M. Sc. In Mathematics

Semester-I (35 Credits)

S. No.	Course Title	Credits	L-T-P-C
1	Analysis 1	6	3-0-0-6
2	Introduction to Linear Algebra	6	3-0-0-6
3	Introduction to probability theory	8	3-1.5-0-9
4	Groups and Rings	6	3-0-0-6
5	Ordinary Differential Equations	6	2-1-0-6
6	Computer Programming	3	0-0-3-3

Semester-II (33 Credits)

S. No.	Course Title	Credits	L-T-P-C
1	Analysis 2	6	3-0-0-6
2	Fields and Galois theory	6	2-1-0-6
3	General Topology	6	2-1-0-6
4	Measure Theory	6	3-0-0-6
5	Statistics	6	2-1-0-6
6	Statistics laboratory	3	0-0-3-3

Semester-III (32 Credits)

S. No.	Course Title	Credits	L-T-P-C
1	Functional Analysis	6	3-0-0-6
2	Numerical Analysis	6	2-1-0-6
3	Introduction to complex analysis	6	2-1-0-6
4	Discrete Structures and Cryptography	6	3-0-0-6
5	Program Elective 1	6	3-0-0-6

Semester-IV (30 Credits)

S. No.	Course Title	Credits	L-T-P-C
1	Partial Differential Equations	6	3-0-0-6
2	Program Elective 2	6	3-0-0-6
3	Program Elective 3	6	3-0-0-6
4	Institute Elective 1	6	3-0-0-6
5	Institute Elective 2	6	3-0-0-6
	OR Those who maintain more than 9 CPI can do 1 Masters Thesis Semester Long instead of 4 Electives (2 Program Elective and 2 Institute Elective). Will be evaluated by a committee including one external subject expert.		Master thesis has 24 credits – only to facilitate exceptional students.

List of elective courses:

1. Graph Theory and Combinatorics
2. Stochastic Models
3. Introduction to Mathematical Finance 1
4. Introduction to Mathematical Finance 2
5. Algebraic Topology
6. Advanced Algebra
7. Homological Algebra
8. Introduction to Representation Theory
9. Differential Topology
10. Introduction to Graduate Algebra
11. Numerical Analysis of Partial Differential Equations
12. Advanced Commutative Algebra
13. Algebraic Geometry I
14. Algebraic Geometry II
15. Algebra
16. Random Schrodinger Operators
17. Advanced Graph Theory
18. Linear Integral Equations
19. Theory of Perfect Graphs
20. Topics in Elliptic Partial Differential Equations
21. Numerical Solution of linear Integral Equations
22. Introduction to Diophantine Approximation
23. Introduction to Lie Algebras
24. Irrational and Transcendental Numbers
25. Algebraic Number Theory
26. Complex Analysis with Applications to number theory

1	**Title of the course** (L-T-P-C)	**Analysis 1** (3-0-0-6)
2	**Pre-requisite courses(s)**	
3	**Course content**	Review of the real number system, Basic concepts/ Metric spaces, compactness, and connectedness, (with emphasis on R^n). Completeness, Cantor intersection theorem, Baire category theorem.Continuity and uniform continuity. Derivatives of functions and Taylor's theorem. Monotonic functions. Functions of bounded variation, Absolutely continuous functions.The Riemann-Stieltjes integral, Improper integrals, Gamma functions. Sequences and series of functions, uniform convergence and its relation to continuity, differentiation, and integration, pointwise convergence, Weierstrass approximation theorem. Equicontinous family of function, Power series, special functions (like Gamma, logarithmic, trigonometric etc.), Fourier series.
4	**Texts/References**	1. T. Apostol, Mathematical Analysis, 2nd ed., Narosa Publishers, 2002. 2. R. G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 2nd ed. 1994. 3. S. R. Ghorpade and B. V. Limaye, A Course in Calculus and Real Analysis, Springer, 2006. 4. W. Rudin, Principles of Mathematical Analysis, McGraw Hill Education; Third edition (1 July 2017)

1	**Title of the course** (L-T-P-C)	**Introduction to Linear Algebra** 3-0-0-6
2	**Pre-requisite courses(s)**	-
3	**Course content**	Revision of solutions of a system of linear equations, elementary row operations, row-reduced echelon matrices. Vector spaces over arbitrary field, spam of a subset, bases and dimension, direct sums quotient spaces, tensor products. Linear transformations, rank-nullity, matrix representation of a linear transformation, algebra of linear transformations, dual transpose of a linear transformation. Determinant. Eigenvalues, eigenvectors, Cayley-Hamilton theorem, invariant subspaces, triangulable and diagonalizable linear operators. Simultaneous triangulation and diagonalization, Primary decomposition theorem, rational canonical form, Jorden decomposition, Inner product spaces over real and complex numbers, Gram-Schmidt orthogonalization process, orthogonal projection, best approximation. Adjoint of a linear operator, unitary and normal operators, spectral theory of normal operators. Bilinear forms, Symmetric and skew-symmetric bilinear forms, real quadratic forms, Sylvester's law of inertia, positive definiteness.
4	**Texts/References**	1. K. Hoffman, R. Kunze: Linear Algebra, Prentice-Hall Inc, Englewood Cliffs, NJ 1971. 2. S. Lang: Linear Algebra, Undergraduate Texts in Mathematics, Springer Verlag, New York, 1989. 3. Gilbert Stang: Linear Algebra and its applications. 4th ed. Cengage, 2006. 4. Peter D Lax: Linear Algebra and its applications, John Wily & Sons, Inc., new Jersey.

1	**Title of the course** (L-T-P-C)	**Introduction to probability theory** (3-1-0-8)
2	**Pre-requisite courses(s)**	Combinatory probability and urn models,
3	**Course content**	Independence of events, conditional probabilities, Random variables, Distributions, Expectation, Variance and moments, probability generating functions and moment generating functions. Standard discrete distributions (Uniform, binomial, Poisson, geometric, hypergeometric), Independence of random variables, joint and conditional discrete distributions. Univariate densities and distributions, standard univariate densities (normal, exponential, gamma, beta, chi-square. Cauchy). Expectation and moments of continuous random variables. Transformation of univariate random variables. Chebyshev's inequality. Modes of convergence. Law of large numbers. Central limit theorem.
4	**Texts/References**	1. K . L Chaung and F. A it Shalia, Elementary probability Theory., 4^{th} Edition, Springer Verlag, 2003. 2. R. Ash: Basic probability Theory, Dover publication, 3. W. feller: Introduction to Probability theory and its applications, Volume I, Wiley-India Edition. 4. W. feller: Introduction to Probability theory and its applications, Volume 2, Wiley-India Edition.

1	**Title of the course** (L-T-P-C)	**Groups and Rings** (3-0-0-6)
2	**Pre-requisite courses(s)**	
3	**Course content**	Groups, subgroups, Lagrange theorem, quotient groups, isomorphism theorems; cyclic groups, dihedral groups, symmetric groups, alternating groups; simple groups, simplicity of alternating groups; generators and relations, Cayley's Theorem, Group action, Sylow theorems and applications; Direct and semidirect products, free abelian groups, structure of finitely generated abelian groups; Solvable and nilpotent groups, composition series, Jordan-Holder theorem. Rings, examples: polynomial rings, formal power series, matrix rings, group rings; prime ideals, maximal ideals, quotient rings, isomorphism theorems; Integral domains, PID, UFD, Euclidean domains, division rings, field of fractions; primes and irreducibles, irreducibility criteria; product of rings, Chinese remainder theorem
4	**Texts/References**	1. M. Artin, Algebra, Prentice Hall of India, 1994. 2. D. S. Dummit and R. M. Foote, Abstract Algebra, 2nd Edition, John Wiley, 2002. 3. J. A. Gallian, Contemporary Abstract Algebra, 4th Edition, Narosa, 1999. 4. K. D. Joshi, Foundations of Discrete Mathematics, Wiley Eastern, 1989. 5. T. T. Moh, Algebra, World Scientific, 1992. 6. S. Lang, Algebra, 3rd Edition, Springer (India), 2004. 7. J. Stillwell, Elements of Algebra, Springer, 1994.

1	**Title of the course** (L-T-P-C)	**Ordinary Differential Equations**. 2-1-0-6
2	**Pre-requisite courses(s)**	Calculus 1 and 2, Linear Algebra DE 1 or Instructor's consent.
3	**Course content**	Review of solution methods for first order as well as second order equations, power series method with properties of Bessel functions and Legendre polynomials. Existence and Uniqueness of Initial value problems: Picard's and piano's theorems, gromwell's inequality, continuation of solutions and maximal interval of existence, continuous dependence. Higher order linear equations and linear systems: fundamental solutions, Wronskian, variation of constants, matrix exponential solution, behavior of solution. Two Dimensional autonomous systems and phase space analysis: critical points, proper and improper nodes, spiral points and saddle points. Asymptotic Behavior: stability (linearized stability and Lyapunov methods). Boundary problems for second order equations: Green's function, Sturm comparison theorems and oscillations, eigenvalue problems.
4	**Texts/References**	1. M. Hirsch, S.Smale and R. Deveney, Differential Equations, Dynamical systems and introduction to chaos, academic press, 2024. 2. Perko. Differemtial equations and Dynamical systems, texts in Applied mathematics, Vol.7, 2^{nd} Edition, Springer verlag, New Ylrk, 1998. 3. M.Rama Mohana Rao, Ordinary Differential Equations: Theory and Applications. Affilations. East-West Press Pvt Ltd. New Delhi 1980. 4. D. A. Sanchez, Ordinary Differential Equations and stability Theory: An Introduction, Dover Public Inc. New York, 1968.

1	**Title of the course** (L-T-P-C)	**Computer Programming** **0-0-3-3**
2	**Pre-requisite courses(s)**	--
3	**Course content**	1. Topics in C: Data types, operations, flow control, array & structures, functions pointers, file handling 2. Introduction to utilities: make file, GDB, and profiling tools 3. Data visualization using gnu plot 4. Basics of multithreaded programming in C Using P-threads. 5. Interfacing with BlAS (Basic Linear Algebra Sibprograms) and LAPACK (Linear Algebra Package), solving problems using BLAS and LAPACK 6. Ideas of object orientation programming using C++: Classes and Objects Polymorphism, Inheritance, Operator overloading
4	**Texts/References**	1. Kernighan B.W. & Ritchie D, The Programming Language 2e, Pearson education Indian, 2015. 2. Stroustrup. B., C++ Programming language, 4e person education, 2022. 3. Editors, Coline C., Wilmore F.T Jankowski E. Introduction to scientific and Technical computing, CRC Press.

1	**Title of the course** (L-T-P-C)	**Analysis 2** (3-0-0-6)
2	**Pre-requisite courses(s)**	Real analysis, Linear algebra
3	**Course content**	Differentiability in R^n, directional derivatives, Chain rule, Inverse function theorem, Implicit function theorem, Lagrange multiplier method. Riemann integral of real-valued functions on Euclidean spaces, Fubini's theorem, Partition of unity, change of variables. Differential forms on R^n, simplices and singular chains, Stokes' theorem for integral of differential forms on chains (general version) on R^n, closed and exact forms, Poincaré lemma, Classical Green's theorem, divergence theorem and Stokes' formula as applications of general form of Stokes' theorem. Arbitrary submanifolds of R^n not necessarily open, differentiable functions on submanifolds, tangent spaces, vector fields. Curves in two and three dimensions, Curvature and torsion for space curves, Existence theorem for space curves, Serret-Frenet formula for space curves.
4	**Texts/References**	1. V. Guillemin and A. Pollack, Differential Topology, American Mathematical Society; Reprint edition (August 16, 2010) 2. W. Fleming, Functions of Several Variables, 3rd printing 1987 edition 3. J.R. Munkres, Analysis on Manifolds, Westview Press; 1st edition (7 July 1997) 4. W. Rudin, Principles of Mathematical Analysis, McGraw Hill Education; Third edition (1 July 2017) 5. M. Spivak, Calculus on Manifolds, A Modern Approach to Classical Theorems of Advanced Calculus, Westview Press Inc; 1st edition (22 January 1971)

1	**Title of the course** (L-T-P-C)	**Fields and Galois theory** **2-1-0-6**
2	**Pre-requisite courses(s)**	Group Theory, Rings and modules OR Instructor's consent
3	**Course content**	Polynomial rings, Gauss lemma, Irreducibility criteria definition of a field and basic examples. Characteristic and prime subfields, Field extensions, Algebraic extensions, Algebraic extensions. Classical rules and compass constructions finite fields splitting fields and normal extensions, algebraic, closures, separable and inseparable extension, Golis extension, Galois extension cyclotomic fields, Galois groups , fundamental theorem of Galois theory. Composite extensions, Examples (including cyclotomic extensions and extensions of finite fields), Abelian extension over Q Galois groups of polynomials, solvability by radicals, solvability of polynomial computations of Galois groups over Q Norm Trace and discriminant, cyclic extensions, Abelian extensions, polynomials with Galois groups S_n. Transcendental extensions.
4	**Texts/References**	1. M Artin, Algebra, Prentice hall of India 1994. 2. D S Dimmit and R M Foote abstract Algebra, 2nd Edition, John Wiley. 2002. 3. D J H Garling A course in galois theory, combridge university press, 1986. 4. N. Jacobson, Basic Algerbra I, 2nd Edition, W.H. freeman, 1985 and 1989. 5. Lang, Algebra, 3rd Edition, Springer (India), 2004.I. Stewart, Galois Theory, 3rd Edition. Campman & Hall/CRC Press (2004). 6. J Rotman Galois theory,2nd Edition, Springer (2005), O. Zariski and P. Samuel, Commulative Algebra, Vol.I, Springer, 197.

1	**Title of the course** (L-T-P-C)	**General Topology** **2-1-0-6**
2	**Pre-requisite courses(s)**	Calculus, Linaer Algebre, Real analysis and Elements of metric space theory or instructor'
3	**Course content**	Topological spaces: Open sets, closed sets, neighborhood, bases, sub bases, limit pointers, closures, interiors, continuous functions, homeomorphisms. Examples of topological spaces: Subspace topology, product topology, metric topology, order topology, Quotient topology, Construction of cylinder, cone, moebius band, torus, etc. Connectedness and compactness: Connect spaces, connected subspaces of the real line, components and local connectedness, compact spaces, heine-Borel theorem, local compactness. Separation axioms: Harsdorf spaces regularity, complete regularity, normality, Ursohn lemma, Tycho off embedding and urysohn metrization theorem, Tietze Extension theorem, Tychoff theorm, One-Point compact Complete metric spaces and function spaces, charaterizartion of compact metric spaces, equicotinuity, Ascoli-Arzela Theorem, Baire category theorem. Applications: Space filling curve. Nowhere differentiable continuous function.
4	**Texts/References**	1. J R Munkres Topology, 2nd Edition, Pearson Eduction (India) 2001. 2. G F Simmons, Introduction to topology and modern analysis, McGraw-Hill, 1963. 3. M A Armstrong, basic topology, Springer (India), 2004.

1	**Title of the course** (L-T-P-C)	**Measure Theory** 3-0-0-6
2	**Pre-requisite courses(s)**	Real Analysis
3	**Course content**	Construction of Lebesgue measure on Real line, Introduction to abstract measure theory, Measurable functions, Caratheodory's Extension Theorem, MCT, Fatou's Lemma, DCT, Product space, Product measure, Fubini's Theorem, Definition of signed measures, Positive and negative sets. Hahn-Jordan Decomposition. Absolute continuity of two σ - finite measures. Radon-Nikodyme Theorem and Lebesgue Decomposition.
4	**Texts/References**	1. H. L. Royden; Real analysis. Third edition. Macmillan Publishing Company, New York, 1988. 2. W. Rudin; Real and complex analysis. Third edition. McGraw- Hill Book Co., New York, 1987. 3. S. Athreya and V.S. sunder; Measure & probability. CRC Press, Boca Raton, FL, 2018. 4. K.R. Parthasarathy; Introduction to probability and measure, Hindustan Book Agency, 2005.

1	**Title of the course** (L-T-P-C)	**Statistics** 2-1-0-6
2	**Pre-requisite courses(s)**	Probability or Instructor's consent
3	**Course content**	Introduction to Statistics with examples of its use; Descriptive statistics; Graphical representation of data: Histogram, Stem-leaf diagram, Box-plot; Exploratory statistical analysis with a statistical package; Basic distributions, properties; Model fitting and model checking: Basics of estimation, method of moments, Basics of testing, interval estimation; Distribution theory for transformations of random vectors; Sampling distributions based on normal populations: t, 2 and Fx distributions. Bivariate data, covariance, correlation and least squares.
4	**Texts/References**	Lambert H. Koopmans. An introduction to contemporary statistics. Devid S Moore, George P McCade and Bruce craig: Introduction to the practice of statistics. David S Moore, George P McCabe and Bruce Craig: Introduction to the Practice of Statistics Larry Wasserman: All of Statistics. A Concise Course in Statistical Inference. John A. Rice: Mathematical Statistics and Data Analysis Robert V. Hogg, J.W. McKean, and Allen T. Craig: Introduction to Mathematical Statistics, Seventh Edition, Pearson Education, Asia. Edward J Dudewicz and Satya N. Mishra: modern mathematics statistics, Wiley.

1	**Title of the course** (L-T-P-C)	**Statistics laboratory** 0-0-3-3
2	**Pre-requisite courses(s)**	Probability or Instructor's Consent
3	**Course content**	Why R; Installation Procedure and How to Start; Help, Demonstration, and Examples; Command line, Libraries, Packages and Data Editor; Introduction to R Studio; Basics of Calculations and R as a calculator; R as a Calculator with Data Vectors; R as Calculator, Built-in Functions and Assignments; Functions and Introduction to Matrix; Matrices; Matrix Operations; Matrix Operations and Missing Data; Missing Data and Logical Operators; Logical Operators: More Operations; Truth Table and Conditional Executions; Loops; Repeat Loop and Sequences of Numbers; Sequences of Dates and Alphabets; Repeats, Sorting and Mode; Ordering and Lists; Vector Indexing; Data Frames; Data Frames: Creation and Operations; More Operations on Data Frames; Display using Print and Format Functions with Concatenate; Display Strings Using Paste Function and Splitting; Splitting and Substitution in Strings; Search in Strings and Other Data Operations; Factors; Factors - Examples and Operations; Importing, Reading and Saving Data Files; Importing and Reading Data Files; Introduction and Frequencies; Partition Values, Graphics and Plots; Graphics, Plots and Central Tendency of Data; Central Tendency and Variation in Data; Boxplots, Skewness and Kurtosis; Bivariate and Three Dimensional Plots; Programming in R; More Examples of Programming.
4	**Texts/References**	1. Introduction to statistical and data analysis-with exercises, solutions and applications in R by Christian Heumann, Michael Schumaker and Shalabh, Springer. 2016. 2. The R Siftware-Fundamenals of Programming and statistical analysis-Pierre Lafaye de Michaux.

1	**Title of the course** (L-T-P-C)	**Functional Analysis** **3-0-0-6**
2	**Pre-requisite courses(s)**	Basic topological concepts, Metric spaces, Measure theory
3	**Course content**	Stone-Weierstass theorem, L^p spaces. Banach spaces, Bounded linear functionals and dual spaces, Hahn-Banachtheorem, Bonded linear operators, open-mapping theorem, cloased graph theorem, uniform boundedness principle. Hilbertspaces, Riesz representation theorem. Bounded operators on a Hilbert space. The spectral theorem for compact, self-adjoint, normal (including unbounded)
4	**Texts/References**	1. J. B. Conway: A course in functional analysis, Springer-Verlag, New York, 1990 2. B. V. Limaye: Functional Analysis, New Age International Limited, Publishers, New Delhi, 1996. 3. Michael Reed, Barry Simon: Methods of modern mathematical physics. I. Functional analysis. Second edition. Academic Press, Inc, New York, 1980. 4. E. Kreysizg: introductory functional analysis with applications, John Wiley & Sons, New York, 2001.

1	**Title of the course** (L-T-P-C)	**Numerical Analysis** 2-1-0-6
2	**Pre-requisite courses(s)**	Calculus 1 and 2, Linear Algebra, DE 1, Ordinary Differential equations or Instructor's connsent.
3	**Course content**	Linear systems of equation, LU decomposition, classical interactive techniques and ill conditioned systems. Matrix eigenvalue problems, power iteration, Jacobi and QR methods Approximation theory, interpolation (Lagrange, Hermite and piecewise interpolation) and best approximations in inner product spaces. Nonlinear equations and their iterative solution Numerical Integration, interpolator quadratures, Gass quadrature of periodic functins and Romberg integration Finite Difference methods, convergence, stability and consistency, Lax equivalence theorem.
4	**Texts/References**	1. Rainer Kress, Numerical Analysis, 1st Edition Springer- Verlag New York, 1998. 2. J Stoer and R. Bulirsch, Introduction to numerical analysis, 3rd Edition, Springer Verlag New York, 2002. 3. K. Atkinson and weimin han, theoretic numerical analysis, A functional analysis framework, 3rd Edition, springer-Verlag New York, 2001. 4. P.Deuflhard and Hohmann, Numerical Analysis in modern scientific computing, an introduction, 2nd Edition, Springer-Verlag New York, 20023.

1	**Title of the course** (L-T-P-C)	**Introduction to complex analysis** 2-1-0-6
2	**Pre-requisite courses(s)**	Real analysis and calculus OR Instructor's consent
3	**Course content**	Definition and properties of analytic functions. Cauchy-Riemann equations, harmonic functions. Power series and their properties Elementary functions. Cauchy's theorem and its applications. Taylor series and Laurent expansions. Evaluation of improper integrals. Conformal mapping: Inversion of Laplace transforms. Isolated singularities and residues. Residuals and the Cauchy residue formal zeroes and poles, maximum modules principle, Argument principle, Rouche's Theorem.
4	**Texts/References**	1. E. Kreyszig, advanced engineering mathematics (10^{th} Edition), John Wiley (1999) 2. R. V. R. V Churchill and J.W. Brown, Complex variable and applications (7^{th} Edition), McGraw-Hill (2003) 3. Theodore Gamelin, complex analysis-Springer undergraduate texts in mathematics(2003) 4. J B Conway, Functions of one complex variable, springer, 7^{th} Printing 1995 edition.

1	**Title of the course** (L-T-P-C)	**Partial Differential Equations** 3-0-0-6
2	**Pre-requisite courses(s)**	Calculus 1 and 2, Linear Algebra, DE 1, Ordinary Differential equations or Instructor's consent
3	**Course content**	Example of partial differential equations, Cauchy problems for first order hyperbolic equations, method of characteristics, mongcone, classification of second order partial differential equations, normal forms and characteristics. Laplace equations: mean value property, week and strong minimum principle, Gree's function, Dirichlet's principle, existence of solution using perron's method (with/without proof). Heat equation: Initial value problem, fundamental solution, weak and strong maximum principle and uniqueness results. Wave equation: Uniqueness, D' Alembert;s method, method of spherical means and Duhamel's principle, method of separation of variables of heat, laplace and wave equations.
4	**Texts/References**	1. L.C.Evans, Partial differential equations, Graduatestudies in mathematics, Vol. 19 american mathematical society, 1998. 2. F John Mc Owen, Patial Diffrential equations: Methods and applications, 2nd edition, peatson, 2003 3. M. Renardy and R.C Raers, Introduction to patial differential equations, 2nd Edition, Springer0Velag new York, 2004.

1	**Title of the course** (L-T-P-C)	**Graph theory and combinatorics** **3-0-0-6**
2	**Pre-requisite courses(s)**	Discrete Structures
3	**Course content**	Fundamentals of graph theory. Topics include: connectivity, planarity, perfect graphs, coloring, matchings and extremal problems. Basic concepts in combinatorics. Topics include: counting techniques, inclusion-exclusion principles, permutations, combinations and pigeon-hole principle.
4	**Texts/References**	1. An introduction to quantum field theory", Micheal peaskin and Daniel Schroeder (Addison Wesley) 2. "Introduction to quantum field theory", A Zee. 3. Quantum Filed theory Lewis H Ryder 4. Quantum field theory and critical phenomena, By Zinn-Justin 5. Quantum Field theory for the gifted amateur, T. Lancaster and Stepher J. Blundell 6. NPTEL lecture in quantum field theory (hhttp://nptl.ac.in/course/115106056/)

1	**Title of the course** (L-T-P-C)	**Stochastic Models** **3-0-0-6**
2	**Pre-requisite courses(s)**	Probability or Instructor’s Consent
3	**Course content**	Definition and classification of general stochastic processes. Markov chains: definition, transition probability matrices, classification of states, limiting properties, Markov chains with discrete state space: Poisson process, birth and death processes. Renewal process: renewal equation, mean renewal time. stopping time. Applications to queuing models. Markov process with continuous state space: Introduction to Brownian motion.
4	**Texts/References**	1. Bhat U N and Miler, G K., Elements of applied stochastic processes, 3rd edition, John Wiley & sons, new York, 2002. 2. Kulkarni V G modeling and analysis of stochastic systems, 3rd edition, Chapman and hall/CRC, Bocs raton. 2017. 3. J. Medhi, Stochastic models in queuing theory, Academic press, 1991. 4. R Nelson probability stochastic processes, and Queuing theory: The mathematics of computer performance modeling. Springer Verlag new York, 1995 5. Sheldon M Ross: Stochastic processes, John Wiley and sons 1996. 6. S Kalin and H M Taylor: A first course in stochastic processes, academic proess, 1975.

1	**Title of the course** (L-T-P-C)	**Introduction to Mathematical Finance-I** **3-0-0-6**
2	**Pre-requisite courses(s)**	Calculus linear algebra and probability. Instructor’s permission may be sought to enroll for the course otherwise
3	**Course content**	Introduction to financial market and financial instruments: bonds, annuities, equities, contracts, swaps and options. Risky and risk free assets, time value of money, binomial model for risky assets and corresponding properties. Portfolio management, capital asset pricing model options, futures and derivative, European options, Elementary stochastic calaculus and black scholes
4	**Texts/References**	1. John Hull. Options, futures and Derivatives, 10th Edition Pearson, US, 2018. 2. Marek Capiriski, Tomasz Zastawniak, mathematical for finance: An introduction to financial engineering 2nd Edition, Springer Verlag, Landon, 2011. 3. Paul Wilmott, Paul Wilmott introduces quantitative finance, 2nd Edition, John Eiler & sons, US, 2013. 4. Mark H.A. Davis, Mathematical finance: A very short introduction, oxfard university Press, UK 2019.

1	**Title of the course** (L-T-P-C)	**Introduction to Mathematical Finance-2** **3-0-0-6**
2	**Pre-requisite courses(s)**	Calculus, Linear Algebra, Probability, Statistics, Stochastic Models or Instructor's consent
3	**Course content**	Basics, Risk Assessment and Diversification Single period utility analysis, Mean-variance portfolio analysis, Graphical Analysis of portfolios and efficient portfolio, Efficient portfolios with and without risk-free assets, Single, two and multi-index models Risk management: Concept of VaR, measuring VaR and estimating volatilities via simple moving averages and GARCH, Var in Black-Scholes, Average VaR in Black-Scholes Capital asset pricing model and its extension, continuous- time asset pricing. Arbitrage pricing.
4	**Texts/References**	1. J. C. Francis and D. Kim, Modern Portfolio Theory: Foundations, Analysis, and New Developments, John Wiley and Sons, 2013 2. M. J. Capinski and E. Kopp, Portfolio Theory and Risk Management, Cambridge University Press, 2014 3. J. mCvitanic and F. Zapatero, Introduction to the Economics and Mathematics of Financial Markets, MIT press, 2004 4. E. J. Elton, M. J. Gruber, S. J. Brown, W. N. Goetzmann, Modern Portfolio Theory and Investment Analysis, 9th Edition, John Wiley and Sons, 2014

1	**Title of the course** (L-T-P-C)	**Algebraic Topology** **3-0-0-6**
2	**Pre-requisite courses(s)**	**Topology/ Instructor's consent**
3	**Course content**	Path and homotopy, homotopy equivalence, contractibility, deformation retracts Basic construction: cones, mapping cones, mapping cylinder, suspensions. Cell complex, subcomplexes, CW pairs fundamental groups. Examples (including the fundamental group of the circle). And applications (including fundamental theorem of algebra, Brouwer fixed point theorem and Borsuk-Ulam theorem, both in dimension transformations, universal coverings. Simplicial complexes, barycentric subdivision stars and links, simplicial approximation, simplicial homology. Singular homology. Mayer- Victoria sequence of pairs and triples. Homotopy invariance and excision. Degree, cellular homology. Applications of homology: Jordan-Brouwer separation theorem, Invariance of dimension, Hopf's Theorem for commutative division algebras with identity, Borsuk-Ulam Theorem, Lefschetz Fixed Point Theorem Optional Topics: Outline of the theory of: cohomology groups, cup products, Kunneth formulas, Poincare duality
4	**Texts/References**	1. M. J Greenberg and J. R. Harper. Algebraic topology, Benjamin, 1981. 2. W. Fauton, Algebriac topology: A First course, Springer-Verlag, New York, 1995. 3. A Hatcher, algebraic topology, combridge Univ. Press. Combridge 20002. 4. W. Massey, A basic course in algebra topology, springer-verlag, Berlin, 1991. 5. J.R. Munkress, Elements of Algebric topology, Addision-wesley, Menlo park, CA, 1984. 6. J.J. Rotman, An introduction to algebraic topology, springer (India), 2994. 7. H. Seifert and W. Threifall, A textbook of topology, Academic press, New York-Landon, 1980.

1	**Title of the course** (L-T-P-C)	**Advanced Algebra** **3-1-0-8**
2	**Pre-requisite courses(s)**	**Introduction to Algebra**
3	**Course content**	Semi simple and Simple rings: Semi simple modules, Jacobson density theorem, semi simple and simple rings, Wedderburn-Artin structure theorems, Jacobson radical, The effect of a base change on semi simplicity. Representations of finite groups: Basic definitions, characters. Class functions, orthogonality relations, induced representations and induced characters, Frobenius reciprocity, decomposition of the regular representation, super solvable groups, representations of symmetric groups. Noetherian modules and rings: Primary decomposition, Nakayama's lemma, filtered and graded modules, the Hilbert polynomial, Artinian modules and rings, projective modules, Krull-Schmidt theorem, completely reducible modules
4	Texts/References	1. Dimmit, Foote: Abstract algebra, second edition, Wiley student editions, 2005. 2. Jacobson basic algebra, I, Dover publications, 2009. 3. Jacobson: Basic algebra, II, Dover Publications, 2009. 4. Lang: Algebra, third edition, Springer-Verlag, GTM 211, 2002.

1	**Title of the course** (L-T-P-C)	**Homological Algebra** 3-1-0-4
2	**Pre-requisite courses(s)**	Basic group theory. Ring theory and model theory, Linear Algebra.
3	**Course content**	Categories and factors: definitions and examples. Functors and natural transformations, equivalence of categories,. Products and coproducts, the hom functor, representable functors, universals and adjoints. Direct and inverse limits. Free objects. Homological algebra: Additive and abelian categories, Complexes and homology, long exact sequences, homotopy, resolutions, derived functors, Ext, Tor, cohomology of groups, extensions of groups.
4	Texts/References	1. M. Artin, Algebra, 2nd Edition, Prentice Hall of India, 1994. 2. N. Jacobson, Basic Algebra, Vol. 1, 2nd Edition, Hindustan Publishing corporation, 1985. 3. N. Jacobson, Basic Algebra, Vol. 1, 2nd Edition, Hindustan Publishing corporation, 1989. 4. S. Lang, Algebra, 3rd Edition Addison Wesley, 1993. 5. O. Zariski and P. Samuel, Commutative Algebra, Vol, Corrected reprinting of the 1958 edition, Springer Verlag, New York, 1975. 6. O. Zariski and P. Samuel, Commutative algebra, Vl 1, Reprint of the 1960 edition, Springer-Verlag, 1975.

1	**Title of the course** (L-T-P-C)	**Introduction to Representation theory** 3-0-0-6
2	**Pre-requisite courses(s)**	A Course in (Graduate) algebra
3	**Course content**	Basic notions of representation theory that includes irreducible modules and complete reducibility theorem. Character theory, Schur's orthogonality relations, isotopic components and the canonical decomposition. Group algebra and integrality, and the degree of an irreducible representation. Induced representations, Frobenius reciprocity, and Mackey theory. Various examples: Abelian groups, Dihedral groups, Symmetric groups in 3,4, and 5 letters.
4	**Texts/References**	1. J.-P.Serre, Linear representations of finite groups, Graduate Texts in Mathematics, Vol. 42, Springer- Verlag, New York-Heidelberg 1977. 2. W. Fulton and J. Harris, Representation theory, A first course, Graduate Texts in Mathematics, 129. Readings in Mathematics, Springer-Verlag, New York, 1991. 3. I. Benjamin Steinberg, Representation theory of finite group: Introductory approach, springer-Verlag, New York. 2012.

1	**Title of the course** (L-T-P-C)	**Differential Topology** 3-0-0-6
2	**Pre-requisite courses(s)**	Multivariable calculus, General topology and linear Algebra
3	**Course content**	Differentiable manifolds, smooth maps between manifolds, Tangent spaces and cotangent spaces, Vector fields, tangent and cotangent bundles, Vector bundles, Sub manifolds, submersion and immersions, Basic notion of Lie groups, Tensors and differential forms, Integration on manifolds and de Rham theory
4	**Texts/References**	1. John M. Lee, Introduction to Smooth Manifolds, Springer Verlag, New York, 2003. 2. Frank Warner, Foundations of Differentiable Manifolds and Lie Groups, Springer Verlag, New York, 1983 3. Glen Bredon, Topology and Geometry, Springer Verlag, New York, 1993.

1	**Title of the course** (L-T-P-C)	**Numerical Analysis of Partial Differential Equations** 4-0-0-8
2	**Pre-requisite courses(s)**	Analysis, ODE, PDE and Numerical Analysis
3	**Course content**	Numerical ODE - Multi Step and Multi Stage methods, A-stability, Stiffness Numerical solution of Elliptic Boundary value problems - Consistency, Stability and Convergence, Solution of Poisson's Equation in 2D, Numerical solution of Elliptic Eigenvalue problems Numerical solution of Conservation Laws Local and Global Errors, Conservative Methods, Godunov Methods and High Resolution Methods, WENO scheme
4	**Texts/References**	1. Arieh Iserles, A first course in the numerical analysis of differential equations, 2nd Edition, Cambridge University Press, UK, 2008. 2. K. W. Morton & D. F. Mayers, Numerical solution of partial differential equations: An Introduction, 2nd Edition, Cambridge University Press, UK, 2005 3. Randall J. LeVeque, Finite volume methods for Hyperbolic Problems, 2nd Edition, Cambridge University Press, UK, 2002 4. Stig Larsson & Vidar Thomee, Partial Differential Equations with numerical methods, Text in Applied Mathematics, Springer-Verlag Berlin Heidelberg, 2003.

1	**Title of the course** (L-T-P-C)	**Advanced Commutative Algebra** 3-1-0-8
2	**Pre-requisite courses(s)**	Introduction to Algebra
3	**Course content**	1. Homological Algebra: Flat and faithfully flat modules, Complexes, homology and cohomology, the Tor modules, Injective resolutions and Ext modules, Projective dimension, Global Dimension. 2. Dimension Theory: Noether's Normalization lemma, Graded rings and modules, Hibert function and series, Hilbert's Theorem, Hilbert-Samuel functions, Dimension Theorem. 3. Regular Local Rings: Homological Characterisation of regular rings, the jacobian criterion for geometric regularity. 4. Cohen-Macaulay rings: Koszul complexes, Properties of CM modules. 5. Complete local rings: Derivations and the module of Kahler differentials, formal smoothness, Cohen's structure theorem for complete local rings. 6. Gorenstein rings: Basic properties of Gorenstein rings, Matlis duality
4	**Texts/References**	1. S. Bosch, Algebraic geometry and commutative algebra, Universitext, Springer, (2013). 2. W. Bruns, and J. Herzog, Cohen-Macaulary rings, Combridge studies in advance mathematics 39. Revised ed., Combridge university press, (1998). 3. H. Matsumura, H, Commutative ring theory, Cambridge university Press, 1986. 4. M. P. Murthy, Commutative algebra, course-notes, university of chicage, 1972/73. 5. J.P. Serre, Local Algebra. Springer- verlag(2000). 6. B. Singh, Basic commutative algebra, World scientific publications, (2011).

1	**Title of the course** (L-T-P-C)	**Algebraic Geometry I (3-1-0-8)**
2	**Pre-requisite courses(s)**	Introduction to Algebra
3	**Course content**	Affine, projective varieties, Hilbert's nullstellensatz, morphisms, rational maps, blowing up of a variety at a point, non-singular varieties, non-singular curves, intersection multiplicity Bézout's theorem
4	**Texts/References**	1. S. S. Abhyankar, Algebraic Geometry for Scientists and Engineers, American Mathematical Society, Providence, RI, 1990. 2. D. Eisenbud and J. Harris, The Geometry of Schemes, Springer-Verlag, 2000. 3. W. Fulton, Algebraic Curves, Benjamin, 1969. 4. J. Harris, Algebraic Geometry: A First Course, Springer-Verlag, 1992. 5. R. Hartshorne, Algebraic Geometry, Springer- Verlag, 1977. 6. I. R. Shafarevich, Basic Algebraic Geometry, Vol. 1 and 2, Second edition, Springer-Verlag, 1994.

1	**Title of the course** (L-T-P-C)	**Algebraic Geometry II** **(3-1-0-8)**
2	**Pre-requisite courses(s)**	Introduction to Algebra
3	**Course content**	Schemes: Sheaves, schemes, morphisms, separated and proper morphisms, sheaves of modules, divisors, Projective morphisms, differentials, formal scheme Cohomology: cohomology of sheaves, cohomology of a Noetherian affine scheme, Cech cohomology, the cohomology of projective space, the Serre duality theorem, flat morphism, smooth morphisms
4	**Texts/References**	1. R. Hartshorne, Algebraic Geometry, Springer- Verlag, 1977. 2. D. Mumford. The red book of varieties and schemes expanded ed., Lecture Notes in Mathematics 1358, Springer, 1999. 3. I. R. Shafarevich, Basic Algebraic Geometry, Vol. 1 and 2, Second edition, Springer-Verlag, 1994.

1	**Title of the course** (L-T-P-C)	**Algebra** **(3-1-0-8)**
2	**Pre-requisite courses(s)**	Basics of Group Theory, Ring Theory and Module Theory, Linear Algebra, Field Theory and Galois Theory
3	**Course content**	Categories and functors: definitions and examples. Functors and natural transformations, equivalence of categories, Products and coproducts, the hom functor, representable functors, universals and adjoints. Direct and inverse limits. Free objects. Homological algebra: Additive and abelian categories, Complexes and homology, long exact sequences, homotopy, resolutions, derived functors, Ext, Tor, cohomology of groups, extensions of groups, Review of field and Galois theory, Infinite Galois extensions, Fundamental Theorem of Galois theory for infinite extensions, Transcendental extensions, Luroth`s theorem, Review of integral ring extensions, prime ideals in integral ring extensions, Dedekind domains, discrete valuations rings.
4	**Texts/References**	1. M. Artin, Algebra, Prentice Hall of India, 1994. 2. N. Jacobson, Basic Algebra, Vol. 1 and 2, Hindustan Publishing Corporation. 3. S. Lang, Algebra, 3rd Ed., Addison Wesley, 1993. 4. O. Zariski and P. Samuel, Commutative Algebra, Vol.1 and 2, Springer-Verlag, 1975.

1	**Title of the course** (L-T-P-C)	**Random Schrodinger operators**. 2-1-0-6
2	**Pre-requisite courses(s)**	Real analysis, Measure theory, Function analysis and probability theory
3	**Course content**	Review of spectral theorem and functional calculus of self-adjoint operator on Hilbert space, Borel (or stieltjes) transform of measure, the Anderson model: Discrete Schrodinger operators, random potentials, Ergodic operators, Wegner estimate integrated density of states (Proof of existence), Lifshitz tail, the spectrum, Anderson localization in large disorder, fractional moments of green's function, Multiscale analysis.
4	**Texts/References**	1. Aizen man M, WarzelS; Random operators: Disorder effects on Quantum spectra and Dynamics, Graduate studies in mathematics, vol 168, Amer, math, soc. 2015. 2. Carmona C, Lacroix J: Spectral th

1	**Title of the course** (L-T-P-C)	**Advanced Graph Theory (3-1-0-8)**
2	**Pre-requisite courses(s)**	Real analysis, Measure theory, Functional analysis and Probability Theory
3	**Course content**	Fundamental concepts of graph theory, Trees and distances, Planar graphs, Graphs on surfaces, Coloring and chromatic numbers, Edge coloring and chromatic index, Total coloring and total chromatic number, List coloring and choosability, Graph minors, Directed and Oriented graphs, Graph homomorphisms, Graph homomorphisms and colorings, Graph homomorphisms and minors, Extremal graph theory, Random graphs.
4	**Texts/References**	1. B. West, Introduction to Graph Theory 2nd edition. Prentice Hall. 2. Harary. Graph Theory. Reading, MA: Perseus Books, 1999. 3. R. Diestel, Graph Theory, 5th edition. Springer.

1	**Title of the course** (L-T-P-C)	**Linear Integral Equations** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Real Analysis
3	**Course content**	Different types of integral equations and their applications. Basic solution strategies like successive approximation Review of normed spaces bounded and compact operator on normed spaces. linear integral operator with continuous and weakly singular kernel, compact linear integral operators Riesz theory and Fredholm theory and application to linear integral equations Boundary integral equations corresponding to interior and exterior problems of Laplace equations Cauchy Integral Operator, Singular integral equations with Cauchy Kernel Integral equations in the context of heat equations (If time permits)
4	**Texts/References**	Kress R., Linear Integral Equations, 3rd Edition, Springer New York (2013) Kanwal Ram P., Linear Integral Equations: Theory and Technique, 2nd Edition, Springer New York (2012). Hack Busch W., Integral Equations, Theory and Numerical Treatment, 1st Edition, Burkhouse Basel (1995).

1	**Title of the course** (L-T-P-C)	**Theory of Perfect Graphs** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	CS 201/113 Data Structures and Algorithms or equivalent CS 203/207 Discrete Structures or equivalent
3	**Course content**	Perfect graphs, The historical definition of perfect graphs, The Weak Perfect Graph Theorem, It's proof by Lovasz, The Strong Perfect Graph Theorem (statement only), Chrodal graphs, Perfect Elimination Order and Scheme, Proof of the correctness of Perfect Elimination Algorithm, The subtree intersection representation of chordal graphs, Split graphs, Degree sequence, Erdos-Gallai Theorem, Intersection graphs, Interval graphs, Adjacency and incidence Matrix Characterization, Properties
4	**Texts/References**	1. Golumbic M. C. *Algorithmic Graph Theory and Perfect Graphs*, Academic Press, New York, 1980 2. West D. B., Introduction to Graph Theory, 2nd Edition, Prentice Hall, Uper Saddle River, NY, 2001

1	**Title of the course** (L-T-P-C)	**Topics in Elliptic partial Differential equations** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Measure Theory, Metric spaces & Introductory Functional Analysis
3	**Course content**	Convolutions, mollifiers, cut-off functions & partitions of unity Elliptic and Uniformly Elliptic Operators, Maximum principles, Hopf's lemma, Uniqueness of boundary value problems of elliptic PDEs, Weak derivatives and their properties, Definition of Sobolev spaces, Global and local approximation of functions in W^{k,p} by smooth functions, Trace theorem, Sobolev inequalities, imbedding results Idea of weak solution of elliptic PDEs, Lax-Milgram theorem and existence and uniqueness of weak solutions of linear Elliptic pdes, Interior and boundary regularity of weak solutions
4	**Texts/References**	**1.** Evans L., Partial Differential Equations, 2nd Edition, GSM, Vol 19, AMS, Providence, Rhode Island (2010) **2.** Han Q. and Lin F., Elliptic Partial Differential Equations, 2nd Edition, Vol 1, CIMS and AMS, Providence, Rhode Island (2011) **3.** Renardy M. & Rogers R. C., An Introduction to Partial Differential Equations, 2nd Edition, Springer NY (2006) **4.** Gilberg D. & Trudinger N. S., Elliptic Partial DIfferential Equations of second order, 2nd ed. Springer-Verlag, Berlin (1983)

1	**Title of the course** (L-T-P-C)	**Numerical Solution of Linear Integral Equations** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Metric spaces & Introductory Functional Analysis
3	**Course content**	Operator approximations, approximations based on norm and pointwise convergence Method of degenerate kernels, degenerate kernels via Taylor expansion, orthogonal expansion and expansion by interpolation Theory of projection methods, Collocation and Galerkin techniques, their examples Nystrom technique for continuous and weakly continuous kernels Boundary integral equations of Laplace equation in 2 Dimension and 3 Dimension in domains with smooth boundary Multivariable integral equations and their numerical solutions
4	**Texts/References**	**1.** Kress R., Linear Integral Equations, 3rd Edition, Springer New York (2013). **2.** Atkinson K., The Numerical Solution of Integral Equations of the Second Kind, 1st Edition, Cambridge University Press, (1997). **3.** Hackbusch W., Integral Equations, Theory and Numerical Treatment, 1st Edition, Birkhäuser Basel (1995)

1	**Title of the course** (L-T-P-C)	**Introduction to Graduate Algebra** 3-1-0-8
2	**Pre-requisite courses(s)**	Basic group Theory, Ring theory and module theory, Linear algebra, field theory and Galois theory
3	**Course content**	Review of Group theory: Sylow's theorem and Group Actions, Ring theory: Euclidean Domains, PID and UFD's Module theory: structure theorem of modules over PID Review of field and Galois theory, Infinite Galois extensions, Fundamental Theorem of Galois theory for infinite extensions, Transcendental extensions, Luroth`s theorem Review of integral ring extensions, prime ideals in integral ring extensions, Dedekind domains, discrete valuations rings, Categories and functors, Basic Homological algebra: Complexes and homology, long exact sequences, homotopy, resolutions, derived functors, Ext, Tor, cohomology of groups.
4	**Texts/References**	1. M. Artin, Algebra, 2nd Edition, Prentice Hall of India, Delhi 1994. 2. N. Jacobson, Basic Algebra, Vol, 1, 2nd Edition, Hindustan Publishing corporation, Delhi, 1985. 3. N. Jacobson, Basic Algebra, Vol. 2, 2nd Edition, Hindustan Publishing Corporation, Delhi, 1989. 4. S. Lang, Algebra, 3rd Edition, Addison Wesley, Boston, 1993. 5. O. Zariski and P. Samuel, Commutative Algebra, Vol.1, Corrected reprinting of the 1958 edition, Springer-Verlag, New York, 1975. 6. O. Zariski and P. Samuel, Commutative Algebra, Vol.2, Reprint of the 1960 edition, Springer-Verlag, New York, 1975.

1	**Title of the course** (L-T-P-C)	**Introduction to Diophantine Approximation** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Linear algebra, prior knowledge of Field and Galois theory over Q is helpful, but not necessary as the course is self-contained
3	**Course content**	b-ary expansion, Continued fraction expansion, Legendre theorem, Dirichlet approximation Theorem, Simultaneous approximation theorem, Minkowski's convex body theorem. Linear independence criteria (including Siegel and Neste Renko's criterion Liouville) theorem, Transcendence of e and π, Roth's theorem on the approximation of algebraic numbers by rationales, Brief introduction to Schmidt Subspace theorem(higher dimensional generalization of Roth's Theorem) and some of its application, b-ary(or base b-expansion) expansion of algebraic numbers Finite Automata, Automatic Sequences and Transcendence
4	**Texts/References**	1. Allouche J. P. and Shallit J.. Automatic sequences: Theory, Applications, Generalizations, 1st Edition, Cambridge University Press (2003). 2. Bugeaud Y., Approximation by algebraic numbers, 1st Edition, Cambridge University Press (2004). 3. Ram Murty M. and Rath P., Transcendental numbers, 1st Edition, Springer, New York (2014). 4. Natarajan S. and Thangadurai R., Pillars of Transcendental number theory, 1st Edition, Springer Verlag (2020). 5. Niven I., Irrational numbers, Sixth printing, The Mathematical Association of America (2006). 6. Schmidt W. M., Diophantine Approximation, 1st Edition, Springer Verlag, Lecture Notes in Mathematics 785 (1980). 7. Waldschmidt M., Criteria for irrationality, linear independence, transcendence, and algebraic independence, Lecture Notes at CMI and 8. IMSc, http://people.math.jussieu.fr/~miw/enseignements.htMl

1	**Title of the course** (L-T-P-C)	**Introduction to Lie Algebras** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Linear algebra. Familiarity with the basics of rings and modules is preferable but not mandatory.
3	**Course content**	Definition and examples of Lie algebras, namely, classical Lie algebras: general linear, special linear, symplectic, even-odd orthogonal Lie algebras. Elementary properties of Lie algebras: solvable and nilpotent. Theorems ofLie, Cartan, and Engel. Structure and classification of semisimple Lie algebras over the field of complex numbers. Root systems and their construction, Dynkyn diagrams. Representation theory of semisimple Lie algebras (if time allows): highestweight modules, Borel subalgebras and Verma modules. Course will have the rank two simple algebra (namely all two-by-two tracelessmatrices) as a running example.
4	**Texts/References**	**1.** Humphreys J. E., Introduction to Lie Algebras and Representation Theory,1st Edition, Springer-Verlag, 3rd printing (1980), **2.** Carter R., Lie Algebras of Finite and Affine Type, 1st Edition, Cambridge Studies in Advanced Mathematics, Cambridge University Press (2005) **3.** Harris J. and Fulton W., Representation Theory: A First Course, 1st Edition,GTM, Vol. 129, Springer Verlag NY (2004). **4.** Erdman K. and Wildon, M. J., Introduction to Lie Algebras, 1st Edition,Springer Undergraduate Mathematics Series, Springer London (2006)

1	**Title of the course** (L-T-P-C)	**Irrational and Transcendental Numbers** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Linear Algebra, Complex Analysis, and prior knowledge of Field and Galois theory over Q is helpful
3	**Course content**	Hermite Pade-Approximation, Transcendence of e and pi, Lindemann Weierstrass Theorem, Gelfond-Schneider Theorem, Six-Exponential Theorem, Schneider-Lang Theorem and its applications, Baker's theory of linear form in logarithm of algebraic numbers. Criterion for linear independence– Siegel and Nesterenko's methods, Irrationality of Reimann Zeta function at odd positive integers: Apery's irrationality proof of zeta(3) and Beukers's proof, Ball-Rivoal theorem, recent results about infinitely many odd zeta values are irrational due to Fischler-Zudilin-Sprang.
4	**Texts/References**	• Baker A., Transcendental Number Theory, Cambridge University Press, 1975. • Burger E. B. and Tubbs R., Making Transcendence Transparent: An intuitive approach to classical transcendental number theory, Springer NewYork, 2004. • Ram Murty M. and Rath P., Transcendental numbers, 1st Edition, Springer,New York (2014). • Natarajan S. and Thangadurai R., Pillars of Transcendental number theory,1st Edition, Springer Verlag (2020). • Ball, K. and Tanguy R., Irrationality of infinitely many values of the zeta function at odd integers, Invent. Math. (2001) • Fischler S., Johannes S. and Zudilin W., Many odd zeta values are irrational, Compos. Math. (2019)

1	**Title of the course** (L-T-P-C)	**Algebraic Number Theory (3-0-0-6)**
2	**Pre-requisite courses(s)**	Group Theory, Elementary Number Theory. We will also need some concepts about rings, modules, and Galois theory throughout the course.
3	**Course content**	Algebraic numbers and Algebraic integers, Number Fields and Number rings, Traces and Norms, Discriminant, Dedekind domains, Ideal class group, Unique factorization and prime decomposition in Number rings, Galois theory of Number Fields. Finiteness of ideal class group, Lattices, Minkowski Theory, Dirichlet unit theorem, p-adic numbers, Absolute values, Valuationsand completions of number fields.
4	**Texts/References**	**1.** Lang S., Algebraic Number Theory, Graduate Texts in Mathematics 110, Springer-Verlag, 1994. **2.** Murty Ram M., and Esmonde J., Problems in Algebraic Number Theory, Graduate Texts in Mathematics, Springer-Verlag, New York,2001. **3.** Neukirch J., Algebraic Number Theory, Springer-Verlag, 1999. **4.** Samuel P., Algebraic Theory of Numbers, Houghton Mifflin Co., Boston, MA, 1970. 109 pp. **5.** Janusz G. J., Algebraic Number Fields, Graduate Studies in Mathematics 7, American Mathematical Society, 1996. **6.** Milne J.S., Algebraic Number Theory, Available at https://www.jmilne.org/math/CourseNotes/ANT.pdf, 2020.

1	**Title of the course** (L-T-P-C)	**Complex Analysis with Applications to Number Theory** **(3-0-0-6)**
2	**Pre-requisite courses(s)**	Real Analysis, Basic Complex Analysis
3	**Course content**	Introduction to holomorphic functions, Complex integration, Cauchy's Theorem, and its applications**.** Entire and Meromorphic functions, functions of finite order, Argument principle, Maximum Modulus principle, Jensen's formula. Estimate for the number of zeros of an exponential polynomial inside a disc, zero density estimates (Use of three circle method, effect of small derivatives) to estimate growth of a function in terms of zero and derivatives, Hermite Interpolation formula. Weier strass infinite product, Hadamard's factorization theorem, Gamma and Riemann Zeta functions, Euler product, Functional equation and Analytic continuation An introduction to Elliptic functions, Introduction of Jacobi theta functions, Hermite Pade-Approximation, Transcendental function, algebraically independent functions, Entire functions with rational values
4	**Texts/References**	**1.** Lang S., Complex Analysis, 4th Edition, Springer-Verlag, New York (1999). **2.** Stein E. M. and Shakarchi R., Complex Analysis, Vol. 2, 1st Edition Princeton Lectures in Analysis, Princeton University Press, Princeton, NJ (2003). **3.** Shorey T. N., Complex Analysis with Applications to Number Theory, 1st Edition, Springer, Singapore (2020) **4.** Ahlfors L., Complex Analysis, 3rd Edition, McGraw-Hill Book Co., New York (1978)