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Sikkim University

[A Central University Established by an Act of Parliament of India in 2007]



M.Sc. in Mathematics
(4 Semester Programme)

Syllabus

Department of Mathematics
Sikkim University
Gangtok-737102

M. Sc. in Mathematics

Course Layout

Subject Code	Paper name	Credits	L-T-P
Semester I			
MATH C-401	Analysis-I	4	4-0-0
MATH C-402	Linear Algebra		4-0-0
MATH C-403	Combinatorics and Elementary Number Theory	4	4-0-0
MATH C-404	Differential Equations	4	4-0-0
Semester II			
MATH C-405	Analysis II	4	4-0-0
MATH C-406	Complex Function Theory	4	4-0-0
MATH C-407	Algebra	4	4-0-0
	Open Elective-I	4	
Semester III			
MATH C-501	Topology	4	4-0-0
MATH C-502	Numerical Analysis	4	4-0-1.5
MATH E-503	Elective-I	4	4-0-0
	Open Elective-II	4	
Semester IV			
MATH C-504	Functional Analysis	4	4-0-0
MATH E-505	Elective-III	4	4-0-0
MATH E-506 OR 507	Elective-IV OR Elective-V	4	4-0-0
	OR		
MATH P-508	Project Work*	4	0-0-6
Total Credits for M.Sc. 64			

Open Elective: Papers which shall be opted from other departments

Elective: Papers which shall be opted from the department

*Students having good SGPA are eligible to take a project of 8 credits in lieu of two elective papers in final semester, subject to the approval of the department.

Departmental Electives:

MATH-E-503 FOR III SEMESTER STUDENTS

1. Galois Theory
2. Probability and Distributions
3. Differential Geometry
4. Optimization Techniques
5. Mathematical Ecology

MATH-E-504-507 FOR IV SEMESTER STUDENTS

1. Statistical Inference
2. Measure Theory
3. Algebraic Topology
4. Functional Analysis and PDE
5. Cryptography
6. Finite Element Methods
7. Nonlinear Dynamics
8. Financial Mathematics
9. Applied Stochastic Processes
10. Dynamic Meteorology and Numerical Weather Prediction
11. Renewable Bio-Economic Modelling
12. Computational Biology

MATH C-401: ANALYSIS-I

UNIT I Real Numbers

Relations and functions, Finite and infinite sets, countable and uncountable sets, least upper bound property, the field of real numbers, Archimedean property, density of rational numbers, existence of n^{th} root of positive real numbers, exponential and logarithm, the extended real number system.

UNIT II Numerical Sequences and Series

Numerical sequences and their convergence, bounded sequences, Cauchy sequences, construction of real numbers using Cauchy sequences; limit supremum and limit infimum, Bolzano-Weierstrass' theorem for sequences of real number, series of nonnegative terms, the number e , tests of convergence of series, power series, absolute convergence, addition and multiplication of series, rearrangements (statement only).

UNIT III Topology of $\mathbb{R}^n$

Euclidean spaces, open and closed sets, limit points, interior points, compact subsets of $\mathbb{R}^n$, nested interval theorem, Heine-Borel theorem, and Bolzano-Weierstrass' theorem.

Limits of functions, continuous functions, continuity and compactness, uniform continuity, connected sets, connected subsets of real numbers, continuity and connectedness, intermediate value theorem; discontinuities and their classifications, monotonic functions, infinite limits and limits at infinity.

UNIT-IV Differentiation & Integration

Differentiation of real-valued functions and its elementary properties; mean value theorem; Taylor's theorem; elementary properties of Riemann integral, Fundamental theorem of Calculus, mean value theorem, convergence of improper integrals.

Textbooks:

1. Rudin, W. (2013) Principles of Mathematical Analysis (3rd Edition), Tata McGraw Hill Education.
2. Rotman, J.J. (2002) An Introduction to the Theory of Groups (4th edition) Allyn and Bacon, Inc., Boston.

Reference books:

1. Apostol, T. (2000) Mathematical Analysis (2nd edition) Narosa Book Distributors Pvt. Ltd.
2. Bartle, R.G. and Sherbert D. R. (2000) Introduction to Real Analysis (3rd edition) John Wiley & Sons, Inc., New York.
3. Fraleigh, J. B. (2002) A First Course in Abstract Algebra (4th edition) Narosa Publishing House, New Delhi.
4. Gallian, J. A. (1999) Contemporary Abstract Algebra (4th edition) –Narosa Publishing House, New Delhi.

MATH C-402: LINEAR ALGEBRA

UNIT I Vector Space

Vector spaces, linear independence; linear transformations, matrix representation of a linear transformation; isomorphism between the algebra of linear transformations and that of matrices;

UNIT II Eigenvalues and Eigenvectors

Similarity of matrices and linear transformations; trace of matrices and linear transformations, characteristic roots and characteristic vectors, characteristic polynomials, relation between characteristic polynomial and minimal polynomial; Cayley-Hamilton theorem (statement and illustrations only); diagonalizability, necessary and sufficient condition for diagonalizability;

UNIT III Canonical Forms

Projections and their relation with direct sum decomposition of vector spaces; invariant subspaces; primary decomposition theorem, cyclic subspaces; companion matrices; a proof of Cayley-Hamilton theorem; triangulability; canonical forms of nilpotent transformations; Jordan canonical forms; rational canonical forms.

UNIT IV Inner Product Spaces

Inner product spaces, properties of inner products and norms, Cauchy-Schwarz inequality; orthogonality and orthogonal complements, orthonormal basis, Gram-Schmidt process; adjoint of a linear transformation; Hermitian, unitary and normal transformations and their diagonalizations.

Textbooks:

1. Hoffman, K., Kunze, R. (2000) Linear Algebra (2nd edition) Prentice Hall of India Pvt. Ltd., New Delhi.
2. Bhattacharya, P. B. Jain, S. K. and Nagpal, S. R. (2000) First Course in Linear Algebra, Wiley Eastern Ltd., New Delhi.

Reference books:

1. Herstein, I. N. (2003) Topics in Algebra (4th edition), Wiley Eastern Limited, New Delhi.
2. Shilov, G. E. (1998) Linear Algebra, Prentice Hall Inc.
3. Halmos, P. R. (1965) Finite Dimensional Vector Spaces, D. Van Nostrand Company Inc.
4. Finkbeiner, D. T. (2011) Introduction to Matrices and Linear Transformations (3rd edition) Dover Publications.
5. Kumaresan, S. (2001) Linear Algebra: A Geometric Approach, Prentice-Hall of India Pvt. Ltd., New Delhi.

MATH C-403: COMBINATORICS AND ELEMENTARY NUMBER THEORY

UNIT I Elementary Combinatorics

Divisibility; Euclidean algorithm; primes; congruences; Fermat's theorem, Euler's theorem and Wilson's theorem; Fermat's quotients and their elementary consequences; solutions of congruences; Chinese remainder theorem; Euler's phi-function.

UNIT II Congruences

Congruence modulo powers of prime; primitive roots and their existence; quadratic residues; Legendre symbol, Gauss' lemma about Legendre symbol; quadratic reciprocity law; proofs of various formulations; Jacobi symbol.

UNIT III Diophantine Equations Solutions of $ax + by = c$, $x^2 + y^2 = z^2$, $x^4 + y^4 = z^2$; properties of Pythagorean triples; sums of two, four and five squares; assorted examples of diophantine equations.

UNIT IV Generating Functions and Recurrence Relations

Generating Function Models, Calculating coefficient of generating functions, Partitions, Exponential Generating Functions, A Summation Method.

Recurrence Relations: Recurrence Relation Models, Divide and conquer Relations, Solution of Linear, Recurrence Relations, Solution of Inhomogeneous Recurrence Relations, Solutions with Generating Functions.

Textbooks:

1. Niven, I., Zuckerman, H. S. and Montgomery, H. L. (2003) An Introduction to the Theory of Numbers (6th edition) John Wiley and sons, Inc., New York.
2. Burton, D. M. (2002) Elementary Number Theory (4th edition) Universal Book Stall, New Delhi.
3. Balakrishnan, V. K. (1994) Schaum's Outline of Theory and Problems of Combinatorics Including Concepts of Graph Theory, Schaum's Outline.
4. Balakrishnan, V. K. (1996) Introductory Discrete Mathematics, Dover Publications.

Reference books:

1. Dickson, L. E. (1971) History of the Theory of Numbers (Vol. II, Diophantine Analysis) Chelsea Publishing Company, New York.
2. Hardy, G.H. and Wright, E. M. (1998) An Introduction to the Theory of Numbers (6th edition), The English Language Society and Oxford University Press.
3. Niven, I. and Zuckerman, H. S. (1993) An Introduction to the Theory of Numbers (3rd edition), Wiley Eastern Ltd., New Delhi.

MATH C-404: DIFFERENTIAL EQUATIONS

UNIT I Initial Value Problems

Existence and uniqueness of solutions of IVP: method of successive approximations, system of first order approximations, Picards theorem, Continuous dependence of the solution on initial data, general theory of system of first order equations. Linear systems: Homogenous and nonhomogenous linear systems with constant coefficients.

UNIT II Series Solution

Power series solution, second order equations, ordinary points, regular points and singular points, special functions, Hermite polynomials, Chebychev polynomials, Legendre polynomials, Bessel functions, Gamma functions

UNIT III Boundary Value Problem

Boundary value problem, Green function, Sturm-Liouville Theory, eigenvalues and eigenfunctions, qualitative properties of solutions, Sturm comparison theorem, Sturm separation theorem

UNIT IV Partial Differential Equations

First order equations, Cauchy Kowlewski theorem, classification of second order PDE, canonical form second order linear equations with constant co-efficients, method of separation of variables. Characteristics and uniqueness theorem for hyperbolic theorems with initial boundary conditions. Elliptic and Parabolic partial differential equations

Text Book :

1. Ross, S. L. (1984) Differential Equations (3rd edition), John Wiley & Sons.
2. Coddington, E. A. An Introduction to Ordinary Differential Equations, Prentice-Hall.
3. Sneddon, I.N. (1957) Elements of Partial Differential Equations, McGraw Hill.

References:

1. G. F. Simmons, Differential Equations with Applications and Historical Notes, McGraw Hill Education.
2. Fritz John (1982) Partial Differential Equations, Springer-Verlag, New York Inc.
3. Coddington, E. A. and Levinson, N. (1955) Theory of Ordinary Differential equations, TMH Education.
4. Cronin, J. (1994) Differential Equations: Introduction and Qualitative Theory, Marcel Dekker.
5. Hirsch, M.W. Smale, S. and Devaney, R.L. (2004) Differential Equations, Dynamical Systems and an Introduction to Chaos, Elsevier.

MATH C-405: ANALYSIS II

UNIT I Sequences & Functions Sequences of functions, pointwise and uniform convergence, uniform convergence and continuity, uniform convergence and integration, uniform convergence and differentiation, Weierstrass' approximation theorem.

UNIT II Differentiability of Functions of Several Variables Directional derivatives and differentiability of functions of several variables and their interrelationship, chain rule, mean value theorem; higher order partial derivatives, equality of mixed partial derivatives, Taylor's theorem.

UNIT III Inverse & Implicit Function Theorem

Injective mapping theorem, surjective mapping theorem, inverse function theorem and implicit function theorem of functions of two and three (for analogy) variables, extremum problems with and without constraints of functions of two and three (for analogy) variables.

UNIT IV Multiple Integrals, Multiple integrals, repeated integrals, interchange of order of integrations, change of variable theorem, mean-value theorems for multiple integrals, line integral and Green's theorem, Convergence of improper integrals.

Textbooks,:

1. Rudin, W. (2013) Principles of Mathematical Analysis (3rd Edition), Tata McGraw Hill Education.
2. Apostol, T. (2000) Mathematical Analysis (2nd edition) Narosa Book Distributors Pvt. Ltd.
3. Bartle, R.G. (1994) The Elements of Real Analysis (3rd edition), Wiley International Edition.
4. Buck, R. C. & Buck, E. F. (1999) Advanced Calculus (4th Edition), McGraw Hill, New York.
5. Simmons, G. F. (2003) Introduction to Topology and Modern Analysis (4th edition), McGraw Hill.
6. Bartle, R. G. and Sherbert, D. R. (2000) Introduction to Real Analysis (3rd edition), John Wiley & Sons, Inc., New York.

MATH C-406: COMPLEX FUNCTION THEORY

UNIT I Holomorphic Functions

Holomorphic Functions, Cauchy-Riemann equations and its applications, Formal power series, radius of convergence of power series, exponential, cosine and sine, logarithm functions introduced as power series, their elementary properties.

UNIT II Complex Integration

Integration of complex-valued functions and differential 1-forms along a piecewise differentiable path, primitive, local primitive and primitive along a path of a differential 1-form, Index of a closed path, Cauchy's theorem for convex regions.

Cauchy's integral formula, Taylor's expansion of holomorphic functions, Cauchy's estimate; Liouville's theorem; fundamental theorem of algebra; zeros of an analytic function and related results; maximum modulus theorem; Schwarz' lemma.

UNIT III Singularities and Residues

Laurent expansion of a holomorphic function in an annulus, singularities of a function, removable singularities, poles and essential singularities; extended plane and stereographic projection, residues, calculus of residues; evaluation of definite integrals; argument principle; Rouché's Theorem.

UNIT IV Conformal Mapping

Complex form of equations of straight lines, half planes, circles, etc., analytic (holomorphic) function as mappings; conformal maps; Möbius transformation; cross ratio; symmetry and orientation principle; examples of images of regions under elementary analytic function.

Textbooks:

1. Sarason, D. (2008) Complex Function Theory, Texts and Readings in Mathematics/ 5, Hindustan Book Agency, New Delhi.

Reference books:

1. Ahlfors, L. V. (1990) Complex Analysis (2nd Edition), McGraw-Hill International Student Edition.
2. Conway, J. B. (2000) Functions of one complex variable, Springer International Student edition, Narosa Publishing House, New Delhi.
3. Churchill, R. V. (1996) Complex Variables and applications, McGraw-Hill.
4. Copson, E. T. (1995) An Introduction to the Theory of functions of a complex Variable, Oxford University Press.
5. Shastri, A. R. (2003) An Introduction To Complex Analysis, Macmillan India Ltd.

MATH C-407: ALGEBRA

UNIT I Basic Concepts of Groups

A brief review of groups, their elementary properties and examples, subgroups, cyclic groups, homomorphism of groups and Lagrange's theorem; permutation groups, permutations as products of cycles, even and odd permutations, normal subgroups, quotient groups; isomorphism theorems, correspondence theorem;

UNIT II Sylow's Theorem

Group action; Cayley's theorem, group of symmetries, dihedral groups and their elementary properties; orbit decomposition; counting formula; class equation, consequences for p-groups; Sylow's theorems (proofs using group actions)

Applications of Sylow's theorems, conjugacy classes in S_n and A_n , simplicity of A_n . Direct product; structure theorem for finite abelian groups; invariants of a finite abelian group (Statements only)

UNIT III Rings

Basic properties and examples of ring, domain, division ring and field; direct products of rings; characteristic of a domain; field of fractions of an integral domain; ring homomorphisms (always unitary); ideals; factor rings; prime and maximal ideals, principal ideal domain; Euclidean domain; unique factorization domain.

UNIT IV Polynomial Rings

A brief review of polynomial rings over a field; reducible and irreducible polynomials, Gauss' theorem for reducibility of $f(x) \in \mathbb{Z}[x]$; Eisenstein's criterion for irreducibility of $f(x) \in \mathbb{Z}[x]$ over $\mathbb{Q}$, roots of polynomials; finite fields of orders 4, 8, 9 and 27 using irreducible polynomials over $\mathbb{Z}_2$ and $\mathbb{Z}_3$.

Textbooks:

1. Bhattacharya, P.B., Jain, S. K. and Nagpal S. R. (2000) Basic Abstract Algebra (3rd edition), Cambridge University Press.
2. Jacobson, N. (2002) Basic Algebra I (3rd edition), Hindustan Publishing Corporation, New Delhi.
3. Gallian, J. A. (1999) Gallian Contemporary Abstract Algebra (4th edition), Narosa Publishing House, New Delhi.

Reference books:

1. Herstein, I. N. (2003) Topics in Algebra (4th edition), Wiley Eastern Limited, New Delhi.
2. Fraleigh, J. B. (2002) A First Course in Abstract Algebra (4th edition), Narosa Publishing House, New Delhi.
3. Dummit, D.S. and Foote, R.M (2003) Abstract Algebra, John Wiley & Sons.

MATH C-501: TOPOLOGY

UNIT I Topology

Definition and examples of topological spaces; basis and sub basis; order topology; subspace topology. Continuity and related concepts; product topology; quotient topology; countability axioms; Lindelof spaces and separable spaces.

UNIT II Connectedness

Connected spaces, generation of connected sets; component, path component; local connectedness, local path-connectedness.

UNIT III Compactness Compact spaces; limit point compact and sequentially compact spaces; locally compact spaces; one point compactification; finite product of compact spaces, statement of Tychonoff's theorem (Proof of finite product only).

UNIT IV Separability & Countability Separation axioms; Urysohn's lemma; Tietze's extension theorem; Urysohn's embedding lemma and Urysohn's metrization theorem for second countable spaces.

Textbooks:

1. Munkres, J. R. (2000) Topology: a First Course, Prentice-Hall of India Ltd., New Delhi.

Reference books:

1. J. Dugundji (1990) General Topology, Universal Book Stall, New Delhi.
2. Pervin, W. J. (1964) Foundations of General Topology, Academic Press, New York.
3. Willard, S. (1970) General Topology, Addison-Wesley Publishing Company, Massachusetts.
4. Armstrong, M. A. (2005) Basic Topology, Springer International Ed.
5. Kelley, J. L. (1990) General Topology, Springer Verlag, New York.
6. Joshi, K. D. (2002) An Introduction to General Topology (2nd edition), Wiley Eastern Ltd., New Delhi.

MATH C-502: NUMERICAL ANALYSIS

UNIT I Non- linear system of equations and linear system of algebraic equations

System of non-linear equations: Fixed point iteration method for the system $x = g(x)$, sufficient condition for convergence, Newton's method for nonlinear systems

Solution of Linear equations: Direct methods: Gaussian elimination, LU and Cholesky factorizations. Operational counts for all these direct methods. Iterative methods: General framework for iterative methods, Jacobi and Gauss Seidel methods, Necessary and sufficient conditions for convergence, order of convergence, successive relaxation method.

UNIT II Eigenvalue Problem

Gershgorin theorem, Power and inverse power method, QR method. Jacobi, Givens and Householder's methods for symmetric eigenvalue problem

UNIT III Finite Difference Methods:

Finite difference methods for two point boundary value problems, convergence and stability. Finite difference methods for parabolic, hyperbolic and elliptic partial differential equations: Discretization error, Idea of convergence and stability, Explicit and Crank-Nicolson implicit method of solution of one dimensional heat conduction equation: convergence and stability. Standard and diagonal five point formula for solving Laplace and Poisson equations, Explicit and Implicit method of solving Cauchy problem of one-dimensional wave equation, CFL conditions of stability and convergence, Finite difference approximations in polar coordinates.

UNIT IV Practical

1. Gauss-Jordan method
2. LU and Cholesky factorization methods
3. Inverse of a matrix
4. S.O.R. / S.U.R. method
5. Relaxation method
6. Power and inverse power methods
7. Jacobi, Givens and Householder's methods
8. Solution of one dimensional heat conduction equation by
 - i) Explicit and
 - ii) Crank-Nicolson implicit method
9. Solution of Laplace equation
10. Solution of Poisson equation
11. Solution of one-dimensional wave equation

Textbooks:

1. K. E. Atkinson, K. E. (1989) Introduction to Numerical Analysis, John Wiley.
2. Smith, G. D. (1986) Numerical Solution of Partial Differential Equations, Oxford University Press.
3. Dutta, B. N. (2010) Numerical Linear Algebra and Its Application (2nd Edition) SIAM.

Reference books:

1. Conte, S. D. and de Boor, C. (1980) Elementary Numerical Analysis: An Algorithmic Approach (3rd edition), McGraw Hill, New York.
2. Scarborough, J. B. (2001) Numerical Mathematical Analysis, Oxford & IBH Publishing Co.
3. Isaacson, E. and Keller, H. B. (1966) Analysis of Numerical Methods, Wiley (Dover Edition) New York.
4. J. Stoer (2002) Introduction to Numerical Analysis (3rd edition), Springer.

MATH C-504: FUNCTIONAL ANALYSIS

UNIT I Normed Linear Spaces

Vector spaces, normed spaces, linear operators, boundedness, Hahn-Banach theorem, completeness, Cantor intersection, Baire Category theorem.

UNIT II Basic Theorems

Open Mapping and Closed Graph Theorems, Uniform Boundedness Principle, seminorms, weak and weak* topologies, Alaoglu's theorem, Hahn-Banach Separation theorem.

UNIT III Hilbert Spaces

Inner product spaces, Cauchy Schwarz inequality, Parallelogram identity, Polarisation identity. Hilbert spaces, examples, uncountable sums (unconditional summability), orthonormal sets, Bessel's inequality, orthonormal bases, separable Hilbert spaces, orthogonal complements, projection theorem, orthogonal projections and direct sums of Hilbert spaces.

UNIT IV Linear Operators (12)

Riesz lemma, equivalence between bounded sesquilinear forms and bounded operators, adjoint operator, self-adjoint operators and Cartesian decomposition, projections, isometries and unitary operators, unitary equivalence, examples: unilateral and bilateral shifts, multiplication operators. Strong and weak operator topologies, operators on direct sums and matrices of operators

Text Book:

1. Sunder, V.S. (1997) Functional Analysis : Spectral Theory, TRIM Series, No. 13, Hindustan Book Agency, Delhi.

Reference Book:

1. Rudin, W. (1973) Functional Analysis, Mc-Graw Hill.
2. Simmons, G.F. (1963) Topology and Modern Analysis, McGraw-Hill.

ELECTIVES FOR MATH- E-503

1. GALOIS THEORY

UNIT I Field Theory

Extension fields, finite extensions; algebraic and transcendental elements, adjunction of algebraic elements, Kronecker theorem, algebraic extensions, splitting fields – existence and uniqueness; extension of base field isomorphism to splitting fields;

UNIT II Polynomials: Simple and multiple roots of polynomials, criterion for simple roots, separable and inseparable polynomials; perfect fields; separable and inseparable extensions, finite fields; prime fields and their relation to splitting fields; Frobenius endomorphisms; roots of unity and cyclotomic polynomials.

UNIT III Galois group: Algebraically closed fields and algebraic closures, primitive element theorem; normal extensions; automorphism groups and fixed fields; Galois pairing; determination of Galois groups, fundamental theorem of Galois theory, abelian and cyclic extensions.

UNIT IV Solvability

Normal and subnormal series, composition series, Jordan-Holder theorem (statement only); solvable groups, Solvability by radicals; solvability of algebraic equations; symmetric functions; ruler and compass constructions, fundamental theorem of algebra.

Textbooks:

1. T. I. F. R. Mathematical pamphlets, No. 3, (1965) Galois Theory.
2. Artin, E. (1997) Galois Theory, Edited by Arthur N. Milgram, Dover Publications.

Reference books:

2. Herstein, I. N. (2003) Topics in Algebra (4th edition), Wiley Eastern Limited, New Delhi.
3. Bhattacharya, P. B., Jain, S. K. and Nagpal, S. R. (2000) Basic Abstract Algebra (3rd edition), Cambridge University Press.
4. Jacobson, N. (2002) Basic Algebra I (3rd edition), Hindustan Publishing Corporation, New Delhi.
5. Fraleigh, J. B. (2002) A First Course in Abstract Algebra (4th edition), Narosa Publishing House, New Delhi.

2. PROBABILITY AND DISTRIBUTIONS

UNIT I Probability

Classical and relative frequency interpretation of probability; Sigma algebra of events; Axiomatic definition of probability measure and its properties; Conditional probability; Theorem of total probability; Baye's theorem, Independence of events; Sequences of events and their limits; Continuity of probability measures.

Random Variable and Its Distribution: Random variables and induced probability measures; Distribution function and its properties; Discrete type random variable and probability mass function; Continuous type random variable; Absolutely continuous random variable and probability density function.

Function of a Random Variable and Its Distribution: Function of a random variables and its distribution; Probability mass function and probability density function of a random variable; Expectation; Moments; Moment generating function and its uniqueness; Properties of moment generating function; Markov's and Chebyshev's inequalities; Characteristics of probability distributions (measures of central tendency; measures of dispersion; measures of skewness and measures of kurtosis).

UNIT II Special Discrete Distributions and their Properties

Discrete uniform distribution; Bernoulli trials and related distributions (binomial distribution; Geometric and negative binomial distribution); Hypergeometric distribution; Poisson distribution; Binomial approximation to Poisson distribution.

Special Absolutely Continuous Distributions and Their Properties: Uniform distribution; Cauchy distribution; Exponential and gamma distribution; Chi-square distribution; Beta distribution; Normal distribution; Student's-t and Snedcor's-F distributions.

UNIT III Random Vector and Its Joint Distribution

Random vectors; Joint distribution function and its properties; Marginal and conditional distributions of a random vector; Independent random vectors/variables; Discrete type random vector and its probability mass function; Multinomial distribution and its properties; Absolutely continuous type random vector; Absolutely continuous random vector and its probability density function; Expectation of a function of a random vector; Joint moments; Joint moment generating function and its uniqueness; Properties of joint moment and joint cumulant generating functions; Covariance; Correlation; Bivariate normal distribution and its properties; Idea of multivariate normal distribution.

UNIT V Distribution of Functions of Random Vectors

Distribution of functions of discrete type and absolutely continuous type random variables; Jacobian method for finding distribution of functions of absolutely continuous type random vectors; Use of moment generating function in finding distribution of functions of random vectors; Reproductive property of binomial, Poisson, negative binomial, normal, gamma and chi-square distributions; Basic ideas of sampling theory; Random sample; Distribution of order statistics; Joint distribution of sample mean and sample variance based on a random sample from normal population.

Text books:

1. Hogg, R. V., McKean, J. W. and Craig, A.T. (2004) An Introduction to Mathematical Statistics, Pearson.
2. Rohatgi, V. K. (1976) An introduction to probability and statistics, Wiley.
3. Dudewicz, E. J. and Mishra, S. N. (1988) Modern Mathematical Statistics, Wiley.

3. DIFFERENTIAL GEOMETRY

UNIT I Vectors

Vectors in R^3 ; tangent vectors; tangent spaces; tangent vector fields; derivative mappings; translations; affine transformations and rigid motions (isometries); exterior derivatives.

UNIT II Space curves

Space curves; arc length; tangent vectors and vector fields on a curve; curvature and torsion; Serret-Frenet formulas; osculating plane; osculating circle; osculating sphere; fundamental theorem of local theory of space curves (existence and uniqueness theorems).

UNIT III Surfaces

Surfaces and their (local) parametrization on coordinate systems; change of parameters; parametrized surfaces; curves on surfaces; tangent and normal vectors; tangent and normal vector fields on a surface; first, second and third fundamental forms of a surface at a point; Gauss mapping.

UNIT IV Curvature

Normal sections and normal curvature of a surface at a point; Meusnier's theorem; elliptic, hyperbolic, parabolic and planar points; Dupin indicatrix; principal directions; principal curvatures of a surface at a point; Mean curvature and Gaussian curvature of a surface at a point.

Line of curvature; asymptotic curves; conjugate directions; fundamental equations of the local theory of surfaces; statement of Bonnet's fundamental theorem of local theory of surfaces.

Textbook:

1. Hsiung, C. C. (1997) A first Course in Differential Geometry, International Press, University of Michigan.

Reference:

1. Eissenhart, P. (1960) A Treatise on the Differential Geometry of Curves and Surfaces, Dover Publications, Inc., New York.
2. Weatherburn, C. R. (1964) Differential Geometry of Three Dimensions, The English Language Book Society and Cambridge University Press.
3. Willmore, T. S. (1979) An Introduction to Differential Geometry, Clarendon Press, Oxford.
4. Klingenberg, V. (1978) A Course in Differential Geometry, Graduate Texts in Mathematics 51, Springer-Verlag.
5. Pressley, A. (2005) Elementary Differential Geometry, Springer International Edition.

4. OPTIMIZATION TECHNIQUE

UNIT I Introduction

Nature and Features of Operations Research (O.R)- Convex set- Polyhedral Convex Set- Linear Programming (L.P)-Mathematical Formulation of the Problem- Graphical Solution Method-Some Exceptional Cases-General Linear Programming Problem (General L.P.P)

UNIT II Linear Programming Problem

Slack and Surplus Variables-Reformulation of the General L.P.P.- Simplex Method- Matrix Notation-Duality (Statement only of Property without Proof)- Initial Simplex Tableau- Pivot-Calculating the new Simplex Tableau-Terminal Simplex Tableau- Algorithm of the Simplex Method.

UNIT III Games and Strategies

Introduction- Two- person Zero-sum games-Pay-off Matrix – some basic terms-the Maximum –Minimal Principle-Theorem on Maximum and Minimal Values of the Game-Saddle Point and Value of the Game-Rule for determining a Saddle Point-Games without Saddle Points-Mixed Strategies-Graphic solution of $2 \times n$ and $m \times 2$ games- Dominance Property- General rule for Dominance-Modified Dominance Property.

UNIT IV Integer Programming

Travelling Salesman Problem, Transport and Assignment Problem, Max flow-Min cut problem, Minimal spanning tree, shortest path problem.

Text Book:

1. Hadley, G. (1966) Linear Programming, Addison.
2. Gale, D. (1989) The Theory of Linear Economic Model, University of Chicago Press.
3. Swarup, K, Gupta, P. K. and Mohan, M. (2002) Operations Research, Sultan Chand & Sons, New Delhi.

Reference Books:

1. Friderick S. H. and Gerald J. L. (1974) Operations Research, Holden-Day Inc, San Fransisco, USA.
2. Hamdy A. T. (2002) Operation Research: An Introduction, Prentice-Hall of India Pvt. Ltd., New Delhi.

5. MATHEMATICAL ECOLOGY

UNIT I Introduction

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: Continuous growth models – their stability analysis, Influence of random perturbations on population stability. Insect out break model- Spruce-Budworm model. General autonomous models. Delay Models

UNIT II Population Dynamics of Two Interacting Species

Introduction, Lotka-Volterra system of predator-prey interaction, Trophic function, Gauss's Model, Gause Model, Kolmogorov Model, Leslie Gower Model, Analysis of predator-prey model with limit cycle periodic behavior, parameter domains of stability. Competition models- exclusion principle and stability analysis. Models on mutualism.

UNIT III 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.

UNIT IV Biological Models Using Linear and Nonlinear Difference Equations

Nicholson-Bailey model, modification of Nicholson-Bailey model (density dependence in the host population), model for plant-herbivore interaction and its stability analysis.

Text Books:

1. Freedman, H. I. (1980) Deterministic Mathematical Models in Population Ecology, Marcel Dekker, New York.
2. Kot, M. (2001): Elements of Mathematical Ecology, Cambridge Univ. Press.
3. Alstod, D. (2001): Basic Populas Models of Ecology, Prentice Hall, Inc., New Jersey.

ELECTIVES FOR MATH-E-505-507

1. STATISTICAL INFERENCE

UNIT I Introduction

Introduction to statistical inference problems; Parametric and nonparametric statistical inference problems; Formulation of point estimation, interval estimation and testing of hypotheses problems as statistical inference problems.

Sufficiency and Completeness: Information in data about the parameter as variation in likelihood function; Sufficient statistic; Neyman factorization theorem; Likelihood equivalence; Minimal sufficient statistic; Complete family of distributions; Complete statistic; Complete and sufficient statistic; Exponential families; Fisher information for one and several parameter model.

UNIT II Point Estimation

Different methods of point estimation and properties of corresponding estimators: Method of moments and percentiles; Method of maximum likelihood; Invariance of maximum likelihood estimators; Large sample properties of maximum likelihood estimators; Criteria for comparing estimators: Unbiasedness, variance, mean squared error; Uniformly minimum variance unbiased estimator; Rao-Blackwell theorem; Cramer-Rao lower bound and its applications; Lehmann-Scheffe theorem Consistent estimators.

UNIT III Interval Estimation

Interval estimation problems; Confidence intervals; Construction of confidence intervals using pivots; Confidence intervals for normal population(s): mean, variance, difference of means, ratio of variances; Confidence intervals for proportions and difference of proportions; Average length of confidence intervals; Problem of finding Confidence interval with smallest average length.

UNIT IV Testing of Hypotheses

Tests of hypothesis; Neyman-Pearson lemma; Most powerful and uniformly most powerful tests and their examples; p-value; Examples of non-existence of uniformly most powerful tests for testing simple null hypothesis against two-sided alternative hypothesis; Likelihood ratio tests; Likelihood ratio tests for statistical hypotheses in one and two sample problems involving normal populations; Tests for proportions; Relationship between confidence intervals and tests of hypotheses; Chi-square goodness of fit test; Contingency tables.

Text books:

1. Arnold, S.F. (2000) Mathematical Statistics, Prentice Hall.
2. Hogg, R. V., McKean, J. W. and Craig, A.T. (2004) An Introduction to Mathematical Statistics, Pearson.
3. Rohatgi, V. K. (1976) An introduction to probability and statistics, Wiley.
4. Dudewicz, E. J. and Mishra, S. N. (1988) Modern Mathematical Statistic

2. MEASURE THEORY

Unit I: Measures

Algebras, sigma-algebras, monotone classes; outer measures and Caratheodory's extension theorem; existence of Lebesgue measure and of non-measurable sets.

Unit II: Integration

Measurable functions, monotone approximability by simple functions, integrability and Lebesgue integration; standard limit theorems: Fatou's lemma, monotone convergence and dominated convergence theorems; almost everywhere considerations.

Unit III: Random Variables & Distributions

Probability, random variables and their distributions, joint distributions and independence, Borel-Cantelli lemma and Kolmogorov's zero-one law, Some of the more standard distributions - both discrete (Bernoulli, Binomial, Poisson, etc.) and continuous (Uniform, Normal, etc.); a brief introduction to conditional expectations and probabilities.

Unit IV: Measures on Product Spaces

Product measures, theorems of Tonelli and Fubini, independence and product measures, infinite products and finite state Markov Chains, Kolmogorov consistency theorem. Characteristic functions, modes of convergence.

Text book:

1. Athreya, S. R. and Sunder, V.S. (2008) Probability and Measure, Universities Press, India.

Reference:

1. Rana, I. K. (2002) An Introduction to Measure and Integration, American Math. Soc.
2. Chung, K. L. (2001) A Course in Probability Theory, Academic Press.

3. ALGEBRAIC TOPOLOGY

UNIT I The fundamental group

Homotopy of paths, fundamental group of a topological space, fundamental group functor, homotopy of maps of topological spaces; homotopy equivalence; contractible and simply connected spaces;

Calculation of fundamental groups of $\mathbb{S}^n$ ($n > 1$) using Van Kampen's theorem (special case); fundamental group of a topological group; Brouwer's fixed point theorem; fundamental theorem of algebra; vector fields, Frobenius theorem on eigenvalues of 3×3 matrices.

UNIT II Covering spaces

Covering spaces, unique lifting theorem, path-lifting theorem, covering homotopy theorem, fundamental group of $\mathbb{S}^1$, $\mathbb{S}^1 \times \mathbb{S}^1$ etc., degree of maps of $\mathbb{S}^1$ and

applications; criterion of lifting of maps in terms of fundamental groups; universal coverings and its existence; special cases of manifolds and topological groups.

UNIT III Homology

Category and Functors, Singular homology, relative homology, Eilenberg-Steenrod axioms (without proof), Reduced homology, relation between Π_1 and H_1 ;

UNIT IV Applications

Calculations of homology of $\mathbb{S}^n$; Brouwer's fixed point theorem and its applications to spheres and vector fields; Meyer-Vietoris sequence and its application.

Textbooks:

1. Munkres, J. R. (2000) Topology: A First Course, Prentice-Hall of India Ltd., New Delhi.
2. Greenberg, M. J. and Harper, J. R. (1997) Algebraic Topology: A First Course (2nd edition), Addison-Wesley Publishing Co.
3. Hatcher, A. (2002) Algebraic Topology, Cambridge University Press.

Reference:

1. Armstrong, M. A. (2000) Basic Topology, UTM Springer
2. Greenberg, M. J. and Harper, J. R. (1997) Algebraic Topology: A First Course (2nd edition), Addison-Wesley Publishing Co.
3. Hatcher, A. (2002) Algebraic Topology, Cambridge University Press.
4. Spanier, E. H. (2000) Algebraic Topology (2nd edition), Springer-Verlag, New York.
5. Rotman, J. J. (2004) An Introduction to Algebraic Topology, Text in Mathematics, No. 119, Springer, New York.

4. FUNCTIONAL ANALYSIS AND PDE

UNIT I Distributions

Test functions and distributions, calculus of distributions, support and singular support, convolution of distributions, fundamental solutions, Fourier transform, the Schwarz space, inverse Fourier transform, tempered distributions.

UNIT II Sobolev spaces

Sobolev spaces - density theorems, extension theorems, imbedding theorems, compact imbeddings, fractional order spaces, trace theory.

UNIT III Weak solutions of elliptic equations

Lax-Milgram lemma and Babuška-Brezzi theorems, weak formulations of elliptic boundary value problems, regularity theory, maximum principles, eigenvalue problems, introduction to the Galerkin method and the finite element method.

UNIT IV Semi-groups and Evolution Equations

Unbounded operators and adjoints, exponential map, C_0 -semigroups, Hille-Yosida theorem for contraction semigroups, exponential formula, regularity, maximal dissipative operators on a Hilbert space, application to the heat, wave and Schrodinger equations, inhomogeneous equations (variation of parameters).

Text Book:

1. Kesavan, S. (1989) Topics in Functional Analysis and Applications, John Wiley & Sons Inc.

Reference Books:

1. Evans, L. C. (2010) Partial Differential Equations (Graduate Studies in Mathematics), American Mathematical Society.
2. Lieb, E. H. and Loss, M. (2001) Analysis (Graduate Studies in Mathematics), American Mathematical Society

5. CRYPTOGRAPHY

UNIT I Number Theory and Time estimates required for Cryptography

The big Oh notation, time estimates for doing addition, subtraction, multiplication, division. Euclidean Algorithm and the time estimate to find the greatest common divisor of two integers, extended Euclidean algorithm. Properties of congruences: addition, multiplication, subtraction and division; solution of linear congruences, modular exponentiation by repeated squaring method.

UNIT II Fundamental Theorems

Fermat's little theorem, Euler's totient function, Euler's theorem, Primitive roots. Finite fields: Primitive polynomials, Irreducible polynomials, Time estimations for doing arithmetic operations in finite fields, Construction of finite fields.

UNIT III Classical Cryptosystems

Shift cipher, Affine cipher, Substitution cipher, Vigenere cipher, Hill cipher, permutation cipher. Public Key cryptography: One way function, Trap door functions, Concept of public

key cryptography, RSA, Digital signature scheme.

UNIT IV Primality Testing and Integer Factorization

Primality testing: pseudo primes, Rabin Miller probabilistic primality test, Carmichael numbers. Factoring algorithms: Pollard's rho method, Pollard's p-1 method, Fermat's factorization method. Discrete logarithm, Diffie-Hellman Key exchange protocol, El Gamal cryptosystem over prime field and finite fields, El Gamal digital signature scheme.

(Note: A basic introduction to Elliptic curve cryptography should be taught for the benefit of the students but it should not be included for examination purpose).

Text book:

1. Koblitz, N. (1994) A course in Number Theory and Cryptography, (Second Ed.), Springer-Verlag.

Reference books:

1. Stinson, D. R. (1995) Cryptography: Theory and Practice, CRC Press series on Discrete Mathematics and its applications.
2. Yan, S. Y. (2003) Primality Testing and Integer Factorization in Public-Key Cryptography, Springer

6. FINITE ELEMENT METHOD

UNIT I Basic Results

Review of basic PDE's, elliptic boundary value problems and its weak formulation, existence, uniqueness and regularity of weak solutions, Lax-Milgram lemma, Poincare's inequality, Poissons equation in 1d and 2d with Dirichlet, Neumann and Robin boundary conditions.

UNIT II Approximation Methods

Method of weighted residuals, best approximation in Hilbert spaces: existence and its computation, approximation via Galerkin method its analysis of existence, uniqueness, stability and convergence.

UNIT III Finite Element Method in 1D

Piecewise linear approximation, interpolation operator and its error, estimate of finite element error in H^1 norm, finite element in multidimensions, estimate of approximation in various norms, weak formulation of heat equation in 1d and 2d and its semi-discretization in space variable, a-priori estimates and convergence of the semi-discrete problem.

UNIT IV Finite Element Method in 2D

Generation of 1d and 2d grids, grids for a polygonal domain, A posteriori error estimates in L^2 norm, grid adaptivity, elementary aspects of finite element programming or getting familiarized with a finite element package like (say) FEniCS.

Text book:

1. Quarteroni, A. (2009) Numerical models for differential problems, Springer.

Reference Books:

1. Babuska, Whiteman and Strouboulis (2011) Finite elements: An Introduction to the Method and Error Estimation, Oxford University Press.
2. Larsson and Thomee (2003) Partial Differential Equations with Numerical Methods, Springer, Texts in Applied Mathematics, Vol. 45.

7. NON-LINEAR DYNAMICS

UNIT I Linear Systems

System of linear ordinary differential equations; Fundamentals of linear systems; Linear Systems in $\mathbb{R}^2$; Stability theory, phase portraits in $\mathbb{R}^2$.

UNIT II Non- Linear Systems

System of nonlinear ordinary differential equations; Fundamental existence-uniqueness theorem, dependence on initial conditions and parameters; flow defined by differential equations; linearization; Hartman-Grobman theorem; Stability and Lyapunov functions.

UNIT III Stable Points

Stable manifold theorem, Center manifold theorem; Elementary bifurcations- Saddle-node, Transcritical, Pitch-fork, Hopf bifurcation.

UNIT IV Attractors

Limit sets and attractors, periodic orbits and limit cycles, stable manifold theorem for periodic orbits, Lienard systems, Bendixon's Criteria, global bifurcation of systems in $\mathbb{R}^2$.

Text Books

1. Perko, L. (2001) Differential Equations and Dynamical Systems, Springer.
2. Jordan, D. W. and Smith, P. (1999) Nonlinear Ordinary Differential Equations: An Introduction to Dynamical Systems, Oxford University Press.

8. FINANCIAL MATHEMATICS

UNIT I Introduction

Fundamentals of the financial markets; Meaning of notions like asset portfolio derivatives (Example: Futures, Options forward etc.) Binomial asset pricing model under no arbitrage condition, Single period model; Multi-Period model;

UNIT II Continuous time model-I

Risk neutral probabilities; Martingales in the discrete framework; Risk neutral evaluation of European and American options under no arbitrage condition in the binomial framework. Introduction to continuous time models; Basic notions of probability theory on an infinite sample space

UNIT III Continuous time model-II

Filtrations and Martingales in continuous time frame. Change of measure and the Radon-Nikodym derivative; Random walk and Brownian motion; Ito integral; Ito formula; Black Scholes formula for pricing an European call option.

UNIT IV Optimization

Basics of Optimization, Convexity, KKT conditions. Markowitz mean-variance portfolio optimization problem; Single-period and multi-period model; Capital asset pricing model; Outlines of the measures of risk; Value-at-Risk (VaR) and conditional Value-at-Risk (CVaR).

Text Books :

1. Luenberger, D. G. (1997) Investment Science, Oxford University Press.
2. Shreve, S. (2004) Stochastic Calculus for Finance I: The Binomial Asset Pricing Model, Springer.
3. Shreve, S. (2010) Stochastic Calculus for Finance II: Continuous Time Model Springer.

9. APPLIED STOCHASTIC PROCESSES

UNIT I Markov Chains

Definition of stochastic processes; Classification of stochastic processes according to state space and time domain; Markov chains; Transition probability matrices; Computation of n-step transition probability matrices; Chapman-Kolmogorov equations; Classification of states; Irreducible Markov chains; Equivalence classes of states; Different results about transition, recurrent, null recurrent, ergodic and periodic states; Limiting distributions; Stationary distributions; Random walk in one, two and three dimensions; Gambler's ruin problem.

UNIT II Stochastic Processes

Stochastic Processes with discrete space and continuous time domain: Birth and death processes; Pure birth process with emigration; Yule process; Applications of birth and death models to various queuing models; Kolmogorov forward and backward equations; Poisson process as a pure birth process; Waiting times and inter-arrival times of Poisson process; Various equivalent definitions of Poisson process; Non-homogeneous Poisson process and its properties.

UNIT III Renewal Process

Renewal Process: Elementary renewal theorem and applications; Renewal equation; Mean renewal time; Stopping time; Statement and applications of key renewal theorem. Branching Process: Galton-Watson branching process; Probability of ultimate extinction; Distribution of population size.

UNIT IV Brownian Motion

Brownian motion as a limit of random walk; First passage time; Reflection principle; Variants of Brownian motion; Introduction to stationary process, processes with independent increments and Gaussian process.

Text Books:

1. Ross, S. M. (1995) Stochastic Processes, John Wiley.
2. Ross, S. M. (2009) Introduction to Probability Models, Academic Press.
3. Medhi, J. (1994) Stochastic Processes, New Age International.
4. Karlin, S. and Taylor, H. M. (1975) A First Course in Stochastic Processes, Academic Press.

10. DYNAMIC METEOROLOGY AND NUMERICAL WEATHER PREDICTION (NWP)

UNIT I Thermodynamics of Air

Thermodynamics of dry air: Composition of the atmosphere, Equation of state of a perfect gas, 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.

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

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

UNIT II Hydrostatics

Hydrostatic equilibrium: The hydrostatic equation, definition of lapse rate, the thickness equation pressure 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.

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.

UNIT III Equations of Motion:

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.

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

UNIT IV Balanced Flow

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’ non-geostrophic front, geostrophic front, Tropopause frontal theory.

Text Books:

1. Gordon, A., Grace, W., Schwerdtfeger, P., Byron-Scott, R. (1997) Dynamic Meteorology: A basic course; Routledge, Hodder Arnold Publication
2. Haltiner, G. J., Martin, F. (1957) Dynamical and Physical Meteorology, McGraw Hill.
3. Holton, G. R., and Hakim, G. J. (2012) An Introduction to Dynamical Meteorology, Academic Press.
4. Salby, M. L. (1961) Fundamental of Atmospheric Physics, Volume 61 (International Geophysics), Academic Press.

11. RENEWABLE BIO-ECONOMIC MODELLING

UNIT I Elementary Dynamics of Exploited Populations

The logistic growth models, constant rate harvesting, fishing effort, generalized logistic model's depensation, Yield-effort curves, critical depensation.

UNIT II 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.

UNIT III 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.

UNIT IV 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.

Text Books:

1. Clark, C. W. (1976) Mathematical Bioeconomics: The optimal Management of Renewable Resources, John Wiley & Sons, New York.
2. Clark, C. W. (1985): Bioeconomics Modeling and Fisheries Management, John Wiley & Sons, New York.
3. Goh, B. S. (1980) Management and Analysis of Biological Populations, Elsevier, Amsterdam.

12. COMPUTATIONAL BIOLOGY

UNIT I Dynamic Modelling with Difference Equations

The Malthusian Model, Non-linear Models, Analyzing Non-linear Models, Variations on the Logistic Model, Discrete and Continuous Models.

UNIT II Linear Models of Structured Populations

Linear Models and Matrix Algebra, Projection Matrices for Structured Models, Eigenvectors and Eigenvalues, Computation of Eigenvectors and Eigenvalues.

UNIT III Non-linear Models of Interactions

A simple Predator-Prey Model, Equilibria of Multi-population Models, Linearization and Stability, Positive and Negative Interactions.

UNIT IV Modelling Molecular Evolution and Curve Fitting

Background on DNA, An Introduction to Probability, Conditional Probability, Matrix Models of Base Substitution, Phylogenetic Distances.

Mendelian Genetics, Probability Distributions in Genetics, Linkage, Gene Frequency in Populations. Curve fitting: Fitting Curves to Data, The Method of Least Squares, Polynomial Curve Fitting.

Text Book:

1. Elizabeth A. A. and John A. R. (2004) Mathematical Models in Biology: An Introduction. Cambridge University Press.

MATH P-508 (Project Work)

Course MTH P-508 is a Project Work for dissertation/thesis of full marks of 200 offered in the curriculum of the M.Sc. Mathematics programme in the final semester.

Course Objectives:

- a) To provide students with skill and knowledge in conducting research in fundamental and application aspects of mathematics.
- b) To train students in developing analytical and numerical as well as argumentative skills.

Acceptance of Project Work:

A student's project work can be either a guided study of advanced topics not covered in the curriculum or a guided field work. It is expected that the student learns and applies some theoretical or numerical techniques taught in the classes.

Evaluation of the Project Work:

The thesis/dissertation evaluation committee will consist of the following four members: Head of the Department, the Supervisor, an Internal Examiner and an External Examiner.

Proper acknowledgement and permission of unavoidable earlier published work must be given. If any kind of plagiarism is practised by the student, his/her dissertation or project work shall be liable to be rejected.