Course Outcomes

M.Sc. First Semester

Course: Group Theory

Students will able to

CO1: Define Symmetric groups, Alternating groups, Dihedral groups, Matrix groups, Isometry groups of R^2 and R^3.

CO2: Prove Isomorphism theorems for groups.

CO3: Prove Internal and External direct product and their relationship.

CO4: Define Indecomposable groups.

CO5: Prove Zassenhaus' lemma, Schreier's refinement theorem, Jordan-Holder's theorem.

CO6: Define Subnormal and normal series, Composition series, Chain conditions.

CO7: Define Action of a group G on a set, Stabilizer subgroups and Orbit decomposition, Class equation of an action.

CO8: Prove Burnside's theorem.

CO9: Illustrate Transitive and effective actions, Equivalence of actions, core of a subgroup.

Solvability of subgroups and factor groups and of finite p-groups, Examples, Lower and upper central series.

CO10: Prove Sylow's theorems, and illustrate groups of order pq.

CO11: Study Commutator subgroup and commutator series of a group, Solvable groups, Nilpotent groups and their equivalent characterizations.

Course: Complex Analysis

Students will able to

CO1: Compute sums, products, quotients, conjugate, modulus and argument of complex numbers.

CO2: Calculate exponentials and integral powers of complex numbers.

CO3: Write equation of straight line, circle in complex form.

CO4: Define reflection points, concyclic points, inverse points.

CO5: Understand the significance of differentiability for complex functions and be familiar with the Cauchy-Riemann equations.

CO6: Determine whether a given function is analytic.

CO7: Define Bilinear transformation, cross ratio, fixed point.

CO8: Write the bilinear transformation which maps real line to real line, unit circle to unit circle, real line to unit circle.

CO9: Find parametrizations of curves, and compute complex line integrals directly.

CO10: Use Cauchy's integral theorem and formula to compute line integrals.

CO11: Represent functions as Taylor, power and Laurent series.

CO12. Classify singularities and poles.

CO13. Find residues and evaluate complex integrals, real integrals using the residue theorem.

Course: Point Set Topology

Students will able to

CO1: Define and understand several Topological Spaces with differences between metric space and Topological Space via different kinds of compactness of Topological spaces.

CO2: Characterize closed sets and dense sets and define separable spaces, basis and sub-basis of a topology.

CO3: Describe first countable and second countable spaces.

CO4: Explain Sequences in a metric space, convergence of a sequence, complete metric spaces, nets and filters, continuous maps and their characterization.

CO5: Compute open maps, closed maps, homeomorphisms, topological invariants.

CO6: Interpret Product topology, Quotient topology and identification spaces.

CO7: Define connected spaces with properties and theorems.

CO8: Define T0 spaces, T1 spaces, T2 spaces, regular spaces, T3 spaces, completely regular spaces, normal spaces, Tychonoff spaces, T4 spaces, with characterization.

CO9: Prove Urysohn's lemma, Tietze's extension theorem, Urysohn's embedding and metrization theorem.

CO10: Define compact spaces and their characterizations and prove Tychonoff's theorem and one point compactification.

Course: Differential Geometry I

Students will able to

CO1: Describe curves in space R^3, parameterized curves, regular curves, helices, arc length and reparameterizations.

CO2: Define tangent, principal normal, binormal, osculating plane, normal plane, rectifying plane and curvature and torsion of smooth curves.

CO3: Derive Frenet Serret formulae and give Frenet approximation of a space curve.

CO4: Explain Osculating circle, osculating sphere, spherical indicatrices, involutes and evolutes, intrinsic equations of space curves and isometries of R^3.

CO5: Prove fundamental theorem of space curves.

CO6: Interpret regular surfaces, co-ordinate neighborhoods, parameterized surfaces, change of parameters and level sets of smooth functions on R^3.

CO7: Introduce surfaces of revolution, tangent vectors, tangent plane and differential of a map.

CO8: Study Normal fields and orientability of surfaces and angle between two intersecting curves on a surface.

CO9: Study several maps like Gauss map and its properties and Weingarten map, with second and third fundamental forms and classification of points on a surface.

CO10: Evaluate curvature of curves on surfaces, normal curvature, principal curvatures and mean curvature.

CO11: Prove Meusnier theorem, Euler theorem, Gauss Theorem and derive Gauss formulae, Weingarten formulae, Gauss equations, Codazzi-Mainardi equations.

Course: Classical Mechanics

Students will able to

CO1: Study the momentum of a system of particles with all the properties, principles and theorems.

CO2: Learn about the kinetic energy of a system of particles in terms of the motion relative to the center of mass of the system.

CO3: Study about rigid bodies as systems of particles with general displacement of a rigid body, the displacement of a rigid body about one of its points and the concept of angular velocity.

CO4: Evaluate the angular momentum and the kinetic energy of a rigid body in terms of inertia constants.

CO5: Derive equations of motion, Euler's dynamical equations of motion, Eulerian angles and the geometrical equations of Euler.

CO6: Obtain generalized co-ordinates and geometrical equations.

CO7: Study holonomic and nonholonomic systems, configuration space, Lagrange's equations using D' Alembert's Principle for a holonomic conservative system.

CO8: Deduce equation of energy when the geometrical equations do not contain time t explicitly and Euler's dynamical equations from Lagrange's equations.

CO9: Study the theory of small oscillations and Lagrange equations for impulsive motion.

CO10: Learn about generalized momentum and the Hamiltonian for a dynamical system.

CO11: Derive Hamilton's canonical equations of motion and Hamiltonian as a sum of kinetic and potential energies.

CO12: Study Hamilton's variational principle, the principle of least action, Canonical transformations, Poisson-Brackets, Poisson-Jacobi identity and Hamilton-Jacobi theory.

M.Sc. Second Semester

Course: Module Theory

Students will able to

CO1: Define modules over a ring and construct R-Module structure on an abelian group M as a ring homomorphism from R to End_Z(M).

CO2: Discuss submodules, direct summands, annihilators, faithful modules, homomorphism, factor modules and Hom_R(M, M) as a ring.

CO3: Explain exact sequences, five lemma, external and internal direct sums and their universal property.

CO4: Learn about free modules, homomorphism extension property, equivalent characterization as a direct sum of copies of the underlying ring.

CO5: Check existence of a basis of a vector space and illustrate Split exact sequences and their characterizations.

CO6: Explain projective modules, injective modules, Baer's characterization and divisible groups.

CO7: Study Factorization theory in commutative domains.

CO8: Prove Chinese remainder theorem for rings and PID's.

CO9: Be aware about prime and irreducible elements, G.C.D., Euclidean domains, maximal and prime ideals, principal ideal domains, divisor chain condition, unique factorization domains.

CO10: Extract submodules of finitely generated free modules over a PID.

CO11: Do reduction of matrices over polynomial rings over a field.

CO12: Study rational canonical form of matrices, elementary Jordan matrices, reduction to Jordan canonical form, diagonalizable and nilpotent parts of a linear operator.

CO13: Prove Jordon-Chevalley theorem.

Course: Measure and Integration

Students will able to

CO1: Define and illustrate countable sets, uncountable sets, cardinality, cardinal arithmetic and the Cantor's ternary set with its properties.

CO2: Prove Schroder-Bernstein theorem.

CO3: Study semi-algebras, algebras, monotone class, σ-algebras, measure and outer measures.

CO4: Explain caratheodory extension process of extending a measure on a semi-algebra to generated σ -algebra.

CO5: Discuss Borel sets, Lebesgue outer measure, Lebesgue measure on R and translation invariance of Lebesgue measure.

CO6: Find existence of a non-measurable set, characterizations of Lebesgue measurable sets and the Cantor-Lebesgue function.

CO7: Illustrate Measurable functions on a measure space with their properties, Borel and Lebesgue measurable functions.

CO8: Describe simple functions and their integrals on R, Littlewood's three principles (statement only), Lebesgue integral on R and its properties.

CO9: Prove Bounded convergence theorem, Fatou's lemma, Lebesgue monotone convergence theorem, Lebesgue dominated convergence theorem, Minkowski's and Holder's inequalities.

Course: Partial Differential Equations and Integral Equations

Students will able to

CO1: Do formation of P.D.E. 's, solve and classify first order P.D.E.'s.

CO2: Obtain complete, general and singular integrals, Lagrange's or quasi-linear equations, Integral surfaces through a given curve.

CO3: Describe orthogonal surfaces to a given system of surfaces, Characteristic curves.

CO4: Explain Pfaffian differential equations, compatible systems, Charpit's method and Jacobi's method.

CO5: Solve linear equations with constant coefficients with reduction to canonical forms and classify second order P.D.E.'s.

CO6: Discuss method of separation of variables.

CO7: Solve Laplace, Diffusion and Wave equations in cartesian, cylindrical and spherical polar coordinates.

CO8: Obtain solution for boundary value problems for transverse vibrations of strings and heat diffusion in a finite rod and classify linear integral equations with relation between differential and integral equations.

CO9: Study and solve Fredholm equations of second kind with separable kernels.

CO10: Prove Fredholm alternative theorem.

CO11: Discuss method of successive approximation for Fredholm and Volterra equations.

Course: Mathematical Methods

Students will able to

CO1: Define Sturm-Liouville (S-L) problems and obtain reality of eigenvalues and orthogonality of eigenfunctions of S-L problems.

CO2: Discuss mean square Convergence, completeness of orthonormal sets and prove Bessel's inequality.

CO3: Obtain Fourier series and solve it in its various forms.

CO4: Determine Fourier coefficients without integration and approximate by trigonometric polynomials.

CO5: Obtain Fourier integral from Fourier series and study in detail with all its properties and forms.

CO6: Define Laplace transform, study in detail with all its properties and forms and find applications to the initial value problems and system of ODE.

CO7: Study and illustrate calculus of variations with simple applications.

Course: Differential Geometry II

Students will able to

CO1: Describe n-dimensional real vector space, contravariant vectors, dual vector space, covariant vectors, tensor product and second order tensors.

CO2: Define symmetry and skew symmetry of tensors, fundamental algebraic operations and quotient law of tensors.

CO3: Describe topological manifolds, compatible charts, smooth manifolds with examples.

CO4: Explain smooth maps and diffeomorphisms and Lie group with examples.

CO5: Study tangent and cotangent spaces to a manifold, immersions and submersions, submanifolds, vector fields and left and right invariant vector fields on Lie groups.

CO6: Illustrate integral curves of smooth vector fields and complete vector.

CO7: Find tensor fields on manifolds, exterior product, exterior differentiation and pull-back differential forms.

CO8: Illustrate affine connections on a smooth manifold and torsion and curvature tensors of an affine connection.

M.Sc. Third Semester

Course: Field and Galois Theory

Students will able to

CO1: Describe Eisenstein's irreducibility criterion, characteristic of a field, prime subfields and field extensions.

CO2: Obtain finite, Simple, algebraic and transcendental extensions and do factorization of polynomials in extension fields.

CO3: Describe splitting fields with their uniqueness and separable field extensions.

CO4: Explain perfect fields, separability over fields of prime characteristic and transitivity of separability.

CO5: Study automorphisms of fields, fixed fields, normal extensions, splitting fields and normality, normal closures and Galois extensions.

CO6: Prove Dedekind's theorem**,** fundamental theorem of Galois theory and Compute Galois groups of polynomials.

CO7: Prove primitive element theorem, existence and uniqueness theorem and fundamental theorem of algebra.

CO8: Study finite fields, subfields of finite fields and characterization of cyclic Galois groups of finite extensions of finite fields.

CO9: Illustrate cyclotomic extensions and polynomials, cyclic extensions and solvability by radicals with Galois' characterization.

CO10: Prove Abel-Ruffini theorem.

Course: Functional analysis

Students will able to

CO1: Describe normed linear spaces, Banach spaces and continuous linear transformations, with examples and topological properties.

CO2: Define spaces of continuous linear transformations from a linear space to a Banach space and continuous linear functionals.

CO3: Prove Hahn-Banach theorem, open mapping theorem, closed graph theorem and Banach-Steinhaus theorem**.**

CO4: Explain conjugate spaces, natural embedding of N in N**, weak and weak* topology on a conjugate space.

CO5: Compute conjugate of an operator and do some simple applications to reflexive separable spaces.

CO6: Study Hilbert Spaces, Schwarz's inequality, orthogonal complement, Bessel's inequality and orthonormal sets.

CO7: Prove Riesz representation theorem and spectral theorem.

CO8: Study self-adjoint, normal and unitary operators on a Hilbert space.

CO9: Illustrate projections on Hilbert spaces, determinant and the spectrum of an operator.

Course: Theory of Ordinary Differential Equations

Students will able to

CO1: Prove Picard's theorem for local existence and uniqueness of solutions of an initial value problem of first order.

CO2: Discuss singular solutions, envelopes of one parameter family of curves, singular solutions as envelopes of families of solution curves and sufficient conditions for existence and nonexistence of singular solutions**.**

CO3: Solve systems of first order equations arising out of equations of higher order, local existence and uniqueness theorems for systems of I order equations, Gronwall's inequality, global existence and uniqueness theorems for existence of unique solutions over whole of the given interval and over whole of R.

CO4: Explain existence theory for equations of higher order and conditions for transformability of a system of I order equations into an equation of higher order.

CO5: Compute Wronskians and general solutions covering all solutions for homogeneous and non-homogeneous linear systems along with Abel's formula.

CO6: Obtain method of variation of parameters for particular solutions and solve linear systems with constant coefficients.

CO7: Illustrate matrix methods with different cases involving diagonalizable and non-diagonalizable coefficient matrices and find real solutions of systems with complex eigenvalue.

CO8: Learn power series solution method using ordinary and singular points.

CO9: Explain Legendre's equation, Legendre polynomial, Rodrigues' formula, Fourier-Legendre expansion, Bessel's equation and Bessel functions of I and II kind.

CO10: Prove Sturm comparison theorem and Orthogonality relations.

Course: Fluid Mechanics

Students will able to

CO1: Describe real and ideal fluids, Newton's law of viscosity, convective transport of scalar and vector quantities, the equation of continuity, velocity potential, body forces and surface forces.

CO2: Define Cauchy's stress formula, state of stress at a point, stress tensor, isotropic law of pressure and principal stresses and principal directions.

CO3: Describe relation between stress and rates of strain, transformation of Stress-components and transformation of rates of strain.

CO4: Obtain Navier- Stokes equation, Euler's equation, energy dissipation due to viscosity and diffusion of vorticity.

CO5: Prove Helmholtz's vorticity theorem, Kelvin's circulation theorem, Kelvin's minimum kinetic energy theorem and uniqueness of the irrotational motion.

CO6: Interpret energy flux, mean potential over a spherical surface in a simply connected region and kinetic energy in irrotational flow.

CO7: Explain two dimensional irrotational motion, complex potential, concept of line-sources, sinks, doublets and vortices, images, the vortex pair, vortex rows: single infinite row of line vortices and the Karman vortex street.

CO8: Prove Milne-Thomson circle Theorem and Blasius Theorem.

CO9: Illustrate conformal transformation (uniform line distributions) and three dimensional irrotational flow.

CO10: Find uniform motion of a sphere in a liquid at rest at infinity.

CO11: Obtain gravity waves – Surface waves on the infinite free surface of liquids and waves at the interface between finitely and infinitely deep liquids.

Course: Riemannian Geometry

Students will able to

CO1: Describe Riemannian metrics, Riemannian manifolds, Levi-Civita connection, Riemannian curvature tensor, sectional curvature, Ricci curvature, scalar curvature and Einstein manifolds.

CO2: Prove fundamental theorem of Riemannian geometry and Schur's Theorem.

CO3: Describe gradient vector fields, divergence of a vector field, covariant derivative along a curve and parallel transport and geodesics.

CO4: Explain Jacobi fields, complete Riemannian manifolds, Riemannian immersions, Gauss equation and model spaces of constant curvature.

CO5: Prove Gauss Lemma, Hopf –Rinow Theorem and the theorem of Hadamard.

CO6: Interpret Lie derivatives of scalars, vectors, tensors and linear connections.

CO7: Obtain commutation formula for Lie differential operator and covariant differential operator**.**

CO8: Explain motion, affine motion, projective motion in a Riemannian space.

CO9: Illustrate curvature collineation, conformal and homothetic transformations.

M.Sc. Fourth Semester

Course: Wavelets

Students will able to

CO1: Describe the discrete Fourier transform and the inverse discrete Fourier transform, the fast Fourier transform, the discrete cosine transform and the fast cosine transform.

CO2: Define and Construct wavelets on Z_N, the Haar system, Shannon wavelets, Daubechies' D_6 wavelets on Z_N.

CO3: Describe Fourier transform and convolution on $l\_2(Z)$, wavelets on Z, Haar wavelets on Z, Daubechies D_6 wavelets for $l\_2(Z)$.

CO4: Explain orthonormal bases generated by a single function in $L\_2(R)$, Fourier transform and inverse Fourier transform of a function f in $L\_1(R) \mid L\_2(R)$.

CO5: Establish Parseval's relation, Plancherel's formula, Orthonormal wavelets in $L\_2(R)$, and prove Balian-Low theorem.

CO6: Give interpretation of multi-resolution analysis and MRA wavelets, certain function in $L\_2(R)$ for which $\{\psi j, k\}$ does not form an orthonormal system, compactly supported wavelets and band-limited wavelets.

CO7: Explain Franklin wavelets on R, dimension function, Characterization of MRA wavelets and minimally supported wavelets.

CO8: Illustrate Wavelet sets, characterization of two-interval wavelet sets, Shannon wavelet, Journe's wavelet and decomposition and reconstruction algorithms of Wavelets.

CO9: Perform some practical work on wavelets.

Course: Advanced Fluid Mechanics

Students will able to

CO1: Describe stress principle of Cauchy, equations for conservation of linear and angular Momentum and constitutive equations for Newtonian fluids.

CO2: Define Navier- Stokes equations in vector and tensor form and in orthogonal coordinate system.

CO3: Describe vorticity equations, energy dissipation due to viscosity and dynamical similarity and dimensionless numbers and their significance in the fluid dynamics.

CO4: Explain fully developed plane Poiseuille and Couette flows between parallel plates and steady flow between pipes of uniform cross-section.

CO5: Explain Couette flow between coaxial rotating cylinders and small Reynolds number flow like flow between steadily rotating spheres.

CO6: Find and interpret Stokes equations, dynamic equation satisfied by stream function, relation between pressure and stream function.

CO7: Describe flow past a circular cylinder, Stokes paradox and Oseen's equations.

CO8: Understand elementary ideas about perturbation and cell methods as applied to slow flow problems and boundary layer concept.

CO9: Obtain two-dimensional boundary layer equations, separation phenomena, Boundary layer on a semi-infinite plane.

CO10: Establish Blasius equation and solution, Karman's Integral method and explain displacement thickness, momentum thickness and energy thickness.

Course: Advanced Module Theory

Students will able to

CO1: Describe modules over rings, modular law, annihilators, projections and idempotent endomorphisms.

CO2: Prove factor theorem.

CO3: Describe chain conditions on modules, Noetherian modules and rings, Artinian modules and rings.

CO4: Explain composition series of modules, Jordan–Holder theorem and Hilbert basis theorem.

CO5: Interpret Jacobson radical, Jacobson semi-simple ring, nilpotent and nil ideals.

CO6: Prove Fitting lemma, Hopkins Levitzki theorem and Nakayama's Lemma.

CO7: Explain injective modules and divisible modules, essential extension and injective envelope of a module.

CO8: Prove embedding theorem for modules.

CO9: Illustrate small submodules, projective modules, projective covers and Jacobson radical of a projective module.

Course: Representation Theory of Finite Group

Students will able to

CO1: Describe irreducible and completely reducible modules.

CO2: Prove Schur's Lemma, Jacobson density theorem, Wedderburn structure theorem for semi simple modules and rings and group algebra Maschke's theorem.

CO3: Describe representations of a group on a vector space and matrix representation of a group.

CO4: Explain equivalent and non-equivalent representations, decomposition of regular representation and number of irreducible representations.

CO5: Explain characters, irreducible characters, orthogonality relations, integrality properties of characters and character ring.

CO6: Prove Burnside's *paqb* - theorem.

CO7: Find representations of direct product of two groups, induced representations and the character of an induced representations.

CO8: Prove Frobenius reciprocity theorem and do construction of irreducible representations of Dihedral group D_n, alternating group A_4, symmetric groups S_4 and S_5.

CO9: Prove Mackey's irreducibility criterion, Clifford's theorem and state Brauer and Artin's theorems.

Course: Stability Theory of Differential Equations and Its Applications

Students will able to

CO1: Describe uncoupled and coupled linear systems, reduction of coupled linear system to uncoupled linear system and exponentials of operators.

CO2: Prove fundamental theorem for linear systems and explain non-homogeneous linear systems.

CO3: Describe non-linear autonomous system, the phase plane & its phenomena, Types of critical points, Phase plane analysis and conservative systems.

CO4: Explain variational matrix, stability analysis of linear and nonlinear systems using variational matrix, Liapunov function and stability by Liapunov's direct method.

CO5: Formulate and classify mathematical models, Malthusian growth model, logistic growth model, regrowth model and delayed differential models.

CO6: Interpret Lotka-Volterra predation model, Rosenzweig-MacArthur model, Lotka-Volterra competition model, Lotka-Volterra models of mutualism.

CO7: Illustrate obligate and non-obligate mutualism, effect of mutualism on predator-prey and competitive systems.