hall

12. Xevier, C, *C Language and Numerical Methods,* New Age International.

<u>SEMESTER-7 (With Research)</u>

C4101

Real Analysis-III (50 Marks)

Fourier Series and Fourier Transformation .

Bounded Variation .

Functions of Bounded Variation and their properties, Differentiation of a function of bounded variation, Absolutely Continuous Function, Representation of an absolutely continuous function by an integral.

The Theory of Measure .

Semiring and ring of sets, σ-ringand σ-algebra, Ring and σring generated by a class of sets, Monotone class of sets, Monotone class generated by a ring, Borel Sets. Measures on semirings and their properties, Outer Measure and Measurable Sets, Caratheodory Extension : measure generated by an outer measure, Lebesgue measure on R^n, Measure space, Finite and σfinite measure spaces. Measurable Functions, Sequence of measurable functions, Egorov's Theorem, Convergence in Measure.

The Lebesgue Integral .

Simple and Step Functions, Lebesgue integral of step functions, Upper Functions, Lebesgue integral of upper functions, Lebesgue Integrable functions, Fatou's Lemma, Dominated Convergence Theorem, Monotone Convergence Theorem, Riemann integral as a Lebesgue integral, LebesgueVitali Theorem, Application of the Lebesgue Integral.

References:

1. Aliprantis, C.D., Burkinshaw, O., *Principles of Real Analysis* , 3rd Edition, Harcourt Asia Pte Ltd., 1998.
2. Royden, H.L., *Real Analysis* , 3rd Edition, Macmillan, New York & London, 1988.
3. Halmos, P.R., *Measure Theory* , Van Nostrand, New York, 1950.
4. Rudin, W., *Real and Complex Analysis* ,McGrawHill Book Co., 1966.
5. Kolmogorov, A.N., Fomin, S.V., *Measures, Lebesgue Integrals, and Hilbert Space* , Academic Press, New York & London, 1961.

Note : This course is based on book (1), Chapters 3, 4.

C4102

Complex Analysis-II (50 Marks)

Complex Integration :

The complex integral (over piecewise C^1curves), Cauchy's Theorem and Integral Formula, Power series representation of analytic functions, Morera's Theorem, Goursat's Theorem, Liouville's Theorem, Fundamental Theorem of Algebra, Zeros of analytic functions, Identity Theorem, Weierstrass Convergence Theorem, Maximum Modulus Principle and its applications, Schwarz's Lemma, Index of a closed curve, Contour, Index of a contour, Simply connected domains, Cauchy's Theorem for simply connected domains.

Singularities :

Definitions and Classification of singularities of complex functions, Isolated singularities, Laurent series, CasoratiWeierstrass Theorem, Poles, Residues, Residue Theorem and its applications to contour integrals, Meromorphic functions, Argument Principle, Rouche's Theorem.

Analytic Continuation :

Schwarz Reflection Principle, Analytic Continuation along a path, Monodromy Theorem.

References:
1. Conway, J.B., *Functions of one complex variable* , Second Edition, Narosa Publishing House.
2. Sarason, D., *Complex Function Theory* , Hindustan Book Agency, Delhi, 1994.
3. Ahlfors, L.V., *Complex Analysis* ,McGrawHill, 1979. Rudin, W., *Real and Complex Analysis* McGrawHill Book Co., 1966.
4. Hille, E., *Analytic Function Theory* (2 vols.), Gonn& Co., 1959. Titchmarsh, E.C., *The Theory of Functions* , Oxford University Press, London.
5. Ponnusamy, S., *Foundations of Complex Analysis* ,Narosa Publishing House, 1997.

Note : This course is based on the books (1) and (2), as described below:
Section (i) : Books (1) & (2), Chapter I. Section (ii) : Book (2), Chapter II.
Section (iii) : Book (1), Chapter III. Section (iv) : Book (2), Chapters VI, VII, IX.
Section (v) : Book (1), Chapter V & Book (2), Chapter VIII. Section (vi) : Book (1), Chapter IX.

C4103

Ring Theory (50 Marks)

Ideals and Homomorphisms, Quotient Rings, Prime and Maximal Ideals, Quotient Field of an Integral Domain, Divisibility Theory, Euclidean Domain, Principal Ideal Domain, Unique Factorization Domain, Gauss' Theorem, Polynomial Rings, Irreducibility of Polynomials.Characteristics of field, Prime subfield.

References:
1. Artin, M., Algebra.
2. P. B. Bhattacharya, S.K.Jain&S.R.Nagpaul – Basic Abstract Algebra (Cambridge).
3. Dummit, D.S., Foote, R.M., Abstract Algebra, Second Edition, John Wiley & Sons, Inc.,1999.
4. Goldhaber, J.K., Ehrlich, G., Algebra, The Macmillan Company, CollierMacmillan Limited, London.
5. Herstein, I.N., Topics in Abastract Algebra, Wiley Eastern Limited, Hungerford, T.W., Algebra, Springer.
6. Hungerford, T.W., Algebra, Springer.
7. Jacobson, N., Basic Algebra, I & II, Hindusthan Publishing Corporation, India.
8. Lang, S., Algebra.
9. Malik, D.S., Mordesen, J.M., Sen, M.K., Fundamentals of Abstract Algebra, TheMcGrawHill Companies, Inc.
10. Rotman, J.J., The Theory of Groups: An Introduction, Allyn and Bacon, Inc., Boston.
11. Sen, M.K., Ghosh, S. and Mukhopadhyay, P., Topics in Abstract Algebra, Universities Press, 2006.
12. Gareth A Jones and J. Mary Jones : Elementary Number Theory, Springer International

Edition.
13. Neal Koblitz, A Course in Number Theory and Cryptography, SpringerVerlag, 2^{nd} Edition.
14. D. M. Burton : Elementary Number Theory, Wim C. Brown Publishers Duireque, Lowa, 1989.

C4104

Classical Mechanics (50 Marks)

Rotating frames of reference: Rotating coordinate system, motion of a particle relative to rotating earth, Coriolis force, deviation of freely falling body from vertical, Foucault's pendulum.

Motion of a rigid body: Two-dimensional motion of a rigid body rotating about a fixed point - velocity, angular momentum and kinetic energy, Euler's dynamical equations and its solutions, invariable line and invariable plane, torque free motion, Euler's angles, Components of angular velocity in terms of Euler's angles, motion of a top in a perfectly rough floor, stability of top motion.

Constrained motion: Constraints and their classification with examples, Lagrange's equation of motion of the first kind, Gibbs-Appell's principle of least action, D'Alembert's principle.

Lagrangian mechanics: Degrees of freedom, generalised coordinates, Lagrange's equations of motion of the second kind (holonomic and non-holonomic systems), velocity dependent potential, dissipative forces, Rayleigh's dissipation function, generalised momenta and energy, gauge function for Lagrangian, invariance of the Euler-Lagrange equations (under coordinate transformation, Galilean transformation), cyclic coordinates, Routh process for ignorable coordinates, symmetry and conservation laws.

Hamiltonian mechanics: Legendre dual transformation, Hamilton's canonical equations of motion, properties of Hamilton's function, principle of least action, Hamilton's principle, derivation of the Euler-Lagrange's equations of motion, derivation of the Hamilton's equations of motion, invariance of Hamilton's principle under coordinate transformation.

Calculus of Variations: Derivation of Euler-Lagrange's equation, sufficient condition for existence of extremals, Brachistochrone problem, geodesic, isoperimetric problem, variational problems with moving boundaries.

Canonical transformations: Definition, examples and properties of canonical transformations, generating functions, Liouville's theorem, Poisson bracket (definition and properties), Poisson's theorems, Condition of canonicality in terms of Poisson bracket, Lagrangian bracket, Poisson's bracket of angular momentum, Infinitesimal canonical transformations, Hamilton-Jacobi theory, Hamilton's principle and characteristic functions, Noether's theorem.

Small oscillations: Small oscillations in systems with more than one degree of freedom, Normal coordinates, Oscillations under constraints, Oscillations with dissipation, Forced oscillations.

References:
1. H. Goldstein, Classical Mechanics, Narosa Publ. House, 1997.

2. V. B. Bhatia, Classical Mechanics with introduction to nonlinear oscillation and chaos, Narosa Publishing House, 1997.

3. N. C. Rana & P.S. Jog, Classical Mechanics, Tata McGraw Hill, 2001.

4. A. S. Gupta, Calculus of Variations with Applications, Prentice –Hall of India, 1996.

Reference Books:

1. E. T. Whittaker – A Treatise on the Analytical Dynamics of Particles and Rigid Bodies, Cambridge University Press, 1993.

2. D. T. Green Wood – Classical Dynamics, Dover Publication, 2006.

3. F. R. Gantmakher – Lectures in Analytical Mechanics, Mir Publishers, 1970

4. J. L. Synge & B. a. Graffith, Principles of Mechanics, Mc. Graw-Hill Book Co. 1960.

5. I. M. Gelfand and S.V. Fomin, Calculus of Variations, Prentice Hall Inc, 2012.

SEMESTER-7 (Without Research)

C4101: Real analysis-III

C4102: Complex Analysis-II

C4103: Ring Theory

C4104:Classical Mechanics

C4106: Topology -I

Topology-I (50 Marks)

Set Theory :
Countable and Uncountable Sets, Schroeder Bernstein Theorem, Cantor's Theorem, Cardinal

Numbers and Cardinal Arithmetic, Continuum Hypothesis, Zorn's Lemma, Axiom of Choice, Well Ordered Sets, Maximum Principle,Introduction to Ordinal Numbers.

Topological Spaces and Continuous Functions :
Topological spaces, Basis and Sub basis for a topology, Order Topology, Subspace Topology, Interior Points, Limit Points, Derived Set, Boundary of a set, ClosedSets, Closure and Interior of a set, Kuratowski closure operator and the generated topology,
Continuous Functions, Open maps, Closed maps and Homeomorphisms, Product Topology, Box Topology. Separation Axioms (Upto T_4)
Connectedness and Compactness :
Connected and Path Connected Spaces, Connected Sets in R, Components and Path Components, Local Connectedness. Compact Spaces, AscoliArzelà Theorem
References:
1. Munkres, J.R., *Topology, A First Course* , Prentice Hall of India Pvt. Ltd., New Delhi,2000.
2. Dugundji, J., *Topology* ,Allyn and Bacon, 1966.
3. Simmons, G.F., *Introduction to Topology and Modern Analysis* , McGrawHill,1963.
4. Kelley, J.L., *General Topology* , Van Nostrand Reinhold Co., New York, 1995.
5. Hocking, J., Young, G., *Topology* ,AddisonWesley Reading, 1961.
6. Steen, L., Seebach, J., *Counter Examples in Topology* , Holt, Reinhart and Winston, New York, 1970.
Note : This course is based on the book (1), Chapters 1 5. 0.5in

SEMESTER-8 (With Research)

C4201

Functional Analysis (50 Marks)

Normed Linear Spaces & Banach Spaces :
Normed Linear Spaces, Banach Spaces, Equivalent Norms, Finite dimensional normed linear spaces and local compactness, Quotient Space of normed linear spaces and its completeness, Riesz Lemma, Fixed Point Theorems and its applications. Bounded Linear Transformations, Normed linear spaces of bounded linear transformations, Uniform Boundedness Theorem, Principle of Condensation of Singularities, Open Mapping Theorem, Closed Graph Theorem, Linear Functionals, Hahn Banach Theorem, Dual Space, Reflexivity of Banach Spaces.
Hilbert Spaces :
Real Inner Product Spaces and its Complexification, Cauchy Schwarz Inequality, Parallelogram law, Pythagorean Theorem, Bessel's Inequality, GramSchmidtOrthogonalization Process, Hilbert Spaces, Orthonormal Sets, Complete Orthonormal Sets and Parseval's Identity, Structure of Hilbert Spaces, Orthogonal Complement and Projection Theorem. Riesz Representation Theorem, Adjoint of an Operator on a Hilbert Space, Reflexivity of Hilbert Spaces, Selfadjoint Operators, Positive Operators, Projection Operators, Normal Operators, Unitary Operators. Introduction to Spectral Properties of Bounded Linear Operators.

References:
1. Aliprantis, C.D., Burkinshaw, O., *Principles of Real Analysis* , 3rd Edition, Harcourt Asia Pte Ltd., 1998.
2. Goffman, C., Pedrick, G., *First Course in Functional Analysis* , Prentice Hall of India, New Delhi, 1987.
3. Bachman, G., Narici, L., *Functional Analysis* , Academic Press, 1966.
4. Taylor, A.E., *Introduction to Functional Analysis* , John Wiley and Sons, New York,1958.
5. Simmons, G.F., *Introduction to Topology and Modern Analysis* , McGrawHill,1963.
6. Limaye, B.V., *Functional Analysis* , Wiley Eastern Ltd.
7. Conway, J.B., *A Course in Functional Analysis* , Springer Verlag, New York, 1990.
8. Kreyszig, E., *Introductory Functional Analysis and its Applications* , John Wiley and Sons, New York, 1978.

C4202

Differential Equations-III & Integral Equations (50 Marks)

Group-A: Differential Equation (ODE)-II (25 Marks, 2 Credits)

First order system of equations: Wellposed problems, existence and uniqueness of the solution, simple illustrations. Peano's and Picard's theorems (statements only), Linear systems, nonlinear autonomous system, phase plane analysis, critical points, stability, Linearization, Liapunov stability, undamped pendulum, Applications to biological system and ecological system.

Special Functions

Series Solution : Ordinary point and singularity of a second order linear differential equation in the complex plane; Fuch's theorem, solution about an ordinary point, solution of Hermite equation as an example; Regular singularity, Frobenius' method – solution about a regular singularity, solutions of hypergeometric, Legendre, Laguerre and Bessel's equation as examples Legendre polynomial : its generating function; Rodrigue's formula, recurrence relations and differential equations satisfied by it; Its orthogonality, expansion of a function in a series of Legendre Polynomials Adjoint equation of nth order: Lagrange's identity, solution of equation from the solution of its adjoint equation, selfadjoint equation, Green's function

Group B: Integral Equations (25 Marks, 2 Credits)

1. Linear integral equations of 1st and 2nd kinds – Fredholm and Volterra types. Relation between integral equations and initial boundary value problems.

2. Existence and uniqueness of continuous solutions of Fredholm and Volterra's integral equations of second kind. Solution by the method of successive approximations. Iterated kernels. Solution of volterra integral equation with difference kernel.Resolvent kernel.

3. Fredholm theory for the solution of fredholm's integral equation. Fredholm's determinant D(lamda). Fredholm'sfirst , second and third fundamental theorems.Fredholm's alternatives.

References:

1. Codington ,E.A and Levinson , N ., Theory of ordinary differential equation , Mcgraw Hill .
2. Estham , Ordinary differential equation .
3. Hartman , P , Ordinary differential equation , John wiley and sons
4. Reid , W.T . Ordinary differential equation , John wiley and sons .
5. Burkhill , J .C ., Theory of ordinary differential equation
6. Ince , E .L . Ordinary differential equation , Dover
7. S. G. Mikhlin – *Integral Equation* (Pergamon Press).
8. F. G. Tricomi – *Integral Equation* (Interscience Publishers) .
9. A.Chakrabarti,Applied Integral Equation (Vijay Nicole Imprints Pvt Ltd)

SEMESTER-8 (Without Research)

C4201: Functional Analysis

C4202: Differential Equations(ODE)-II & Integral Equations

C4204: Optional-I

Linear Algebra-II (Optional) (50 Marks)

Dual space, Adjoints of Linear Transformations,, annihilators
Dual Basis. Eigen Values and Eigen Vectors, Characteristic and Minimal Polynomials, Cayley-Hamilton theorem. Inner product space, Cauchy-Schwartz inequality, orthogonal vectors and orthogonal complements, orthonormal sets and orthonormal basis, Bessel's inequality, GramSchmidtorthogonalization method. Spectral Theorem. Canonical forms : similarity of linear transformations, Diagonalization, invariant subspaces, reduction to triangular forms, Nilpotent transformations, Hermitian, Selfadjoint, unitary and orthogonal transformations, Jordan blocks and Jordan forms, Rational Canonical forms, The primary decomposition theorem, cyclic subspaces of annihilators, cyclic decomposition. Billinear and Quadratic forms.

References:

1. Artin, M., Algebra.
2. Friedberg, Insel and Spence, Linear Algebra.
3. Halmos, Finite Dimensional Vector Spaces.
4. Hoffman and Kunze, Linear Algebra, Prentice Hall.
5. Hungerford, T.W., Algebra, Springer.
6. Kumerason, S., Linear Algebra.
7. Lang, S., Linear Algebra.
8. Rao and Bhimsankaran, Linear Algebra.
9. Jin HoKwak and Sungpyo Hong, Linear Algebra, Birkhauser.

OR

Operation Research (optional) (50 Marks)

Operations Research anoverview. Revised Simplex Method minimizationandmaximization problem.Sensitivity Analysis Changein profit (or cost) contribution coefficients, change in availabilityof resources. change in inputoutputcoefficients.Integer Linear Programming Branchand Bound algorithm, Cutting plane algorithm.NonlinearProgramming Formulation of Nonlinearprogramming problem Graphicalmethod of solution. Unconstrained optimization.Optimization with equality constraints.KuhnTuckerconditions for constrained optimization. Convex programming.Quadraticprogramming Problems by (i) Wolfe's method and (ii) Beale's method.Dynamic Programming Deterministicand probabilistic models.Inventory Introduction,

Features of inventory system, Inventory model building.Deterministic models with (i) No Shortage, (ii) Shortage. Multi item inventory models withconstraints. Probabilistic models Singleperiod probabilistic models (i) without set up cost, (ii)with set up cost.Queuing Theory Introduction.Essential features of Queuing system.Probability distributionin Queuing Models.Classification of Queue models. Solution of Queuing models:
[1]{(M/M/1):(infinity/FCFS)}, [2]{(M/M/1):(n/FCFS)} [3] {(M/M/s):(infinity/FCFS)}
[4]{(M/M/s):(n/FCFS).

References:

1. H. A. Taha, OperationsResearchAnIntroduction. Macmillan Pub.Co., Inc., NewYork.
2. G. Hadley, Nonlinearand Dynamic Programming, AdditionWesley.
3. S. S. Rao, OptimizationTheory and Application, Wiley Eastern.
4. KantiSarup, P. K. Gupta and Man Mohan, OperationResearch, Sultan Chand & Sons.
5. J. K. Sharma, Operation Research, Mcmillan India.
6. S. D. Sharma, Operation Research, Kedarnath&Ramnath, Meerat.
7. O. L. Mangasarian,Non linear Programming, McGraw Hill.
8. Peressini, Sullivan and Uhl, The mathematics of Nonlinear programming,SpringerVerlog.
9. Rabindran, Phillips, Solberg Operation Research, John Wiley & Sons.

C4205: Optional-II

Topology-II (Optional)(50 Marks)

Countability Axioms :

Countability Axioms, Equation spaces, Urysohn Lemma, Tietze Extension Theorem.

Nets and Filters : Directed Sets, Nets and Subnets, Convergence of a net, Ultranets, Partially Ordered Sets and Filters, Convergence of a filter, Ultrafilters, Basis and Subbase of a filter, Nets and Filters in Topology.

Tychonoff Theorem & Compactification :Tychonoff Theorem, Completely Regular spaces, Local Compactness, Onepoint compactification, StoneCech Compactification.

Metrization: Urysohn Metrization Theorem, Topological Imbedding, Imbedding Theorem of a regular space with countable base in R^n , Partitions of Unity, Topological mManifolds, Imbedding Theorem of a compact mmanifold in R^n.Local Finiteness, NagataSmirnov Metrization Theorem, Paracompactness, Stone's Theorem, Local Metrizability, Smirnov Metrization Theorem. Uniform Spaces.

Complete Metric Spaces & Function Spaces: Complete Metric Spaces, The Peano SpaceFilling Curve, HahnMazurkiewicz Theorem (statement only). Compactness in Metric Spaces, Equicontinuity, Pointwise and Compact Convergence, The CompactOpen Topology, StoneWeierstrass Theorem, Ascoli's Theorem, Baire Spaces, A Nowhere Differentiable Function. An Introduction to Dimension Theory, Topological notion of (Lebesgue) dimension.

References :

1. Munkres, J.R., Topology, A First Course, Prentice Hall of India Pvt. Ltd., New Delhi,

2000.

2. Dugundji, J., Topology, Allyn and Bacon, 1966.

3. Simmons, G.F., Introduction to Topology and Modern Analysis, McGrawHill, 1963.

4. Kelley, J.L., General Topology, Van Nostrand Reinhold Co., New York, 1995.

5. Bourbaki, N., Topologie Générale.

6. Hocking, J., Young, G., Topology, AddisonWesley Reading, 1961.

7. Steen, L., Seebach, J., Counter Examples in Topology,

8. Holt, Reinhart and Winston, New York, 1970

OR

Fluid Mechanics (Optional)(50 Marks)

Theory of Incompressible flow
Lagrange's and Euler's methods in fluid motion. Equation of motion and equation of continuity, Boundary conditions and boundary surface stream lines and paths of particles.Irrotational and rotational flows, velocity potential. Bernoulli"s equation. Impulsive action equations of motion and equation of continuity in orthogonal curvilinear coordinate.Euler's momemtum theorem andD'Alemberts paradox.Theory of irrotational motion flow and circulation.Permanence irrotational motion.Connectivityof regions of space.Cyclic constant and acyclic and cyclic motion.Kinetic energy. Kelvin'sminimum. Energy theorem.Uniqueness theorem. Dimensional irrotational motion.Function. Complex potential, sources. sinks, doublets and their images circle theorem. Theoremof Blasius.Motion of circular and elliptic cylinders.Circulation about circular and ellipticcylinder. Steady streaming with circulation. Rotation of elliptic cylinder.Theorem of Kutta andJuokowski.Conformal transformation.Juokowski transformation.Schwartzchirstoffeltheorem.Motion of a sphere.Stoke's stream function. Source, sinks, doublets and their images withregards to a plane and sphere.Vortex motion. Vortex line and filament equation of surface formed by stream lines and vortexlines in case of steady motion. Strength of a filament.Velocity field and kinetic energy of avortex system.Uniqueness theorem rectilinear vortices.Vortex pair.Vortex doublet.Images of avortex with regards to plane and a circular cylinder.Angle infinite row of vortices.Karman'svortex street. Waves: Surface waves. Paths of particles.Energy of waves.Group velocity.Energy of a long wave.

Reference Books :

1. Hydrodynamics –A.S.Ramsay(Bell) .
2. Hydrodynamics – H. Lamb(Cambridge).
3. Fluid mechanics – L.D.Landau and E.M.Lifchiz(Pergamon),1959.
4. Theoritical Hydrodynamics –I.M.MilneThomson;Macmillan,1958.

Minor

SEM 1: G1103

Algebra and Geometry-I (50 Marks)

Group A :Classical Algebra (20 Marks, 2 Credits)

01. Complex Numbers : De Moivre's Theorem and its Applications. Exponential,Sine, Cosine, and Logarithm of a complex number. Definition of az, (a≠0).Inverse circular and Hyperbolic functions.

02. Polynomials: Fundamental Theorem of Classical Algebra (Statement only).Polynomials with real coefficients: The *nth-degree* polynomial equation has exactly roots. Nature of roots of an equation (Surd or Complex roots occur in pairs). Statement of Descarte's Rule of signs and its applications.Statements of **:**(i) If the polynomial f(x) has opposite signs for two real values of x,e.g. a and b, the equation f(x) = 0 has an odd number of real roots between a and b; if f(a) and f(b) are of same sign, either no real root or an even number of roots lies between a and b.
(ii) Rolle's Theorem and its direct applications.Relation between roots and coefficients. Symmetric functions of roots, Transformations of equations. Cardan's method of solution of a cubic.

03. Determination up to the third order: Properties, Cofactor, and Minor.Product of two determinants. Adjoint, Symmetric, and Skew-symmetric determinants. Solutions of linear equations with not more than three **variables by** Cramer's Rule.

04. Matrices of Real Numbers: Equality of matrices. Addition of matrices.Multiplication of a matrix by a scalar. Multiplication of matrices – Associative properties. Transpose of matrix – its properties. The inverse of a non-singular square matrix. Symmetric and Skew-symmetric matrices. Scalar matrix.Orthogonal matrix. Elementary operations on matrices.
Rank of a matrix : Determination of rank either by considering minors or by sweep-out process. Consistency and solution of a system of linear of equations with not more than 3 variables by matrix method.

Group B : Analytical Geometry of 2 Dimensions (15 Marks, 1 Credit)

01. Transformations of Rectangular axes : Translation, Rotation and their combinations. Invariants.

02. General equation of second degree in *x* and *y* :Reduction to canonical forms. Classification of conic.

03. Pair of straight lines : Condition that the general equation of 2nd degree in x and y may represent two straight lines. Points of intersection of two intersecting straight lines. Angle between two lines given by $ax2 + 2hxy + by2= 0$. Equation of bisectors. Equation of two lines joining the origin to the points in which a line meets a conic.

04. 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, Hyperbola.
05. Polar equation of straight lines and circles. Polar equation of a conic refers to a focus as a pole. Equation of chord joining two points. Equations of tangent and normal.

Group C : Vector Algebra (15 Marks, 1 Credit)

Addition of Vectors. Multiplication of a Vector by a scalar. Collinear and Coplanar Vectors. Scalar and Vector products of two and three vectors. Simple applications to problems of Geometry. Vector equation of plane and straight line.Volume of Tetrahedron. Application to problems of Mechanics (Work done andMoment).

SEM 2: G1203

Calculus and Differential Equation-I (50 Marks)

Group A :Differential Calculus-I (25 Marks, 2 Credits)

01. Rational Numbers. Geometrical representation. Irrational number. Real number represented as a point on a line – Linear Continuum. Acquaintance with basic properties of real number (No deduction or proof is included).

02. Sequence : Definition of bounds of a sequence and monotone sequence. Limit of a sequence. Statements of limit theorems. Concept of convergence and divergence of monotone sequences – applications of the theorems, in particular, definition of *e*. Statement of Cauchy's general principle of convergence and its application.

03. Infinite series of constant terms : Convergence and Divergence (definitions). Cauchy's principle as applied to infinite series (application only). Series of positive terms **:**Statements of Comparison test, D.Alembert's Ratio test. Cauchy's nth root test and Raabe's test – Applications. Alternating series: Statement of Leibnitz test and its applications.

04. Real-valued functions defined on an interval : Limit of a function (Cauchy's definition). Algebra of limits. Continuity of a function at a point and in an interval. Acquianance (no proof) with the important properties of continuous functions on closed intervals. Statement of existence of inverse function of a strictly monotone function and its continuity.

05. Derivative – its geometrical and physical interpretation. Sign of derivative – Monotonic increasing and decreasing functions. Relation between continuity and derivability. Differential – application in finding approximation.

06. Successive derivative – Leibnitz's Theorem and its application.

07. Application of the principle of Maxima and Minima for a function of single variable in geometrical, physical and other problems.

08. Applications of Differential Calculus : Tangents and Normals, Pedal equation and Pedal of a curve. Rectilinear Asymptotes (Cartesian only). Definition and examples of singular points (viz. Node, Cusp, Isolated point).

Group B : Integral Calculus-I (10 Marks, 1 Credit)

01. Integration of the form **:**Integration of Rational functions.
02. Evaluation of definite integrals.
03. Integration as the limit of a sum (with equally spaced as well as unequal intervals)

Group C : Differential Equations-I (15 Marks, 1 Credit)

01. Order, degree and solution of an ordinary differential equation (ODE) in presence of arbitrary constants. Formation of ODE. First order 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'sEquations : General and Singular solutions.

02. Simple applications : Orthogonal Trajectories.

SEM 3: G2103

Algebra and Geometry-II (50 Marks)

Group A : Modern Algebra (25 Marks , 2 Credits)

01. Basic concept : Sets, Sub-sets, Equality of sets, Operations on sets : Union, intersection and complement. Verification of the laws of Algebra of sets and De Morgan's Laws. Cartesian product of two sets. Mappings, One-One and onto mappings. Composition of Mappings– concept only, Identity and Inverse mappings. Binary Operations in a set.Identity element. Inverse element.

02. Introduction of Group Theory : Definition and examples taken from various branches (examples from number system, roots of unity, 2 x 2 real matrices, non-singular real matrices of a fixed order). Elementary properties using definition of Group. Definition and examples of sub-group – Statement of necessary and sufficient condition – its applications.

03. Definitions and examples of (i) Ring, (ii) Field, (iii) Sub-ring, (iv) Subfield.

04. Concept of Vector space over a Field : Examples, Concepts of Linear combinations, Linear dependence and independence of a finite set of vectors, Sup-space. Concepts of generators and basis of a finite-dimensional vector space. Problems on formation of basis of a vector space (No proof required).

05. Real Quadratic Form involving not more than three variables – Problems only.

06. Characteristic equation of a square matrix of order not more than three – determination of Eigen Values and Eigen Vectors – Problems only. Statement and illustration of Cayley-Hamilton Theorem.

Group B : Analytical Geometry of 3 Dimension (25 Marks, 2 Credits)

01. 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.

02. 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.

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

04. Sphere and its tangent plane.

05. Right circular cone.

SEM 4: G2205

Calculus and Diffrential Equation-II (50 Marks)

Group A: Differential Calculus-II (25 Marks, 2 Credits)

01. Statement of Rolle's theorem and its geometrical interpretation. Mean Value Theorems of Lagrange and Cauchy. Statements of Taylors and Maclaurin's Theorems with Lagrange's and Cauchy's form of remainders. Taylor's and Maclaurin's Infinite series for some popular functions.

02. Indeterminate Forms :L'Hospital's Rule : Statement and problems only.

03. Functions of two and three variables : Their geometrical representations. Limit and Continuity (definitions only) for functions of two variables. Partial derivatives : Knowledge and use of Chain Rule. Exact differentials (emphasis on solving problems only). Functions of two variables – Successive partial derivatives : Statement of Schwarz's Theorem on commutative property of mixed derivatives. Euler's theorem on homogeneous function of two and three variables. Maxima and minima of functions of not more than three variables – Lagrange's Method of undetermined multiplier – Problems only. Implicit function in case of function of two variables (existence assumed) and derivative.

Group B : Integral Calculus-II (15 Marks, 1 Credit)

01. Reduction formulae of $\int \sin m\, x \cos nx\, dx$, $\int \tan nx\, dx$ and associated problems (*m* and *n* are non-negative integers).

02. Definition of Improper Integrals : Statements of (i) μ -test, (ii) Comparison test (Limit form excluded) – Simple problems only. Use of Beta and Gamma functions (convergence and important relations being assumed).

03. Working knowledge of Double integral.

04. Applications : Rectification, Quadrature, Volume and Surface areas of solids formed by revolution of plane curve and areas – Problems only

Group C : Differential Equations-II (10 Marks, 1 Credit)

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

SEM 5: G3105

Numerical Methods and Linear Programming (50 Marks)

Group A : Numerical Methods (20 Marks, 1 Credit)

01. Approximate numbers, Significant figures, Rounding off numbers. Error –Absolute, Relative and Percentage.

02. Operators - Δ , ∇ and E (Definitions and some relations among them).

03. Interpolation : The problem of Interpolation, Equispaced arguments –Difference Tables, Deduction of Newton's Forward Interpolation Formula. Remainder term (expression only). Newton's Backward Interpolation formula (statement only) with remainder term. Unequally – spaced arguments – Lagrange's Interpolation Formula (statement only). Numerical problems on Interpolation with both equi- and unequally-spaced arguments.

04. Number Integration : Trapezoidal and Simpson's ⅓rd formula (statement only). Problems on Numerical Integration.

05. Solution of Numerical Equation : To find a real root of an algebraic or transcendental equation. Location of root (Tabular method), Bisection method. Newton-Raphson method with geometrical significance. Numerical problems. **(**Note : emphasis should be given on problems**)**

Group B : Linear Programming (30 Marks, 3 Credits)

01. Motivation of Linear Programming problem. Statement of L.P.P. formulation of L.P.P. Slack and Surplus variables. L.P.P. is matrix form. Convex set, Hyperplane, Extreme points, Convex Polyhedron, Basic solutions and Basic Feasible Solutions (B.F.S.) Degenerate and Non-degenerate B.F.S. The set of all feasible solutions of an L.P.P. is a convex set. The objective function of an L.P.P. assumes its optimal value at an extreme point of the convex set of feasible solutions. A B.F.S. to an L.P.P. corresponds to an extreme point of the convex set of feasible solutions. Fundamental Theorem of L.P.P. (Statement only). Reduction of a feasible solution to a B.F.S. Standard form of an L.P.P. Solution by graphical method (for two variables), by simplex method and method of penalty. Concept of duality. Duality theory. The dual of the dual is the primal. Relation between the objective values of dual and the primal problems. Dual problems with at most one unrestricted variable, one constraint of equality. Transportation and Assignment problem and their optimal solutions.

SEM 6: G3205

Analytical Dynamics (50 Marks)

01. Velocity and Acceleration of a particle. Expressions for velocity and acceleration in rectangular Cartesian and polar coordinates for a particle moving in a plane. Tangential and normal components of velocity and acceleration of a particle moving along a plane curve.

02. Concept of Force : Statement and explanation of Newton's laws of motion.Work, power and energy. Principles of conservation of energy and momentum. Motion under impulsive forces. Equations of motion of a particle(i) moving in a straight line, (ii) moving in a plane.

03. Study of motion of a particle in a straight line under (i) constant forces, (ii)variable forces (S.H.M., Inverse square law, Damped oscillation, Forced and Damped oscillation, Motion in an elastic string). Equation of Energy.Conservative forces.

04. Motion in two dimensions : Projectiles in vacuo and in a medium with resistance varying linearly as velocity. Motion under forces varying as distance from a fixed point.

05. Central orbit. Kepler's laws of motion. Motion under inverse square law.

SEM 7: G4105

Calculus (50 Marks)

01. Concept of Point-wise and Uniform convergence of sequence of functions and series of functions with special reference of Power Series. Statement ofWeierstrass M-Test for Uniform convergence of sequence of functions and of series of functions. Simple applications. Statement of important properties like boundedness, continuity, differentiability and integrability of the limit function of uniformly convergent sequence of functions and of the sum function of uniformly convergent series of functions. Determination of Radius of convergence of Power Series.Statement of properties of continuity of sum function power series. Term by term integration and Term by term differentiation of Power Series.Statements of Abel's Theorems on Power Series. Convergence of PowerSeries. Expansions of elementary functions such as ex, sin x, log(1+x), (1+x)n.Simple problems.

02. Fourier series on (-π, π) **:**Periodic function. Determination of Fourier coefficients.Statement of Dirichlet's conditions of convergence and statement of the theorem on convergence of Fourier Sine and Cosine series.

03. Third and Fourth-order ordinary differential equation with constant coefficients.Euler's Homogeneous Equation.

04. Second order differential equation **:**(a) Method of variation of parameters. (b)Method of undetermined coefficients. (c) Simple eigenvalue problem.

05. Simultaneous linear differential equation with constant co-efficients.

06. Laplace Transform and its application to ordinary differential equation.Laplace Transform and Inverse Laplace Transform. Statement of Existence theorem. Elementary properties of Laplace Transform and its Inverse.Application to the solution of ordinary differential equation of second orderwith constant eo-efficients.

07. Partial Differential Equation (PDE) **:**Introduction, Formation of PDE,Solutions of PDE, Lagrange’s method of solution.

SEM 8: G4203

Discrete Mathematics (50 Marks)

01. Integers : Principle of Mathematical Induction. Division algorithm.Representation of integer in an arbitrary base. Prime integers. Some properties of prime integers. Fundamental theorem of Arithmetic. Euclid’s Theorem.Linear Diophantine Equations. (Statement of Principle of MathematicalInduction, Strong form of Mathematical induction. Applications in different problems. Proofs of division algorithm. Representation of an integer uniquely in an arbitrary base, change of an integer from one base to another base.Computer operations with integers – Divisor of an integer, g.c.d. of two positive integers, prime integer, Proof of Fundamental theorem, Proof of Euclid’s Theorem. To show how to find all prime numbers less than or equal to a given positive integer. Problems related to prime numbers. LinearDiophantine equation – when such an equation has solution, some applications).
02. Congruences : Congruence relation on integers, Basic properties of this relation. Linear Congruences, Chinese Remainder Theorem. System of LinearCongruences. (Definition of Congruence – to show it is an equivalence relation, to prove the following **:**$a \equiv b \pmod m$ implies (i) $(a+c) \equiv (b+c)(\mathrm{mod}\ m)$ (ii) $ac \equiv bc \pmod m$ (iii) $an \equiv bn \pmod m$, for any polynomial f(x) with integral coefficients $f(a) \equiv f(b) \pmod m$ etc. Linear Congruence, to show how to solve these congruences, Chinese remainder theorem – Statement and proof and some applications. System of linear congruences, when solution exists – some applications).

03. Application of Congruences : Divisibility tests. Computer file, Storage and washing functions. Round-Robin Tournaments. Check-digit in an ISBN, inUniversal Product Code, in major Credit Cards. Error detecting capability.(Using Congruence, develop divisibility tests for integers base on their expansions with respect to different bases, if d divides (b-1) then n = (akak-1a1b) is divisible by d if and only if the sum of the digits is divisible by d etc.Show that congruence can be used to schedule Round-Robin tournaments. A university wishes to store a file for each of its students in its computer.Systematic methods of arranging files have been developed based on Hashingfunctionsh(k) $\equiv$ k (mod m). Discuss different properties of this congruence and also problems based on this congruence. Check digits for different identification numbers – International standard book number, universal product code etc. Theorem regarding error detecting capability).

04. Congruence Classes : Congruence classes, addition and multiplication of congruence classes. Fermat’s little theorem. Euler’s Theorem. Wilson’stheorem. Some simple applications.

(Definition of Congruence Classes,properties of Congruence classes, addition and multiplication, existence of inverse. Fermat's little theorem. Euler's theorem. Wilson's theorem Statement, proof and some applications).

05. Recurrence Relations and Generating functions: Recurrence Relations.The method of Iteration. Linear difference equations with constant coefficients. Counting with generating functions.

06. Boolean Algebra : Boolean Algebra, Boolean functions, Logic gates, Minimization of circuits.

Multi –Disciplinary

MD-1

Basic Algebra (50 Marks)

Group A: Basics of Set Theory (15 Marks, 1 Credit)

• Concept and definition of sets, subsets and set operations (Union, Intersection, Complementation, Subtraction); Statements of basic laws of set algebra.

• Venn diagrams. Statement of the formula $(A \cup B) = (A) + (B) - (A \cap B)$ and its application in daily life.

Group B:: Understanding Integers (35 Marks, 2 Credits)

• Statement and simple problems on First Principle of Mathematical Induction.

• Statement of Division algorithm; G.C.D. of two positive integers, Expression of G. C. D. of two integers x, y in the form px + qy (p, q are integers), (Euclidean Algorithm without proof).

• Representation of a positive integer in Binary and decimal mode.

• Linear Diophantine equation in two variables: Statement of condition on the existence of integral solution, General / particular solution, Simple real life applications;

• Prime Integers. Some elementary properties of prime integers (only statement), Fundamental theorem of Arithmetic (only statement), Algorithm for Primality test.

• Congruence of Integers: Meaning of $a \equiv b \pmod{m}$, Statements of elementary properties of congruence; if $a \equiv b \pmod{m}$ then for any integer c, $a+c \equiv (b + c) \pmod{m}$, $(a-c) \equiv (b - c) \pmod{m}$, $ac \equiv bc \pmod{m}$, $a^n \equiv b^n \pmod{m}$ for natural numbers n;

• Application of congruence of integers: Divisibility tests by 2, 3, 4, 5, 7, 9, 11, 13 (Statements of relevant results and problems only), Check Digits in International Standard Book Number (ISBN), Universal Product Code (UPC), VISA and MASTER card (Statements of relevant results and Problems only), Formation of Round Robin Tournament Table using congruence of integers (Technique and Problems only).

MD-2

Mathematical logic and Optimization (50 Marks)

Group C::Mathematical logic (20 Marks, 1 Credit)

• Proposition, propositional variables and propositional Logic;

• Logical Connectives: NOT (Negation), OR (Disjunction), AND (Conjunction), Exclusive OR(XOR), IMPLICATION(If p then q) and BIIMPLICATION (If and only if) and their Truth Tables; Truth value of a proposition, Truth tables of expressions involving more than one logical connective;

• Tautology, logical consequence, logical equivalence, contradiction;

Group D:: Basics of Operations Research (30 Marks, 2 Credits)

• Idea of Linear Programming Problems: Objective function, decision variables, constraints.

• Formulation of daily life problems as an LPP (e.g. Carpenter problem, preparation of mixtures of chemicals, diet problems etc.);

• Solution of an LPP by graphical method.(only bounded region)

• Definition of Game, Examples from daily life Two person zero sum game, Strategy, Payoff, Saddle point, Solution of a game problem with saddle point (only elementary problems)

MD-3

Financial Mathematics and Vector Algebra

Group E: Financial Mathematics (20 Marks, 1 Credit)

• Time value of money:- Simple interest and Compound interest (Fundamental Formulae); Interest payable monthly, quarterly, annually; (Only problems).

• Ordinary Simple Annuities – Accumulated value and Discounted Value of an ordinary simple annuity – Idea of repayment of loans, Simple problems. (No formula derivation).

• Problems on Dividend calculation and Calculation of income tax on taxable income (old and new regime).

Group F: Vector Algebra (30 Marks, 2 Credits)

- Addition of Vectors. Multiplication of a Vector by a scalar.
- Collinear and Coplanar Vectors.
- Scalar and Vector products of two and three vectors.
- Simple applications to problems of Geometry.
- Vector equation of plane and straight line.
- Volume of Tetrahedron. Application to problems of Mechanics (Work done and Moment).

References:

1. Elementary Number Theory with Applications Second Edition Thomas Koshy, Academic Press, 2007

2. Elementary Number Theory and its Applications , Kenneth H. Rosen, Addison-Wesley Publishing Company, 1984

3. An Introduction to the Theory of Numbers, G. H. Hardy and E. M. Wright, Oxford University Press, sixth edition, 2008

4. The Higher Arithmetic: An Introduction To The Theory Of Numbers, H. Davenport, Cambridge University Press, Eighth edition, 2008

5. Introduction to Mathematical Logic, MichałWalicki, World Scientific, 2016

6. Discrete Mathematics for Computer Science, Gary Haggard, John Schlipf and Sue Whitesides , Thomson Brooks/Cole, 2006

7. An Introduction To Linear Programming And Game Theory, Paul R. Thie and G. E. Keough, John Wiley & Sons, INC., Third Edition, 2008

8. Schaum's Outline of Operations Research, Richard Bronson and GovindasamiNaadimuthu , McGraw Hill, 1997

9. Petr Zima and Robert L. Brown, Mathematics of Finance, Schaum's Outline Series, McGraw-Hill, 2nd edition, 1996

10.Samuel A. Broverman, Mathematics of Investment and Credit, ACTEX Publications, 4th edition, 2008

11.The Theory of Interest, Stephen G. Kellison, McGraw-Hill, 3rd edition, 2009 12.An Introduction to the Mathematics of Finance, John McCutcheon and William F. Scott, Elsevier Butterworth-Heinemann, 1986

Skill Enhancement Course

SEC-1

C Language with Mathematical Applications (50 Marks)

Overview of architecture of computer, compiler, assembler, machine language, high level language, object oriented language, programming language, higher level language

• Constants, Variables and Data type of C-Program: Character set. Constants and variables data types, expression, assignment statements, declaration.

• Operation and Expressions: Arithmetic operators, relational operators, logical operators.

• Decision Making and Branching: decision making with if statement, if-else statement, Nesting if statement, switch statement, break and continue statement.

• Control Statements: While statement, do-while statement, for statement.

•Arrays: One-dimension, two-dimension and multidimensional arrays, declaration of arrays, initialization of one and multi-dimensional arrays.

• User-defined Functions: Definition of functions, Scope of variables, return values and their types, function declaration, function call by value, Nesting of functions, passing of arrays to functions, Recurrence of function.

• Introduction to Library functions: stdio.h, math.h, string.h, stdlib.h, time.h etc.

Sample problems: 1. Display first 15 natural numbers.

2. Compute the sum of first 10 natural numbers.

3. Read 10 numbers from keyboard and find their average.

4. Find the sum of first 15 even natural numbers.

5. Write a program to find factorial of a number using recursion.

6. Write a program to make a pyramid pattern with numbers increased by 1.

7. From the terminal read three values, namely, length, width, height. Print a message whether the box is a cube or rectangle or semi-rectangle.

8. Find the AM, GM, HM of a given set of numbers.

9. Write a program to print multiplication table.

10.Write a program that generates a data file containing the list of customers and their contact numbers.

11. Find the maximum and minimum element of a given array.

12. Sort the elements of an array in ascending order

13. Write a program to read in an array of names and to sort them in alphabetical order.

14. Write a program for addition of two matrices.

15. Find the transpose of a given matrix.

16. Find the product of two matrices.

17. Write a program to check whether two given strings are an anagram.

18. Write a program to check Armstrong and Perfect numbers.

19. Write a program to check whether a number is a prime number or not.

References [1] B. W. Kernighan and D. M. Ritchi : The C-Programming Language, 2nd Edi.(ANSI Refresher), Prentice Hall, 1977.

[2] E. Balagurnsamy : Programming in ANSI C, Tata McGraw Hill, 2004

[3] Y. Kanetkar : Let Us C ; BPB Publication, 1999.

[4] C. Xavier : C-Language and Numerical Methods, New Age International, 2007.

[5] V. Rajaraman : Computer Oriented Numerical Methods, Prentice Hall of India, 1980

SEC-2

Introduction to Latex (50 Marks)

Introduction to LATEX: Preparing a basic LATEX file. Compiling LATEX file. Document classes: Different type of document classes, e.g., article, report, book etc. Page Layout: Titles, Abstract, Chapters, Sections, subsections, paragraph, verbatim, References, Equation references, citation. List structures: Itemize, enumerate, description etc. Representation of mathematical equations: Inline math, Equations, Fractions, Matrices, trigonometric, logarithmic, exponential functions, line, surface, volume integrals with and without limits, closed line integral, surface integrals, Scaling of Parentheses, brackets etc. Customization of fonts: Bold fonts, emphasise, mathbf, mathcal etc. Changing sizes Large, Larger, Huge, tiny etc. Writing tables: Creating tables with different alignments, placement of horizontal, vertical lines. Figures: Changing and placing the figures, alignments Packages: amsmath, amssymb, graphics, graphicx, Geometry, algorithms, color, Hyperref etc. Use of Different LATEX commands and environments, Changing the type style, symbols from other languages. special characters.

Sample Projects:

1. Write down a research article.

2.Write down a given mathematical derivation.

3. Write a book chapter.

4. Write a report on a practical done in laboratory with results, tables and graphs.

5. Present graphical analysis taking graphs plotted in gnuplot

References

[1] LATEX- A Document Preparation System, Leslie Lamport, Addison- Wesley, 1994.

[2] E. Krishnan, LATEX Tutorials A PRIMER, Indian TEX users group, 2003.

[3] George Gratzer, Practical LATEX, Springer, 2014.

SEC-3

Introduction to Python Programming (50 Marks)

Python Programming Language, features, Installing Python. Running Code in the Interactive Shell, IDLE. Input, Processing and Output, Editing, Saving, and Running a Script, Debugging: Syntax Errors, Runtime Errors, Semantic Errors.

Data types and expressions: Variables and the Assignment Statement, Program Comments and Doc strings. Data Types-Numeric integers and Floating-point numbers. Boolean string. Mathematical operators, PEMDAS.Arithmetic expressions, Mixed-Mode Arithmetic and type Conversion, type( ). Input( ), print( ), program comments. id( ), int( ), str( ), float( ).

Loops and selection statements: Definite Iteration: for Loop, Executing statements a given number of times, Specifying steps using range( ) , Loops that count down, Boolean and Comparison operators and Expressions, Conditional and alternative statements- Chained and Nested Conditionals: if, if-else, if-elseifelse, nested if, nested if-else. Compound Boolean Expressions, Conditional Iteration: while Loop –with True condition, break Statement. Random Numbers. Loop Logic, errors and testing.

Strings, Lists, Tuple, Dictionary: Accessing characters, indexing, slicing, replacing.Concatenation (+), Repetition (*).Searching a substring with the ‘in’ Operator, Traversing string using while and for. String methods- find, join, split, lower, upper. len( ).

Lists – Accessing and slicing, Basic Operations (Comparison, +), List membership and for loop.Replacing element (list is mutable). List methodsappend, extend, insert, pop, sort. Max( ), min( ). Tuples. Dictionaries-Creating a Dictionary, Adding keys and replacing Values , dictionary - key( ), value( ), get( ), pop( ), Traversing a Dictionary. Math module: sin(), cos(),exp(), sqrt(), constants- pi, e.

Design with functions: Defining Simple Functions- Parameters and Arguments, the return Statement, tuple as return value. Boolean Functions. Defining a main function. Defining and tracing recursive functions.

Working with Numbers: Calculating the Factors of an Integer, Generating Multiplication Tables, converting units of measurement, Finding the roots of a quadratic equation

Algebra and Symbolic Math with SymPy: symbolic math using the SymPy library. Defining Symbols and Symbolic Operations, factorizing and expanding expressions, Substituting in Values, Converting strings to mathematical expressions. Solving equations, Solving quadratic equations, Solving for one variable in terms of others, Solving a system of linear equations. Plotting using SymPy, Plotting expressions input by the user,

Plotting multiple functions

Sample problems:

1. Convert number from decimal to binary system.

2. Convert number from decimal to octal system.

3. Convert from Hexadecimal to binary system.

4. Write a program to read one subject mark and print pass or fail. Use single return values function with argument.

5. Find the median of a given set of numbers.

6. Write a Python function that takes two lists and returns True if they have at least one common member.

7. Write a program for Enhanced Multiplication Table Generator.

8. Write down Unit converter code.

9. Write down Fraction Calculator code.

10. Write down Factor Finder code.

11. Write down Graphical Equation Solver code.

12. Write down a code for solving Single-Variable Inequalities.

13. Prepare an investment report by calculating compound interest.

14.Write a python program to open and write the content to file and read it.

15. Write a python program to check whether a given year is leap year or not and also print all the months of the given year.

References

[1] Kenneth A Lambert, Fundamentals of Python: First programs, 2nd edition – Cengage Learning India, 2019.

[2] Saha Amit, Doing Math with Python - No starch press, San Francisco, 2015.

[3] E. Balgurusamy, Problem solving and Python programming- Tata McGraw Hill, 2017.