# DEPARTMENT OF MATHEMATICS
## JADAVPUR UNIVERSITY
### M.Sc. Syllabus (Semester System)

#### 1st Year M.Sc. 1st Semester

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#### 2nd Year M.Sc. 1st Semester

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#### 2nd Year M.Sc. 2nd Semester

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<td>4.1</td>
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<td>4.2</td>
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<td>4.3</td>
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<td>4.5</td>
<td>Special Paper (OP – B-2.1 to B-2.39)</td>
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M.Sc. First Year First Semester (250 marks)

Unit 1.1: Algebra-I (50 Marks)

Groups (25 Marks):
Homomorphism of groups, Normal Subgroups, Quotient Groups, Isomorphism Theorems, Cayley’s Theorem.
Generalized Cayley’s Theorem, Cauchy’s Theorem, Group Action, Sylow Theorems and their applications.
Normal and Subnormal Series, Composition Series, Solvable Groups and Nilpotent Groups, Jordan-Hölder Theorem and its applications.

Rings (15 Marks):
Ideals and Homomorphisms, Prime and Maximal Ideals, Quotient Field of an Integral Domain, Polynomial and Power Series Rings.
Divisibility Theory: Euclidean Domain, Principal Ideal Domain, Unique Factorization Domain, Gauss’ Theorem.
Noetherian and Artinian Rings, Hilbert Basis Theorem, Cohen’s Theorem.

Modules (10 Marks):
Left and Right Modules over a ring with identity, Cyclic Modules, Free Modules, Fundamental Structure Theorem for finitely generated modules over a PID and its applications to finitely generated abelian groups.

References:

Hungerford, T.W., Algebra, Springer.
Jacobson, N., Basic Algebra, I & II, Hindustan Publishing Corporation, India.
Unit 1.2 : Real Analysis (50 Marks)

Fourier Series and Fourier Transformation.

Bounded Variation.

Functions of Bounded Variation and their properties, Differentiation of a function of bounded variation, Absolutely Continuous Function, Representation of an absolutely continuous function by an integral.

The Theory of Measure.

Semiring and ring of sets, σ-ring and σ-algebra, Ring and σ-ring generated by a class of sets, Monotone class of sets, Monotone class generated by a ring, Borel Sets. Measures on semirings and their properties, Outer Measure and Measurable Sets, Caratheodory Extension: Outer measure generated by a measure, Lebesgue measure on $\mathbb{R}^n$, Measure space, Finite and σ-finite measure spaces. Measurable Functions, Sequence of measurable functions, Egorov’s Theorem, Convergence in Measure.

The Lebesgue Integral.


References:

Halmos, P.R., Measure Theory, Van Nostrand, New York, 1950.

Note: This course is based on book (1), Chapters 3, 4.
Unit 1.3 : (Complex Analysis)

Complex Numbers:
Complex Plane, Lines and Half Planes in the complex plane, Extended plane and its Spherical Representation, Stereographic Projection.

Complex Differentiation:
Derivative of a complex function, Comparison between differentiability in the real and complex senses, Cauchy-Riemann Equations, Necessary and Sufficient Criterion for complex differentiability, Analytic functions, Entire functions, Harmonic functions and Harmonic conjugates.

Complex Functions and Conformality:
Polynomial functions, Rational functions, Power series, Exponential, Logarithmic, Trigonometric and Hyperbolic functions, Branch of a logarithm, Analytic functions as mappings, Conformal maps, Möbius Transformations.

Complex Integration:
The complex integral (over piecewise $C^1$ curves), Cauchy’s Theorem and Integral Formula, Power series representation of analytic functions, Morera’s Theorem, Goursat’s Theorem, Liouville’s Theorem, Fundamental Theorem of Algebra, Zeros of analytic functions, Identity Theorem, Weierstrass Convergence Theorem, Maximum Modulus Principle and its applications, Schwarz’s Lemma, Index of a closed curve, Contour, Index of a contour, Simply connected domains, Cauchy’s Theorem for simply connected domains.

Singularities:
Definitions and Classification of singularities of complex functions, Isolated singularities, Laurent series, Casorati-Weierstrass Theorem, Poles, Residues, Residue Theorem and its applications to contour integrals, Meromorphic functions, Argument Principle, Rouche’s Theorem.

Analytic Continuation:
Schwarz Reflection Principle, Analytic Continuation along a path, Monodromy Theorem.

References:

Note: This course is based on the books (1) and (2), as described below:
Section (i) : Books (1) & (2), Chapter I. Section (ii) : Book (2), Chapter II.
Section (iii) : Book (1), Chapter III. Section (iv) : Book (2), Chapters VI, VII, IX.
Section (v) : Book (1), Chapter V & Book (2), Chapter VIII. Section (vi) : Book (1), Chapter IX.
Unit 1.4 : General Mechanics (50 Marks)


Time dependent Hamilton-Jacobi equation and Jacobi’s Theorem. Lagrange Brackets. Condition of canonical character of transformation in terms of Lagrange brackets and Poisson brackets. Invariance of Lagrange brackets and Poisson brackets under canonical transformations.

References:

Unit 1.5 : Differential Geometry ( 50 Marks)

**Tensors:**
Tensor and their transformation laws, Tensor algebra, Contraction, Quotient law, Reciprocal tensors, Kronecker delta, Symmetric and skew-symmetric tensors, Metric tensor, Riemannian space, Christoffel symbols and their transformation laws, Covariant differentiation of a tensor, Riemannian curvature tensor and its properties, Bianchi identities, Ricci-tensor, Scalar curvature, Einstein space.

**Curves in Space:**
Parametric representation of curves, Helix, Curvilinear coordinates in $E_3$. Tangent and first curvature vector, Frenet formulas for curves in space, Frenet formulas for curve in $E_n$. Intrinsic differentiation, Parallel vector fields, Geodesic.

**Surfaces :**
Parametric representation of a surface, Tangent and Normal vector field on a surface, The first and second fundamental tensor, Geodesic curvature of a surface curve, The third fundamental form, Gaussian curvature, Isometry of surfaces, Developable surfaces, Weingarten formula, Equation of Gauss and Codazzi, Principal curvature, Normal curvature, Meusnier’s theorem.

**References :**
1. Tensor Calculas and Application to Geometry and Mechanics : (chapter-II and III) – I.S.SOKOLNIKOFF.
3. Differential Geometry:- BARY SPAIN.
M.Sc. First Year Second Semester (250 marks)

Unit 2.1 : Algebra II (50 Marks)

Fields (40 Marks) :
Field Extensions : Algebraic and Transcendental Extensions, Finite Extension, Algebraic Closure of a field, Algebraically Closed Field, Splitting Field of a polynomial, Normal Extension, Separable Extension, Impossibility of some constructions by straightedge and compass.
Finite Fields and their properties, Galois Group of automorphisms and Galois Theory, Solution of polynomial equations by radicals, Insolvability of the general equation of degree 5(or more) by radicals.

Linear Algebra (10 Marks) : Canonical Forms : Similarity of linear transformations, Diagonalization, Invariant Subspaces, Reduction to Triangular Forms.
Nilpotent Transformations, Index of Nilpotency, Invariants of a nilpotent transformation, Jordan Blocks and Jordan Forms, Rational Canonical Form, Generalized Jordan Form over an arbitrary field.

References :

Hungerford, T.W., Algebra, Springer.
Jacobson, N., Basic Algebra, I & II, Hindusthan Publishing Corporation, India.
Unit 2.2 : Topology (50 Marks)

Set Theory :
Countable and Uncountable Sets, Schroeder-Bernstein Theorem, Cantor’s Theorem, Cardinal Numbers and Cardinal Arithmetic, Continuum Hypothesis, Zorn’s Lemma, Axiom of Choice, Well-Ordered Sets, Maximum Principle, Ordinal Numbers.

Topological Spaces and Continuous Functions :

Connectedness and Compactness :
Connected and Path Connected Spaces, Connected Sets in $\mathbb{R}$, Components and Path Components, Local Connectedness.
Compact Spaces, Compact Sets in $\mathbb{R}$, Compactness in Metric Spaces, Totally Bounded Spaces, Ascoli-Arzelà Theorem, The Lebesgue Number Lemma, Local Compactness.

References :

Note : This course is based on the book (1), Chapters 1 - 5. 0.5in
Unit 2.3 : Functional Analysis (50 Marks)

Banach Spaces :

Normed Linear Spaces, Banach Spaces, Equivalent Norms, Finite dimensional normed linear spaces and local compactness, Quotient Space of normed linear spaces and its completeness, Riesz Lemma, Fixed Point Theorems and its applications.

Bounded Linear Transformations, Normed linear spaces of bounded linear transformations, Uniform Boundedness Theorem, Principle of Condensation of Singularities, Open Mapping Theorem, Closed Graph Theorem, Linear Functionals, Hahn-Banach Theorem, Dual Space, Reflexivity of Banach Spaces.

Hilbert Spaces :

Real Inner Product Spaces and its Complexification, Cauchy-Schwarz Inequality, Parallelogram law, Pythagorean Theorem, Bessel’s Inequality, Gram-Schmidt Orthogonalization Process, Hilbert Spaces, Orthonormal Sets, Complete Orthonormal Sets and Parseval’s Identity, Structure of Hilbert Spaces, Orthogonal Complement and Projection Theorem.


Introduction to Spectral Properties of Bounded Linear Operators.

References :


Note : This course is based on book (1), Chapters 5, 6.
Unit 2.4 : Mechanics of Continua (50 Marks)


References:
1. Y.C. Fung : A first course in continuum mechanics.

Unit 2.5 : Ordinary Differential Equation and Special Function (50 Marks)


References:
2. Estham, Ordinary differential equation.
3. Hartman, P., Ordinary differential equation, John wiley and sons
4. Reid, W.T. Ordinary differential equation, John wiley and sons.
5. Burkhill, J.C., Theory of ordinary differential equation
6. Ince, E.L. Ordinary differential equation, Dover
M.Sc. Second year First Semester (250 Marks)

Unit 3.1: Numerical Analysis (Theory :30, Practical: 20)

Numerical Analysis Theory (30 Marks):

System of linear equations and eigenvalue problem:


System of non-linear method equations:

Finite difference method:

Numerical Analysis Practical (20 Marks):

List of Practical Problems

2. Inverse of a matrix
4. Relaxation method
5. Solution of one dimensional heat conduction equation by
   i) Explicit and
   ii) Crank-Nicolson implicit method.
6. Solution of Laplace equation.
7. Solution of Poisson equation.
8. Solution of one-dimensional wave equation.
References:

1. Computing methods; Berzin and Zhidnov.
3. A first course in Numerical Analysis; Ralston and Rabinowitz.
6. The finite element method in structural and continuum mechanics; O.C.Zienkiewics.
8. An introduction to boundary element methods; Prem K. Kytbe.
9. Computational Mathematics; B.P.Demidovich and J.A.Maron.
10. Applied Numerical Methods; A. Gourdin & M. Boumahrat.

Unit 3.1: Advanced Topology

Countability and Separation Axioms:

Nets and Filters:
Directed Sets, Nets and Subnets, Convergence of a net, Ultranets, Partially Ordered Sets and Filters, Convergence of a filter, Ultrafilters, Basis and Subbase of a filter, Nets and Filters in Topology.

Tychonoff Theorem & Compactification:
Tychonoff Theorem, Completely Regular spaces, Local Compactness, One-point compactification, Stone-Cech Compactification.

Metrization:
Urysohn Metrization Theorem, Topological Imbedding, Imbedding Theorem of a regular space with countable base in $\mathbb{R}^n$, Partitions of Unity, Topological $m$-Manifolds, Imbedding Theorem of a compact $m$-manifold in $\mathbb{R}^n$. Local Finiteness, Nagata-Smirnov Metrization Theorem, Paracompactness, Stone’s Theorem, Local Metrizability, Smirnov Metrization Theorem.
Uniform Spaces.

Complete Metric Spaces & Function Spaces:
Complete Metric Spaces, The Peano Space-Filling Curve, Hahn-Mazurkiewicz Theorem (statement only).
An Introduction to Dimension Theory, Topological notion of (Lebesgue)dimension.
References:
Bourbaki, N., *Topologie Générale*.

Note: This course is based on the books [1]; Chapters 4 - 7 and [4].

Unit 3.1: Discrete Mathematics – I

Graph Theory
Introduction to Graphs: The concept of a graph, Paths in graphs, Graphs and graph models, Graph terminology and special types of graphs, Bipartite graphs, Complete graphs, External graphs, Intersection graphs, Operations on graph, Graph Isomorphism.

Blocks: Cutpoints, bridges and blocks. Block graphs and cutpoint graphs.

Trees: Introduction to trees and characterizations, Applications of Trees, Spanning Trees, Minimum Spanning Trees, Trees in computer science, Centers and centroids, Block-cutpoint trees, Independent cycles and cocycles, Matroids.

Connectivity: Connectivity and line-connectivity, Graphical version of Menger's theorem.

Traversability: Eulerian Graphs, Hamiltonian Graphs.

Coverings and Matching: Coverings and independence, Critical points and lines, Matching, Maximum Matching Problem, Minimum covering problems.

Representing Graphs: Adjacency matrix, Incidence matrix, Cycle matrix.

Planarity: Plane and planar graphs, Outerplanar graphs, Kuratowski's theorem, other characterizations of planar graphs.

Colorability: Vertex coloring, Chromatic number, Edge coloring, Five color theorem, Four color conjecture, Unique colorable graphs.

Directed Graphs: Basic definitions, Type of Connectedness, Covers and Bases, Distance concepts and matrices, Connectivity, Acyclic digraphs, Cycles and traversability, Orientations and Tournaments.

Text Books:

References:

Unit 3.2: PDE and Nonlinear ODE

Theory of Partial Differential Equations
Introduction, Cauchy-kowalewski’s theorem (statement only) classification of second order partial differential equations to Hyperbolic, Elliptic and Parabolic types. Reduction of linear and quasilinear equations in two independent variables to their canonical forms, characteristic curves. Well-posed and ill-posed problems.

(i) Hyperbolic Equations:
The equation of vibration of a string. Formulation of mixed initial and boundary value problem. Existence, uniqueness and continuous dependence of the solution to the initial conditions. D’Alembert’s formula for the vibration of an infinite string. The domain of dependence, the domain of influence use of the method of separation of variables for the solution of the problem of vibration of a string. Investigation of the conditions under which the infinite series solution convergence and represents the solution. Riemann method of solution, Problems, Transmere of vibration of membranes. Rectangular and circular membranes problems.

(ii) Elliptic Equations:
Occurrence of Laplace’s equation. Fundamental solutions of laplace’s equation in two and three independent variables. Laplace equation in polar, Spherical polar and in cylindrical polar coordinates, Minimum – Maximum theorem and its consequences. Boundary value problems, Dirichlets and Neumann’s interior and exterior problems uniqueness and continuous dependence of the solution on the boundary conditions. Use of the separation of variables method for the solution of Laplace’s equations in two and three dimensions interior and exterior Dirichlet’s problem for a circle, and a semi circle, steady-state heat flow equation Problems, Higher dimensional problems, Dirichlet’s problem for a cube, cylinder and sphere, Green’s function for the Laplace equation, in two and three dimensions.
(iii) **Parabolic Equation**

**Non-linear ODE**
Flows, phase space, existence and uniqueness of solution (statement only) Definition of stability, Lyapunov function, fixed points and their nature, saddlepoint, node, focus points, stable, unstable and center subspaces. Hartman-Grotman theorem (statement only), Poincare map, periodic orbits, invariant sets, limit points and limit cycles, attracting and repelling sets, trapping regions, two dimensional flow, Poincare Benedixon theorem (statement only) bifurcation.

**References**

5. Courant and Hilbert: Methods of Mathematical Physics, Vol – II
Unit 3.3: Any One Course from A-1.1 to A-1.8*

A - 1.1   :   Advanced Algebra – I
A - 1.2   :    Algebraic Topology
A - 1.3   :    Introduction to Algorithms - I
A - 1.4   :   Fluid Mechanics I
A - 1.5   :    Mathematical Modelling of Biological Systems I
A - 1.6   :    Mathematical Theory of Elasticity I
A - 1.7    :    Principles of Operations Research I
A - 1.8   :    Non-Relativisitic Quantum Mechanics

(* Choice of course in unit 4.3 will depend on this course, if a student opts for A-1.5 then the student has to go for A-2.5 in unit 4.3)

A – 1.1 : Advanced Algebra - I (50 Marks)

Modules Theory (20 Marks):

Modules and Module Homomorphisms, Submodules and Quotient Modules, Operations on submodules, Direct Sum and Product, Finitely Generated Modules, Free Modules.
Tensor Products of modules, Universal Property of the tensor product, Restriction and Extension of Scalars, Algebras.
Exact Sequences, Projective, Injective and Flat Modules, Five Lemma, Projective Modules and $\text{Hom}_R(M,-)$, injective modules and $\text{Hom}_R(-,M)$, Flat modules and $M \otimes_R -$.

Note: This course is based on the books [2]; Chapter 2 and [1]; Chapter 10.

Commutative Ring Theory (30 Marks):

Rings and Ring Homomorphisms, Ideals, Quotient Rings, Zero-divisors, Nilpotent elements, Units, Prime and Maximal ideals, Nilradical and Jacobson radical, Nakayama’s Lemma, Operations on Ideals, Prime Avoidance, Chinese Remainder Theorem, Extension and Contraction of ideals.
Rings and Modules of Fractions, Local Properties, Extended and contracted ideals in rings of fractions.
Noetherian Rings, Primary Decomposition in Noetherian Rings.
Integral Dependence, Lying-Over Theorem, Going-Up Theorem, Integrally Closed Domains, Going-Down Theorem, Noether Normalization, Hilbert Nullstellensatz.
Transcendence Base, Separably Generated Extensions, Schmidt and Lüroth Theorems.

Note: This course is based on the book [2]; Chapters 1, 3, 4, 5.
References:


**A – 1.2 : Algebraic Topology : 50 Marks**

**Algebraic Topology (50 Marks)**

**The Fundamental Group and Covering Spaces (25 marks)**:

Homotopy of paths, Fundamental Group, Covering Spaces, Fundamental Group of the Circle, Fundamental Group of the Punctured Plane, Special Van Kampen Theorem, Fundamental Group of $S^n$, Seifert - Van Kampen Theorem (statement and applications), Fundamental Group of Surfaces.
Essential and Inessential Maps, Borsuk - Ulam Theorem for $S^2$, Fundamental Theorem of Algebra, Vector Fields and Fixed Points, Brouwer’s Fixed-Point Theorem for the disc, Homotopy Type, Deformation Retract, Strong Deformation Retract.
Jordan Separation Theorem, Jordan Curve Theorem (statement only).
Classification of Covering Spaces, General Lifting Lemma, Existence of Coverings, Semilocally Simply Connectivity, Deck Transformations.

**Note**: This course is based on the book [1]; Chapter 8.

**Simplicial Homology (25 Marks)**:

Geometric Complexes and Polyhedra, Orientation of Geometric Complexes.

Simplicial Approximation, Induced Homomorphisms on the Homology Groups, Brouwer Fixed Point Theorem and Related Results.

**Note**: This course is based on the book [2]; Chapters 1 - 3.
References:


A – 1.3 : Introduction to Algorithms - I : 50 marks

Theory - 35, Assignment - 15 (Computer lab access is necessary and mandatory)


Induction and Recursion: Mathematical Induction, Strong Induction and Well-Ordering, Recursive Definitions and Structural Induction, Recursive Algorithms, Program Correctness 10 Lectures

Designing Algorithms: Recurrence relations, Solving linear recurrence relations, Divide-and-conquer approach, The Master method. 10 Lectures

Data Structure: Introduction to ADT, implementations of basic data structures, array, stack, queue, dequeue, priority queue, linked list, binary tree and traversal algorithms, threaded tree, m-ary tree, heap, generalized list and garbage collection. 15 Lectures

Searching: Fibonacci search, binary search tree, Searching in static table - binary search, path lengths in binary trees and applications, optimality of binary search in worst case and average-case, binary search trees, construction of optimal weighted binary search trees; Searching in dynamic table - randomly grown binary search trees, AVL and (a,b) trees. 20 Lectures

Hashing: Techniques, analysis with chaining and open addressing. 7 Lectures

Sorting and selection: Finding maximum and minimum, k largest elements in order; Sorting by selection, tournament and heap sort, lower bound for sorting, quick sort, merge sort and sorting in linear time; Selection of k-th largest element. 20 Lectures

Union-Find problem: Tree representation of a set, weighted union and path compression-analysis and applications. 8 lectures
**Text books:**

**References:**

**A– 1.4 : Fluid Mechanics I (50 marks)**

Lagrange’s and Euler’s methods in fluid motion. Equation of motion and equation of continuity, Boundary conditions and boundary surface stream lines and paths of particles. Irrotational and rotational flows, velocity potential. Bernoulli’s equation. Impulsive action equations of motion and equation of continuity in orthogonal curvilinear coordinate. Euler’s momentum theorem and D’Alemberts paradox.


Dimensional irrotational motion.


Motion of a sphere. Stoke’s stream function. Source, sinks, doublets and their images with regards to a plane and sphere.


Reference Books:

1. Hydrodynamics – A.S.Ramsay(Bell)
2. Hydrodynamics – H. Lamb(Cambridge)
3. Fluid mechanics – L.D.Landou and E.M.Lifchiz(Pergamon), 1959
4. Theoretical hydrodynamics – L.M.Thomson

A – 1.5 : Mathematical Modelling of Biological Systems I : 50 Marks

(Qualitative Theory of Linear and Nonlinear systems)

Linear systems:
Linear autonomous systems, existence, uniqueness and continuity of solutions, diagonalization of linear systems, fundamental theorem of linear systems, the phase paths of linear autonomous plane systems, complex eigen values, multiple eigen values, similarity of matrices and Jordan canonical form, stability theorem, reduction of higher order ODE systems to first order ODE systems, linear systems with periodic coefficients.

Nonlinear systems:
The flow defined by a differential equation, linearization of dynamical systems (two, three and higher dimension), Stability: (i) asymptotic stability (Hartman’s theorem), (ii) global stability (Liapunov’s second method).

Periodic Solutions (Plane autonomous systems):
Translation property, limit set, attractors, periodic orbits, limit cycles and separatrix, Bendixon criterion, Dulac criterion, Poincare-Bendixon Theorem, index of a point, index at infinity.

Bifurcation and Center Manifolds:
Stability and bifurcation, saddle-node, transcritical and pitchfork bifurcations, hopf-bifurcation, center manifold (linear approximation).

Linear difference equations:
Difference equations, existence and uniqueness of solutions, linear difference equations with constant coefficients, systems of linear difference equations, qualitative behavior of solutions to linear difference equations.

Nonlinear difference equations (Map):
Steady states and their stability, the logistic difference equation, systems of nonlinear difference equations, stability criteria for second order equations, stability criteria for higher order system.

Chaos:
One-dimensional logistic map and chaos.

References:
A – 1.6: Mathematical Theory of Elasticity I (50 Marks)


Reference:

2. Mathematical Theory of Elasticity - I. S. Sokolnikoff
3. Theory of Elasticity – S. Timoshenko and J. N. Goodier
4. Elasticity Theory and Applications – A. S. Saada
5. Foundations of Solid Mechanics – Y. C. Fung
6. Theory of Elasticity – Y. A. Amenzade
7. Applied Elasticity – Zhilun Xu
8. Wave Propagations in Elastic Solids – J. D. Achenbach
9. Elasto-dynamics – A. C. Eringen
10. Wave Motion in Elastic Solids – K. F. Graff
1. Allocation Problems

(i) Transportation Problems
Mathematical representation of transportation problems, Unbalanced transportation problems, Degenerate transportation problems, Resolution of degeneracy.

(ii) Assignment Problems
Mathematical representation of assignment problems, Reduction theorems, Solution methods of assignment problems, Hungarian method of zero assignment technique, Restriction assignment, Negative cost etc, Variations of assignment problem, Multiple optimal solution, Maximization in assignment problem, Unbalanced assignment problem

(iii) Travelling Salesman Problem/ Routing Problem
Origin of travelling salesman problem, Symmetrical and asymmetrical problems, Mathematical representation of problems, Solution techniques for such problems using zero assignment/unit assignment etc.

2. Competitive Strategy (Game Theoretic Problems)


3. Queueing Theory (Theory of Waiting Lines)

Introduction, Queueing system, Queue disciplines FIFO, FIFS, LIFO, SIRO, FILO etc. The Poisson process (Pure birth process), Arrival distribution theorem, Properties of Poisson process, Distribution of inter arrival times (exponential process), Markovian property of inter arrival times, Pure death process (Distribution of departures), Derivation of service time distribution, Analogy of exponential service times with Poisson arrivals, Erlang service time distribution, Kendals notations, Probabilistic queueing models

\[ \text{(M=M=1) : (I=FCFS)} \]
\[ \text{(M=M=1) : (N=FCFS)} \]
\[ \text{(M=M=S) : (I=FCFS)} \]
and their properties.

Reference Books
1. Operations Research - S.D. Sharma
2. Operations Research - Kanti Swarup, P.K. Gupta and Manmohan
3. OR methods and Problems - Sasieni Maurice, Arther Yaspan, Lawrence Friedman
5. Operations Research - T.L. Satty
A-1.8 Non-Relativisitic Quantum Mechanics (50 Marks)

Different approaches to quantum mechanics: Schrödinger representation, Heisenberg approach. Harmonic oscillator and Angular momentum as examples.

Time independent perturbation theory. Spin: two component wave function.
Pauli’s spin matrices. Variation method. Ground state energy level of helium atom as an application of variational method. Indistinguishable particles.

References:

1. L.I.Schiff: “Quantum Mechanics” (Mc Graw Hill)
2. E. Merzbacher: “Quantum Mechanics” (John Wiley)
5. R.H.Landau: “Quantum Mechanics II” (John Wiley)
6. L.H.Ballentine “Quantum Mechanics ” (World Scientific)
7. P.J.E. Peebles “Quantum Mechanics ” (Prentice Hall)
**Unit 3.4 and Unit 3.5 : Two courses from B-1.1 to B-1.39**

<table>
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<td>B - 1.1</td>
<td>Advanced Complex Analysis I</td>
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<td>B - 1.2</td>
<td>Advanced Differential Geometry I</td>
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<td>Artificial Intelligence &amp; Soft Computing I</td>
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(* Choice of course in unit 4.4 and 4.5 will depend on this course, if a student opts for B-1.19 and B-1.30 then the student has to go for B-2.19 and B-2.30 in unit 4.4 and 4.5 *)
B – 1.1: Advanced Complex Analysis I (50 Marks)

The Functions $M(r)$, $A(r)$, Hadamard Theorem on Growth of $\log M(r)$, Schwarz Inequality, Borel-Caratheodory Inequality.

Entire Functions, Growth of an Entire Function, Order and Type and their Representations in terms of the Taylor Coefficients, Distribution of Zeros, Schottky’s Theorem (no proof), Picard’s Little Theorem, Weierstrass Factor Theorem, The Exponent of Convergence of Zeros, Hadamard Factorization Theorem, Canonical Product, Borel’s First Theorem, Borel’s Second Theorem (statement only).

Analytic Continuation, Natural Boundary, Analytic Element, Global Analytic Function, Concept of Analytic Manifolds, Multiple Valued Conditions, Branch Points and Branch Cut, Riemann Surfaces.

References:

Hayman, W.K., *Meromorphic Functions*.
Kaplan, W., *An Introduction to Analytic Functions*.

B – 1.2 : Advanced Differential Geometry I (50 Marks)

Topological Manifold, differentiable Manifold, Differentiable functions, Tangent and cotangent spaces, vector fields, Maps, Integral curves, Lie brackets, Lie algebra of vector fields, One parameter group of transformations, 1-forms, Submanifolds, Distribution, Tensor field.

Symmetrisation and alteration of fully contravariant and fully covariant tensors, Exterior algebra, Exterior derivative, Differential forms.

Lie groups and Lie algebras of Lie group, One parameter subgroups and Exponential maps, Homomorphisms and Isomorphisms, Lie transformation groups, General linear groups.
References

1. Foundation of differential Geometry (vol-1) :- S.KOBAYASHI and K.NOMIZU.
2. An Introduction to Differentiable Manifolds and Riemannian Geometry : - W.M.BOOTHBY.
3. Introduction to Differentiable Manifolds : - L.AUSLANDER and R.E.MACKENZIE.

B – 1.3 : Artificial Intelligence and Soft Computing I : 50 marks


References:

3. Neural Networks by Simon Haykin – Pearson
4. Genetic Algorithms by David E. Goldberg – Addison-Wesley

B – 1.4 : Astrophysics I (50 marks)

Application of General Relativity to Astrophysics

3. Interior of Schwarzschild metric, massive objects, Openheimer – Volkoff limit, Gravitational lensing , Quasars , Pulsars, Supernova.
4. Openheimer-Snydder non static dust model, Gravitational collapse.
5. Accretion into compact objects, Boltzmann formula, Saha Ionization equation, H-R diagram.
References:

1. The Structure of the Universe – J.V. narlikar
2. Astrophysics – B. Basu
3. Astrophysics – B. Basu
4. Astrophysical Concept – M. Harmitt
5. Galactic Structure – A. Blauaw & M. Schmidtw
6. Large Scale Structure of Galaxies – W.B. Burton
8. Cosmic Electrodynamics – J.H. Piddington

B – 1.5 : Combinatorial Mathematics I (50 Marks)

General Principles of Enumeration, Counting of Sub-Sets, Partitions, Bionomial Theorem, Multinomial Theorem.
Principles of Inclusion and Exclusion, Derangements, Rook polynomials, Arrangement with Forbidden Positions.
General Principles of Enumeration, Counting.
Latin Square, Quasi-group, Orthogonal Latin Square.

References:

3. DISCRETE AND COMBINETORIAL MATHEMATICS by Ralph P. Grimaldi (AWL).
B – 1.6: Commutative Algebra and Algebraic Geometry I (50 Marks)

Commutative Rings and Ideals, Ring Homomorphisms, Zero-divisors, Nilpotent elements, Nilradical and Jacobson radical, Nakayama’s Lemma, Prime Avoidance, Chinese Remainder Theorem.

Modules and Module Homomorphisms, Tensor Products of modules, Exact Sequences, Projective, Injective and Flat Modules, Five Lemma, Projective Modules and Hom_R(M,-), injective modules and Hom_R(-,M), Flat modules and M ⊗_R -..

Local rings, Localisation, Applications.

Noetherian Modules, Primary Decomposition, Associated Primes, Artinian Modules, Length of a Module.

Integral Dependence, Lying-Over Theorem, Going-Up Theorem, Integrally Closed Domains, Going-Down Theorem, Noether Normalization.

Transcendence Base, Separably Generated Extensions, Schmidt and Lüroth Theorems.

References:


Fulton, W., Algebraic Curves, W.A. Benjamin, INC., 1969.


Lang, S., Algebra, Addison-Wesley, 1993.

B – 1.7 : Computational Biology I (50 marks)

1. **Dynamic Modelling with Difference Equations.**

2. **Linear Models of Structured Populations.**

3. **Non-linear models of Interactions.**

4. **Modelling Molecular Evolution.**

References:

Finite difference method:


Finite Volume method:


References:

7. J.D. Andersson, Computational Fluid Dynamics
Introduction to computational methods in continuum mechanics. Stages of developments and features of computational mechanics. Different methods.

Finite Element Method:

Boundary Element Method:

References:
2. Finite Element Procedures : K.J.Bathe
B -1. 10. Computer Graphics  (50 Marks)

Theory - 30, Assignment - 20  (Computer lab access is necessary and mandatory)

Introduction: Objective, applications, GKS/PHIGS, normalized co-ordinate system, aspect ratio.
Graphics system: Vector and raster graphics, various graphics display devices, graphics interactive devices, segmented graphics, attribute table.
Raster scan Graphics: Line drawing algorithms, circle/ellipse drawing algorithms, polygon filling algorithms.
Geometric transformation: Homogeneous co-ordinate system, 2D and 3D transformations, projection orthographic and perspective.
Curve and Surfaces: Curve approximation and interpolation, Lagrange, Hermite, Bezier and B-Spline curves/surfaces and their properties, curves and surface drawing algorithms.
Geometric modeling: 3D object representation and its criteria, edge/vertex list, constructive solid geometry, wire-frame model, generalized cylinder, finite element methods.
Clipping: Window and viewport, 2D and 3D clipping algorithms.
Hidden line and hidden surfaces: Concept of object- and image-space methods, lines and surface removal algorithms.
Intensify and color models: RGB, YIQ, HLS and HSV models and their conversions, gamma correction, half toning.
Rendering: Illumination models, polygon mesh, shading, transparency, shadow, texture.
Some advance topics/applications: (i) Animation and morphing, (ii) Virtual reality, (iii) User interface design, (iv) Fractal graphics, (v) Multimedia authoring, (vi) 3D visualization..

References:

B – 1.11 Database Management Systems (50 Marks)

Theory - 30, Assignment - 20  (Computer lab access is necessary and mandatory)

Introduction: Purpose of database systems, data abstraction and modeling, instances and schemes, database manager, database users and their interactions, data definition and manipulation language, data dictionary, overall system structure. 16 lectures

Entity-relationship model: Entities and entity sets, relationships and relationship sets, mapping constraints, E-R diagram, primary keys, strong and weak entities, reducing E-R diagrams to tables, trees or graphs, generalization and specialization, aggregation. 10 lectures

Relational model: Structure of a relational database, operation on relations, relational algebra, tuple and domain relational calculus, salient feature of a query language. 6 lectures

Structured query language: Description an actual RDBMS and SQL. 6 lectures

Normalization: Pitfalls in RDBMS, importance of normalization, functional, multi-valued and join dependencies, 1NF to 5NF, limitations of RDBMS. 10 lectures

Database tuning: Index selection and clustering, tuning of conceptual schema, denormalization, tuning queries and views. 6 lectures

Query optimization: Importance of query processing, equivalence of queries, cost Estimation for processing a query, general strategies, bi-relational and multi-relational join algorithms, algebraic manipulation. 10 lectures

Crash recovery: Failure classification, transactions, log maintenance, check point implementation, shadow paging, example of an actual implementation. 8 lectures

Object oriented model: Nested relations, modeling nested relations as object model, extension of SQL, object definition and query language (ODL, OQL), object relational database model, storage and access methods. Active databases, Advanced trigger structures, SQL extensions. 8 lectures

References:

B – 1.12 : Coupled fields of Solid Mechanics and Plasticity I (50 marks)

Theory of Plasticity:


General form of yield condition for an ideal plastic. Tresca and von mises yield conditions- physical aspects.


References

1. R. Hill : Mathematical theory of plasticity
2. Hoffman and Saches : Intorduction to the theory of plasticity for engineers
3. Mendelson : Plasticity theory and applications
5. J. Chakraborty : Plasticy
6. S.K. Chakravorty : Mathematical theory of plasticity
7. Frager and Hodge : Theory of Perfectly plastic solid.

B – 1.13 : Differential Geometry and its Applications I (50 marks)

Differentiable Manifold, Differentiable Curve, Tangent Space, Vector Field, Integral Curve, Differential of a mapping, One parameter group of transformations, Cotangent Space, r-form, Wedge Product, Exterior Product, Pull back differential form, Linear Connection, Torsion Tensor field, Curvature tensor field, Riemannian metric, Riemannian Connection, Riemannian manifold, Einstein manifold, Weyl conformal curvature tensor, Almost complex manifold, Complex manifold, Nijenhuis tensor, Hermite manifold, Almost contact manifold, contact manifold, Killing vector field, K- contact manifold

References:

2. D.E.BLAIR–Contact Manifolds in Riemannian Geometry,Lecture Notes in Maths.
B – 1.14 : Dynamic Meteorology and NWP I (50 marks)

1: Introduction
The physical foundation, units and dimensions.

2: Thermodynamics of dry air
Composition of the atmosphere, variable of state, Equation of state of a perfect gas, the Universal gas constant, mixture of the gases, molecular weight of dry air, the first law of thermodynamics, specific heats of gases, adiabatic process, potential temperature, entropy and the second law of thermodynamics.

3: Aerological diagrams
Properties, area equivalence, different kinds of TD diagrams, the emagram, the skew (T,-log p) diagram, the tephigram.

4: Thermodynamics of water vapour and moist air
Equation of state for water vapour, specific heats of water substance, equation of state of most air, virtual temperature, change of phase, variation of latent heat, with temperature, the Clausius-Clapeyron equation, adiabatic process for saturated air, moisture variables.

5: Hydrostatic equilibrium
The hydrostatic equation, definition of lapse rate, the thickness equation presser height formulae in model atmospheres, dry atmosphere with a constant lapse-rate, height and lapse rate of a homogeneous atmosphere the dry adiabatic atmosphere, the isothermal atmosphere the Us standard atmosphere.

6: Hydrostatic stability and convection
State, unstable and neutral equilibrium the parcel method, convective available potential energy, lapse rate for unsaturated air, lapse rate for saturated air.

7: The equation of motion 1: The coriolis force
Introduction, motion as observed with reference to a fixed frame of coordinates, motion as observed in a rotating frame of coordinates, simple mathematical derivation of the Coriolis force.

8: The equation of motion 2: Derivation in various coordinates
The pressure gradient force, the spherical earth, inertia motion, The equation of motion, Derivation of the components of the Coriolis force from the law of conservative of angular momentum, Derivation of the equation of motion in plane coordinates from rotating axes, Derivation of equation of motion in rotating polar coordinates, Derivation of the three dimensional equations of motion in spherical coordinate system, Equation of motion in tangential curvilinear coordinates.

9: Balanced flow
Introduction, geostrophic equation, effect of friction, the gradient wind equation, gradient wind solutions for the anticyclonic and cyclonic cases, comparison of geostrophic and
gradient wind values, the cyclostrophic wind, the ‘strong roots’ the non-geostrophic front, geostrophic front, Tropopause frontal theory.

**Reference:**

1. Dynamic Meteorology- A basic course: Adrian Gordon, Warwick Grace, Peter Schwerdtfeger, Ronald Byron-Scott.
3. Introduction to Dynamical Meteorology: Holton.
4. Fundamental of atmospherica physics: Murray L Salby.

**B – 1.15: Dynamical Oceanography I (50 marks)**

**Properties of Sea Water:**


**Properties of Fluid at Rest.**


**Equations Satisfied by Moving Fluids.**


**Adjustment under Gravity of a Density Stratified Fluid.**


**Gravity Waves in a Rotating Fluid.**

**References:**

1. O. M. Philips: Dynamics of the Upper Ocean. Cambridge University Press (1966)

**B – 1.16 : Elastodynamics – I (50 Marks)**


**References :**

1. Elastodynamics, Vol.-II : A.C.Eringen and E.S.Suhubi.
5. Wave Motion : J.Billingham and A.C.King.

**B – 1.17 : General Theory of Relativity and Cosmology I(50 Marks)**

References:

1. The large scale structure of space-time - Hawking and Ellis (Camb. Univ. Press).
5. General Relativity, Astrophysics and Cosmology – Raychaudhury, Banerji and Banerjee (Springer-Verlag).

**B – 1.18 : Generalised Functions and Wavelet Theory I (50 Marks)**

**Generalised Functions - 50 marks**

Good function, Fairly good function, Generalised function, Ordinary function as generalised function, Addition of generalised function, Derivatives of generalised functions, Fourier transform of generalised functions, Limits of generalised function, Powers of \( |x| \) as generalised functions, Even and odd generalised functions, Integration of generalised functions, Integration of generalised function, Multiplication of two generalised functions.

**Reference:**


**B – 1.19 : Graph Theory I (50 Marks)**


Hamiltonian Graphs: Necessary condition, Sufficient conditions (Dirac, Ore, Chvatal, Chvatal-Erdos), Hamiltonian Closure, Traveling Salesman Problem. (10)

Trees: Basic properties, distance, diameter. Rooted trees, Binary trees, Binary Search Trees. Cayley’s Formula for counting number of trees. Spanning trees of a connected graph, Depth first search (DFS) and Breadth first search (BFS) Algorithms, Minimal spanning tree, Shortest path problem, Kruskal’s Algorithm, Prim’s Algorithm, dijkstra’s Algorithm. Chinese Postman Problem. (10)


References:
2. Graph Theory, F. Harary, Addison-Wesley, 1969.

B –1. 20: Information Theory and Coding I (50 Marks)

Information Theory (50):


Discrete memory less channel. Classification of channels. Information processed by a channel. Calculation of channel capacity. Cost function.
Continuous channels. The time-discrete Gaussian channel. The converse to the coding theorem for time-discrete Gaussian channel. The time-continuous Gaussian channel. Problems.

References:

1. Elements of Information Theory : Thomas M. Cover and Joy A. Thomas.
3. Information Theory, Inference and learning algorithms : David J.C. KacKay.
5. An introduction to information theory : F.M. Reza.
8. A first course in coding theory : R. Hill.

B – 1.21 : Magneto Fluid Mechanics I(50 Marks)

I: Basic concepts of Electromagnetic theory:
Coulomb’s law, electric field, Gauss flux theorem and Gauss law, Polarisation, electrostatic energy due to a system of charges, Fundamental equations of electrodynamics, the law of Biot and Savart, magnetic induction field, Lorentz force, Maxwell’s electromagnetic field equations. Laws of electromagnetic induction : Faraday’s law and Lenz’s law, Ohm’s law.

II: Magneto Hydrodynamics
Equation of motion of a conducting fluid, simplification of MHD equations using dimensional consideration (i.e. MHD approximations), magnetic Reynold’s number, Alfven’s theorem, the magnetic body force, Ferraro’s law of isoration, Non-dimensional form of the equation.

III: Magneto Hydrostatics
Force-free magnetic fields, Pinches, Bennett pinch or linear pinch, instability of linearpinch, equilibrium of sunspots, Chandrasekhar’s equipartition of energy theorem.

IV: Few solutions on MHD flows
Steady laminar flow of a viscous conducting fluid between parallel walls in the presence of a transverse magnetic field (i.e. Hortmann flow), Two dimensional MHD equations, Couette flow, Transient Couette flow, steady flow of a conducting liquid through a pipe of rectangular cross section in the presence of a transverse magnetic field, unsteady flow of a conducting liquid near an infinite flat plate in the presence of a transverse magnetic flow.
B – 1.22 : Mathematical Ecology I (50 Marks)

The nature of ecosystems, Autotroph-based ecosystem, Detritus-based ecosystem, Different types of population growth, Community dynamics- succession and community responses.

**Single Species Population Dynamics:**

**Population Dynamics of Two Interacting Species:**

**Continuous models for three or more interacting species:**
Three species simple and general food chain models- its stability and persistence. Models on one prey two competing predators with limited resources and living resource supporting three competing predators- stability analysis and persistence.

**Biological Models Using Linear and Nonlinear Difference Equations:**

References:

B – 1.23: Mathematical Statistics I (50 Marks)


References:
3) Text Book on Fluid Dynamics – F. Chorlton.
Gauss-Markoff setup and least squares estimation. LS estimation with restriction on parameters. Simultaneous estimation of parametric functions.

Multivariate normal distribution. Hotelling's $T^2$.

**References:**


**B – 1.24 : Measure and Topology I (50Marks)**

**Integration:**

Signed Measure, Hahn Decomposition Theorem, Mutually Singular Measures, Radon-Nikodym Theorem, Lebesgue Decomposition, Riesz Representation Theorem, Extension Theorem (Carathéodory), Lebesgue Stieltjes Integral, Product Measure, Fubini’s Theorem, Differentiation and Integration, Decomposition into Absolutely Continuous and Singular Parts.

Measure on Locally Compact Spaces: Borel Sets, Baire Sets, Baire Sandwich Theorem, Borel and Baire Measure, Regularity of Measures, Regular Borel Extension of a Baire Measure, Completion, Continuous Functions with Compact Support, Integration of Continuous Functions with Compact Support, Riesz-Markoff Theorem.

**References :**


**B – 1.25: Mechanics of Viscous fluids and Boundary layer Theory I (50 Marks)**

**Mechanics of viscous fluids –**

Viscous fluids, velocity strain – tensor and stress-strain relations for viscous fluids (statement of relations only). The Navier – Stokes equations of motion in Cartesian Coordinates and statements of its equivalent forms in spherical, polar and cylindrical Coordinates. Dissipation of energy due to viscosity, steady motion between parallel planes, Theory of lubrication, steady motion in a tube of different cross-sections. Vorticity in viscous fluids, Circulation in viscous fluids. Diffusion of vorticity, steady flow past a
fixed sphere, Dimensional Analysis, Reynolds number, Steady motion of a viscous fluid due to a slowly rotating sphere.

**Two Dimensional Motion**

Equation satisfied by the stream function for a motion under conservative field of external forces, Hamel’s equation, Logarithmic spirals,

**Three Dimensional Motion**

Stokes’ solution for a slow steady parallel flow past a sphere, stream function and the flow pattern, Oseen’s criticism, Oseen’s solution for slow steady parallel flow past a sphere and past a circular cylinder.

**References :**

1. Theoretical Hydrodynamics --- Milne – Thomson
2. Viscous flow Theory --- S.I. Pai
3. Hydrodynamics --- H. Lamb
5. Text book of Fluid Dynamics --- F. Chorlton

**B – 1.26 : Non-linear and Dynamic Programming I (50 Marks)**

Unconstrained and equality-constrained extremum. First order and second order necessary conditions. Sufficient conditions. Working principle for testing optimality.


Quadratic programming. Necessary and Sufficient condition for optimal solution.

**References :**

2. Hydrodynamics --- H. Lamb
3. New methods in laminar boundary layer theory --- D. Meksyn.
4. Elementary treatise on hydrodynamics and sound --- A.B. Besset.
5. Modern developments in fluid dynamics --- S. Goldstein.
7. Laminar boundary layers --- L. Rosenhead
8.  

**B -1. 27 : Number Theory : 50 Marks**

Revision of Unique Factorization, Congruencies, Chinese Remainder Theorem, Structure of \( U(Z/nZ) \), Quadratic Reciprocity, Quadratic Gauss Sum, Finite Fields, Gauss and Jacobi Sums, Cubic and Biquadratic Reciprocity, Equations over Finite Fields, Zeta...
Function.
Algebraic Number Fields and the Ring of Integers, Units and Primes, Factorisation, Quadratic and Cyclotomic Fields, Dirichlet L Function, Diophantine Equations, Elliptic Curves.

References:

B – 1.28. Operating Systems (50 Marks)

Theory - 30, Assignment - 20  *(Computer lab access is necessary and mandatory)*

Introduction: Basic architectural concepts, interrupt handling, concepts of batch-processing, multiprogramming, time-sharing, real-time operations; Resource Manager view, process view and hierarchical view of an OS.

Processor management: CPU scheduling - short-term, medium term and long term scheduling, non-preemptive and preemptive algorithms, performance analysis of multiprogramming, multiprocessing and interactive systems; Concurrent processes, precedence graphs, critical section problem – 2-process and n-process software and hardware solutions, semaphores; Classical process co-ordination problems, Producer consumer problem, Reader-writer problem, Dining philosophers problem, Barbar’s shop problem, Inter-process communication.

Concurrent Programming: Critical region, conditional critical region, monitors, concurrent languages, concurrent pascal, communicating sequential process (CSP);

Deadlocks: prevention, avoidance, detection and recovery.

Memory management: Partitioning, paging, concepts of virtual memory, demand-paging – page replacement algorithms, working set theory, load control, segmentation, segmentation and demand paging, Cache memory management.

Device Management: Scheduling algorithms - FCFS, shortest-seek-time-first, SCAN, C-SCAN, LOOK, C-LOOK algorithms, spooling, spool management algorithm.

Information Management: File concept, file support, directory structures, symbolic file directory, basic file directory, logical file system, physical file system, access methods, file protection, file allocation strategies.

Protection: Goals, policies and mechanisms, domain of protection, access matrix and its implementation, access lists, capability lists, Lock/Key mechanisms, passwords, dynamic protection scheme, security concepts and public and private keys, RSA algorithms.

A case study: UNIX OS file system, shell, filters, shell programming, programming with the standard I/O, UNIX system calls.

References:
B – 1.29: Operator Algebra I (50 Marks)

Banach Algebra


C*-Algebras:

References:
1. Bonsall and Duncan, Complete Normed algebras, Springer-Verlag.

B – 1.30: Operator Theory I (50 Marks)

Unit 3.3 Bounded linear Operators: (50 Marks)
Resolvent set, Spectrum, Point spectrum, Continuous spectrum, Residual spectrum, Approximate point spectrum, Spectral radius, Spectral properties of a bounded linear operator, Spectral mapping theorem for polynomials, Numerical range, Numerical radius, Convexity of numerical range, Closure of numerical range contains the spectrum, Relation between the numerical radius and norm of abounded linear operator A()

Banach Algebra:
Definition of normed and Banach Algebra and examples, Singular and Non-singular elements, The spectrum of an element, The spectral radius.
Compact linear operators:
Spectral properties of compact linear operators on a normed linear space, Operator equations involving compact linear operators, Fredholm alternative theorem, Fredholm alternative for integral equations. Spectral theorem for compact normal operators.

Reference Books:
5. P.R. Halmos, Introduction to Hilbert space and the theory of Spectral Multiplicity, Chelsea Publishing Co., N.Y.

B – 1.31: Plasma Mechanics I (50 Marks)

Definition of Plasma as an ionized gas. Saha’s equation of ionization. Occurrence of plasma in nature. Plasma as mixture of different species of charged particles.

Elements of kinetic theory (Statistical approach), Single particle phase space, Volume elements
Distribution function, Characterization of plasma with respect to the nature of the distribution function: Homogeneous, Inhomogeneous, Isotropic, Anisotropic

Derivation of Boltzmann equation, Average values and Macroscopic variables, Derivation of Macroscopic equations (Moment equations): Equation of continuity, Equation of motion, Equation of energy, Assumption on the nature of the distribution function to form a closed and consistent system of macroscopic equations (Equation of State), Cold Plasma limit, The equilibrium state: Maxwellian Distribution, Debye Shielding, The plasma parameter and the criteria for plasma formation,


First order orbit theory (Single particle motion): Uniform E and B fields, Larmor orbits and guiding centers, The magnetic moment and the magnetization current, Non-uniform B field, Non-uniform E field, Time varying E field, Time varying B field, Adiabatic invariants,

References:
1. Plasma Physics and controlled Fusion, F.F. Chen, PLENUM PRESS, NEW YORK AND LONDON.
2. Fundamental of Plasma Physics, J.A. Bittencourt, Pergamon Press, NEW YORK AND LONDON.  

B – 1.32 : Probability and Stochastic Processes I (50 Marks)

Definition and classification of stochastic processes.
Simple random walk and gambler’s ruin problem. Probability of ultimate ruin. Expected duration of game.

References:

B – 1.33 : Production and Inventory Control I (50 marks)

Deterministic inventory models / systems. Harris-Wilson model. Economic lot size systems. Sensitivity of the lot size systems. Order level systems and their sensitivity analysis. Order level lot size and their sensitivity studies. Non-constant demand models under \((s, q)\), \((t, s)\) and \((t_0, s)\) policies. Power law and linear travel demand situations. Lot size systems with different cost properties: (i) Quantity discounts, (ii) Price-change anticipation, (iii) Perishable goods system.
Multi-item inventory models with (i) single linear restriction, (ii) More than one linear restrictions, (iii) non-linear restrictions.

References:
**B- 1.34 : Quantum Field Theory and Statistical Mechanics I (50 marks)**

**Quantum Field Theory**

**References:**

**B – 1.35 : Queuing Theory and Game Theory I (50 Marks)**


**References:**
B – 1.36: Renewable Bio-Economic Modelling (50 Marks)

**Elementary dynamics of exploited populations:**
The logistic growth models, constant rate harvesting, fishing effort, generalized logistic model’s depensation, Yield-effort curves, critical depensation

**Open-Access Fishery:**
Gordon’s static model, opportunity cost, externality, economic over fishing, production function, Cobb-Douglas production function, discounting, Schaefer model: optimal harvesting policy, effect of discounting.

**Elements of Control Theory:**
One-dimensional control problem, linear variational problem-singular path, blocked interval, impulse control

**The Maximum Principle and Its Application in Linear Variational Problem:**
Transversality condition, feedback control, Pontryagin’s maximal theory, its economic interpretation, structure of the multidimensional optimal control problem and the maximum principle, growth and aging, Beverton-Holt fishery model, dynamic optimization.

**Multi-species models in fishery management:**
Combined harvesting of two ecologically independent fish species following logistic growth, bionomic equilibrium optimal harvest policy, combined harvesting of two competing fish species following logistic growth.

**Forestry Management:**
The Faustmann model, Kilkki-Vaisanen model, matrix model for the management of a height structured forest, modeling on degradation and subsequent regeneration of forestry resources.

**References:**
**B – 1.37 : Theory of Marketing Decisions I (50 marks)**

Elements of control theory, Basic optimal control problem, Augmented functional, Hamiltonian function, Adjoint equation, Transversality condition, Pontryagin’s maximum principal (formulation only) with continuous and discontinuous controls, Applications.

Basic concepts of demand curve, Supply curve, Price elasticity of demand and supply, Utility of consumption and consumers surplus, Different market forms of pure computations, Competitive equilibrium, Monopoly, Multi-product monopoly, Price discrimination, Oligopoly, Conjectural variation. Theory of costs of production, Marginal costs, Relationship between marginal productivity, average cost and marginal cost.

Theory of production, Production function, Cobb-Douglas production function and its properties, Elasticity of substitution, Constant production function, Derivation of the cost function from the production function – The Cobb-Douglas case, Solow-Minhaus-Arrow-Chenery production function and its properties.

**References:**


**B – 1.38: Theory of Semigroups I (50 Marks)**


**Green’s Equivalences:** Green’s equivalence relations: \( a \equiv_1 a \), \( a \equiv_2 a \), \( a \equiv_3 a \), and \( a \equiv_4 a \). The structure of \( a \)-classes, Regular \( a \)-classes, Regular semigroups.

**Completely regular semigroups:** Characterization of completely regular semigroups as union of groups, Semilattices of groups, Clifford semigroups, Orthodox semigroups.

**References:**

5. Introduction to semigroups, M. Petrich, Merrill, Columbus, 1973.
7. Lectures in semigroups, M. Petrich, 
8. Semigroups and combinatorial applications, G. Lallement,

B – 1.39 : Topological Groups and Harmonic Analysis I : 50 Marks)

Definition of a topological group and its basic properties, Subgroups and Quotient Groups, First, Second, Third Isomorphism Theorems, Properties of Topological Groups involving Connectedness, Separation Axioms in topological groups, Invariant Pseudo Metrics, Uniform Structure in Topological Groups, Compact and Locally Compact Topological Groups

Preliminaries of Lebesgue Measure, Measurable Function, Integration, Product Measure, Fubini’s Theorem, Signed Measure, Hahn Decomposition Theorem, Mutually Singular Measure, Radon Nikodym Theorem, Lebesgue Decomposition, Decomposition into Absolutely Continuous and Singular parts, Differentiation and Integration. Baire and Borel Sets, baire Sandwich Theorem, Borel and Baire Measures on Locally Compact Spaces, Regularity of Measure, Integration of Continuous Functions with compact Support, Riesz-Markoff Theorem.

References:

Second year Second Semester (250 Marks)

Unit 4.1: Advanced Numerical Analysis
(Theory : 20, Practical : 30)

Numerical solution of integral equations:

Finite element and Boundary element methods:

References:
1. Computing methods; Berzin and Zhidnov.
3. A first course in Numerical Analysis; Ralston and Rabinowitz.
6. The finite element method in structural and continuum mechanics; O.C.Zienkiewics.
8. An introduction to boundary element methods; Prem K. Kytbe.
9. Computational Mathematics; B.P.Demidovich and J.A.Maron.
10. Applied Numerical Methods; A. Gourdin & M. Boumahrat.

List of Practical Problems
1. Solution of ordinary differential and partial differential equation by weighted
   Residual method:
   a. Least square method.
   b. Galerkin method.

2. Solution of simple boundary value problem by
   a. Finite element and
b. Boundary element method.

3. Solution of system of Non-linear equations by Newton’s method.

Unit 4.1 Advanced Functional Analysis

Examples of Banach Spaces, Stone-Weierstrass Theorem, Ascoli-Arzela Theorem. $L^p$-spaces, Completeness and other Properties. Linear Topological Spaces, Locally Convex Spaces and their Characterization in terms of a family of Seminorms, Hahn-Banach Theorem, Separation Theorem, Open Mapping Theorem, Closed Graph Theorem, Weak Topology and Duality Theorem for Normed Linear Spaces, Krein-Milman Theorem and its Applications, Uniform Convexity, Strict Convexity and their Applications. 0.25in

References:

Unit 4.1: Discrete Mathematics – II

**The Foundations: Logic and Proofs**: (15 marks)
Propositional Logic, Propositional Equivalences, Predicates and Quantifiers, Nested Quantifiers, Rules of Inference, Introduction to Proofs, Proof methods and strategy.

**Introduction to Combinatorics**: (35 marks)

The Mathematics of Choice: The fundamental counting principle, Pascal’s triangle, Error-correcting codes, Combinatorial identities, Four ways to choose, The binomial and multinomial theorems, Partitions, Elementary symmetric functions.

Recurrence: Some examples, The auxiliary equation method, Generating functions, Derangements, Catalan numbers.
Partitions and Colorings: Partitions of a Set, Stirling Numbers, Counting Functions, Vertex Colorings of Graphs, Edge Colorings of Graphs.


Latin squares and Hall's theorem: Latin squares and orthogonality, Magic squares, Systems of distinct representatives, From Latin squares to Affine planes.

Schedules and 1-Factorizations: The circle method, Bipartite tournaments and 1-factorizations of $K_{n,n}$, Tournaments from orthogonal Latin squares.

Introduction to designs: Balanced incomplete block designs, Resolvable designs, Finite projective planes, Hadamard matrices and designs, Difference methods, Hadamard matrices and codes.

Text Books:

References:

Unit 4.2 Integral Equation and Integral Transform

Integral Equations – 25 marks
3. Fredholm theory for the solution of fredholm’s integral equation. Fredholm’s determinant $D(\lambda)$. Fredholm’s first minor $D(x,y,\lambda)$ Fredholm’s first and second fundamental relations. Fredholm’s $p$-th minor. Fredholm’s first, second and third fundamental theorems. Fredholm’s alternatives.
complete orthonormalised system of fundamental functions. Expansion of iterated kernel \( k(x,t) \), in terms of fundamental functions. Schmidt’s solution of Fredholm’s integral equations.

5. Applications

**Integral Transforms – 25 marks**


**References :**

1. I.N. Sneddon : The Uses of Integral Transforms.
4. Lovitt : Linear Integral Equations.
5. Tricomi : Integral Equations.
Unit 4.3 One course from A-2.1 to A-2.8

(*corresponding to the course selected in Unit 3.3 in the 2nd year 1st semester)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
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<tbody>
<tr>
<td>A - 2.1</td>
<td>Advanced Algebra – II</td>
</tr>
<tr>
<td>A - 2.2</td>
<td>Differential Topology</td>
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<tr>
<td>A - 2.3</td>
<td>Introduction to Algorithms - II</td>
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<tr>
<td>A - 2.4</td>
<td>Fluid Mechanics II</td>
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<td>A - 2.5</td>
<td>Mathematical Modelling of Biological Systems II</td>
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<tr>
<td>A - 2.6</td>
<td>Mathematical Theory of Elasticity II</td>
</tr>
<tr>
<td>A - 2.7</td>
<td>Principles of Operations Research II</td>
</tr>
<tr>
<td>A - 2.8</td>
<td>Quantum Mechanics</td>
</tr>
</tbody>
</table>

(*If a student has studied A-1.4 in the 2nd year 1st semester then the student has to go for A-2.4 in this semester.)

A – 2.1 : Advanced Algebra - II (50 Marks)

Multilinear Algebra (10 Marks):


**Note**: This course is based on the book [1]; Chapter 11.

Structure of Rings (30 Marks):

Artinian rings, Simple rings, Primitive rings, Jacobson density theorem, Wedderburn - Artin theorem on simple (left)Artinian rings. The Jacobson radical, Jacobson semisimple rings, subdirect product of rings, Jacobson semisimple rings as subdirect products of primitive rings, Wedderburn - Artin theorem on
Jacobson semisimple (left)Artinian rings.
Simple and Semisimple modules, Semisimple rings, Equivalence of semisimple rings with Jacobson semisimple (left)Artinian rings, Properties of semisimple rings, Characterizations of semisimple rings in terms of modules.

**Note**: This course is based on the books [4] and [3]; Chapter XVII.

**Group Representations (10 Marks)**:

Representations, Group-Rings, Maschke’s Theorem, Character of a Representation, Regular Representations, Orthogonality Relations, Burnside Two-Prime Theorem.

**Note**: This course is based on the book [3]; Chapter XVIII.

**References**:


**A – 2.2 : Differential Topology (50) Marks**

**Smooth Mappings**: Inverse Function Theorem, Local Submersion Theorem (Implicit Function Theorem).

**Differentiable manifolds**: Differentiable manifolds and submanifolds, examples, including surfaces, $S^n$, $\mathbb{RP}^n$, $\mathbb{CP}^n$, and lens spaces, tangent bundles; Sard’s theorem and its applications. Differentiable transversality, orientation, Whitney’s embedding theorems. Pontryagin-Thom construction, Fruedenthal suspension theorem.

**Vector fields and differential forms**: Integrating vector fields, degree of a map, Brouwer Fixed Point Theorem, Poincare-Hopf Theorem, differential forms, deRham’s theorem.

**References**:  

56

Spivak: Calculus on Manifolds, Benjamin, 1965 (differentiation, Inverse Function Theorem, Stokes Theorem)
Milnor: Topology from the Differentiable viewpoint, University of Virginia Press, 1965
James R Munkres: Elementary Differential Toplogy, 1966
Guillemen Pollack: Differential Toplogy, Prentice-Hall, 1974 (basic reference)

For the examples we refer to the books of

A – 2.3: Introduction to Algorithms - II: 50 marks

Theory - 35, Assignment - 15 (Computer lab access is necessary and mandatory)


Graph problems: Graph searching - BFS, DFS, topological sort; connected and biconnected components; minimum spanning trees - Kruskal’s and Prim’s algorithms, Single-source shortest paths - Dijkstra's algorithm, Bellman-ford algorithm, All-pair shortest paths – Shortest paths and matrix multiplication, Floyd-Warshall algorithm, Maximum flow – Flow networks, Ford-Fulkerson method, Maximum bipartite matching. 14 Lectures

Algebraic problems: Evaluation of polynomials with or without preprocessing. Winograd’s and Strassen’s matrix multiplication algorithms and applications to related problems, FFT, simple lower bound results. 10 Lectures

String processing: String searching and Pattern matching, Knuth-Morris-Pratt algorithm and its analysis. 6 Lectures

Computational geometry: Line-segment properties, Determining whether any pair of segments intersects, Finding the convex hull, Finding the closest pair of points. 10 Lectures
NP-completeness: Turing machines, Church's Thesis, P and NP, NP-completeness, statement of Cook’s theorem, some standard NP-complete problems, NP-hard problems, Some standard NP-complete problems, NP-hard problems, Graph Realization in two and three-dimensional real spaces. 20 Lectures

Approximation algorithms: Vertex covering, Traveling salesman problem, Set covering, Subset-sum problem. 10 Lectures

Text books:

References:

A – 2.4: Fluid Mechanics II (50 marks)

Basic thermodynamics of one compressible fluids:

Steady flow through a De Level nozzle. Normal and oblique shock wave shock polar diagram one dimensional similarity folw.


Reference Books:
1. Hydrodynamics – A.S. Ramsay (Bell)
2. Hydrodynamics – H. Lamb (Cambridge)
3. Fluid mechanics – L.D. Landou and E.M. Lifchitz (Pergamon), 1959
4. Theoretical hydrodynamics – L.M. Thomson
7. Inviscid gas dynamics – P. Niyogi, Mcmillan, 1975 (India)

### A-2.5 Modelling of Biological Events II (50 marks)

#### Models for Molecular Events:
Law of mass action, basic enzyme reaction, the quasi-steady-state assumption and its consequences, validity of the quasi-steady-state assumption, motion kinetics, cooperative kinetics, stability of activator–inhibitor and positive feedback systems.

#### The Chemostat Model:
Bacterial growth in a chemostat, formulation of the chemostat model, stability analysis of the steady states, construction of phase-plane diagram, saturating nutrient consumption rate (Monod model).

#### Diffusion Model:
The general balance law, Fick’s law, diffusivity of motile bacteria.

#### Models for Developmental Pattern Formation:
Background, model formulation, spatially homogeneous and inhomogeneous solutions, Turing model, conditions for diffusive stability and instability, pattern generation with single species model.

#### Models of Biological Oscillators:
Oscillation in chemical systems, Goodwin’s model, its stability and oscillations, simple two species oscillators- parameter domain determination for oscillations.

#### Models for Population Genetics:
Introduction, basic model for inheritance of genetic characteristic, Hardy-Wienberg law, models for genetic improvement, selection and mutation- steady state solution and stability theory.

#### References:


Reference:

2. Mathematical Theory of Elasticity - I. S. Sokolnikoff
3. Theory of Elasticity – S. Timoshenko and J. N. Goodier
4. Elasticity Theory and Applications – A. S. Saada
5. Foundations of Solid Mechanics – Y. C. Fung
6. Theory of Elasticity – Y. A. Amenzade
7. Applied Elasticity – Zhilun Xu
8. Wave Propagations in Elastic Solids – J. D. Achenbach
9. Elasto-dynamics – A. C. Eringen
10. Wave Motion in Elastic Solids – K. F. Graff
A – 2.7 : Principles of Operations Research II : 50 marks

**Sequencing**

Sequencing problems, Solution of sequencing problems, Processing $n$ jobs through two machines, Processing $n$ jobs through three machines, Optimal solutions, Processing of two jobs through $m$ machines, Graphical method of solution, Processing $n$ jobs through $m$ machines.

**Project Scheduling and Network Analysis**

Project scheduling by PERT and CPM, Construction of a network, Fulkerson's $i, j$ rule, Errors and dummies in a network, Critical path analysis, Forward and backward pass methods, Floats of an activity, Project costs by CPM, Crashing of an activity, Crash-cost slope, Time-cost trade off®, Solution of network problems using Simplex technique. Time estimates for PERT, Probability of completion of a project within a scheduled time.

**Replacement Models**

Replacement problem, Types of replacement problems, Replacement of capital equipment that varies with time, Replacement policy for items where maintenance cost increases with time and money value is not considered, Money value, Present worth factor (pwf), Discount rate, Replacement policy for item whose maintenance cost increases with time and money value changes at a constant rate, Choice of best machine, Replacement of low cost items, Group replacement, Individual replacement policy, Mortality theorem, Recruitment and promotional problems.

**Inventory Problems**

Introduction, Inventory problems, Inventory parameters, Variables in inventory problems, Controlled and uncontrolled variables, Classification of inventory models, Deterministic elementary inventory models, Economic lot size formula and its properties, Problems.

**Reference Books**

1. Operations Research - S.D. Sharma
2. Operations Research - Kanti Swarup, P.K. Gupta and Manmohan
3. OR methods and Problems - Sasieni Maurice, Arther Yspan, Lawrence Friedman
A – 2.8 : Quantum Mechanics (50 marks)

**Scattering Theory:** Kinematics of the scattering Process: Differential and total cross section. Laboratory and centre of mass system. Wave Mechanical Picture of scattering; scattering amplitude, boundary conditions, Optical Theorem. Born Approximation, its validity. Partial wave analysis. Phase shifts.


**References:**

1. L.Schiff: “Quantum Mechanics”.
2. P.M. Mathews and K Venkatesan: “Quantum Mechanics”.


Unit 4.4 and Unit 4.5 : Two courses from B-2.1 to B-2.39

(*corresponding to the course selected in Unit 3.4 and unit 3.5 in the 2nd yr 1st semester.
If a student has studied B-1.4 and B-1.34 in the 2nd year 1st semester then the student has
to go for B-2.4 and B-2.34 in this semester)

B - 2.1 Advanced Complex Analysis II
B - 2.2 Advanced Differential Geometry II
B - 2.3 Artificial Intelligence & Soft Computing II
B - 2.4 Astrophysics II
B - 2.5 Combinatorial Mathematics II
B - 2.6 Commutative Algebra and Algebraic Geometry II
B - 2.7. Computational Biology II
B - 2.8 Computational Fluid Dynamics Practical
B - 2.9. Computational Solid Mechanics II
B - 2.10 Image Processing
B – 2.11 Introduction to Computer Networks
B - 2.12 Coupled Fields of Solid Mechanics & Plasticity II
B - 2.13 Differential Geometry and its application II
B - 2.14 Dynamical Meteorology & Numerical weather prediction II
B - 2.15 Dynamical Oceanography II
B - 2.16. Elastodynamics II
B - 2.17 General Theory of Relativity and Cosmology II
B - 2.18 Generalized function & Wavelet Theory II
B - 2.19 Graph Theory II
B - 2.20 Information Theory & Coding II
B - 2.21 Magneto Fluid Mechanics II
B - 2.22 Mathematical Ecology II
B - 2.23 Mathematical Statistics II
B - 2.24 Measure and Topology II
B - 2.25 Mechanics of Viscous Fluid and Boundary Layer Theory II
B - 2.26 Nonlinear and Dynamic Programming II
B - 2.27 Introduction to Cryptography
B - 2.28 Introduction to Compiler Design
B - 2.29 Operator Algebra II
B - 2.30 Operator Theory II
B - 2.31 Plasma Mechanics II
B - 2.32 Probability & Stochastic Processes II
B - 2.33 Production and Inventory Control II
B - 2.34 Quantum Field Theory & Statistical Mechanics II
B - 2.35. Queuing Theory and Game Theory II
B - 2.36 Renewable Bio-economic Modelling and Epidemiology II
B - 2.37 Theory of Marketing Decisions II
B – 2.1: Advanced Complex Analysis II (50 Marks)

Harmonic Functions, Characterization of Harmonic Functions by Mean-Value Property, Poisson’s Integral Formula, Dirichlet Problem for a Disc.

Doubly Periodic Functions, Weierstrass Elliptic Functions.

Meromorphic Functions, Expansions, Definition of the functions $m(r,a)$, $N(r,a)$ and $T(r)$. Nevanlinna’s First Fundamental Theorem, Cartan’s Identity and Convexity Theorems, Order of Growth, Order of a Meromorphic Function, Comparative Growth of $\log M(r)$ and $T(r)$, Nevanlinna’s Second Fundamental Theorem, Estimation of $S(r)$ (statement only), Nevanlinna’s Theory of Deficient Values, Upper Bound of the Sum of Deficiencies.

References:
Hayman, W.K., *Meromorphic Functions*.
Kaplan, W., *An Introduction to Analytic Functions*.

B – 2.2: Advanced Differential Geometry II (50 Marks)

Principal fibre bundle, Linear frame bundle, Associated fibre bundle, Vector bundle, Tangent bundle, Induced bundle, Bundle homomorphisms.

Linear and affine connections, Riemannian connection, riemannian manifolds, Curvature tensors, Sectional curvature, Schur’s theorem,
Geodesics in a Riemannian manifold, Projective curvature tensor, Conformal curvature tensor, Submanifolds and hypersurfaces.

References
1. Foundation of differential Geometry (vol-1) :- S.KOBAYASHI and K. NOMIZU.
2. An Introduction to Differentiable Manifolds and Riemannian
3. Geometry :- W.M.BOOTHBY.
5. Introduction to Differentiable Manifolds : - L.AUSLANDER and R.E.MACKENZIE.

**B – 2.3 : Artificial Intelligence and Soft Computing II : 50 marks**


**References:**
3. Neural Networks by Simon Haykin – Pearson
4. Genetic Algorithms by David E. Goldberg – Addison-Wesley

**B – 2.4 : Astrophysics II (50 marks)**

4.
1.1 Plasma, black Body, Cherenkov & Synchroton Radiation
1.2 Accreation as source of radiation
1.3 Quasar as source of radition, Compton effect effect
1.4 Bremsstrallung Radition.

5. Formation of Galactic Structure – different Theories : -
1.1 Formation of our Galaxy.
1.2 Formation of Galaxy in Evolutionary Universe.
1.3 Formation of Galaxy in Steady State Universe.
1.4 Possibility of galactic structure formation through Explosion.

6.
1.1 Hubble’s Law & Expansion of Universe – Big Bang Model
1.2 Uniformity of Large Scale Structure of the Universe .
1.3 Origin of Cosmic Rays
1.4 Origin of Galaxies and the Universe.

**References:**
1. The Structure of the Universe – J.V. narlikar
2. Astrophysics – B. Basu
3. Astrophysics – B. Basu
4. Astrophysical Concept – M. Harmitt
5. Galactic Structure – A. Blauaw & M. Schmidt
6. Large Scale Structure of Galaxies – W.B. Burton
8. Cosmic Electrodynamics – J.H. Piddington

B – 2.5 : Combinatorial Mathematics II (50 Marks)

Steiner Triple Systems, Packing and covering.
Ramsey’s Theorem, Pigeonhole Principle, Bounds for Ramsey Number.
Design, Fisher’s Inequality.
Linear code, Error Correcting Code, Hamming Code.
Generating Function, Recurrence Relations, Solutions of Recurrence Relations by Generating Functions method.

References :

3. DISCRETE AND COMBINATORIAL MATHEMATICS by Ralph P. Grimaldi (AWL).

B – 2.6 : Commutative Algebra and Algebraic Geometry II (50 Marks)

Commutative algebra :
Valuation Rings, Discrete Valuation Rings, Dedekind Domains, Fractional and Invertible Ideals.
Topologies and Completions, Filtrations, Graded Rings and Modules, The Associated Graded Ring.
Hilbert Functions, Dimension Theory of Noetherian Local Rings, Hilbert-Samuel Polynomials, Krull’s Principal Ideal Theorem, Regular Local Rings, Transcendental Dimension.

Note : This course is based on the books [1], [2]. See [4] for Schmidt and Lüroth Theorems and Elimination Theory.

Algebraic Geometry :
Affine Space, Algebraic Sets, The Ideal of a Set of Points, Irreducible Components of an Algebraic Set, Algebraic Subsets of the Plane, Hilbert Nullstellensatz.
Affine Varieties, Coordinate Rings, Polynomial Maps, Coordinate Changes, Rational Functions and Local Rings, Discrete Valuation Rings, Forms, Ideals with Finite Number of Zeros.
Affine Plane Curves, Multiple Points and Tangent Lines, Multiplicities and Local Rings,
Intersection Numbers.
Resultants and Discriminants of Polynomials, Introduction to Elimination Theory.

**Note:** This course is based on the book [3]; Chapters 1-3. See [4] for Elimination Theory.

**References:**


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**B – 2.7 : Computational Biology II (50 marks)**

5. **Constructing Phylogenetic Trees.**
6. **Genetics.**
7. **Infectious Disease Modelling.**
   Elementary Epidemic Models. Threshold Values and Critical Parameters. Variations on a Theme.. Multiple Populations and Differentiated Infectivity.
8. **Curve fitting and Biological Modelling.**
   Fitting Curves to Data. The Method of Least Squares. Polynomial Curve Fitting.

**References:**

B –2. 8 : Computational Fluid Dynamics (Practical) (50 marks)

Solution of one-dimensional heat conduction equation using Explicit and Implicit scheme. Solution of 2-D heat conduction equation using ADI method. Solution of partial differential equation using Lax-Wendroff and Mac Cormack’s scheme. Solution of Navier-Stokes equation using stream function vorticity formulation. Solution of some problems on fluid dynamics using MAC method and SIMPLE algorithm

**Prerequisites**: Programming in C

**References**:


B –2. 9 : Computational Solid Mechanics II (Practical) :


Boundary Element Method : Numerical computation of some potential and elasticity problems using constant, linear and quadratic elements.

**References** :

B – 2.10. Image Processing (50 Marks)

Theory - 30, Assignment - 20  (Computer lab access is necessary and mandatory)

Introduction, image definition and its representation, neighborhood metrics, image processing systems, 2-D orthogonal transformations of images (DFT, DCT, HT, KLT), enhancement, contrast stretching, histogram specification, local contrast enhancement, smoothing and sharpening, spatial/ frequency domain filtering, segmentation, pixel classification, grey level thresh-holding, global/local thresh-holding, edge detection operators, region growing, split/merge techniques, image feature/primitive extraction, line detection, border following, Hough transform, medial axis transform, skeletonization / thinning, shape properties, compression, Huffman coding, block truncation coding, run-length coding, some applications.

References:


B – 2.11: Introduction to Computer Networks (50 Marks)

Theory - 30, Assignment - 20  (Computer lab access is necessary and mandatory)

Introduction: Computer networks and distributed systems, classifications of computer networks, layered network structures. 5 lectures

Data Communication Fundamentals: Channel characteristics, various transmission media, different modulation techniques. 7 lectures

Network Structure: Concepts of subnets, backbone and local access; Channel sharing techniques-FDM, TDMj Polling and concentration, message transport: circuit, message and packet-switching, topological design of a network. 12 lectures
Data Link Layers: Services and design issues, framing techniques, error handling and flow control, stop and wait, sliding window and APRANET protocols, HDLC standard. 10 lectures

Network Layer: Design issues, internal organization of a subnet, routing and congestion control techniques, network architecture and protocols, concepts in protocol design, CCITT recommendation X.25 12 lectures

LANs and their Interconnection: Basic concepts, architectures, protocols, management and performance of Ethernet, token ring and token bus LANS; Repeaters and Bridges. 10 lectures

Internet: IP protocol, Internet control protocols - ICMP, APR and RAPP, Internet routing protocols OSPF, BGP and CIDR. 12 lectures

ATM: ATM switches and AAL layer protocols. 10 lectures

Network Security: Electronic mail, directory services and network management. 10 lectures

Wireless and mobile communication: Wireless transmission, cellular radio, personal communication service, wireless protocol. Network planning, Gigabit and Terabit technology, CDMA, WCDMA, WDM, optical communication networks. 12 lectures

References:

B – 2.12 : Coupled fields of Solid Mechanics and Plasticity II (50 marks)

Thermoelasticity : 25 Marks


Viscoelasticity : 25 Marks


2. Wave Propagation in Elastic solid : J.D. Achenbach

B – 2.13 : Differential Geometry and its Applications II (50 marks)

Introduction to special theory of relativity and general theory of relativity, Manifolds of special and general theories of relativity, Metric in a gravitational field, Motion of a free particle in a gravitational field, Einstein law of gravitation, Metrics with spherical symmetry, Killing equations and conservation law, Spinor formalism, General theory of relativity in spinor formalism.

References:

2. D.E.BLAIR–Contact Manifolds in Riemannian Geometry,Lecture Notes in Maths.
B – 2.14 : Dynamic Meteorology and NWP II (50 marks)

11 : Unbalanced flow
Introduction, geostrophic adjustment, example of the Lagrangian method, the case of the anticyclone, divergence of parcels in a fluid, stream lines, the stream function.

12 : Euler and Lagrange
Introduction, geostrophic adjustment, example of the Lagrangian method, the case of the anticyclone, divergence of parcels in a fluid, stream lines, the stream function.

13 : Velocity
Introduction, circulation, vorticity, derivation of expressions for vorticity, relative and absolute vorticity, divergence-vorticity relation. A simple wave pattern, constant absolute vorticity trajectories, potential vorticity.

14 : The upper air synoptic chart
Introduction, pressure as vertical coordinate, Thermal wind Barotropic and baroclinic structure, vorticity on isobaric surface, velocity potential.

15 : Friction in the boundary layer of the atmosphere
Introduction, the Guldberg-Mohn approximation, Balanced frictional flow, The Newtonian concept of friction, The surface layer, The spiral or Ekman layer.

16 : Some more advanced equation
The divergence equation, The balanced equation, The omega equation.

17 : The Tropical cyclone
Introduction, structure and energy source, Genesis, Steering and development, movement, Development, Forecasting skill, problems.

18 : Synoptic observation and Numerical model :
Synoptic observation objective analysis, subjective analysis, stream lines, common synoptic patterns, weather associated with synoptic system, Tropical cyclone, genesis, steering, development, movement and forecasting skill, Numerical weather models.

Reference :
Forced Motion

Baroclinic Response of the Ocean.

Effects of Slide Boundary

Tropics

Mid Latitude

Instabilities, Fronts and General Circulation

References:
5. O. M. Philips: Dynamics of the Upper Ocean. Cambridge University Press (1966)
Two dimensional wave propagation. Plane elastic waves in a half-space with free boundary. Reflection of plane waves at a plane surface. Time harmonic SH-waves due to a line source on the free surface of a semi-infinite media. Moving line load on the surface of a half-space.


References:

1. Elastodynamics, Vol.-II : A.C.Eringen and E.S.Suhubi.
5. Wave Motion : J.Billingham and A.C.King.
9. Linear and Nonlinear Waves : G.B
B – 2.17 : General Theory of Relativity and Cosmology II (50 Marks)


Gravitational collapse of a homogeneous dust ball. Schwarzschild black hole. Simple idea of black hole physics.

Reference:s:
3. Introduction to cosmology - J.V. Narlikar.
5. Gravitation and Cosmology – S. Weinberg (J. Wiley and Sons.)
7. Introduction to Cosmology – M. Ross (J. Wiley and Sons).

Home

B – 2.18 : Generalised Functions and Wavelet Theory II (50 Marks)

Wavelets 50 Marks

Introduction – An overview. From Fourier analysis to Wavelet analysis. Classification of Wavelets. Different ways of constructing wavelets. Orthonormal bases generated by single function. Wavelet frames for $L^2(\mathbb{R})$. Local sine and cosine bases and the


References:

5. A primer on Wavelets and their scientific applications : J.S.Walker.
6. An Introduction to wavelets through linear algebra : Michael W. Frazier.

B – 2. 19 : Graph Theory II ( 50 Marks )


Matching : Maximum Matching Problem, Hall’s Marriage Theorem, Minimum covering problems : Vertex Cover, Konig-Egervary Theorem, Edge Cover and its characterization in terms of independence number.

Practical : Programs and Algorithms on problems of graph theory (mentioned above).

References :

2. Graph Theory, F. Harary, Addison-Wesley, 1969.

**B – 2.20: Information Theory and Coding II (50 Marks)**


**References :**

1. Elements of Information Theory : Thomas M. Cover and Joy A. Thomas.
3. Information Theory, Inference and learning algorithms : David J.C. Kackay.
5. An introduction to information theory : F.M. Reza.
8. A first course in coding theory : R. Hill.

**B – 2.21 : Magneto Fluid Mechanics II (50 Marks)**

**MHD waves**

Alfven’s wave and velocity, governing equation for Alfven’s wave, MHD waves in compressible fluids (i.e. Magneto acoustic wave), reflection and refraction of Alfven’s wave, Waves of finite amplitude, Dissipation effects in a viscous medium.

**Hydromagnetic stability**
Preliminaries, the method of small oscillations (the stability problem of an unbounded gravitating adiabatic gas in the presence of a magnetic field), the energy principle, the virial theorem, marginal stability, the Benard problem with a magnetic field.

**Hydromagnetic shock waves**
Introduction, Stationary plane shock waves in the absence of a magnetic field, Stationary plane shock wave in the presence of a magnetic field normal to the direction of flow, oblique shocks.

**Turbulence**
Introduction, spectral analysis, Hydromagnetic turbulence, Inhibition of turbulence by a magnetic field.

References:
3) Text Book on Fluid Dynamics – F. Chorlton.

B – 2.22 : Mathematical Ecology II (50 Marks)

**Effect of Nutrients on autotrophy-herbivore interaction:**
Introduction, Models on nutrient recycling and its stability, Effect of nutrients on autotrophy herbivore stability, Models on herbivore nutrient recycling on autotrophic production.

**Interactions of detritus and decomposers:**
Introduction, influence of decomposers on nutrient recycling. Donor-Controlled models and its stability, Effects of higher trophic levels in the detritus-based food chain.

**Interaction of Ratio-dependent models:**
Introduction, May’s model, ratio-dependent models of two interacting species, Two prey-one predator system with ratio-dependent predator influence- its stability and persistence.

**Ecological Succession:**
Introduction, Succession in a three species food chain model, Models of succession under gradual changes in nutrient level in a food web.

**Dynamics of Phytoplankton-Zooplankton system:**
Introduction, Models on phytoplankton-zooplankton system and its stability, Bio-control in plankton models with nutrient recycling.

References:
B – 2.23: Mathematical Statistics II (50 Marks)


Inference related to linear models – one and several parametric functions. Setup with restrictions. Analysis of variance. One-way classified data. Two-way classified data with single/multiple observations per cell.

General theory of regression. Test for an assigned regression function.

Principal component analysis. Basic concepts of factor analysis.


Sequential probability ratio test and its properties. Fundamental identity. Sequential estimation.

References:

B -2. 24 : Measure and Topology II (50 Marks)

Measure and Category :

Measure and Category on Real Line, Countable and Uncountable Sets, Sets of First Category, Null Sets, Theorems of Cantor, Baire and Borel, Application of Category Method to Nowhere Differentiable Functions, Liouville Numbers, Algebraic and Transcendental Numbers, Measure and Category of the Set of Liouville Numbers. Lebesgue Measure in \( r \) space: Definitions and Principal Properties, Measurable Sets, The Lebesgue Density Theorem.


Theorems of Lusin and Egoroff on Continuity of Measurable Functions and of Functions having the Property of Baire, Uniform Convergence on Subsets.

The Space of Automorphisms of an Interval, Effect of Monotone Substitution on Riemann Integrability, Nullsets Equivalent to Sets of First Category, Open Sets of First Category or Measure Zero, Montegomery’s Lemma, Banach Category Theorem, Theorems of Marczewski and Sikorski, Cardinals of Measure Zero, Decomposition into a Nullset and a Set of First Category.


Category Measure Spaces: Spaces in which Category and Measure Agree, Topologies generated by Lower Densities, The Lebesgue Density Topology.
B – 2.25 : Mechanics of Viscous fluids and Boundary layer Theory II
(50 Maks)

Fundamental concept of boundary layer when the Reynolds number is moderately large. Prandtl’s equation of the boundary layer. Expressions of displacement thickness and momentum thickness of the boundary layer. Vorticity and stress components within the boundary layer in two dimensional motion. Separation of boundary layer from an obstacle.

Blasius equation for steady two dimensional motion past a flat plate and its solution in the form of an infinite series. Boundary layer for two dimensional steady converging radial flow between two non parallel walls. Boundary layer for two dimensional jet. Flow symmetrical about a free stream lines. Problem of steady three dimensional jet. Karman’s integral equation of the boundary layer ; interpretation of its terms. Alternative form of integral equation in term of displacement, thickness and momentum thickness. Application of Karman’s integral equation in the study of the approximate solutions of steady two dimensional flow past a flat plate and comparison with the corresponding exact solutions; calculations of frictional resistance on both sides of the plate and checking of errors. Application of this method by assuming liner, quadratic, cubic, and biquadratic distribution of velocity. Lamb’s Trigonometric solution. Mises’ Transformation of boundary layer equation into an equation of the conduction of heat with variable coefficient of conduction.


References :

2. Hydrodynamics --- H. Lamb
10. Elementary treatise on hydrodynamics and sound --- A.B. Besset.
11. Modern developments in fluid dynamics --- S. Goldstein.
B – 2.26 : Non-linear and Dynamic Programming II (50 Marks)


Deduction of Eikenal equation by the principle of Multi-stage decision process. Shortest path in a network. Discrete and continuous feedback control process. Solution of some non-linear programming problems by dynamic programming.

Some existence theorems for fundamental functional equations in dynamic programming.

References:
2. Mangasarian – Nonlinear Programming

B -2. 27 : Introduction to Cryptography : 50 Marks

Complexity of Computations, Big-O Notation, Length of Numbers, Time Estimates, P, NP, and NP-Completeness.

Note: This course is based on the book [5]; Chapters 1-5.

References:

B -2. 28. Introduction to Compiler Design  (50 Marks)
Theory - 30, Assignment - 20  (Computer lab access is necessary and mandatory)

Introduction: Compiler, phases and passes, bootstrapping, finite state machines and regular expressions and their applications to lexical analysis, implementation to lexical analysers, lexical-analysers generator; LEX-compiler. 15 lectures
Syntax Analysis: Formal grammars, and their application to syntax analysis, BNF notation, ambiguity, LL(k) and LR(k) grammar, bottom-up and top-down parsers, operator precedence, simple precedence, recursive descent and predictive parsers, LR(k) parsers, parse table generation, grammars in YACC. 25 lectures
Syntax directed translation: Quadruples, triples, 3-address code, code generation for standard constructs with top-down and bottom-up parsers, procedure calls, record structuring. 15 lectures
Code optimization: Loop optimization, DAG analysis, loop identification by flow dominance, depth-first search, reducible flow graphs, legal code motion, induction variables, data flow analysis, u-d and d-u chains, copy propagation, elimination of global sub-expressions, constant folding, code hoisting, forward and backward data flow equations, inter procedural data flow analysis. 15 lectures
Code generation: Problems in code generation, code generator, register assignment and allocation problems, usage count, code generation from DAG, peephole optimization. 10 lectures

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Symbol table: Data structure and management, runtime storage administration, error detection and recovery; Lexical, syntactic and semantic errors, case studies with real life compilers. 10 lectures

**References:**


**B – 2. 29 : Operator Algebra II (50 Marks)**

**Von Neumann Algebras :**


**References :**

1. Bonsall and Duncan, Complete Normed algebras, Springer-Verlag.

**B – 2.30: Operator Theory II (50 Marks)**

**Selfadjoint operators: (50 Marks)**

Spectral properties of bounded selfadjoint linear operators on a complex Hilbert space, Positive operators, Square root of a positive operator, Projection operators, Spectral family of a bounded selfadjoint linear operator and its properties, Spectral theorem for a bounded selfadjoint linear operator.

**Normal Operators:**

Spectral properties for bounded normal operators, Spectral theorem for bounded normal operators.
Unbounded linear operators in Hilbert space:
Hellinger-Toeplitz theorem, Symmetric and selfadjoint operators, Closed linear operators, Spectrum of an unbounded selfadjoint linear operator, Cayley Transformation \( U = (T - iI)(T + iI)^{-1} \) of an operator \( T \), Spectral theorem for unitary and selfadjoint operators, Multiplication operator and differentiation operator, Application to Quantum Mechanics.

Reference Books:

B – 2.31: Plasma Mechanics II (50 Marks)


Nonlinear wave processes in plasma: Derivation of KdV-ZK equation for ion-acoustic wave & Alfven wave and their soliton solution.

Applications: Space Plasma, Solar Plasma, Gravitational Plasma, Laboratory Plasma,
References:
4. Fundamental of Plasma Physics, J.A. Bittencourt, PERGAMON PRESS, NEWYORK AND LONDON.

B –2. 32 : Probability and Stochastic Processes II (50 Marks)

Age-dependent branchin process.

References:

B –2. 33 : Production and Inventory Control II (50 marks)

Probabilistic demand models. Expected cost. Probabilistic order level systems.
Equivalence of probabilistic order level systems.

References:
B- 2.34: Quantum Field Theory and Statistical Mechanics II (50 marks)

Statistical Mechanics (50 marks)


Statistical Mechanics after Gibbs: Introduction, some important concept of general mechanics, Gibbs ensemble, Liouville’s theorem, canonical ensemble, fluctuation for canonical ensemble, Microcanonical ensemble, canonical distribution in new-space, in configurational and momentum space, Grand ensemble and physical interpretation.


References::


B – 2.35 : Queuing Theory and Game Theory II (50Marks)

1. What is Game Theory? A game is a collection of four components: players, strategies of players, outcomes and payoffs. We call games not only like chess, poker, bridge and so forth, but also conflicts between companies, military forces and nations.

2. Static vs. dynamic games

3. Cooperative vs. non-cooperative games

4. Related areas

differential games, optimal control theory, mathematical economics
5. Application areas

corporate decision making, defense strategy, market modeling, public policy analysis, environmental systems, distributed computing, telecommunications networks

References:

1. Introduction to Game Theory by Peter Morris, Springer
2. An Introduction to Game Theory by Martin J Osborne, Oxford University Press
3. Game Theory by L. A. Petrosjan, Nikolay A. Zenkevich, World Scientific

B – 2.36: Epidemiology and Eco-epidemiology (50 Marks)

Deterministic Epidemic Models:
Deterministic model of simple epidemic, Infection through vertical and horizontal transmission, General epidemic- Karmac-Mackendric Threshold Theorem, Recurrent epidemics, Seasonal variation in infection rate, allowance of incubation period, models with undamped waves, modeling of Venereal diseases, Simple model for the spatial spread of an epidemic.

Non Constant Total Population Model in Epidemic:
Introduction, Parasite-host system, an SIS model, an SIR model and an SIRS model.

Stochastic Epidemic Models:
Introduction, stochastic simple epidemic model, Yule-Furry model (pure birth process), expectation and variance of infective, calculation of expectation by using moment generating function.

Proportional Mixing Rate in Epidemic:
Introduction, SIS model with proportional mixing rate, SIRS model with proportional mixing rate.

Eco-Epidemiology:
Introduction, host-parasite-predator systems, viral infection on phytoplankton-zooplankton (prey-predator) system.

References:

B –2. 37 : Theory of Marketing Decisions II (50 marks)

Marketing management function, Sequence of marketing decisions, Marketing models-construction and types. Certainty and the marketing decision, Risk and the marketing decision, Uncertainty and the marketing decision, Criterion of pessimism, Criterion of optimism, Criterion of regret, Laplace criterion, Hurwicz criterion, Decision tree analysis.

Application of Bayesian decision theory in marketing management, Subjective and objective probability, Delphi process of pooling group opinion, Prior analysis, Posterior analysis, Pre-posterior analysis, Comparison of prior, posterior and pre-posterior analysis, Applications.

Advertising decisions, Determination of advertising goals – exposure, awareness and attitude, Response of sales to advertising, Vidale–Wolfe model, Determination of advertising budget, Monopoly advertising under static and dynamic conditions, Competitive strategy of promotion, Competitive models under uncertainty – maximin criterion, minimax criterion, Hurwicz criterion, Laplace criterion, minimax regret criterion.

Consumer buying behaviour, Warranty reserve, Competitive bidding model.

References:


B – 2.38: Theory of Semigroups II (50 Marks)

0-Simple Semigroups: Simple and 0-simple semigroups. Principal factors, Completely simple, completely 0-simple semigroups. Rees’ theorem. Primitive idempotents. (20)

Bands: Bands, Free bands, Varieties of bands. (10)

Inverse semigroups: Definition, Elementary properties of inverse semigroups, Congruences on inverse semigroups, Fundamental inverse semigroups. (10)

Automata Theory: Free Monoids, Languages and Codes, Automata, Rational Languages and their Syntactic Monoids. (10)

References:


5. Introduction to semigroups, M. Petrich, Merrill, Columbus, 1973.


7. Lectures in semigroups, M. Petrich,

8. Semigroups and combinatorial applications, G. Lallement,


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B – 2.39 : Topological Groups and Harmonic Analysis II (50 Marks)

The Haar Integral, Haar Measure on Locally Compact Groups, Convolutions of Functions and Measures (Discussions without proof).

Haar Measure on $\mathbb{R}$, $\mathbb{T}$, $\mathbb{Z}$ and some simple matrix groups, Approximate Identities, Fourier Series, Fejer’s Theorem, The Classical Kernels, Fejer’s, Poisson’s and Dirichlet’s Summability in Norm and Pointwise Summability, Fatou’s Theorem, The Fourier Transform, Kernels on $\mathbb{R}$, The Plancherel Theorem on $\mathbb{R}$, Plancherel Measure on $\mathbb{R}$.

Elements of Representation Theory, Unitary Representations of Locally Compact Groups.

References:
