Course Curriculum and Syllabus

(As per NEP-2020)

For

Ph.D. Course Work in Mathematics

Effective from Session 2021-22

Department of Mathematics

School of Natural Sciences

Central University of Jharkhand, Ranchi835222, Jharkhand

Programme Outcomes (POs)

- It equips graduates with the expertise and skills to pursue diverse career paths, contribute significantly to various fields, and engage in lifelong learning and professional growth.
- Ability to conduct independent research, formulates hypotheses, develop models, and solve complex problems.
- Enhanced ability to think critically and solve problems analytically.

Based on New Ph.D. ordinance 2016, a Ph.D. student has to complete minimum 12 credits of course work.

Syllabus for Papers in PhD. Course work in Department of Mathematics 2021 onwards.
L – Lecture, T- Tutorial, P – Practical (Lab), Cr – Credits.

Sl. No	Category	Subject Code	Course Title	Periods Per Week			Credit
				L	T	P	
1.	Compulsory	MAT 911010	Research Methodology	3	1	0	4
2.	Compulsory	MAT 911020	Research And Publication Ethics	2	0	0	2
3.	Elective						
4.	Elective						
						Minimum Total Credits	12

Based on the suggestions of Ph.D. Supervisor, the Research Scholar has to take at least two papers from the following list of Elective Papers.						
S. No.	Course Code	Course Title				CR
			L	T	P	
1	MAT 918030	Fundamentals of Computer & C Programming	3	0	1	4
2	MAT 918040	Basics of Number Theory and Discrete Mathematics	3	1	0	4
3	MAT 918050	Numerical Analysis with Lab.– I	3	1	0	4
4	MAT 918060	Field Theory	3	1	0	4
5	MAT 918070	Object Oriented Programming with C++	3	0	1	4
6	MAT 918080	Functional Analysis	3	1	0	4
7	MAT 918090	Numerical Analysis with Lab.– II	3	1	0	4
8	MAT 918100	Algebraic Number Theory	3	1	0	4
9	MAT 918110	Advanced Number Theory	3	1	0	4
10	MAT 918120	Numerical Optimization Techniques	3	1	0	4

11	MAT 918130	Operator Theory	3	1	0	4
12	MAT 918140	Advanced Discrete Mathematics	3	1	0	4
13	MAT 918150	Theoretical Numerical Analysis	3	1	0	4
14	MAT 918160	Coding Theory	3	1	0	4
15	MAT 918170	Optimization by Vector Space Methods	3	1	0	4
16	MAT 918180	Analytic Number Theory	3	1	0	4
17	MAT 918190	Introduction to Integral Equations	3	1	0	4
18	MAT 918200	Advanced Linear Algebra	3	0	1	4
19	MAT 918210	Combinatorics	3	0	1	4
20	MAT 918220	Difference Equations and Discrete Dynamical Systems	3	1	0	4
21	MAT 918230	Theory of Groups and Rings	3	1	0	4
22	MAT 918240	Theory of Modules and Commutative Rings	3	1	0	4
23	MAT 918250	Lie Group and Lie Algebra	3	1	0	4
24	MAT 918260	Representation Theory	3	1	0	4
25	MAT 918270	Theory of Relativity	3	1	0	4
26	MAT 918280	Theory and Applications of Fuzzy Sets	3	1	0	4
27	MAT 918290	Cryptography	3	1	0	4
28	MAT 918300	Differential Equations	3	1	0	4
29	MAT 918310	Differential Manifolds	3	1	0	4
30	MAT 918320	Advanced Numerical Analysis	3	1	0	4
31	MAT 918330	Mathematical Modelling	3	1	0	4
32	MAT 918340	Integral Transforms	3	1	0	4
33	MAT 918350	Tensor Algebra	3	1	0	4
34	MAT 918360	Theory of Rings and Field	3	1	0	4
35	MAT 918370	Number Theory	3	1	0	4
36	MAT 918380	Earthquake Seismology	3	1	0	4
37	MAT 918380	Fluid Dynamics	3	1	0	4

Total Credits	

Research Methodology

A. The syllabus of Research Methodology (Mathematics) (4 credits) (Compulsory):

(i) Latex and Beamer (10 hours).

(ii) At least one mathematical software out of the following: Scilab/KASH/Maxima/SAGE/Other software suggested by the research supervisor (10 hours).

(iii) Working knowledge of MathSciNet, JSTORE and other online journals, Review of a research paper (4 hours),

(iv) Rapid Reader: Mathematics and its History, by J. Stillwell, Springer International Edition, 4^{th} Indian Reprint, 2005, Write Mathematics Right by L. Radhakrishnan (2013) (10 hours).

(v) Participating in seminar/lectures on different topics in Mathematics (6 hours).

B. ATM School Participation (4 credits) (Optional): Advanced Training in Mathematics (ATM) schools have been devised by NBHM to broaden the knowledge of a research student in Mathematics and also inculcating problem solving skills for better understanding of the subject and developing research orientation. These are now organised by National Centre for Mathematics (NCM). A student participating in an NCM-sponsored ATM school of 3-4 weeks duration such as Annual Foundation School I, II or III or an Advanced Instructional School on a specific topic will earn 5 credits provided the school is attended after getting provisional admission for Ph.D. The Research Guide will request the coordinator of the school to give a grade to the student based on the participation of the student in the ATM school.

<u>Texts/References</u>

1. R. Pratap: Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers, Oxford, 2010.
2. M. L. Abell, J. P. Braselton: Mathematica by Example, 4^{th} Edition, Academic Press, 2008.
3. Tobi Oetiker et al. The Not So Short Introduction to LaTeX, web: https://tobi.oetiker.ch/lshort/lshort.pdf

Paper 2: Research and Publication Ethics (RPE)

RPE 01: Philosophy and Ethics (3 hrs)

1. Introduction to Philosophy: definition, nature and scope, concept, branches
2. Ethics: Definition, moral philosophy, nature of moral judgments and reactions.

RPE 02: Scientific Conduct (5 hrs)

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP)

4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

RPE 03: Publication Ethics (7 hrs)

1. Publication ethics: definition, introduction and importance
2. Best practices/standards setting initiatives and guidelines: COPE, WAME etc.
3. Conflicts of interest
4. Publication misconduct: Definition, concept, problems that lead to unethical behavior and vice versa, types
5. Violation of publication ethics, authorship and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

Practice

RPE 04: Open Access Publishing (4 hrs)

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies
3. Software tool to identify predatory publications developed by SPPU: UGC-CARE list of journals
4. Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

RPE05: Publication Misconduct (4 hrs)

A. Group discussions (2 hrs)

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools (2 hrs)

Use of reference management software like Mendeley, Zotero etc. and anti-plagiarism software like Turnitin, Urkund

RPE 06: Databases and research metrics (7 hrs)

A. Databases (4hrs)

1. Indexing databases
2. Citation databases: Web of Science, Scopus etc.

B. Research Metrics (3 hrs)

3. Impact factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
4. Metrics: h-index, g-index, i-10 index, altmetrics

Fundamentals of Computers and C Programming (3-0-1 4)

Introduction to computers, generations of computer, processors, memory hierarchy and I/O devices, System and application software, generation of languages, compiler, interpreter, assembler, Number systems, computer arithmetic.

Flow Charting, Sequential, Branching & Iterative.

Introduction to 'C' as Programming Language, An overview of a 'C' programme, 'C' character set, 'C' tokens, 'C' key words, Data Types (primary, derived & user defined), Storage classes, symbolic constants, operators (arithmetic, logical & relational), Flow of control (If- else, switch-case; while, do-while & for-loops).

Functions (UDF, String Functions, Mathematical functions)

Recursion, pointers, array (2-D & 3-D), Strings, pre-processor directives, structures, linked list file handling.

C-lab: Execution of a simple programme, Conditional & Un-conditional Branching, Loops, Functions (Interactive & Recursive), Arrays (2-D & 3-D), Structures, Linked Lists, File I/O.

Texts/References

1. B.W. Kernighan, D.M. Ritchie: The C Programming Language, Prentice Hall India, 1990.
2. Y.P. Kanetkar: Let us C, BPB Publications, 2002.
3. E. Balagurusamy: Programming in ANSI C, 4th edition, Tata McGraw Hill.

Basics of Number Theory and Discrete Mathematics (3-1-0 4)

Linear congruences, Algebraic congruences of degree ≥ 2. General Taylor Expansion Method for Prime Power Modulus. Theorems of Euler, Lagrange and Wilson. Primality Testing and Factoring, Primitive Roots, Quadratic Congruence, Euler's Criteria and Legendre's Symbol, two square theorem, quadratic reciprocity law. Simple continued fractions, Pell's Equation.

Pigeon Hole Principle, Inclusion Exclusion Principle, Techniques of Counting, Recurrence relations. Introduction to Lattice theory, Boolean algebra with application to switching circuits.

Texts/References

1. G.H. Hardy and E.M. Wright: An Introduction to the Theory of Numbers, 6th edition, Oxford University Press, 2008.
2. D.M. Burton: Elementary Number Theory, 6th edition, McGraw-Hill, 2005.
3. I. Niven, H.S. Zuckerman and H.L. Montgomery: An Introduction to the Theory of Numbers, 5th edition, Wiley, 1991.
4. K. D. Joshi: Foundations of Discrete Mathematics, New Age International, 1996.

Introduction to Numerical Analysis - I (3-1-0- 4)

Nature of numerical computations: Errors and their propagation, convergence and stability of numerical algorithms; efficiency and arithmetic, complexity.

Numerical solution of systems of linear equations: Direct methods for solving linear systems, error analysis. The residual correction method. Iteration methods, Error prediction and Acceleration.

Matrix Eigenvalue problem: Eigenvalue location, error, and stability results, Power method. Orthogonal transformations using Householder matrices. The eigenvalues of a symmetric Tridiagonal matrix. QR method. The calculation of Eigenvectors and Inverse iteration.

Numerical solutions of Non-linear equations: Solution of non-linear equations by iterative methods, acceleration of convergence. Newton's methods for polynomials, quotient-difference algorithms. Numerical solution of system of Non-linear equations.

Interpolation: Interpolating polynomial and its construction using Lagrange methods and methods of differences, iterated interpolation, method of divided differences, inverse interpolation, Hermite Interpolation. The general Hermite interpolation problem. Spline function and their use.

Lab Component: Exposure to Matlab/Mathematica/Scilab and computational experiments based on the algorithms discussed in the course.

Texts/References:

1. K. Atkinson: An Introduction to Numerical Analysis, 2nd edition, Wiley, 1989.
2. R.L. Burden and J.D. Faires: Numerical analysis, 7th edition, Brooks Cole, 2001.
3. P.J. Davis: Interpolation and Approximation, Dover, 1975.
4. J.M. Ortega: Numerical Analysis: A Second Course, SIAM, 1987.
5. S.S. Sastry:Introductory Methods of Numerical Analysis, Phi Learning, 2009.

Field Theory (3-1-0 4)

Fields- Field extensions, algebraic and transcendental field extensions, finite fields.

Galois extensions. Constructibility by ruler and compass, Fundamental Theorem of Galois Theory.

The impossibility of solving the general quintic by radicals.

Text/References

1. M. Artin: Algebra, Prentice Hall India, 2009.
2. S. Lang: Algebra, 3rd edition, Springer, 2002.
3. J. Rotman: Galois Theory, 2nd edition, Springer, 2006.
4. P. Morandi: Field and Galois Theory, Springer, 2010.
5. I. S. Luthar and I. B. S. Passi: Algebra 4 - Field Theory**,** Narosa, 2004.

Object Oriented Programming through C++ (3-0-1 4)

Concepts of objects, class, inheritance, data encapsulation, polymorphism etc., Introduction to C++, Input and output in C++, C++ declaration, Control structure, Function in C++, Classes and objects in C++. Constructors and destructors, Operator overloading and type conversion, Inheritance, Pointers and arrays in C++, Binding, polymorphism, virtual functions and pure virtual functions. Applications with files, Generic programming with templates, Exception handling, Working with Streams.

Lab work.

Texts/References

A. N. Kamthane: Object oriented programming with ANSI and turbo C++, Pearson Education, 2011.

H. Schildt: C++ The Complete Reference, 4th edition, Tata McGraw Hill, 2003.

E. Balaguruswamy: Object Oriented Programming with C++,4th edition, Tata McGraw Hill, 2008.

R. Lafore: Object-Oriented Programming in C++, Galgotia Publications, 2006.

Functional Analysis (3-1-0 4)

Normed linear spaces: Finite dimensional normed spaces, Heine-Borel theorem, Riesz lemma, Continuity of linear maps, Hahn-Banach extension theorem, Banach spaces, Dual spaces and transposes, Uniform-boundedness principle and its applications; Spectrum of a bounded operator.

Inner product spaces: Hilbert spaces, Orthonormal basis, Total Orthonormal Sets and Sequences Projection theorem and Riesz representation theorem. Representation of Functionals on Hilbert Spaces, Hilbert-Adjoint Operator, Self-Adjoint, Unitary and Normal Operators, Open Mapping Theorem, Closed Graph Theorem.

Texts/References

E. Kreyszig: Introduction to Functional Analysis with Applications, Wiley, 1974.

J.B. Conway: A course in Functional Analysis, 2nd edition, Springer, Berlin, 1990.

A.N. Kolmogorov and S. Fomin: Elements of the theory of functions and functional analysis, Dover, 1999.

A. Taylor and D. Lay: Introduction to Functional Analysis, 2nd edition, Wiley, 1980.

Introduction to Numerical Analysis - II (3-1-0 4)

Approximation of functions: The Minimax and Least squares approximation problem. Orthogonal polynomials, Recurrence relations. Least squares approximations using orthogonal polynomials. Minimax and Near-minimax approximations using orthogonal polynomials.

Numerical Integration: Newton-Cotes integration formulas. Gaussian Quadrature. Asymptotic error formulas and their applications. Romberg integration. Automatic numerical integration. Multiple Integrals, Singular integrals. Numerical Differentiations.

Ordinary differential equations: Numerical solutions of IVP – Difference equations, stability, error and convergence analysis. Single step methods - Taylor series method, Euler method, Picard's method of successive approximation, Runge-Kutta method. Multi step methods – Predictor-Corrector(PC) method, Euler PC method, Milne and Adams Moulton PC method. System of first order ODE, higher order IVPs. Numerical solutions of BVP – Linear BVP, finite difference methods, shooting methods, stability, error and convergence analysis, nonlinear BVP, higher order BVP.

Lab Components: Exposure to Matlab/Mathematica/SciLab and computational experiments based on the algorithms discussed in the course.

Texts/References

1. K. Atkinson: An Introduction to Numerical Analysis, 2nd edition, Wiley, 1989.
2. R.L. Burden and J.D. Faires: Numerical Analysis, 7th edition, Brooks Cole, 2001.
3. A. Iserles: A First Course in the Numerical Analysis of Differential Equations, Cambridge University Press, 1996.
4. P.J. Davis and P. Rabinowitz: Methods of Numerical Integration, 2nd edition, AP, 1984.
5. R. LeVeque: Finite Difference Methods for Ordinary and Partial Differential Equations Steady-State and Time-Dependent Problems, SIAM, 2007.
6. L. N. Trefethen and D. Bau III: Numerical Linear Algebra, SIAM, Philadelphia, 1997.
7. G. Sewell: The Numerical Solution of Ordinary and Partial Differential Equations, 2nd edition, Wiley, 2005.
8. E. Isaacson and H.B. Keller: Analysis of Numerical Methods, Dover, 1994.
9. P.J. Davis: Interpolation and Approximation, Dover, 1975.
10. J.M. Ortega: Numerical Analysis: A Second Course, SIAM, 1987.

Algebraic Number Theory (3-1-0 4)

Integral domain: Basic Properties of Integral Domain, Units, Properties of Units, Associates, Divisibility in an Integral Domain, Prime and Irreducible Elements in an Integral Domain, GCD and HCF of two Elements in an Integral Domain, Prime Ideals and Maximal Ideals, Noetherian Domain, PID,UFD,ED, Field Extensions, Algebraic and Transcendental Extension, Algebraic and Transcendental Numbers, algebraic integers, Algebraic Number Field, Ring of Integers in Algebraic Number Field, Ring of Gaussian Integers.

Bases: Finite extensions and bases, Properties of finite extensions, Conjugates and discriminants, The cyclotomic field.

Arithmetic in Algebraic Number Fields: Units and primes, Units in a quadratic field, The uniqueness of factorization, Ideals in an algebraic number field.

The Fundamental Theorem of Ideal Theory: Basic properties of ideals, The classical proof of the unique factorization theorem.

Consequences of the Fundamental Theorem: The highest common factor of two ideals, Unique factorization of integers, The problem of ramification, Congruences and norms, Further properties of norms.

Class-Numbers and Fermat's Problem: Class numbers, The Fermat conjecture.

Texts/References

1. Harry Pollard, Harold G. Diamond: The Theory of Algebraic Numbers, Dover, 2010.
2. S. Alaca, K. S. Williams: Introductory Algebraic Number Theory, CUP, 2003.
3. E. Weiss: Algebraic Number Theory, Dover, 1998.
4. I. Stewart, D. Tall: Algebraic Number Theory and Fermat’s Last Theorem, 3rd edition, A K Peters/CRC Press, 2001.
5. G.J. Janusz: Algebraic Number Fields, 2nd edition, 1996.

Advanced Number Theory (3-1-0 4)

The partition function $P(n)$ and congruence relations of Ramanujan.
Application to Cryptography. Factoring Methods using continued fractions, Binary quadratic form, Diophantine approximations and some results from geometry of numbers.
Dirichlet series, Dirichlet's theorem on primes in AP. Riemann zeta Function, Prime Number Theorem.

Texts/References

1. R. Kumanduri and C. Romero: Number Theory with Computer Applications, Prentice Hall, 1997.
2. G. H. Hardy: Introduction to the Theory of Numbers, 6th edition, Oxford University Press, 2008.
3. G. E. Andrews: Number Theory, Dover, 1994.
4. J. W. S. Cassels: An Introduction to Diophantine Approximation, Cambridge University Press, 1957.

Numerical Optimization Techniques (3-1-0 4)

Introduction: Optimization, Types of Problems and Algorithms. Convex Sets and Convex Functions, Unconstrained Optimization: Basic properties of solutions and algorithms, Global convergence, Basic Descent Methods: Line Search Methods, Steepest Descent and Newton Methods, Modified Newton methods, Globally convergent Newton Method. Nonlinear Least Squares Problem and Algorithms, Conjugate Direction Methods, Trust-Region Methods.
Lab Component: Exposure to Matlab/Mathematica and computational experiments based on the algorithms discussed in the course.

Texts/References

1. E.K.P. Chong and S.H. Zak: An Introduction to Optimization, 2nd edition, Wiley, 2001.
2. R. Fletcher: Practical Methods of Optimization, 2nd edition, Wiley, 2000.
3. S. S. Rao: Engineering Optimization: Theory and Practice, 4th edition, Wiley, 2009.
4. D. Luenberger and Y. Ye: Linear and Nonlinear Programming, 3rd edition, Springer, 2008.
5. M.S. Bazaraa et al.: Nonlinear Programming - Theory and Algorithms, 3rd edition, Wiley, 2006.

Operator Theory (3-1-0 4)

Unit-I Linear Operators, self adjoint operators and compact operators.
Unit-II Eigenvalues, Eigenvectors, Spectrum, spectral theorem, Sturm-Liouville systems, and the Fredoholm alternative.
Unit-III Nonlinear operators, variational inequalities, complementarity problems.

Texts/References

1. B. Choudhary and S. Nanda: Functional Analysis with Applications, Wiley, 1989.
2. E. Kreyszig: Introductory Functional Analysis with Applications, Wiley, 1978.
3. N. Dunford and J. T. Schwartz: Linear Operators, Part I-III, Wiley, 2009.
4. G. Bachman and L. Narici: Functional analysis, AP, 1966.

Advanced Discrete Mathematics (3-1-0 4)

Polya's Enumeration formula: Equivalence and Symmetry Groups; Burnside's Theorem; The Cycle Index; Polya's Formula.
Ramsey numbers and general existence theorem and simple calculations.
Erdős–De Bruijn sequence and its enumeration.
Balanced incomplete block designs, parametric relations and Bruck–Ryser–Chowla theorem.
Constructions via difference sets, association scheme, partially balanced designs and
Steiner triple systems.
Latin squares, orthogonality, orthogonal array and disproof of Euler's conjecture.
Hadamard matrix together with some important constructions and links with PBIBD, BIBD.

Texts/References

1. M. Hall: Combinatorial Theory, Blaisdel Publication, 1967.
2. A. Dey: Theory of Block Designs, Wiley, 1986.
3. R.A. Brualdi: Introductory Combinatorics, 5th edition, Pearson, 2010.
4. J. H. van Lint and R. M. Wilson: A Course in Combinatorics, 2nd edition, Cambridge University Press, 2001.
5. A. Tucker: Applied Combinatorics, 5th edition, Wiley, 2010.
6. A. Hedayet, N.J.A. Sloane and J. Stufken: Orthogonal Arrays,Theory and Applications, Springer, 1999.

Theoretical Numerical Analysis (3-1-0 4)

Review of Functional Analysis: Linear Spaces, Norms,Banachand Hilbert Spaces, Mapping and Operators, Classification of Problems in Computational Mathematics.
Approximation Theory: The General Interpolation Problem, Polynomial Interpolation, Piecewise Polynomial Approximations andSplines, Best Approximations in Inner product Spaces, Best Approximations in the Maximum Norm, Approximations in Several Variables.
Nonlinear Equations and Their Solution by Iteration: The Banach fixed-point theorem, Applications to iterative methods, Differential calculus for nonlinear operators, Fréchet and Gâteaux derivatives, Newton's method in Banach spaces, Completely continuous vector fields, Conjugate gradient method for operator equations.
The Approximate Solution of Linear Operator Equations: Some Theorems on Linear Operators, Approximate Expansion Methods, Stability and Convergence, Error Estimates and Extrapolation, approximate Computation of Eigenvalues.
Numerical Solution of Fredholm Integral Equations of the Second Kind: Projection methods: General theory, Collocation methods, Galerkin methods, Iterated projection methods, The Nyström method, Product integration, Iteration methods, Projection methods for nonlinear equations, Linearization.

Texts/References:

1. K.E. Atkinson and W. Han: Theoretical Numerical Analysis: A Functional Analysis Framework, 3rd edition, Springer, 2009.
2. L.B. Rall: Computational solutions of nonlinear operator equations, Wiley, 1969.
3. L.V. Kantorovich, G.P. Akilov: Functional Analysis, Pergamon Press, Oxford, 1982.
4. P. Linz:Theoretical Numerical Analysis:An Introduction to Advanced Techniques, Wiley, New York, 1979.
5. P. Davis:Interpolation and Approximation, Dover, New York, 1975.
6. J. Stoer and R. Bulirsch: Introduction to Numerical Analysis, Springer-Verlag, New York, 2002.
7. E. Kreyszig: Introductory Functional Analysis with Applications, Wiley, 1978.
8. T.J. Rivlin: An Introduction to the Approximation of Functions, Dover, 2010.
9. V.S. Ryaben'kii and S.V. Tsynkov: A Theoretical Introduction to Numerical Analysis, CRC, 2006.
10. K.E. Atkinson: The Numerical Solution of Integral Equations of the Second Kind, Cambridge University Press, 2009.
11. E. Zeidler: Applied Functional Analysis. Applications to Mathematical Physics, Springer, 1995.
12. C. T. Kelley:Solving Nonlinear Equations with Newton's Method, SIAM, 2003.
13. I. Argyros: Computational Theory of Iterative Methods, Elsevier, 2007.
14. I. Argyros: Convergence and Applications of Newton-type Iterations, Springer, 2008.

Coding Theory (3-1-0 4)

Introduction: The coding problem. Linear codes, generator matrix and parity check matrices, dual codes, weights and distances, new codes from old codes, Permutation equivalent codes, Hamming codes, Golay codes, Reed–Muller codes, Encoding, decoding and Shannon’s theorem, sphere packing bound, covering radius and perfect codes.

Bounds on size of codes: $A_q(n, d)$ and $B_q(n, d)$, Johnson upper bounds, the singleton upper bound and MDS codes, Griesmer upper bound, Gilbert lower bound and Varshamov lower bound.

Finite fields: Introduction, Polynomials and Euclidean algorithm, primitive elements, constructing finite fields, subfields, Field automorphisms, cyclotomic cosets and minimal polynomials, Cyclic codes: factoring $x^n - 1$, basic theory of cyclic codes, idempotents and multipliers, zeros of a cyclic codes, minimum distance of cyclic codes.

Constructions of some specific codes: Propagation rules, BCH, Reed-Soloman codes, generalized Reed-Soloman codes, decoding BCH codes, Burst errors, concatenated codes and interleaving, coding for the compact disc.

Texts/References

1. W.C. Huffman and V. Pless: Fundamentals of Error-correcting Codes, Cambridge University Press, 2003.
2. S. Ling and C. Xing: Coding Theory - A First Course, Cambridge University Press, 2004.
3. E. R. Berlekamp: Algebraic Coding Theory, Aegean Park Press, 1984.
4. J. H. Van Lint: Introduction to Coding Theory, 3rd edition, Springer, 1999.

5. R. Roth: Introduction to Coding Theory, Cambridge University Press, 2006.
6. S. Roman: Introduction to Coding and Information Theory, Springer-Verlag, 1997.

Optimization by Vector Space Methods (3-1-0 4)

Geometric form of Hahn-Banach theorem, convex sets and cones, convex functionals in normed linear spaces, optimization by convex functional, conjugate convex functionals, sub-differentiable convex functionals, monotone operator and its relation with convex functional, dual optimization problem, Fenchel duality theorem, minimax theorem of game theory, Lagrange's multiplier, sufficiency, sensitivity, Lagrange duality, Kuhn-Tucker theorem, complementarity problem.

Texts/References

1. J. M. Borwein, A.S. Lewis: Convex Analysis and Nonlinear Optimization Theory and Examples, Springer, 2005.
2. D. G. Luenberger, Y. Ye: Linear and Nonlinear Programming, 3rd edition, Springer, 2008
3. R. T. Rockafellar: The Theory of Subgradients and Its Applications to Problems of Optimization: Convex and Nonconvex Functions, Heldermann, 1981.
4. D. P. Bertsekas, A. Nedic, A.E. Ozdaglar: Convex Analysis and Optimization, Athena Scientific, 2003.
5. Y. Nesterov: Introductory Lectures on Convex Optimization. A Basic Course, Kluwer, 2004.
6. S. Boyd: Convex Optimization, Cambridge University Press, 2004.
7. L. D. Berkovitz: Convexity and Optimization in R^n, Wiley, 2001.
8. S. K. Mishra, S.Y. Wang K. K. Lai: Generalized Convexity and Vector Optimization, Springer, 2009.
9. A. Cambini, L. Martein: Generalized Convexity and Optimization, Springer, 2009.

Analytic Number Theory (3-1-0 4)

The Prime Number Theorem: Dirichlet's theorem for primes in an Arithmetic Progression. Zero free regions for the Riemann zeta function and other L-functions. Euler products and the functional equations for the Riemann zeta function and Dirichlet L-functions.

Modular forms for the full modular group: Eisenstein series, cusp forms, structure of the ring of modular forms. Hecke operators and Euler product for modular forms. The L-function of a modular form, functional equations. Modular forms and the sums of four squares.

Optional topics: Discussion of L-functions of number fields and the Chebotarev Density Theorem. Discussion of elliptic curves and the Shimura-Taniyama conjecture (Wiles' Theorem).

Text/References

T. Apostol: Introduction to Analytic Number Theory, Springer-Verlag, 1998.
J. P. Serre: A Course in Arithmetic, Springer-Verlag, 1996.
S. Lang: Algebraic Number Theory, Springer-Verlag, 2000.
G. J. O. Jameson: The Prime Number Theorem, Cambridge University Press, 2003.

Introduction to Integral Equations (3-1-0 4)

Introduction and basic examples, Classification, Conversion of Volterra Equation to ODE, Conversion of IVP and BVP to Integral Equation, Decomposition, direct computation, Successive approximation, Successive substitution methods for Fredholm Integral Equations, A domain decomposition, series solution, successive approximation, successive substitution method for Volterra Integral Equations, Volterra Integral Equation of first kind, Integral Equations with separable Kernel, Fredholm's first, second and third theorem, Integral Equations with symmetric kernel, Eigenfunction expansion, Hilbert-Schmidt theorem, Fredholm and Volterra Integro-Differential equation, Singular and nonlinear Integral Equation.

Texts/References

1. W. V. Lovitt: Linear Integral Equations, Dover, 2005.
2. R. Courant and D. Hilbert: Methods of Mathematical Physics, Vol I. John Wiley & Sons, 1989.
3. D. Porter and D. S. G. Stirling: Integral Equations - A Practical Treatment from Spectral Theory and Applications, Cambridge University Press, 1990.
4. C. Corduneanu: Integral Equations and Applications, Cambridge University Press, 1991.
5. S. G. Mikhlin: Integral Equations, Hindustan Publishing Co., 1960.
6. E. G. Tricomi: Integral Equations, Interscience, 1957.
7. F. B. Hildebrand: Methods of Applied Mathematics, 2nd edition, Prentice Hall, 1965.
8. R. P. Kanwal: Linear Integral Equations - Theory & Technique, Springer, 2013.

Advanced Linear Algebra (3-1-0 4)

Finite dimensional vector spaces over a field, linear combination, linear dependence and independence, basis, dimension, inner product spaces, linear transformations, matrix representation of linear transformations, linear functional, dual spaces, eigenvalues and eigenvectors, rank and nullity, inverse of a linear transformation, Cayley-Hamilton theorem, norms of vectors and matrices, transformation of matrices, Jordan’s form, adjoint of an operator, normal, unitary, Hermitian and skew-Hermitian operators, bilinear forms. Application of Jordan form to discrete system of equation and system of linear differential equation. Singular value decomposition (SVD) and application of SVD to find least square solution and data compression. Cholesky decomposition and QR decomposition. Positive definite and negative definite matrices, Sylvester’s criterion, orthogonal transformations, Householder and Jacobi transformations. Introduction to pseudo-inverse, Moore-Penrose generalized inverse.

Texts/References

1. P. D. Lax: Linear Algebra and Its Applications, 2nd edition, Wiley, 2007.
2. R. A. Horn and C.R. Johnson: Matrix analysis, Cambridge University Press, 1990.

3. K. Hoffman and R. Kunze: Linear Algebra, 2nd edition, Prentice Hall, 1971.
4. P. R. Halmos: Finite-dimensional Vector Spaces, Springer, 1974.
5. C. D. Meyer: Matrix Analysis and Applied Linear Algebra, SIAM, 2000.
6. S. L. Campbell and C.D. Meyer: Generalized Inverses of Linear Transformations, SIAM, 2008.
7. A. J. Laub: Matrix Analysis for Scientists and Engineers, SIAM, 2004.

Combinatorics (3-1-0 4)

Unit-I

The Pigeonhole Principle:

Pigeonhole Principle: Simple Form, Pigeonhole Principle: Strong Form, A Theorem of Ramsey.

The Inclusion-Exclusion Principle and Applications:

The Principle of Inclusion and Exclusion and a variety of ways to apply it, notably combinations with repetition, Derangements, permutations with forbidden positions, circular permutations with forbidden relations, Möbius Inversion.

Polya's Enumeration formula: Equivalence and Symmetry Groups ; Burnside's Theorem ; The Cycle Index ; Polya's Formula .

Unit - II

Recurrence Relations and Generating Functions: Some Number Sequences, Generating Functions, Exponential Generating Functions, Recurrence relations, Catalan Numbers, Difference Sequences and Stirling Numbers, Partition Numbers.

Introduction to finite geometry: Finite Geometry, Projective and affine geometries, duality, Orthogonal sets of Latin squares, Modular arithmetic (with some finite field arithmetic) and applications to orthogonal Latin squares.

Unit - III

Combinatorial Structures: Hadamard Matrix; Different constructions of Hadamard Matrix, Orthogonal Array, constructions of Orthogonal Array, Association Scheme, Partially Balanced Design. The DeBruijn theorem, Steiner systems, balanced incomplete block designs, Hadamard designs, counting, (higher) incidence matrices, the Wilson-Petrenjuk theorem, symmetric designs, derived and residual designs, the Bruck-Ryser-Chowla theorem, constructions of Steiner triple Systems.

Texts/References

1. R.A. Brualdi: Introductory Combinatorics, 5th edition, Pearson, 2010.
2. J. H. van Lint and R. M. Wilson: A Course in Combinatorics, 2nd edition, Cambridge University Press, 2001.
3. A. Tucker: Applied Combinatorics, 5th edition, Wiley, 2010.
4. Marshal Hall: Combinatorial Theory, 2nd Edition, Wiley, 1998.
5. Aloke Dey :Theory of Block Designs, Wiley, 1987.
6. A.S. Hedayat, N.J.A. Sloane, John Stufken: Orthogonal Arrays: Theory and Applications, Springer, 1999.

Difference Equations and Discrete Dynamical Systems (3-1-0 4)

Difference Equations: Introduction to Difference Equations, First order DEs, linear equations with constant coefficients, variable coefficients, stability in both hyperbolic and nonhyperbolic cases, bifurcations, symbolic dynamics and chaos, linear theory for two dimensional systems of difference equations, equilibria, stability, periodic solutions, period-doubling bifurcation, Lyapunov numbers, box dimension, stable and unstable manifolds, area preserving maps, systems with order higher than 2, numerical issues in difference equations.
Discrete Dynamical Systems: Discrete and continuous dynamical systems, One and two dimensional maps as discrete dynamical systems, Fixed points, periodic points and stability, Chaos, Lyapunov exponents and chaotic attractors, Differential equations as continuous dynamical systems, Periodic orbits and limit sets, Bifurcations.

Text/References

1. S. Goldberg: Introduction to difference Equations, Dover, 1986.
2. K.T. Alligood, T.D. Sauer and J.A. Yorke:An Introduction to Dynamical Systems, Springer, 1997.
3. E.Ott: Chaos in Dynamical Systems, Cambridge University Press, 2nd edition 2002.
4. S.H. Strogatz: Nonlinear Dynamics and Chaos - With Applications to Physics, Biology, Chemistry and Engineering, Westview Press, 2000.
5. S. Elaydi: An Introduction to Difference Equations, Springer, 1995.
6. W.G. Kelley and A.C. Peterson: Difference Equations - An Introduction with Applications, 2nd edition, AP, 2001.

Theory of Groups and Rings (3-1-0 4)

Semigroups, Groups, Homomorphisms, Subgroups, Permutation Groups, Normal Subgroups, Isomorphism Theorem, Automorphisms, Conjugacy and G-sets.
Normal Series, Solvable groups, Nilpotent groups, Cyclic decomposition of permutations, Alternating group. Structure Theorem of Finite abelian groups. Sylows theorems, groups of orders p^2, pq.
Rings, Subrings, Ideals, Homomorphisms, Prime and Maximal Ideals, Nilpotent and Nil Ideals, UFD, PID and ED. Polynomial rings over UFD.

Texts/References

1. P.B. Bhattacharya, S. K. Jain and S. R. Nagpaul: Basic Abstract Algebra, 2nd edition, Cambridge University Press, 1995.
2. J. A. Gallian: Contemporary Abstract Algebra, 4th edition, Narosa, 1998.
3. D. S. Dummit and R. M. Foote: Abstract Algebra, 2nd edition, Wiley, 1999.
4. I. N. Herstein: Topics in Algebra, 2nd edition, Wiley, 1975.

Theory of Modules and Commutative Rings (3-1-0-4)

Rings and Ideals: Introduction, Quotient rings, Zero divisors, Nilpotents, Units, Prime and Maximal Ideals, Nilradical, Jacobson radical, Extension and Contraction, factorization in Integral domains, UFD, PID and ED.
Modules: Introduction, Submodules and Quotient modules, Direct sum and Product, Finitely generated modules, Exact sequences, Tensor product of modules, Algebras.
Rings and Modules of Fractions: Local properties, Extended and Contracted ideals in rings of fractions. Noetherian and Artinian modules.

Texts/References:

M. Atiyah: Introduction to Commutative Algebra, Westview Press, 1994.
D.S. Dummit and R.M. Foote: Abstract Algebra, 3rd edition, Wiley, 2003.
O. Zariski and P. Samuel: Commutative Algebra I. Vol. 1, Springer, 1975.

Lie Groups and Lie Algebras (3-1-0 4)

Lie Algebras and Root Systems: Introduction to Lie Algeras, Representations, Special kind of Lie Algebra, $\mathrm{sl}_n(\mathrm{C})$, Simple Lie Algebras over $\mathbb{C}$, Killing form, Weyl group, Representations of simple Lie algebras, Simple groups of Lie type.
Lie Groups: Introduction, $\mathrm{SU}_2, \mathrm{SO}_3$ and $\mathrm{Sl}_2(\mathrm{R})$, Homogeneous spaces, some theorems about matrices, Lie theory, Representation theory, Compact groups and integration, Maximal compact subgroups, the Peter-Weyl theorem, Functions on R^n and S^{n-1}, Induced representations.

Texts/References

1. R. Carter, G. Segal and I. Macdonald: Lectures on Lie Groups and Lie Algebras, London Mathematical Society, 1995.
2. J. E. Humphreys: Introduction to Lie Algebras and Representation Theory, Springer, 2010.
3. D. A. Bump: Lie Groups, Springer, 2011.

Representation Theory (3-1-0 4)

Representations, Subrepresentations, Irreducible representations, Tensor products, Symmetric and Alternating Squares.
Characters: Schur's lemma, Orthogonality relations, Decomposition of regular representation, Number of irreducible representations, canonical decomposition and explicit decompositions.
Examples: Cyclic groups, alternating and symmetric groups.
Subgroups, Products, Induced Representations, The character of induced representation, Frobenius Reciprocity Theorem, Mackey's irreducibility criterion, Examples of induced representations.

Texts/References

1. J.P. Serre: Linear Representation of Groups, Springer-Verlag, 1977.
2. S. Lang: Algebra, 3rd edition, Springer, 2004.
3. N. Jacobson: Basic Algebra II, Hindustan Publishing Corporation, 1983.
4. M. Burrow: Representation Theory of Finite Groups, Academic Press, 1965.

Theory of Relativity (3-1-0 4)

Classical Theory of Relativity: Inertial frame, Galilean transformations, Lorentz transformation.

Tensor Analysis: Transformation of coordinates, Tensors, Algebra of Tensor, Symmetric and skew-Symmetric tensors, Contraction of Tensor and Quotient law, Riemannian metric, Christoffel Symbol, Covariant derivatives, Intrinsic derivatives and geodesics, Riemann Christoffel Curvature Tensor and it's symmetry properties, Binachi identities and Einstein tensor.

General Theory of relativity: Review of the special theory of relativity and the Newtonian theory of gravitation, Principle of equivalence and general covariance, geodesic principle, Newtonian approximation of relativistic equation of motion, Einstein's Field equations and its Newtonian approximation. Schwarzchild's external solution and isotropic form, Planetary Orbits, Advance of perihelion of a planet, Bending of light rays in a gravitational field. Energy-Momentum tensor of a perfect fluid, Schwarzchild's internal solution, Boundary conditions, Energy-Momentum tensor of an electromagnetic field, Einstein-Maxwell equations, Reissner-Nordstrom solution.

Texts/References

1. C. E. Weatherburn: An Introduction to Riemannian Geometry and the Tensor Calculus, CUP, 2008.
2. H. Stephani et al.: General Relativity: An Introduction to the Theory of Gravitational Field, 2nd edition, CUP, 1990.
3. A. S. Eddington: The Mathematical Theory of Relativity, 2nd edition, CUP, 2010.
4. J. V. Narlikar: Lectures on General Relativity and Cosmology, Macmillan Press, 1979
5. R. Adler: Introduction to General Relativity, 2nd edition, McGraw-Hill, 1975.
6. B. Schutz: A First Course in General Relativity, 2nd edition, CUP, 2010.
7. J.K. Goyal and K.P. Gupta: Theory of Relativity, Krishna Prakashan, 1976.

Theory and Applications of Fuzzy Sets(3-1-0 4)

Basic concepts of fuzzy sets, fuzzy logic, operations on fuzzy sets, fuzzy relations, equivalence and similarity relations, ordering, morphisms, fuzzy relation equations, fuzzy measures, probability measures, possibility and necessity measures, measures of uncertainty, dissonance, confusion and nonspecificity. Principles of uncertainty and information. Applications of fuzzy sets in management, decision making, computer science and systems science.

Texts/References:

1. T. J. Ross: Fuzzy Logic with Engineering Applications, 3rd edition, Wiley, 2010.
2. G.J. Klir and B. Yuan: Fuzzy Sets and Fuzzy Logic Theory and Applications, Prentice Hall, 1995.
3. G. Chen and T. Pham: Introduction to Fuzzy Sets, Fuzzy Logic, and Fuzzy Control Systems, CRC, 2000.
4. H.J. Zimmermann: Fuzzy Set Theory - and Its Applications, 2nd edition, Springer, 1991.

Cryptography (3-1-0 4)

Introduction to basic terminologies associated with Cryptography, Definition and classification of Cryptosystem, Classical crypto systems, Description of rail fence cipher, Simple Columnar cipher, Caesar cipher, Linear cipher, Affine linear cipher, Distinction between Substitution cipher and Permutation cipher. Classical cipher as particular case of Affine linear cipher, Insecurity of Affine linear cipher, Block cipher and different modes of implementation of Block cipher, Stream cipher, Feistel cipher, DES (Data Encryption Standard) and AES (Advanced Encryption Standard).

Public Key cryptosystems, Need for Public Key cryptosystems, Description of RSA, Rabin cryptosystem, Diffie-Hellman key exchange, ElGamal cryptosystem, Cryptanalysis of Public Key cryptosystem, Digital signatures, Introduction to Elliptic curve cryptography, Perfect security and Shanon's Theorem. Mathematical problems related to cryptography, Division Algorithm and extended Division Algorithm, Calculation of Units in Z/nZ, Fast Exponentiation, Factoring problem, Different factorisation Algorithms, Discrete Log Problem, Discussion of different algorithms for finding discrete log.

Lab Component: Cryptography Lab in C (at least 10 Sessions), Use of Sage software.

Texts/References

1. J. A. Buchmann: Introduction to Cryptography, Springer, 2004.
2. N. Koblitz: A Course in Number Theory and Cryptography, Springer, 1994.
3. M. Welschenbach: Cryptography in C and C++, 2nd edition, Apress, 2002.

Theory of Differential Equations (3-1-0 4)

Unit-1

System of Differential Equations: System of First Order Equations, Existence and uniqueness of solution, Gronwall's inequality, continuous dependence on initial conditions and parameters.

Linear systems: Autonomous systems, Transition matrix, Phase-Space of two dimensional systems, Time varying systems, Fundamental matrix and its properties, linear system with periodic coefficients.

Stability of differential systems: Stability of linear systems, almost linear systems, stability of periodic solutions, Lyapunov Stability theorems for nonlinear system, limit cycles Poincare-Bendixon Theorem, Lienard Systems, Constructions of Lyapunov function , Bifurcations (Transcritical, Saddle-node, Pitchfork, Hopf, Sotomayor Theorem).

Unit-2

Review of first order PDE: Classification, solution method for quasi-linear and nonlinear PDE, discontinuous solutions, conservation laws and shocks.

Four important linear PDEs (transport, Laplace, heat and wave equation): Fundamental solution, mean value formulae, properties of harmonic functions, Green's Function and energy method.

Unit-3

Elliptic Equations: Definition, Existence of weak solutions, Regularity, Maximum Principles, Eigenvalues and Eigenfunctions.

Linear Evolution Equations: Parabolic equations, Hyperbolic equations, Semi-group theory.

<u>Texts/References</u>

1. G. F. Simmons, Differential equations with applications and historical notes, 2nd Ed., McGraw-Hill., 1991.
2. R. P. Agarwal, D. O'Regan, An introduction to ordinary differential equations, Springer, 2008.
3. K. S. Bhamra, Ordinary differential equations, Narosa Publications., 2015.
4. I. N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill., 1957.
5. L. C. Evan, Partial differential Equations, 2nd Ed., AMS, 2015.
6. M. Renardy, R. C. Rogers, An introduction to partial differential equations, 2nd Ed., Springer, 2010.

Differential Manifolds (3-1-0 4)

Quick review to Curves and Surfaces (at most 5 classes).
Manifolds, Smooth maps and diffeomorphisms, Tangent Spaces to a manifold, Derivatives of smooths maps, Immersions and submersions, submanifolds, Vector fields, Flows and exponential map, Frobenius theorem, Lie groups and Lie algebras, Homogeneous spaces, Multilinear algebra, Exterior algebra, Tensor fields, Exterior derivative, Lie derivatives. Orientable manifolds, Integration on manifolds, Stokes' theorem, Tangent Bundles and Vector Bundles.

Texts/References

2. S. Kumaresan: A Course in Differential Geometry and Lie Groups, Hindustan Book Agency,2002.
3. J. R. Munkres: Analysis on Manifolds, Westview Press, 1997.
4. S. Lang: Introduction to Differentiable Manifold, 2^{nd} edition, Springer, 1927.
5. L. Auslander and R. E. Mackenzie: Introduction to Differentiable Manifolds, Dover, 2009.

Advanced Numerical Analysis (3-1-0 4)

Interpolation Theory: Review of basic polynomial interpolation. Hermite Interpolation.The general Hermite interpolation problem.

Approximation of functions: The Minimax and Least squares approximation problem. Orthogonal polynomials, The Least squares approximation problem using orthogonal polynomials.Minimax and Near-minimax approximations.

Numerical Integration: Review of Newton-Cotes integration formulas. Gaussian Quadrature.Asymptotic error formulas and their applications.Automatic numerical integration.Multiple Integrals, Singular integrals.

Ordinary differential equations: Numerical solutions of IVP – Difference equations, stability, error and convergence analysis. Single step methods - Taylor series method, Euler method, Picard's method of successive approximation, Runge-Kutta method. Multi step methods – Predictor-Corrector(PC) method, Euler PC method, Milne and Adams Moulton PC method. System of first order ODE, higher order IVPs. Numerical solutions of BVP – Linear BVP, finite difference methods, shooting methods, stability, error and convergence analysis, nonlinear BVP, higher order BVP.

Numerical solution of systems of linear equations: Review of Direct methods for solving linear systems, error analysis. The residual correction method.Iteration methods, Error prediction and Acceleration.

The Matrix Eigenvalue problem: Review of Eigenvalue location, error, and stability results, Power method. Orthogonal transformations using Householder matrices.The eigenvalues of a symmetric Tridiagonal matrix.QR method.The calculation of Eigenvectors and Inverse iteration.

Lab Components: Exposure to MATLAB/Mathematica/SciLab and computational experiments based on the algorithms discussed in the course.

Texts/References

1. K. Atkinson: An Introduction to Numerical Analysis, 2nd edition, Wiley, 1989.

1. R.L. Burden and J.D. Faires: Numerical Analysis, 7th edition, Brooks Cole, 2001.
2. S.D. Conte and C. de Boor: Elementary Numerical Analysis, 3rd edition, Tata McGraw Hill, 1980.
3. A. Iserles: A First Course in the Numerical Analysis of Differential Equations, Cambridge University Press, 1996.
4. P.J. Davis and P. Rabinowitz: Methods of Numerical Integration, 2nd edition, AP, 1984.
5. R. LeVeque: Finite Difference Methods for Ordinary and Partial Differential Equations Steady-State and Time-Dependent Problems, SIAM, 2007.
6. L. N. Trefethen and D. Bau III: Numerical Linear Algebra, SIAM, Philadelphia, 1997.
7. G. Sewell: The Numerical Solution of Ordinary and Partial Differential Equations, 2nd edition, Wiley, 2005.
8. E. Isaacson and H.B. Keller: Analysis of Numerical Methods, Dover, 1994.
9. P.J. Davis: Interpolation and Approximation, Dover, 1975.
10. J.M. Ortega: Numerical Analysis: A Second Course, SIAM, 1987.

Integral Transformations (3-1-0 4)

Laplace Transform: Definition, Transform of some elementary functions, rules of manipulation of Laplace Transform, Transform of Derivatives, relation involving Integrals, the error function, Transform of Bessel functions, Periodic functions, convolution of two functions, Inverse Laplace Transform of simple function, Tauberian Theorems, Solution of Differential Equations- Initial value problems for linear equations with constant coefficients, two-point boundary value problem for a linear equation with constant coefficients, linear differential equation with variable coefficients, simultaneous differential equations with constant coefficients, Solution of diffusion and wave equation in one dimension and Laplace equation in two dimensions.

Fourier Series and Fourier Transforms: Orthogonal set of functions, Fourier series, Fourier sine and cosine series, Half range expansions, Fourier integral Theorem, Fourier Transform, Fourier Cosine Transform, Fourier Sine Transform, Transforms of Derivatives, Fourier transforms of simple Functions, Fourier transforms of Rational Functions, Convolution Integral, Parseval's Theorem for Cosine and Sine Transforms, Inversion Theorem, , Solution of Partial Differential Equations by means of Fourier Transforms. first order and second order Laplace and Diffusion equations.

Books Recommended:

1. Ian N. Sneddon , The use of Integral Transforms ,McGraw Hill; Second Printing edition ,1972.
2. Ian N. Sneddon, Fourier Transforms , Dover Publications,2010 .
3. LoknathDebnath, Integral Transforms and their applications ,Chapman and Hall/CRC; 2 edition ,2006.
4. R. K. Jain, S. R. K. Iyengar : Advanced Engineering Mathematics , Fifth Edition.
5. Murray Spiegel: Schaum's Outlines of Laplace Transform.

6. Murray Spiegel: Schaum's Outlines of Fourier Analysis with Applications to Boundary Value Problems.

Tensor Algebra (3-1-0 4)

UNIT-I Transformation of coordinates, Tensors, Algebra of Tensor, Symmetric and skew-Symmetric tensors, Contraction of Tensor and Quotient law, Riemannian metric, Christoffel Symbol, Covariant derivatives, Intrinsic derivatives and geodesics, Riemann Christoffel Curvature Tensor and it's symmetry properties, Binachi identities and Einstein tensor.

UNIT-II Quick Review of the special theory of relativity and general relativity, Einstein's Field equations , Schwarzchild's external solution and isotropic form, Energy-Momentum tensor of a perfect fluid, Schwarzchild's internal solution, Boundary conditions, Energy-Momentum tensor of an electromagnetic field, Einstein-Maxwell equations, Reissner-Nordstrom solution.

Texts/References

1. C. E. Weatherburn: An Introduction to Riemannian Geometry and the Tensor Calculus, CUP, 2008.
2. H. Stephani et al.: General Relativity: An Introduction to the Theory of Gravitational Field, 2nd edition, CUP, 1990.
3. A. S. Eddington: The Mathematical Theory of Relativity, 2nd edition, CUP, 2010.
4. J. V. Narlikar: Lectures on General Relativity and Cosmology, Macmillan Press, 1979
5. R. Adler: Introduction to General Relativity, 2nd edition, McGraw-Hill, 1975.
6. B. Schutz: A First Course in General Relativity, 2nd edition, CUP, 2010.
7. J.K. Goyal and K.P. Gupta: Theory of Relativity, Krishna Prakashan, 1976.

Theory of Rings and Field (3-1-0 4)

Rings, Subrings, Ideals, Homomorphisms, Prime and Maximal Ideals, Nilpotent and Nil Ideals, UFD, PID and ED. Polynomial rings over UFD.

Fields- Field extensions, algebraic and transcendental field extensions, finite fields.
Galois extensions.Constructibility by ruler and compass, Fundamental Theorem of Galois Theory.

The impossibility of solving the general quintic by radicals.

Text/References

1. M. Artin: Algebra, Prentice Hall India, 2009.
2. S. Lang: Algebra, 3rd edition, Springer, 2002.
3. J. Rotman: Galois Theory, 2nd edition, Springer, 2006.
4. P. Morandi: Field and Galois Theory, Springer, 2010.
5. I. S. Luthar and I. B. S. Passi: Algebra 4 - Field Theory, Narosa, 2004.
6. P.B. Bhattacharya, S. K. Jain and S. R. Nagpaul: Basic Abstract Algebra, 2nd edition, Cambridge University Press, 1995.
7. J. A. Gallian: Contemporary Abstract Algebra, 4th edition, Narosa, 1998.
8. D. S. Dummit and R. M. Foote: Abstract Algebra, 2nd edition, Wiley, 1999.
9. I. N. Herstein: Topics in Algebra, 2nd edition, Wiley, 1975.

Number Theory (3-1-0 4)

Unit I: Fundamental theorem of arithmetic, divisibility in Z, congruences, Chinese Remainder Theorem, Euler's Ø- function, primitive roots, Fermat's Little, Euler and Wilsons Theorem.
Unit II: Linear Conguence, Algebraic congruences of degree ≥ 2. Theorems on Prime Power, Modulus, Lagrange Theorem, Quadratic Congruences, Quadratic reciprocity law, two square theorem, Primality Testing and Factoring.
Unit III: Simple continued fractions, Pell's Equation, Diophantine Approximation. Arithmetical functions. Sum and number of Divisors, Dirichlet Product, Mobius inversion formula, Totally multiplicative functions.

Texts/References

1. G.H. Hardy and E.M. Wright: An Introduction to The Theory of Numbers, 6th edition, Oxford University Press, 2008.
2. D.M. Burton: Elementary Number Theory, 6th edition, McGraw-Hill, 2005.
3. I. Niven, H.S. Zuckerman and H.L. Montgomery: An Introduction to The Theory of Numbers, 5th edition, Wiley, 1991.
4. T. M. Apostol: Introduction to Analytic Number Theory, Springer- Verlag, 1976.