UNIVERSITY OF PUNE

DEPARTMENT OF MATHEMATICS

M.A. / M.Sc. (Mathematics) SYLLABUS

With effect from June 2014

A two years duration course with total 100 credit points.

Introduction:
University of Pune has decided to change the syllabi of various faculties from June, 2014. Taking into consideration the rapid changes in science and technology and new approaches in different areas of Mathematics and related subjects, Board of Studies in Mathematics

MA/MSc in Mathematics.

The course will follow the credit system of the University of Pune.
The total credits required to complete the course will be 100.

To develop the syllabus the U.G.C. Model curriculum is followed.

Aims:
i) Give the students sufficient knowledge of fundamental principles, methods and a clear perception of the innumerous power of mathematical ideas and tools and knowledge of how to use them by modeling, solving and interpreting.
ii) Reflecting the broad nature of the subject and developing mathematical tools for continuing further study in various fields of science.
iii)Enhancing students' overall development and to equip them with mathematical modeling abilities, problem solving skill, creative talent and power of communication necessary for various kinds of employment .
iv) Enabling students to develop a positive attitude towards mathematics as an interesting and valuable subject of study.

Objectives:
(i) A student should be able to recall basic facts about mathematics and should be able to display knowledge of conventions such as notations, terminology and recognize basic geometrical figures and graphical displays, state important facts resulting from their studies.
(ii) A student should get a relational understanding of mathematical concepts and concerned structures, and should be able to follow the patterns involved with mathematical reasoning.
(iii) A student should get adequate exposure to global and local concerns so as to explore many aspects of Mathematical Sciences.
(iv) Students should be able to apply their skills and knowledge, that is, translate information presented verbally into mathematical form, select and use appropriate mathematical formulae or techniques in order to process the information and draw the relevant conclusion.
(v) A student should be made aware of history of mathematics and hence of its past, present and future role as part of our culture.
(vi) A student should be able to write necessary algorithms and programs in different languages as per the need of the industry.

Eligibility: B.Sc. with any Science stream with Mathematics subject up to second year or equivalent examination.

FIRST YEAR

SEMESTER I
(All are compulsory and each course is of 5 credit points)

MT 101 Linear Algebra
MT 102 Topology
MT 103 Measure and Integration
MT 104 Algebra
MT 105 Numerical Analysis.

Total credits:25 points

SEMESTER II
(All are compulsory and each course is of 5 credit points)

MT 201 Functional Analysis
MT 202 Complex Analysis
MT 203 Rings and Modules
MT 204 Advanced Calculus I
MT 205 Differential Equations

Total credits: 25 points

SECOND YEAR

(In each of Semester III and Semester IV, any five of the following courses which are running in the department should be opted. Each course is of 5 credit points.)

MT 01. Operations Research
MT 02. Integral Equations and Transforms
MT 03. Number Theory I
MT 04. Coding Theory
MT 05. Graph Theory I
MT 06. Lattice Theory I
MT 07. Computational Geometry
MT 08. Cryptography
MT 09. Financial Mathematics
MT 10. Modeling and Simulation
MT 11. Artificial Intelligence
MT 12. Symmetries
MT 13. Wavelets
MT 14. Combinatorics
MT 15. Partial Differential Equations
MT 16. Fuzzy Logic
MT 17. Statistics and Probability
MT 18. Fluid Dynamics
MT 19. Banach Algebra
MT 20. Boundary Value Problems
MT 21. Baer * Rings
MT 22. Matroid Theory I
MT 23. Sperner Theory

MT 24. Differential Equation and Dynamical System
MT 25. Mechanics
MT 26. Algebraic Topology
MT 27. Advanced Calculus II
MT 28. Field Theory
MT 29. Differential Geometry
MT 30. Fourier Analysis
MT 31. Commutative Algebra

MT 32. Complex Analysis II
MT 33. Representation Theory of Groups
MT 34. Fourier Analysis on Finite Groups
MT 35. Non-Linear Dynamical System
MT 36. Topics in Lie Groups.
MT 37. Advanced linear algebra
MT 38. Projective Geometry
MT 39. Algebraic Geometry
MT 40. Algebraic Number Theory
MT 41. Algebraic Curves
MT 42. Advanced Lattice Theory II
MT 43. Graph Theory II
MT 44. Matroid Theory II
MT 45. Group Theory II
MT 46. Ring Theory
MT 47. Topics in Non Commutative Rings.
MT 49. Topics in Algebra
MT 50. Topics in Analysis
MT 51. Topics in Discrete Mathematics
MT 52. Topics in Topology
MT 53. Topics in Goemetry
MT 54. Topics in Differential Equations

SEMESTER I

MIM 101 : Linear Algebra

1. Prerequisites: Vector Spaces: Definition and Examples, Subspaces, Bases and Dimensions, Linear Transformations, Quotient Spaces, Direct Sum, The matrix of Linear Transformation, Duality.
2. Canonical Forms: Eigenvalues and Eigenvectors, The minimal Polynomial, Diagonalisability, Triangular sable Operators, Jordan Forms, The Rational Forms.
3. Inner Product Spaces: Inner Product Spaces, Orthogonally, The Adjoint of Linear Transformation, Unitary operators, Self Adjoint and Normal Operators.
4. Bilinear Forms: Definition and Examples, The matrix of a Bilinear Form, Orthogonality, Classification of Bilinear Forms.

Prescribed Books:
² Luthar and Passi, Modules (Narosa Publishing House).
² Vivek Sahai and Vikas Bist, Linear Algebra (Narosa Publishing House).
Hoffman and Kunze : Linear Algebra

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 102 : Topology

1. Prerequisites: Cartesian Products, Finite Sets, Countable and Uncountable Sets, Infinite Sets and Axiom of Choice, Well Ordered Sets.
2. Topological Spaces : Basis for a topology, Order topology, Subspace Topology, Product topology, closed sets and limit points, Continuous functions, Metric Topology
3. Connected and Compact Spaces: Connected spaces, Connected Subspaces of Real Line, Components and Local Connectedness, Compact spaces, Compact Subspaces of the Real Line, Limit point compactness, Local Compactness.
4. Countablity and Separation Axioms: Countability Axioms, Separation axioms Normal Spaces, Urysohn's Lemma(without proof), Titetz Extension Theorem (Without Proof), Metrization Theorem (without proof), Tychonoff's Theorem.

Prescribed Book:
² J.R. Munkres, Topology : A First Course. Second Edition.
(Ch.1 : Sec 5,6,7,9,10; Ch.2 : Sec 12 to 21; Ch.3 : Sec 23 to 29; Ch.4 : Sec 30 to 35; Ch.5 : Sec 37).

MT 103 Measure and Integration

1. Prerequisites: Cardinal Numbers and Countability, Properties of Open Sets, Cantor Like Sets.
2. Measure on Real Line : Lebesgue Outer Measure, Measurable Sets, Regularity, Measurable Functions, Borel and Lebesgue Measurability.
3. Integration of Functions on Real Variable : Integration of Non Negative Functions, General Integral, Integration of Series, Riemann and Lebesgue Integral.
4. Differentiation : Functions of Bounded Variation, Lebesgue Di®erentiation Theorem, Di®erentiation Theorem, Differentiation and Integration.
5. Inequalities and L_p spaces : The Lp Spaces, The Convex Functions, Jensen's Inequalities, Inequalities of Holder and Minkowski, Completion of L_p.
6. Convergence : Convergence in Measure, Almost Uniform Convergence, Convergence Diagrams, Counter Examples

Prescribed Book:
² G. de Barra, Measure Theory and Integration, New Age International Ltd, Publishers.
(Sec 1.5 to 1.7., 2.1 to 2.5., 3.1 to 3.4., 4.1 to 4.5., 5.1 to 5.6., 6.1 to 6.5., 7.1 to 7.4.).

Reference Book:
{ H.L.Roydon, Real Analysis (Third Ed.), Prentice Hall 1995.

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 104 : Algebra

1. Introduction to Groups : Symmetries of a Square , The Dihedral Groups, Definition and Examples of Groups, Elementary Properties of Groups.

2. Subgroups and Cyclic Groups: Terminology and Notation , Subgroup Tests, Examples of Subgroups, Properties of Cyclic Groups, Classification of Subgroups of Cyclic Groups, Properties of Cosets, Lagrange's Theorem and Consequences.

3. Permutation Groups : Definition and Notation ,Cycle Notation , Properties of Permutations, An application of Cosets to Permutation Groups, The Rotation Group of a Cube and a Soccer Ball.

4 . Group Homomorphism and Isomorphism: Definition and Examples of Homomorphism, Properties of Homomorphism. Definition and Examples of Isomorphism, Properties of Isomorphism , Cayley's Theorem, The First Isomorphism Theorem, Automorphism.

5. External Direct Products : Definition and Examples, Properties of External Direct Products, The Group of Units Modulo n as an External Direct Product, Applications.

6. Normal Subgroups and Factor Groups: Normal Subgroups, Factor Groups, Applications of Factor Groups, Internal Direct Products.

7. Fundamental Theorem of Finite Abelian Groups: The Fundamental Theorem, The Isomorphism Classes of Abelian Groups.

Prescribed Book:
• Joseph A. Gallian, Contemporary Abstract Algebra (Fourth Ed.), Narosa, 1999. (Part 2 : Groups)

Reference Book:
• P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra (Second Ed.), Cambridge Univ. Press (Indian Ed. 1995).
• I. S. Luthar and I. B. S. Passi, Algebra-Vol. 1: Groups, Narosa, New Delhi, 1996.

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT : 105 Numerical Analysis

1. Iterative solutions of nonlinear equation: bisection method. Fixed-point interation, Newton's method, secant method, acceleration of convergence, Newton's method for two non linear equations, polynomial equation methods.
2. Polynomial interpolation: interpolation polynomial, divided difference interpolation, Aitken's formula, ¯nite di®erence formulas, Hermite's interpolation, double interpolation.
3. Linear systems of Equations: Gauss Elimination, Gauss-Jordan method, LU decomposition, iterative methods, and Gauss- Seidel iteration.
4. Numerical Calculus : Numerical di®erentiation, Errors in numerical di®erentiation, Numerical Integration, Trapezoidal rule, Simpson's 1/3 - rule, Simpson's 3/8 rule, error estimates for Trapezoidal rule and Simpson's rule.
5. Numerical Solution of Ordinary di®erential Equations : Solution by Taylor series, Picard Method of successive approximations, Euler's Method, Modifed Eular Method, Runge- Kutta Methods, Predicator-Corrector Methods.
6. Eigenvalue Problem : Power method, Jacobi method, Householder method.
7. Practicals with Scilab.

Prescribed Book:
S. S. Sastry, Introduction Methods of Numerical Analysis (4th Edition)(Prentice-Hall).
Refrence Book:
K .E. Atkinson,: An Introduction to Numerical Analysis.
J. I. Buchaman and P. R. Turner, Numerical Methods and Analysis..

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SEMESTER II

MT 201 Functional Analysis

Inequalities, normed spaces bounded linear operators, linear functionals , Hahn Banach theorem, finite dimensional normed spaces, Baire category, closed graph theorem, Stone - Wierstrass theorem, contraction mappping, Hilbert spaces, orthonormal systems, adjoints, algebra of bounded operators.

Prescribed book : B. Bollobas : Linear Analysis an introductory course , Cambridge(1990). Chapters 1-7, 9-12.

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 202 : Complex Analysis

1. Pre-requisites:
(a) Topological and Analytical Preliminaries: Point sets in the plane, sequences, compactness, stereographic projection, continuity.
(b) Elementary Functions: Exponential functions, mapping properties, logarithmic function, complex exponents.
2. Analytic Functions: Cauchy-Riemann Equations, analyticity, harmonic functions.
3. Power Series: Sequences, uniform convergence, Maclaurin and Taylor series, operations on power series.
4. Complex Integration and Cauchy's Theorem: Curves, parameterizations, line integral, Cauchy's Theorem.
5. Applications of Cauchy's Theorem: Cauchy's integral formula, Cauchy's inequality and applications, maximum modulus theorem.
6. Laurent Series and Residue Theorem: Laurent series, classi¯ cation of singularities, evaluation of real integrals, argument principle.
7. Bilinear Transformations and Mappings: Basic mappings, linear fractional transformations, other mappings.

Prescribed Book:

J. B. Conway, *Functions of one complex variables*, Narosa Publishing House.

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 203 Rings and Modules :

Rings, Ideals and homomorphisms, factorization in domains, ,modules , modules with chain conditions.

Prescribed Book:
C. Musili : Rings and modules, Narosa, (1999) Chapters 1-6

Algebraic extension of fields, normal and separable extensions, Galois theory, Applications of Galois theory to classical problems.
Prescribed Book:
P. B. Bhattacharya, S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra, Second Ed., Cambridge University Press, Cambridge, 1995.Chapters 15 -18.

MT 204 : Advanced Calculus I

1. Compact and Connected Subsets of R_n:
2. Differentiation : Derivative, Continuously Differentiable functions, Chain rule, Inverse function theorem, Implicit function theorem.
3. Integration: integral over a rectangle, Existence of the Integral, evaluation of the integral, integral over a bounded set and rectifiable sets, improper integrals
4. Change of Variable Theorem
5.Line Integrals with Applications

Prescribed Book:
J.R. Munkres, Analysis on Manifolds.
(Sections 4 to 15 and Section 17).
Reference Book:
T.M. Apostol, Calculus (Volume II).
(Chapter 10 : Sections 10.1 to 10.9).

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 205 : Differential Equations

1. Prerequisites: Linear equations of the first order.
2. Linear equations with constant coefficients : Second order homogeneous equations, Initial value problems, Linear dependence and independence, Nonhomogeneous equations of n-th order, Algebra of constant coefficients.
3. Linear equations with variable coefficients : Initial value problems, Solutions of the homogeneous equation, Wronskian and linear independence, Reduction of order, Nonhomogeneous equations, Legendre equation.
4. Linear Equations with regular singular points : Euler equation, Second order equation with regular singular points, Exceptional cases, Bessel equation.
5. Existence and uniqueness of solutions to first order equations: Separation of variables, exact equations, Method of successive approximations, Lipschitz condition, Approximation to and uniqueness of solutions.
6. Existence and uniqueness of solutions to systems and n-th order

equations: Complex n-dimensional space, Systems as vector equations, Existence and uniqueness of solutions to systems, Existence, Uniqueness for linear systems and equations of order *n:*

Prescribed Book:
² E. A. Coddington, An Introduction to Ordinary Di®erential Equatins (Prentice- Hall).
Reference Book:
² G. F. Simmons and S. G. Krantz, Di®erential Equatins (Tata McGraw-Hill).

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Second Year M.Sc

Optional Subjects

MT 01 – Operations research

Unit I - Kuhn – Tucker conditions of Optimality – Quadratic Programming
(Sections 19.2.2B, 20.2.2)
Unit II - Inventory Models
(Sections 14.1 to 14.3)
Unit III - Queuing Models
(Section 15.1, 15.2, 15.4, 15.5)
Unit IV - Project Scheduling By PERT – CPM
(Sections 13.1 to 13.4)
Unit V - Simulation Modeling with SIMNET – II
(Sections 17.1 to 17.10)

Textbook :
Hamy A.Taha, Operations Research, Fifth Edition, Prentice Hall of India.

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MT 02- Integral transforms

A) Classification of Liner Integral Equations : Fredholm, Volterra, Integro-Differential Equations, Singular Integral Equations, Converting Volterra Equation to ODE, Conversion of IVP to Volterra equation Conversion of BVP to Fredholm equation
B) Fredholm Intergral Equations - Decomposition method, Direct Computation method, successive approximation method, method of successive substitutions, Homogeneous Fredholm Equations, Comarison between alternative methods.
C) Volterra Integral Equation - Adomian Decomposition method, Series solution method, converting Volterra equation to VIP, Successive Approximation method, successive substitution method, comparison between alternative methods.
D) Integro-Differential Equations - Introduction, Direct Computation method, Adomian Decomposition Method. Conversion to Fredholm integral Equation. Volterra Integro-Differential equations Series Solution, Decomposition Method, Conversion to IVP.

E) Singular Integral Equations - Abel problem , Generalized Abel Integral Equation, Weakly-singular Volterra Equations.
F) Non Linear Integral Equations - Non linear Fredholm Integral equations, Direct Computation, decomposition method, Non liner Volterra Integral Equation, Series solution, Decomposition method
G) Existence and uniqueness of solutions using fixed-point theorems in cash of Liner and nonlinear Volterra and Fredholm integral equations.
H) Fourier Transforms: [FT] Definition Properties evaluation of Fourier and inverse Fourier transforms of functions, Convolution theorem for FT. Sine and Cosine Fourier transforms. Solving differential equations and integral equations using FT.
I) Laplace Transform: Definition Properties, evaluation of Laplace and Inverse Laplace transforms of functions. Convolution theorem for Laplace Transforms. Solving initial value problem using Laplace Transforms. Solving integral equation using Laplace Transforms.

Reference Books:
1) A First course in integral equations –A.M. Wazwaz (1997) (world Scientific)
2) Introduction to Integral Equation with Applications –A.J. Jerri (1999) Second edition Wiley Interscience.

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MT 03 – Number theory

1. Congruences : Solutions of congruencs. Chinese Remainder Theorem, Techniques of numerical calculation Public-Key Cryptography.
2. Prime power moduli. Prime modulus. Primitive roots and power residues, Congruences of degree two.
3. Quadratic Residues, Quadratic Reciprocity.
4. Greatest integer function, Arithmetic functions, Multiplicative functions,Dirichlet multiplication. Mobius Inversion Formula.
5. Diophantine equations. The equation ax + by = c, Pythagorean triangles, Assorted examples. Rational points on curves.
6. Algebraic Numbers :- Algebraic Numbers, Algebraic number fields. Algebraic integers, Quadratic fields. Units in Quadratic fields. Primes in Quadratic fields. Unique factorization Primes in quadratic fields having the unique factorization property.

Text Books:
1.Niven and Zuckerman, An introduction to the Theory of Numbers, Wiley Publishers.
2.David Burton, Elementary Number Theory.

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MT 04 – Coding theory

1. Error detection: correction and decoding: Communication channels, Maximum likelihood decoding, Hamming distance, Nearest neighbor / minimum distance decoding, Distance of a code.
2. Linear codes: Vector spaces over finite fields, Linear codes, Hamming weight, Bases of linear codes, Generator matrix and parity check matrix, Equivalence of linear codes, Encoding with a

linear code, Decoding of linear codes, Cossets, Nearest neighbor decoding for linear codes, Syndrome decoding.
3. Cyclic codes: Definitions, Generator polynomials, Generator and parity check matrices, Decoding of cyclic codes, Burst-error-correcting codes.
4. Some special cyclic codes: BCH codes, Definitions, Parameters of BCH codes, Decoding of BCH codes.

Reference:
1. San Ling and Chaoing xing, Coding Theory- A First Course
2. Applied Abstract Algebra - Lid and Pilz 2nd Edition

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 05 – Graph theory

Paths and cycles, trees, planarity, coloring, digraphs, matchings, marriage and Mengers theorem.

Prescribed Book :
R. J. Wilson, Introduction to graph theory, Pearson, (2003) Chapters 1 – 8.

Reference Books:
1. John Clarke and D.A. Holton, A First Look at Graph Theory, Allied Publisher (1991)
2. Nora Harsfield and Gerhard Ringel , Pearls Theory, Academic Press (1990)
3. Harary, Graph Theory, Narosa Publishers, New Delhi (1989)

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 06 – Lattice theory

Two definitions of lattices, Hasse diagrams, homomorphism, isotone maps, ideals, congruence relations, congruence lattices, the homorphism theorem, product of lattices, complete lattice, ideal lattice, distributive –modular inequalities and identifies, complements, pseudocomplements, Boolean lattice of pseudocomplements, join and meet-irreducible elements.
Characterization theorems and representation theorems-Dedekind`s modularity criterion Birkhoff`s distributivity criterion, hereditary subsets, rings of sets, Stone theorems, Nachbin theorem, statements of Hashimoto's theorem.
Modular lattices, isomorphism theorem, Upper and lower covering conditions, Kuros-Ore theorem, independent sets (Drops results involving projectivity and sublattice generated by sets / elements)
Semimodular lattices Jordan-Holder chain condition, Modular pair, M-sysmmetric lattices.

Prescribed Book :
General Lattice Theory , G. Gratzer (Birkhauser, IInd Edition 1998)
Chap. 1 Section 1,2,3,4,6, Cha. 2 Section-1, Chap.3. Section –1,2.

MT 07 – Computational geometry

1. Geometric primitives [Chap. 1]
2.Line intersection [Chaps. 2] plus randomized incremental
3. Triangulation and visibility and [Chaps. 3,15]

4. Linear programming in two and three dimensions [Chap. 4]
5. Orthogonal range searching [Chaps. 5,10]
6. Point location and Binary Space Partitions [Chaps. 6,12]
7. Voronoi diagrams and Delaunay triangulation [Chaps. 7,9]
8. Convex hulls [Chap. 11]
9. Non-orthogonal range searching [Chap. 16]
10. Curved Elements (Bezier, B-Splines)
11. Curve Reconstruction (reconstruction a curve(surface) from sample points)
12. 3-Dimensional Geometry

Prescribed Book :
Computational Geometry Algorithms and Applications, 2nd ed., by de Berg, van Kreveld, Overmars, and Schwarzkopf (Springer-Verlag, 2000).

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 08 – Cryptography

1. Introduction : Overview of course, Classical cryptography [parts of Chapter 1].
2. Secret Key Encryption : Perfect Secrecy - One time pads [Chapter 2.1], Stream ciphers and the Data Encryption Standard (DES) [Chapter 3 (excluding 3.6)], The Advanced Encryption Standard (AES) - adopted September 2000.
3. Public Key Encryption : Factoring and the RSA encryption [Chapter 4.1 - 4.4], Discrete log. Diffie-Hellman Key Exchange [Chapter 8.4 (only pages 270-273)]. ElGamal encryption [Chapter 5 (only pages 162-164)] , Digital Signatures [Chapter 6 (excluding 6.5 - 6.6)], One-time signatures, Rabin and ElGamal signatures schemes, Digital Signature Standard (DSS).
4. Hashing : Motivation and applications. Cryptographically Secure Hashing. [Chapter 7.1-7.3,7.6], Message Authentication Codes (MAC). HMAC, Network Security , Secure Socket Layer (SSL), I Psec.,Secret Sharing, Definition. Shamir's threshold scheme [Chapter 11.1], Visual secret sharing schemes.

Prescribed Book :
D. R. Stinson. *CRYPTOGRAPHY: Theory and Practice.* CRC Press. 1995.
N. Koblitz : A course in number theory and cryptography. Springer.

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 09 – Financial mathematics

1. Introduction to options and markets: types of options, interest rates and present values.
2. Black Sholes model : arbitrage, option values, pay offs and strategies, put call parity, Black Scholes equation, similarity solution and exact formulae for European options, American option, call and put options, free boundary problem.
3. Binomial methods : option valuation, dividend paying stock, general formulation and implementation.
4. Monte Carlo simulation : valuation by simulation
5. Finite difference methods : explicit and implicit methods with stability and conversions analysis methods for American options- constrained matrix problem, projected SOR, time stepping algorithms with convergence and numerical examples.

6. Lab component: implementation of the option pricing algorithms and evaluations for Indian companies.

Prescribed Book :
1. D.G.Luenberger, Investment Science, Oxford University Press,1998.
2. J.C.Hull , Options, Futures and Other Derivatives, 4th ed., Prentice- Hall ,New York,2000.
3. J.C.Cox and M.Rubinstein, Option Market, Englewood Cliffs,N.J.: Prentice- Hall,1985.
4. C.P. Jones. Investments, Analysis and Measurement, 5th ed.,John Wiley and Sons,1996.

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MT 10 – Modeling and simulation

1. Introduction to modeling and simulation. System analysis, classification of systems. System theory basics, its relation to simulation.
2. Model classification: conceptual, abstract, and simulation models. Heterogeneous models. Methodology of model building
3. Simulation systems and languages, means for model and experiment description. Principles of simulation system design
4. Parallel process modeling. Using Petri nets and finite automata in simulation
Models o queuing systems. Discrete simulation models. Model time, simulation experiment control.
5. Continuous systems modeling. Overview of numerical methods used for continuous simulation.
6. Combined simulation. The role of simulation in digital systems design
7. Special model classes, models of heterogeneous systems.
8. Checking model validity, verification of models. Analysis of simulation results
9. Simulation results visualization. Interactive simulation
10. Design and control of simulation experiments. Model optimization
11. Generating, transformation, and testing of pseudorandom numbers. Stochastic models, Monte Carlo method
12. Overview of commonly used simulation systems.

Prescribed Book :
1. Fishwick P.: Simulation Model Design and Execution, PrenticeHall, 1995, ISBN 0-13-098609-7
2. Law A., Kelton D.: Simulation Modelling and Analysis, McGraw-Hill, 1991, ISBN 0-07-100803-9
3. Rábová Z. a kol: Modelování a simulace, VUT Brno, 1992, ISBN 80-214-0480-9
4. Ross, S.: Simulation, Academic Press, 2002, ISBN 0-12-598053-1.

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 11 – Artificial intelligence

1. Overview of history and goals of AI : Tentative definitions. Turing's test. Knowledge vs. Symbolic Level. Relations with other disciplines, from Philosophy, to Linguistics, to Engineering. Review of AI successes and failures.
2. State Spaces, Production Systems, and Search : State Space representation of problems. Problem solving as search. Constraints. Definition and examples of Production Systems. Heuristic search techniques. Two person games.

3. Knowledge Representation Issues: Procedural Knowledge Representation vs. Declarative Knowledge + Reasoning. Facts, General Assertions, Met knowledge. The Frame Problem.
4. Using First-Order Logic for Knowledge Representation : Propositional Logic: Semantics and Deduction. First Order Logic: Semantics and Deduction. Unification. Resolution-based theorem proving. Using theorem proving to answer questions about the truth of sentences or to identify individuals that satisfy complex constraints. Logic Programming.
5. Common Sense Reasoning : No monotonic reasoning and modal logics for nonmonotonic reasoning. How to deal with Agents and their Beliefs.
6. Weak Slot-and-Filler Structures: Semantic Nets and Frames. Scripts for representing prototypical combinations of events and actions.
7. Rule-Based Systems: Pattern-matching algorithms. The problem of Control in Rule Based Systems. The Rete Algorithm.
8. Planning: Representing plans. Partial order planning. Planning applications.
9. Statistical Reasoning: Use of Certainty Factors in Rule-Based Systems. Associating probabilities to assertions in first-order logic. Bayesian Networks. Fuzzy Logic.
10. Learning: Learning to classify concepts using features of their instances. Learning a concept [Induction] from examples. Explanation-Based Learning. Version Spaces. Neural Nets with back propagation.

Prescribed Book :
Artificial Intelligence: A Modern Approach : Prentice-Hall, 1995

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 12 – Symmetries

1. Symmetry of plane figures of motions of the plan, finite groups of motions, discrete groups of motion, symmetry, cosets, counting formula, permutation representations, finite subgroups of the generators and relations
2. Operation of a group on itself, class equation of the isocahedral groups operations on subsets groups of order12, free group generators and relations.
3. Bilinear forms, symmetric forms, orthogonality, geometry associated to a positive from, Hermitian forms, spectral theorem, conics and quadrics, normal operators, skew symmetric forms.

Prescribed Book :
Artin : Algebra (Prentice-Hall)
Chapters 5, 6 (sections 1, 2, 3), 7.

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 13 – Wavelet analysis

1. Fourier Transform : Fourier transform on $L_1(R)$ and $L_2(R)$ and basic properties and examples
2. Windowed Fourier Transform : Motivation and definition of Windowed Fourier Transform and examples, Time frequency localization, the reconstruction formula.
3. Continuous Wavelet Transform : Motivation and Definition of the wavelet transform and examples, Basic properties, The reconstruction formula, Frequency localization, Orthonormal Wavelets.
4. Multiresolution Analysis : Definition of MRA and examples, Properties of scaling functions and orthonormal wavelets bases, Construction of orthonormal wavelets.

Prescribed Book :
1. Bachman G, L. Narici & E. Beckensterin: Fourier and Wavelet
Analysis, Springer-Verlage (2000)
2. Chui C. K. : An Introduction to Wavelets, Academic Press (1992).
N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 14 – Combinatorics

1. Counting Methods for selections arrangements: Basic counting principles, simple arrangements and selections, arrangements and selection with repetition, distributions, binomial, generating permutations and combinations and programming projects.
2. Generating function : Generating function models, calculating of generating functions, partitions exponential generating functions, a summation method.
3. Recurrence Relations : Recurrence relation model, divide and conquer relations, solution of inhomogeneous recurrence relation, solution with generating functions.
4. Inclusion-exclusion: Counting with Venn diagrams inclusion formula, restricted positions and rook polynomials.
5. Ramsey Theory: Ramsey theorem, applications to geometrical problems.
Prescribed Book :
1. Alan Tucker, Applied Combinatorics (third edition), John Wiley & sons , New York (1995)
2. V. Krishnamurthy, Combinatorial, Theory and Applications, East West Press, New Delhi (1989) Scientific, (1996)

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 15 – Partial differential equations

1. First order PDE, Linear Equations of first order, Charpit's method, Jacobi's method, Quasi-linear equations, Non-linear first order PDE.
2. Second ordered PDE: Genesis, Classification, One dimensional Wave equation, Laplace equation, Boundary Value Problems, Maximum and Minimum Principles, Cauchy Problem,
3. Heat Conduction Problem, Duhamel's Principle

Prescribed Book :
T. Amaranath: An Elementary Course in Partial Differential Equations (Narosa) Chapters 1-2.

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 16 – Fuzzy logic

1. Fuzzy Sets and Operations on Them
2. Fuzzy Relations
3. Fuzzy Rules
4. Approximate Reasoning
5. Fuzzy Logic
6. Fuzzy Systems (e.g., Fuzzy Logic Control)
7. Fuzzy Logic in Pattern Recognition
8. Fuzzy Decision Making
9. Fuzzy Logic Applications

Prescribed Book :
George J. Klir, Bo Yuan, *Fuzzy Sets and Fuzzy Logic: Theory and Applications*, Prentice Hall PTR, 1995.
Hao Ying, *Fuzzy Control and Modeling: Analytical Foundations and Applications*, IEEE Press, 2000. (Do not need to buy it. A handout will be distributed).

MT 17 – Statistics and probability

1. Introduction to Discrete Probability : Intuitive concepts: probability of an event as a measure between 0 and 1; random variable; probability distribution; frequency interpretation of probability; random numbers; coins, dice, and other games; simulations; odds; historical development of probability; random walks. 2. Formal concepts: sample space, outcomes, and events; random variable; discrete distribution functions and axioms of probability; unions, intersections, and complements; properties of probabilities, principle of inclusion and exclusion; tree diagrams; uniform distributions over finite sets, symmetry; infinite sample spaces with discrete probabilities.
3. Introduction to Continuous Probability: The intuitive problems with probabilities over space (line, plane, R_n in general). Monte Carlo simulations, Buffon's needle. Formal concepts: density function for a continuous random variable; integration; cumulative distribution functions; derivatives; exponential density function;
4. Conditional Probability : Intuitive concept of conditional probability; formal definition of conditional probability; Bayes' formula for inverting conditional probabilities; independent events; joint distribution functions; independent random variables; independent trials. Conditional density functions for continuous distributions; the beta distribution
5. Distributions and Densities : Uniform continuous distributions; geometric distribution; Poisson distribution; exponential and gamma distributions; introduction to queuing theory; normal (Gaussian) distribution; Chi-squared distribution
6. Expected Value and Variance : Expected value for discrete random variables, expectation; linearity of expectation; expectation of independent random variables; conditional expectation; variance and standard deviation; variance of various distributions. Expectation and variance for continuous random variables.
7. Sums of Random Variables : Analysis of sums of independent random variables with identical distributions, that is, independent trials.
8. Law of Large Numbers : Chebychev inequality, law of averages, law of large numbers.
9. The Central Limit Theorem : The central limit theorem for Bernoulli trials, binomial distributions again, the normal distribution, the general central limit theorem.

Prescribed Book :
Charles M. Grinstead and J. Laurie Snell's textbook *Introduction to Probability*, published by the American Mathematical Society, 1997

MT 18 – Fluid dynamics

1. Physical Properties of fluids. Concept of fluids, Continuum Hypothesis, density, specific weight, specific volume.
2. Kinematics of Fluids : Eulerian and Lagrangian methods of description of fluids, Equivalence of Eulerian and Lagrangian method, General motion of fluid element, integrability and compatibility conditions, strain rate tensor, stream line, path line, streak lines, stream function¸ vortex lines, circulation.

3. Stresses in Fluids : Stress tensor, symmetry of stress tensor, transformation of stress components from one co-ordinate system to another, principle axes and principle values of stress tensor.
4. Conservation Laws : Equation of conservation of mass, equation of conservation of momentum, Navier Stokes equation, equation of moments of momentum, Equation of energy, Basic equations in different co-ordinate systems, boundary conditions.
5. Irrotational and Rotational Flows : Bernoulli's equation, Bernoulli's equation for irrotational flows, Two dimensional irrotational incompressible flows, Blasius theorem, Circle theorem, sources and sinks, sources sinks and doublets in two dimensional flows, methods of images.

Prescribed Book :
1. An introduction to fluid dynamics, R.K. Rathy, Oxford and IBH Publishing Co. 1976.
2. Theoretical Hydrodynamics, L. N. Milne Thomson, Macmillan and Co. Ltd.
3. Textbook of fluid dynamics, F. Chorlton, CBS Publishers, Delhi.
4. Fluid Mechanics, L. D. Landau and E.N. Lipschitz, Pergamon Press, London, 1985.

MT 19 – Banach algebras

1. Relatively compact sets, compactly continuous operators, finite dimensional operators, transformation that is bounded but not completely continuous, a type of transformation that is always completely continuous, further properties of completely continuous transformations.
2. Spectra and the resolvent set, Approximate proper values, Banach Algebra With identity, compactness of the spectrum, the resolvent operator, Spectral radius and spectral mapping theorem for polynomials, the Gelfand Theory.
3. Sesquilinear functions: Spectral results for normal and completely continuous operators, numerical range
4. The Fredholm alternative theory, the spectral theorem for bounded, normal Finite dimensional operators.
5. Commutative Banach Algebras, ideals and homomorphisms.

Prescribed Book:
1. Walter Rudin: Functional Analysis, Tata MeGrow Hill Publishing co. New Delhi.

MT 20 – Boundary value problems

1. Definition of boundary Value Problems, the heat equation, wave equation, Laplace's equation, the Fourier method, Liner Operators, Principal of Superposition, series solutions, uniform convergence (weierstrass M-test), separation of variables, non homogeneous conditions, Sturm-Liouville problems, formal solutions, the vibrating string.
2. Orthogonal sets of functions, Generalized Fourier series, Best approximation in the mean, Convergence in the mean, the orthonormal trigonometric functions, other types of orthogonality.
3. sturm-Liouville Problem and applications, orthogonality and uniqueness of eigenfunctions, method of solutions, surface heat transfer other boundary value problems.
4. Bessel function J_n, recurrence relation, the zero of $J_0(X)$ and related functions, Fourier-Bessel series, Temperatures in a long cylinder.
5. Legendre polynomials, orthogonality of Legendre polynomials, Legendre series, Dirichlet Problem in spherical regions.

Prescribed Text Book
R.V. Churchill and J. Brown.: Fourier Series and Boundary Value Problems (4th edition)(Publisher: McGraw-Hill Book Company)

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 21 - Baer* rings

1. Rings with involution
2. Poset of projections
3. Proper involutions and C*-algebras
4. Rickart *-rings and Bear *-ring
5. Weakly Rickart *-rings and unitification
6. Central cover
7. Additivity of projections
8. Comparability axioms and parallelogram law
9. Finite and abelian projections
10. Structure Theorem

Prescribed Book: Bear *-rings, S.K. Berberian, Springer

MT 22 – Matroid theory

1. Basic definitions and examples
Independent sets and circuits, bases, rank, closure, geometric representations of matroids of small rank, transversal matroids, the lattice of flats, the greedy algorithm.
2. Duality
The definition and basic properties, duals of representable matroids, duals of graphic matroids, duals of traversal matroids.
3. Minors
Contraction, Minors of certain matroids, flats and the sum theorem
4. Connectivity
Connectivity, for graphs and matroids, properties of matroid connectivity, more properties of connectivity.

Prescribed Book :
James G. Oxley, Matroid Theory Science Publications, Oxford (1992)(Chapter 1 to 4)

MT 23 – Sperner theory

1. Introduction and Sperner`s Theorem: A Simple intersection result, Sperner`s theorem, Theorem of Bollobaas.
2. Normalized Matching and rank numbers: Sperner`s proof, system of distinct representatives, L Y M inequalities, and normalized matching property. Rank numbers, some examples.
3. Symmetric Chain: Symmetric chain decompositions, Dilworth`s theorem, symmetric chains of sets, Application to Nested chains, posets with sysmmetric chain decompositions.
4. Rank numbers of multisets. Unimodality and log connectivity, the normalized matching property. The largest size of a rank number.

Prescribed Text Book
Ian Anderson : Combinatorics of Finite Sets. (Oxford Science Publications)

Reference Book.
Konrad Engel: Sperner Theory (Cambride University Press)

MT 24 – Differential equations and dynamical systems

1) Liner Systems: Uncoupled Liner Systems, Diagonalization, Exponential of operators Fundamental theorem for liner systems, liner systems in R, Complex eigenvalues, multiple eigenvalues,jorden Canonical Forms, stability theory Nohomogeneous Liner systems.
2) Nonlinear Systems: Local Theory, Fundamental existence theorem dependence on initial conditions and parameters, the maximal interval of existence, Flow defined by a differential equation. Linearization, stable manifold theorem, Hartman-Grobman theorem, Stability and Lipunov functions, Saddles, Nodes, Foci and centers, Nonhyperbolic critical points in R_n, Gradient and Hamiltonian system.

Prescribed book :
(1) L. Perko- Differential Equations and Dynamical systems (1991) Springer-verlag
(2) Hirsch and Smale – Differential Equations, Dynamical Systems, and Liner Algebra - Academic Press, New York, (1974) .

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 25 – Mechanics

1. Sec 1.1-1.6 Survey of Elementary Principles.
2. Sec. 2.1-2.7 Variational Principles & Lagrange`s Equation
3. Sec.3.1-3.7 Central Force problem
4. Sec. 4.1-4.10 Kinematics of rigid body motion
5. Sec. 8.1-8.2 Hamilton Equations of motion
6. Sec.9.1-9.9 Canonical Transformations

Prescribed Book :
Classical Mechanics by Goldstein, Poole and Safko (Third Edition) 2002, Person Education Inc.
Supplementary Reading (1) Rana & Joag Classical Machanics (Tata McGraw Hill)

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 26 Algebraic Topology

Fundamental group, Separation theorems in the plane, Siefert- van Kampen Theorem, Classification of covering spaces.

Prescribed book:
James R. Munkres : Topology, Pearson,(2002) Chapters 9, 10, 11, 13.

MT 27 Advanced Calculus II

Manifolds, Differential forms, Stokes theorem.

Prescribed book :
J. R. Munkres : Analysis on Manifolds , Addison Wesley, (1993) Chapters 5,6,7.

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 28 Field Theory

1. Field Extensions :
   Basic Theory of Field Extensions
   Algebraic Extensions
   Classical Straightedge and Compass Constructions
   Splitting Fields and Algebraic Closures
   Separable and Inseparable Extensions
   Cyclotomic Polynomials and Extensions

2. Galois Theory :
   Basic Definitions
   The Fundamental Theorem of Galois Theory
   Finite Fields
   Galois Groups of Polynomials
   Solvable and Radical Extensions: Insolvability of the Quintic

Text Book : Dummit and Foote, Abstract Algebra, 2nd Edition, Wiley Eastern Ltd.
Chapters : 13.1 to 13.6
14.1 to 14.3, 14.6 , 14.7 (statements only)
Reference Books :
1. O. Zariski and P. Sammuel, Commutative Algebra, Vol. 1, Van Nostrand.
2. P. Bhattacharya and S. Jain, Basic Abstract Algebra, Second Edition,
   Cambridge University Press.

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 29 Differential Geometry

Graphs and level sets, vector fields, tangent spaces, surfaces, vector fields on surfaces, orientation, gauss map, geodesics, parallel transport,Weingarten map, curvature, arc length and line integrals, curvature of surfaces, parametrised surfaces, surface area and volume, exponential map, surfaces with boundary.

Prescribed Book:
John A. Thorpe : Elementary topics in differential Geometry , Springer (2004) Chapters : 1-12, 14, 17, 19,20.

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 30 Fourier Analysis

Vibrating string, heat equation, basic properties of Fourier series, convergence of Fourier series, applications of Fourier series, Fourier transform on R.

Prescribed Book:
E. Stein and Shakarachi : Fourier Analysis, Princeton University, Chapters 1-5.

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.

MT 31 Commutative Algebra

Rings and ideals, modules, rings and modules of fractions, primary decomposition, integral dependence and valuations, chain conditions, Noetherian rings, Artin rings, discrete valuation rings, and Dedekind domains.

Prescribed book : M. F. Atiyah and I. G. Macdonald :Introduction to commutative algebra, Sarat Impressions, (2007) Chapters 1 – 9.

N. B. : Students are also required to use suitable mathematical softwares to solve relevant problems.