MA 401 Linear Algebra  3  1  0  8
Vector spaces over fields, subspaces, bases and dimension.

Systems of linear equations, matrices, rank, Gaussian elimination.

Linear transformations, representation of linear transformations by matrices, rank-nullity theorem, duality and transpose.

Determinants, Laplace expansions, cofactors, adjoint, Cramer's Rule.

Eigenvalues and eigenvectors, characteristic polynomials, minimal polynomials, Cayley-Hamilton Theorem, triangulation, diagonalization, rational canonical form, Jordan canonical form.


Bilinear forms, symmetric and skew-symmetric bilinear forms, real quadratic forms, Sylvester's law of inertia, positive definiteness.

Texts / References

MA 403 Real Analysis I  3  1  0  8
Review of basic concepts of real numbers: Archimedean property, Completeness.

Metric spaces, compactness, connectedness, (with emphasis on $\mathbb{R}^n$).

Continuity and uniform continuity.

Monotonic functions, Functions of bounded variation; Absolutely continuous functions. Derivatives of functions and Taylor’s theorem.

Riemann integral and its properties, characterization of Riemann integrable functions. Improper integrals, Gamma functions.

Sequences and series of functions, uniform convergence and its relation to continuity, differentiation and integration. Fourier series, pointwise convergence, Fejer’s theorem, Weierstrass approximation theorem.

Texts / References

MA 405 Basic Algebra  3  1  0  8
Review of basics: Equivalence relations and partitions, Division algorithm for integers, primes, unique factorization, congruences, Chinese Remainder Theorem, Euler $\varphi$-function.

Permutations, sign of a permutation, inversions, cycles and transpositions. Rudiments of rings and fields, elementary properties, polynomials in one and several variables, divisibility, irreducible polynomials, Division algorithm, Remainder Theorem, Factor Theorem, Rational Zeros Theorem, Relation between the roots and coefficients, Newton's Theorem on symmetric functions, Newton's
identities, Fundamental Theorem of Algebra, (statement only), Special cases: equations of degree $\leq 4$, cyclic equations.

Cyclotomic polynomials, Rational functions, partial fraction decomposition, unique factorization of polynomials in several variables, Resultants and discriminants.

Groups, subgroups and factor groups, Lagrange's Theorem, homomorphisms, normal subgroups. Quotients of groups, Basic examples of groups (including symmetric groups, matrix groups, group of rigid motions of the plane and finite groups of motions).

Cyclic groups, generators and relations, Cayley's Theorem, group actions, Sylow Theorems.

Direct products, Structure Theorem for finite abelian groups.

Texts / References

MA 406 General Topology 3 1 0 8

Prerequisite: MA 403 Real Analysis

Topological Spaces: open sets, closed sets, neighbourhoods, bases, subbases, limit points, 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: Connected spaces, Connected subspaces of the real line, Components and local connectedness, Compact spaces, Heine-Borel Theorem, Local compactness.


Tychonoff Theorem, One-point Compactification.


Optional Topics:
1. Topological Groups and orbit spaces.
2. Paracompactness and partition of unity.

Texts / References

MA 408 Measure and Integration 3 1 0 8
Prerequisite: MA 403 Real Analysis
Semi-algebra, Algebra, Monotone class, Sigma-algebra, Monotone class theorem. Measure spaces.
Outline of extension of measures from algebras to the generated sigma-algebras: Measurable sets; Lebesgue Measure and its properties.
Measurable functions and their properties; Integration and Convergence theorems.
Product measure spaces, Fubini’s theorem.
Fundamental Theorem of Calculus for Lebesgue Integrals (an outline).

Texts / References

MA 410 Multivariable Calculus 2 1 0 6
Prerequisites: MA 403 Real Analysis, MA 401 Linear Algebra
Functions on Euclidean spaces, continuity, differentiability; partial and directional derivatives, Chain Rule, Inverse Function Theorem, Implicit Function Theorem.
Riemann Integral of real-valued functions on Euclidean spaces, measure zero sets, Fubini's Theorem.
Partition of unity, change of variables.
Differentiable manifolds (as subspaces of Euclidean spaces), differentiable functions on manifolds, tangent spaces, vector fields, differential forms on manifolds, orientations, integration on manifolds, Stokes' Theorem on manifolds.

Texts / References

MA 412 Complex Analysis 3 1 0 8
Zeroes and poles, Maximum Modulus Principle, Argument Principle, Rouche’s theorem.

Texts / References


MA 414 Algebra - I 3 1 0 8

Prerequisite: MA 401 Linear Algebra, MA405 Basic Algebra

Simple groups and solvable groups, nilpotent groups, simplicity of alternating groups, composition series, Jordan-Holder Theorem. Semidirect products. Free groups, free abelian groups.

Rings, Examples (including polynomial rings, formal power series rings, matrix rings and group rings), ideals, prime and maximal ideals, rings of fractions, Chinese Remainder Theorem for pairwise comaximal ideals.

Euclidean Domains, Principal Ideal Domains and Unique Factorizations Domains. Polynomial rings over UFD's.

Fields, Characteristic and prime subfields, Field extensions, Finite, algebraic and finitely generated field extensions, Classical ruler and compass constructions, Splitting fields and normal extensions, algebraic closures. Finite fields, Cyclotomic fields, Separable and inseparable extensions.

Galois groups, Fundamental Theorem of Galois Theory, Composite extensions, Examples (including cyclotomic extensions and extensions of finite fields).

Norm, trace and discriminant.

Solvability by radicals, Galois' Theorem on solvability.

Cyclic extensions, Abelian extensions, Transcendental extensions.

Texts / References


MA 417 Ordinary Differential Equations 3 1 0 8

Review of solution methods for first order as well as second order equations, Power Series methods with properties of Bessel functions and Legendre polynomials.

Existence and Uniqueness of Initial Value Problems: Picard’s and Peano’s Theorems, Gronwall’s inequality, continuation of solutions and maximal interval of existence, continuous dependence.


Two Dimensional Autonomous Systems and Phase Space Analysis: critical points, proper and improper nodes, spiral points and saddle points.


Boundary Value Problems for Second Order Equations: Green's function, Sturm comparision theorems and oscillations, eigenvalue problems.

Texts / References


**MA 503 Functional Analysis 3 1 0 8**

Prerequisites: MA 401 Linear Algebra, MA 408 Measure and Integration


Texts / References


**MA 504 Operators on Hilbert Spaces 2 1 0 6**

Prerequisite: MA 503 Functional Analysis

Adjoints of bounded operators on a Hilbert space, Normal, self-adjoint and unitary operators, their spectra and numerical ranges.


Application to Sturm-Liouville Problems.

Texts / References


**MA 505 Algebra- II 3 1 0 8**

Prerequisite: MA 414 Algebra I

Modules, submodules, quotient modules and module homomorphisms.

Generation of modules, direct sums and free modules. Tensor products of modules. Exact sequences, projective modules.

Tensor algebras, symmetric and exterior algebras.

Finitely generated modules over principal ideal domains, invariant factors, elementary divisors, rational canonical forms. Applications to finitely generated abelian groups and linear transformations.

Noetherian rings and modules, Hilbert basis theorem, Primary decomposition of ideals in noetherian rings.

Integral extensions, Going-up and Going-down theorems, Extension and contraction of prime ideals, Noether's Normalization Lemma, Hilbert's Nullstellensatz.

Localization of rings and modules. Primary decompositions of modules.

Texts / References


MA 508 Mathematical Methods 3 1 0 6

Prerequisite: MA 515 Partial Differential Equations


Texts / References


MA 510 Introduction to Algebraic Geometry 2 1 0 6

Prerequisite: MA 414

Varieties: Affine and projective varieties, coordinate rings, morphisms and rational maps, local ring of a point, function fields, dimension of a variety.

Curves: Singular points and tangent lines, multiplicities and local rings, intersection multiplicities, Bezout's theorem for plane curves, Max Noether's theorem and some of its applications, group law on a nonsingular cubic, rational parametrization, branches and valuations.

Texts / References


MA 515 Partial Differential Equations 3 1 0 8

Prerequisites: MA 417 Ordinary Differential Equations. MA 410 Multivariable Calculus

Cauchy Problems for First Order Hyperbolic Equations: method of characteristics, Monge cone.

Classification of Second Order Partial Differential Equations: normal forms and characteristics.

Initial and Boundary Value Problems: Lagrange-Green's identity and uniqueness by energy methods.

Stability theory, energy conservation and dispersion.
Laplace equation: mean value property, weak and strong maximum principle, Green's function, Poisson's formula, Dirichlet's principle, existence of solution using Perron's method (without proof).

Heat equation: initial value problem, fundamental solution, weak and strong maximum principle and uniqueness results.


Methods of separation of variables for heat, Laplace and wave equations.

Texts / References

MA 516 Algebraic Topology 3 1 0 8

Prerequisite: MA 406 General Topology

Paths and homotopy, homotopy equivalence, contractibility, deformation retracts.

Basic constructions: cones, mapping cones, mapping cylinders, suspension.

Cell complexes, 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 two). Van Kampen's Theorem, Covering spaces, lifting properties, deck transformations. Universal coverings (existence theorem optional).


Degree. Cellular Homology.


Optional Topics:
Outline of the theory of: cohomology groups, cup products, Kunneth formulas, Poincare duality.

Texts / References

MA 518 Spectral Approximation 2 1 0 6

Prerequisite: MA 503 Functional Analysis

Convergence of operators: norm, collectively compact and $\nu$ convergence. Error estimates.

Finite rank approximations based on projections and approximations for integral operators.

A posteriori error estimates.

Matrix formulations for finite rank operators.

Iterative refinement of a simple eigenvalue.

Numerical examples.

Texts / References


MA 521 Theory of Analytic Functions 2106

Prerequisites: MA 403 Real Analysis, MA 412 Complex Analysis.

Maximum Modulus Theorem. Schwarz Lemma.

Phragmen-Lindelof Theorem.

Riemann Mapping Theorem. Weierstrass Factorization Theorem.

Runge’s Theorem. Simple connectedness. Mittag-Leffler Theorem.

Schwarz Reflection Principle.

Basic properties of harmonic functions.

Picard Theorems.

Texts / References


MA 522 Fourier Analysis and Applications 3108

Prerequisite: MA 403 Real Analysis

Basic Properties of Fourier Series: Uniqueness of Fourier Series, Convolutions, Cesaro and Abel Summability, Fejer’s theorem, Poisson Kernel and Dirichlet problem in the unit disc. Mean square Convergence, Example of Continuous functions with divergent Fourier series.


Paley-Wiener Theorems, Poisson Summation Formula: Radial Fourier transforms and Bessel’s functions. Hermite functions.

Optional Topics:

Applications to PDEs, Wavelets and X-ray tomography.

Applications to Number Theory.

Texts / References:


**MA 523 Basic Number Theory  2 1 0 6**

Prerequisites: MA 405 Basic Algebra

Infinitude of primes, discussion of the Prime Number Theorem, infinitude of primes in specific arithmetic progressions, Dirichlet's theorem (without proof).

Arithmetic functions, Mobius inversion formula. Structure of units modulo n, Euler's phi function

Congruences, theorems of Fermat and Euler, Wilson's theorem, linear congruences, quadratic residues, law of quadratic reciprocity.

Binary quadratics forms, equivalence, reduction, Fermat's two square theorem, Lagrange's four square theorem.

Continued fractions, rational approximations, Liouville's theorem, discussion of Roth's theorem, transcendental numbers, transcendence of "e" and "pi".

Diophantine equations: Brahmagupta's equation (also known as Pell's equation), the Thue equation, Fermat's method of descent, discussion of the Mordell equation.

Optional Topics:

Discussion of Waring's problem.

Discussion of the Bhargava-Conway "fifteen theorem" for positive definite quadratic forms.

The RSA algorithm and public key encryption.

Primality testing, discussion of the Agrawal-Kayal-Saxena theorem.

Catalan's equation, discussion of the Gelfond-Schneider theorem, discussion of Baker's theorem.

Texts / References


**MA 524 Algebraic Number Theory  2 1 0 6**

Prerequisites: MA 505 Algebra - II (Exposure)

Algebraic number fields.

Localisation, discrete valuation rings.

Integral ring extensions, Dedekind domains, unique factorisation of ideals. Action of the galois group on prime ideals.

Valuations and completions of number fields, discussion of Ostrowski's theorem, Hensel's lemma, unramified, totally ramified and tamely ramified extensions of p-adic fields.

Discriminants and Ramification.

Cyclotomic fields, Gauss sums, quadratic reciprocity revisited.

The ideal class group, finiteness of the ideal class group, Dirichlet units theorem.

Texts / References


S. Lang, Algebraic Number Theory, Addison-Wesley, 1970.


**MA 525 Dynamical Systems  2 1 0 6**

Prerequisite: MA 417 Ordinary Differential Equations

Texts / References

V.I. Arnold, Ordinary Differential Equations, rentice Hall of India, New Delhi, 1998.


MA 526 Commutative Algebra 2 1 0 6

Prerequisites: MA 405 Algebra - II

Dimension theory of affine algebras: Principal ideal theorem, Noether normalization lemma, dimension and transcendence degree, catenary property of affine rings, dimension and degree of the Hilbert polynomial of a graded ring, Nagata's altitude formula, Hilbert's Nullststellensatz, finiteness of integral closure.

Hilbert-Samuel polynomials of modules: Associated primes of modules, degree of the Hilbert polynomial of a graded module, Hilbert series and dimension, Dimension theorem, Hilbert-Samuel multiplicity, associativity formula for multiplicity,

Complete local rings:
Basics of completions, Artin-Rees lemma, associated graded rings of filtrations, completions of modules, regular local rings

Basic Homological algebra:

Categories and functors, derived functors, Hom and tensor products, long exact sequence of homology modules, free resolutions, Tor and Ext, Koszul complexes.

Cohen-Macaulay rings:


Optional Topics:

1. Face rings of simplicial complexes, shellable simplicial complexes and their face rings.
2. Dedekind Domains and Valuation Theory.

Text/References


MA 530 Nonlinear Analysis 2 1 0 6

Prerequisites: MA 503 Functional Analysis.

Fixed Point Theorems with Applications: Banach contraction mapping theorem, Brouwer fixed point theorem, Leray-Schauder fixed point theorem.

Calculus in Banach spaces: Gateaux as well as Frechet derivatives, chain rule, Taylor's expansions, Implicit function theorem with applications, subdifferential.

Monotone Operators: maximal monotone operators with properties, surjectivity theorem with applications.
Degree theory and condensing operators with applications.

Texts / References


MA 532 Analytic Number Theory  2 1 0 6

Prerequisites: MA 402 Algebra - I
MA 412 Complex Analysis

The Wiener-Ikehara Tauberian theorem, 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:

1. Discussion of L-functions of number fields and the Chebotarev Density Theorem.


3. Discussion of Modular forms for congruence subgroups.

4. Discussion of Artin's holomorphy conjecture and higher reciprocity laws.

5. Discussion of elliptic curves and the Shimura-Taniyama conjecture (Wiles' Theorem)

Text / References:

S. Lang, Algebraic Number Theory, Addison-Wesley, 1970.


T. Apostol, Introduction to Analytic Number Theory, Springer-Verlag, 1976

MA 533 Advanced Probability Theory  2 1 0 6

Probability measure, probability space, construction of Lebesgue measure, extension theorems, limit of events, Borel-Cantelli lemma.

Random variables, Random vectors, distributions, multidimensional distributions, independence.

Expectation, change of variable theorem, convergence theorems.

Sequence of random variables, modes of convergence. Moment generating function and characteristics functions, inversion and uniqueness theorems, continuity theorems, Weak and strong laws of large number, central limit theorem.

Radon Nikodym theorem, definition and properties of conditional expectation, conditional distributions and expectations.

Texts / References


**MA 534 Modern Theory of Partial Differential Equations** 2106

Prerequisites: MA 503 Functional Analysis
MA 515 Partial Differential Equations.

Theory of distributions: supports, test functions, regular and singular distributions, generalised derivatives.

Sobolev Spaces: definition and basic properties, approximation by smooth functions, dual spaces, trace and imbedding results (without proof).

Elliptic Boundary Value Problems: abstract variational problems, Lax-Milgram Lemma, weak solutions and wellposedness with examples, regularity result, maximum principles, eigenvalue problems.

Semigroup Theory and Applications: exponential map, C_0-semigroups, Hille-Yosida and Lummer-Phillips theorems, applications to heat and wave equations.

Texts / References


**MA 538 Representation Theory of Finite Groups** 2106

Prerequisite: MA 414 Algebra I

Representations, Subrepresentations, 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. Subgroups, Product groups, Abelian groups. Induced representations.

Examples: Cyclic groups, alternating and symmetric groups.

Integrality properties of characters, Burnside's p^a q^b theorem. The character of induced representation, Frobenius Reciprocity Theorem, Meckey's irreducibility criterion, Examples of induced representations, Representations of supersolvable groups.

Texts / References


**MA 539 Spline Theory and Variational Methods** 2026

Even Degree and Odd Degree Spline Interpolation, end conditions, error analysis and order of convergence. Hermite interpolation, periodic spline interpolation. B-Splines, recurrence relation for B-splines, curve fitting using splines, optimal quadrature.

Tensor product splines, surface fitting, orthogonal spline collocation methods.

Texts / References


MA 540 Numerical Methods for Partial Differential Equations 2106
Prerequisite: MA 515 Partial Differential Equations
Lab Component: Exposure to MATLAB and computational experiments based on the algorithms discussed in the course.

Texts / References


MA 556 Differential Geometry 2106
Prerequisite: MA 410 Multivariable Calculus
Surfaces in Euclidean spaces, vector fields on surfaces, orientation, Gauss map.
Geodesics, parallel transport, Weingarten map.
Curvature of plane curves, are length and line integrals.
Curvature of surfaces.
Parametrized surfaces, local equivalence of surfaces.
Gauss-Bonnet Theorem, Poincare-Hopf Index Theorem.

Texts / References

MA 562 Mathematical Theory of Finite Elements 2106
Prerequisite: MA 515 Partial Differential Equations
MA 503 Functional Analysis
Parabolic initial and boundary value problems: semidiscrete and completely discrete schemes with convergence analysis.
Lab component: Implementation of algorithms and computational experiments using MATLAB.

Texts / References


MA 581 Elements of Differential Topology 2 1 0 6

Prerequisite: MA 410 Multivariable Calculus

Differentiable Manifolds in $\mathbb{R}^n$: Review of inverse and implicit function theorems; tangent spaces and tangent maps; immersions; submersions and embeddings.

Regular Values: Regular and critical values; regular inverse image theorem; Sard's theorem; Morse lemma.

Transversality: Orientations of manifolds; oriented and mod 2 intersection numbers; degree of maps. Application to Fundamental theorem of Algebra.

*Lefschetz theory of vector fields and flows: Poincare-Hopf index theorem; Gauss-Bonnet theorem.

*Abstract manifolds: Examples such as real and complex projective spaces and Grassmannian varieties; Whitney embedding theorems.

(* indicates expository treatment intended for these parts of the syllabus.)

Texts / References


SI 401 Introduction to Computer Architecture and Operating Systems 0 0 3 3

Introduction to the following topics: computer systems, CPU architecture (memory, registers, addressing, busses, instruction set), data representation, peripheral devices, multiprocessor systems, operating systems (process, memory management, virtual storage, file systems), basic network components and topologies.

Text / References


SI 402 Statistical Inference 3 1 0 8

Prerequisite: SI 407 Introduction to Probability Theory

families, invariance and maximal invariant statistics.

Testing of Hypotheses - parametric and non-parametric problems, examples with data analytic applications.

Confidence Intervals.

**Texts / References**


**SI 404 Regression Analysis**  2 1 0 6

Prerequisites: SI 407 Introduction to Probability Theory

Simple and multiple linear regression models — estimation, tests and confidence regions. Check for normality assumption. Likelihood ratio test, confidence intervals and hypotheses tests; tests for distributional assumptions. Collinearity, outliers; analysis of residuals, Selecting the “Best” regression equation, transformation of response variables. Ridge's regression.

**Texts / Reference**


**SI 407 Introduction to Probability Theory**  3 1 0 8


Expectation, moment generating functions and characteristic functions, Conditional expectation and distribution. Modes of convergence, Weak and strong laws of large numbers, Central limit theorem.

**Text / References**


**SI 412 Algorithms**  3 1 0 8

Tools for Analysis of Algorithms (Asymptotics, Recurrence Relations). Basic Data Structures (Lists, Stacks, Queues, Trees, Heaps) and applications.

Sorting, Searching and Selection (Binary Search, Insertion Sort, QuickSort, Radix Sort, Counting Sort, Heap Sort etc.. Median finding using Quick-Select, Median of Medians). Basic Graph Algorithm (BFS, DFS, strong components etc.).

Algorithm Design Paradigms: Divide and Conquer. Greedy Algorithms (for example, some greedy scheduling algorithms, Dijkstra's Shortest Paths algorithm, Kruskal's Minimum Spanning Tree Algorithm). Dynamic Programming (for example, dynamic programming algorithms for
optimal polygon triangulation, optimal binary search tree, longest common subsequence, matrix chain multiplication, all pairs shortest paths).

Introduction to NP-Completeness (polynomial time reductions, verification algorithms, classes P and NP, NP-hard and NP-complete problems).

Texts / References


SI 413 Combinatorics 2 1 0 6


Groups: Cosets and Lagrange Theorem, Cyclic Groups etc.. Permutation Groups, Orbits and Stabilizers. Generating Functions. Symmetry and Counting: Polya Theory. Special Topics (depending upon the instructor!)

Text / References


J. Hein, Discrete Structures, Logic and Computability, Jones and Barlett, 2002.


SI 416 Optimization 2 0 2 6

Unconstrained optimization using calculus (Taylor's theorem, convex functions, coercive functions ).

Unconstrained optimization via iterative methods (Newton's method, Gradient/ conjugate gradient based methods, Quasi- Newton methods).

Constrained optimization (Penalty methods, Lagrange multipliers, Kuhn-Tucker conditions. Linear programming (Simplex method, Dual simplex, Duality theory). Modeling for Optimization.

Text / Reference


M.C. Joshi and K. Moudgalya, Optimization: Theory and Practice, Narosa, New Delhi, 2004

SI 418 Advanced Programming and Unix Environment 0 0 3 3

UNIX programming environment (file system and directory structure, and processes). Unix tools (shell scripting, grep, tar, compress, sed, find, sort etc). Graphical User Interface Programming using Java. Multithreaded programming in Java.

Text / Reference


SI 422 Applied Stochastic Processes 2 1 0 6

Prerequisite: SI 407 Introduction to Probability Theory or MA 212


Applications to queuuing models and reliability theory.


Texts / References:

SI 501 Topics in Theoretical Computer Science 3 1 0 8

Introduction to Complexity Theory (P, NP, NP-hard, NP-complete etc.). Automata Theory and Formal Languages (finite automata, NFA, DFA, regular languages, equivalence of DFA and NFA, minimization of DFA, closure properties of regular languages, regular grammars, context free grammars, parse-trees, Chomsky Normal Form, top-down parsing).

Randomization and Computation (Monte Carlo and Las Vegas algorithms, Role of Markov and Chebyscheff's inequalities, Chernoff bounds in randomized algorithms, applications of probabilistic method).

Special Topics in Theoretical Computer Science, such as Approximation Algorithms, Number Theoretic Algorithms, Logic and Computability.

Text / References
J. Hein, Discrete Structures, Logic and Computability, Jones and Barlett, 2002.

SI 503 Categorical Data Analysis 3 1 0 8

Prerequisites: SI 404 Regression Analysis


Multi-category Logit Models.
Applications using SAS software.

Texts/ References:

SI 505 Multivariate Analysis 3 1 0 8

Prerequisites: SI 402 Statistical Inference

Distribution theory associated with the analysis.

Texts / References


SI 507 Numerical Analysis 3 0 2 8

Principles of floating point computations and rounding errors.

Systems of Linear Equations: factorization methods, pivoting and scaling, residual error correction method.

Iterative methods: Jacobi, Gauss-Seidel methods with convergence analysis, conjugate gradient methods.

Eigenvalue problems: only implementation issues.

Nonlinear systems: Newton and Newton like methods and unconstrained optimization.

Interpolation: review of Lagrange interpolation techniques, piecewise linear and cubic splines, error estimates.

Approximation: uniform approximation by polynomials, data fitting and least squares approximation.

Numerical Integration: integration by interpolation, adaptive quadratures and Gauss methods.


Two Point Boundary Value Problems: finite difference methods with convergence results.

Lab. Component: Implementation of algorithms and exposure to public domain packages like LINPACK and ODEPACK.

Texts / References


SI 508 Network Models 2 0 2 6

Recap of Linear Programming and duality. Transportation and Assignment. Maximum flow and minimum cut (duality, Ford and Fulkerson algorithm, polynomial time algorithms).

Minimum Cost Flows (cycle cancelling algorithms, successive path algorithms). Matching (bipartite matching, weighted bipartite matching, cardinality general matching).

Routing algorithms (Bellman Ford algorithm in computer networks, Dijkstra's algorithm in computer networks), Application of network models.

Text / Reference

SI 509 Time Series Analysis 2 1 0 6

Prerequisites: SI 402 Statistical Inference

Stationary processes – strong and weak, linear processes, estimation of mean and covariance functions. Wald decomposition Theorem.

Modeling using ARMA processes, estimation of parameters testing model adequacy, Order estimation.


ARMAX, ARIMAX models and introduction to ARCH models.

Multivariate Time Series, State Space Models.

Texts / References


SI 511 Computer-Aided Geometric Design 3 0 0 6


Composite Bezier curves.

Spline curves: Definition and Basic properties of spline functions, B-spline curves, de Boor algorithm. Derivatives. Insertion of new knots. Cubic spline interpolation. Interpretation of parametric continuity in terms of Bezier polygon.

Geometric continuity. Frenet frame continuity. Cubic Beta splines and significance of the associated parameters.


Texts / References:


SI 513 Theory of Sampling 2 1 0 6

Simple random sampling. Sampling for proportions and percentages.


A brief introduction to randomized response techniques and small area estimation

Texts / References


SI 514 Statistical Modeling 2 1 0 6

Prerequisites: SI 402 Statistical Inference

Nonlinear regression, Nonparametric regression, generalized additive models, Bootstrap methods, kernel methods, neural network, Artificial Intelligence, a few topics from machine learning.

Texts / References:


SI 515 Statistical Techniques in Data Mining 2 1 0 6

Pre-requisite: SI 402 Statistical Inference

Introduction to Data Mining and its Virtuous Cycle.


Dimension Reduction and Visualization Techniques: Multidimensional scaling, Principal Component Analysis, Chernoff faces, Sun-ray charts.

Algorithms for data-mining using multiple nonlinear and nonparametric regression.

Neural Networks: Multi-layer perceptron, predictive ANN model building using back-propagation algorithm. Exploratory data analysis using Neural Networks – self organizing maps.


Discussion of Case Studies.

Texts/References:


SI 525 Testing of Hypothesis 2 1 0 6

Prerequisites: SI 402 Statistical Inference

Statistical hypotheses, Neyman-Pearson fundamental lemma, Monotone likelihood ratio, confidence bounds, generalization of fundamental lemma, two-sided hypotheses.

Unbiased tests, UMP unbiased tests, applications to standard distributions, similarity and completion, Permutation tests; most powerful permutation tests.

Symmetry and invariance, most powerful invariant tests, unbiased and invariance.

Tests with guaranteed power, maxi-min tests and invariance. Likelihood ratio tests and its properties.
Texts / References


SI 526 Experimental Designs 2 0 2 6

Prerequisites: SI 402 Statistical Inference

Linear Models and Estimators, Estimability of linear parametric functions. Gauss-Markoff Theorem. One-way classification and two-way classification models and their analyses. Standard designs such as CRD, RBD, LSD, BIBD. Analysis using the missing plot technique.


A brief introduction to Random Effects models and their analyses.

A brief introduction to special designs such as split-plot, strip-plot, cross-over designs.

Response surface methodology.

Applications using SAS software.

Texts / References

A.M. Kshirsagar, A First Course in Linear Models, Marcel Dekker, 1983.


SI 527 Introduction to Derivatives Pricing 2 1 0 6

Prerequisites: SI 407 Introduction to Probability Theory

Basic notions – Cash flow, present value of a cash flow, securities, fixed income securities, types of markets.


Texts / References


SI 528 Biostatistics 2 1 0 6

Pre-requisite: SI 402 Statistical Inference

Introduction to clinical trials and other types of clinical research, bias and random error in clinical studies, overview of Phase I-IV trials, multi-center trials; randomized, controlled clinical trials; concept of blinding/masking in clinical trials.

Design of Phase 1-3 clinical trials: parallel vs. cross-over designs, cross-sectional vs. longitudinal designs, review of factorial designs, objectives and endpoints of clinical trials, formulation of appropriate hypotheses (equivalence, non-inferiority, etc.); sample size calculation; design for bioequivalence/bioavailability trials, sequential stopping in clinical trials.

Analysis of Phase 1-3 trials: Use of generalized linear models; analysis of categorical outcomes, Bayesian and non-parametric methods; analysis of survival data from clinical trials.
Epidemiological studies: case-control and cohort designs; odds ratio and relative risk; logistic and multiple regression models.

Texts/ References:


SI 530 Statistical Quality Control 2106

Total quality control in an industry. Quality planning, quality conformance, quality adherence. Quality assurance and quality management functions.


Different types of control charts. Concept of process capability and its comparison with design specifications, CUSUM charts.

Acceptance sampling. Sampling inspection versus 100 percent inspection. Basic concepts of attributes and variables inspection. OC curve, Single, double, multiple and sequential sampling plans, Management and organisation of quality control.

Texts / References:


SI 532 Statistical Decision Theory 2106

Prerequisite: SI 402 Statistical Inference


Sequential decision problems.

Texts / References


S.S. Gupta and D. Huang, Multiple Statistical Decision Theory, Springer-Verlag, New York, 1981.

SI 534 Nonparametric Statistics 2106

Prerequisite: SI-402, Statistical Inference
Kolmogorov-Smirnov Goodness-of-Fit Test.

The empirical distribution and its basic properties. Order Statistics. Inferences concerning Location parameter based on one-sample and two-sample problems. Inferences concerning Scale parameters. General Distribution Tests based on Two or More Independent Samples.


Asymptotic Relative Efficiency of Tests.
Confidence Intervals and Bounds

Texts / References


J.D. Gibbons, Nonparametric Statistical Inference Marcel Dekker, NewYork, 1985


**SI 540 Stochastic Programming and Applications** 3 0 0 6


Texts / References


V.V. Kolbin, Stochastic programming, D. Reidel Publications, Dordrecht, 1977


**SI 542 Mathematical Theory of Reliability** 2 1 0 6

Pre-requisites: SI 402 Statistical Inference

Coherent Structures, Reliability of systems of independent components, Bounds of system reliability, shape of the system reliability function, notion of ageing, parametric families of life distributions with monotone failure rate, classes of life distributions based on notions of ageing, classes of distributions in replacement.
policies. Limit distributions for series and parallel systems. Statistical inferential aspects for (i) standard reliability models, (ii) parametric and non-parametric classes of aging distributions.

Texts / References


CS 101 Computer Programming & Utilization 2 0 2 6

Functional organization of computers, algorithms, basic programming concepts, FORTRAN language programming. Program testing and debugging, Modular programming subroutines: Selected examples from Numerical Analysis, Game playing, sorting/ searching methods, etc.

Texts / References

K.D. Sharma, Programming in Fortran IV, Affiliated East West, New Delhi, 1976.

CS 206 Formal Methods in CS 2 0 1 6

Propositional Logic and First Order Logic: Syntax and semantics. Proof systems such as Hilbert, Natural Deductions, Sequent and Resolution, Clasual Form, Herbrand Theorem, Unification and Resolution Theorem Proving, Applications of logic to Program Specification and Verification: specification of Abstract Data Types, Hoare logic, assertions, invariants, weakest preconditions, Formal models of programs: Complete partial orders as domains, continuous functions, domain constructors, fix point. Denotational semantic of a while-do language.

Text/References:

N. Francez, Program Verification, Addison Wesley, 1992.

EE 636 Matrix Computations 3 0 0 6


Texts/Reference:

G. Meurant, Computer Solution of Large Linear Systems, North Holland, 1999.


**IT 640 Modern Information System  3 0 0 6**

Introduction to Information Systems, Introduction to Database Management Systems, Software Engineering, Information Technology and basic of networking, Internet Technologies, Web and HTML, Distributed systems, Corporate Information systems.

Texts/References:


**EE 649 Finite Fields and Their Applications  3 0 0 6**


Texts/References:


**EE 720 An Introduction to Number Theory and Cryptography  3 0 0 6**


Finite Fields and Quadratic Residues: Finite fields, Quadratic residues and reciprocity.


Public Key:
The idea of public key cryptography. RSA. Discrete log.

Elliptic Curves:
Basic facts. Elliptic curve cryptosystems.

Texts/References:


A. Weil, Number Theory for Beginners, Additional references.