**APPENDIX-I**

# PONDICHERRY UNIVERSITY
# DEPARTMENT OF MATHEMATICS

## M.Sc. MATHEMATICS PROGRAMME

SYLLABI

WITH EFFECT FROM THE ACADEMIC YEAR

2011 - 2012

# M.Sc. MATHEMATICS PROGRAMME

# Regulations

**Eligibility for admission:**
A candidate for admission into M.Sc. programme shall have studied B.Sc. Mathematics under 10 + 2 + 3 pattern of study.
Candidates who have secured 55% of marks or above in Bachelor's Degree in Mathematics are eligible to apply.

**Duration of study:**
The course duration shall normally be of two years spread over four semesters. The maximum duration to complete the course shall be 4 years.

**Medium:**
The medium of instruction shall be English.

**Passing minimum:**
Passing Eligibility and Classification for the award of the Degree are as per the norms of the Choice Based Credit System.

**Conditions for Affiliation**:
The following are the requirements for the grant of affiliation for M.Sc. Mathematics programme in the institutions affiliated to Pondicherry University:

(i) The institution shall have conducted the B.Sc. Mathematics programme for a minimum period of 6 years

(ii) Faculty strength for M.Sc. Mathematics programme: 3 regular
Faculty in the first year.
Additional 3 regular faculty in the second year.
A total of 6 regular faculty for the whole programme.

(iii) Qualifications for the faculty: The faculty shall possess the qualifications as prescribed by UGC.

(iv) Recruitment of faculty: The recruitment of faculty shall be through a duly constituted Selection Committee with a nominee of the University, by advertisement

(v) Class rooms: 2 permanent rooms with furniture, platform and black board.

(vi) Faculty room: 1 permanent room with furniture.

(vii) Computers: 3 for the faculty.

(viii) Library:
Books: 10 copies of each prescribed text book;
1 copy of each prescribed reference book;
3 reference books for each hard core subject.
Journals: Minimum 2
Library Room: 1 with furniture for books

Reading Space for Students

(ix) Computer Lab: required if computer papers are offered as soft core with 1 computer for every 2 students

## M.Sc. MATHEMATICS

## List of Hard Core Courses offered from the Academic Year 2011-2012

| SL. NO. | COURSE CODE | COURSE TITLE | Number of Credits |
|---|---|---|---|
| 1 | MATH-411 | Advanced Algebra | **4** |
| 2 | MATH-412 | Real Analysis – I | **4** |
| 3 | MATH-413 | Discrete Mathematics | **4** |
| 4 | MATH-414 | Topology | **4** |
| 5 | MATH-421 | Linear Algebra | **4** |
| 6 | MATH-422 | Lebesgue Measure Theory | **4** |
| 7 | MATH-423 | Complex Analysis | **4** |
| 8 | MATH-424 | Ordinary Differential Equations | **4** |
| 9 | MATH-425 | Real Analysis – II | **4** |
| 10 | MATH-511 | Fluid Mechanics | **4** |
| 11 | MATH-512 | Differential Geometry | **4** |
| 12 | MATH-513 | Functional Analysis | **4** |

**M.Sc. MATHEMATICS**
**List of Soft Core Courses offered from the Academic Year 2011-2012**

| SL. NO. | COURSE CODE | COURSE TITLE |
|---|---|---|
| 1 | MATH-514 | Analytical Dynamics |
| 2 | MATH-515 | Fuzzy Sets and its Applications |
| 3 | MATH-516 | Number Theory |
| 4 | MATH-517 | Operations Research |
| 5 | MATH-518 | Algorithms Using C++ |
| 6 | MATH-522 | Graph Theory with Applications |
| 7 | MATH-523 | Graph Theory with Algorithms |
| 8 | MATH-527 | Algebraic Number Theory |
| 9 | MATH-528 | Advanced Algebraic Number Theory |
| 10 | MATH-529 | Theory of Fuzzy Sets |
| 11 | MATH-530 | Algebraic Coding Theory |
| 12 | MATH-531 | Cryptography |
| 13 | MATH-532 | Automata Theory |
| 14 | MATH-533 | Advanced Topics in Topology and Analysis |
| 15 | MATH-534 | Approximation Theory |
| 16 | MATH-536 | Difference Equations |
| 17 | MATH-537 | Partial Differential Equations |
| 18 | MATH-538 | Lie Groups of Transformations and Differential Equations |
| 19 | MATH-539 | Numerical Analysis for Ordinary Differential Equations |
| 20 | MATH-540 | Advanced Fluid Mechanics |
| 21 | MATH-541 | Integral Equations |
| 22 | MATH-542 | Advanced Mathematical Analysis |
| 23 | MATH-543 | Representation Theory of Compact Groups |
| 24 | MATH-544 | Elements of Harmonic Analysis |
| 25 | MATH-545 | Linear Lie Groups |
| 26 | MATH-546 | Graph Theory |
| 27 | MATH-547 | Advanced Functional Analysis |
| 28 | MATH-548 | Advanced Topics in Discrete Mathematics |
| 29 | MATH-549 | Laboratory Practical in Mathematics |
| 30 | MATH-550 | Topic in Topology and Analysis |
| 31 | MATH-551 | Functional Analysis- II |
| 32 | MATH-552 | Operator Theory |
| 33 | MATH-554 | Non-Commutative Rings and Representations |
| 34 | MATH-555 | Advanced Complex Analysis |
| 35 | MATH-557 | Algorithms Using Java |
| 36 | MATH-558 | Functional Analysis-III |
| 37 | MATH-559 | Mathematica Practical |
| 38 | MATH-560 | Mathematical Software |
| 39 | MATH-561 | Computational Algebra |
| 40 | MATH-562 | Numerical Analysis |
| 41 | MATH-563 | Integral Transforms |

# M.Sc. Mathematics

## HARD CORE : MATH-411 ADVANCED ALGEBRA

**Unit-I**

The class equation of a finite groups - Sylow theorems - Direct products.

**Unit-II**

Polynomial rings- Polynomials over the rational field – Polynomial rings over Commutative rings.

**Unit-III**

Field extensions - Algebraic and transcendental extensions, Separable and inseparable extensions – Normal extensions.

**Unit-IV**

Perfect Fields, Primitive elements, Algebraically closed fields, Galois extensions, Fundamental theorem of Galois Theory.

**Unit-V**

Solvable groups - Solvability by radicals and insolvability of the general equation of degree 5 - Finite fields.

**Treatment and Content as in** I.N.Herstein: Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.

Sections – 2.11, 2.12 and 2.13
Sections – 3.9, 3.10 and 3.11
Sections – 5.1, 5.3 and 5.5
Sections - 5.6
Sections – 5.7 and 7.1

**Reference books**


1. M. Artin: Algebra, Prentice-Hall of India, **1991**
2. N.Jacobson: Basic Algebra, Volumes I & II, W.H.Freeman, **1980**
3. S.Lang: Algebra, 3rd edition, Addison-Wesley, **1993**
4. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul: Basic Abstract Algebra ( 2nd Edition), Cambridge University Press, Indian edition, **1997**

**M. Sc. Mathematics**

**Hard Core- 4 credits**
**MATH-412: Real Analysis - I**

**Unit-I**
Finite, Countable and uncountable sets - Metric Spaces - Compact Sets - Perfect sets - Connected sets - Convergent Sequence - Subsequences - Cauchy Sequences - Upper and lower limits – Some special sequences.

**Unit- II**
Series- Series of non- negative terms - The Number e – The Root and Ratio Tests - Power Series - Summation by Parts - Absolute convergence – Addition and Multiplication of series - Rearrangements of series .

**Unit- III**
Limits of Functions - Continuous Functions - Continuity and Compactness - Continuity and Connectedness - discontinuities - Monotonic Functions - Infinite Limits and Limits at Infinity.

**Unit- IV**
The Derivative of a Real Function - Mean Value Theorems – The Continuity of Derivatives - L'Hospital's Rule - Derivatives of Higher Order - Taylor's Theorem - Derivatives of Vector – valued Functions.

**Unit- V**
The Riemann-Stieltjes Integral- Definition and Existence of the Integral - Properties of the Integral - Integration and Differentiation - Integration of Vector- valued functions - Rectifiable Curves.

**Text Book:**

Walter Rudin, "Principles of Mathematical Analysis- McGraw Hill International Editions, Mathematics series, Third Edition **(1964)**
(Chapters 2-6)

**Reference Books:**


1. Patrick M. Fitzpatrick, "Advanced Calculus", AMS, Pine and Applied Undergraduate Texts, Indian Edition, **2006**
2. Apostol, Mathematical Analysis, Narosa Publishing House, Indian edition, **1974**

**M.Sc. MATHEMATICS**
**MATH-413 - DISCRETE MATHEMATICS**
**(HARD CORE: 4 CREDIT)**

**Unit-I**

Inclusion (equality of sets) – Power Set – Cartesion (Products) - Relations - Equivalence Relations – Partial Ordering – Partially Ordered Set (representation and associated terminology) - Lattices as Partially Ordered Sets – Properties of Lattices – Lattices as Algebraic Systems – Sublattices – Direct Product – Homomorphism.

**Unit-II**

Special Lattices (Complete lattices, bounded lattices, complemented lattices, distributive lattices and their properties) – Boolean Algebra – Subalgebra – Direct Product – Homomorphism.

**Unit-III**

Stone's Theorem ( join-irreducible elements, atoms) – Boolean Forms (minterms, sum–of – products canonical form) – Free Boolean Algebra – Values of Boolean Expressions ( a binary valuation process) – Boolean Fucntions – Symmetric Boolean Expressions.

**Unit-IV**

Graphs and simple Graphs – Graph Isomorphism – Complete Graphs – Bipartite Graphs – Complements and Self Complementary Graphs – Incidence and Adjacency Matrices – Subgraphs – Vertex Degrees – Degree – Graphic Sequences – Paths – Connection – Components - Cycles and Characterization of Bipartite Graphs.

**Unit-V**

Trees – Cut Edges and Bonds – Cut Vertices – Cayley's Formula – Connectivity – Blocks – Euler Tours – Hamilton Cycles.

**Text Books:**


1. Discrete Mathematical Structures with Applications to Computer Science, Trembley, J.P and Manohar, R : Mc Graw Hill Books Company, (1997)

Chap.-2: Sec.2-1.1, 2-1.2, 2-1.3, 2-1.4, 2-1.6, 2-1.8, 2-1.9, 2-3.1, 2-3.2, 2-3.5, 2-3.8, 2-3.9.
Chap.-4: Sec.4-1, 4-2, 4-3.

**2**. Graph Theory with Applications, Bondy J.A. and Murthy U.S.R., , Mac Comp.

Chap-1: Sec. (1.1) to (1.7), Chap-2: Sec. (2.1) to (2.4)
Chap-3: Sec. (3.1) to (3.2), Chap-4: Sec. (4.1) to (4.2)


**Reference Books:**


1. Grimaldi R.P., Discrete and Combinatorial Mathematics: An Applied Introd, Pearson Edn Asia, Delh, **2002**
2. Kolman B., Busby R.C, and Ross S.C., Discrete Mathematical Structures, Pearson Edn Pvt. Ltd, New Delhi, **2003**
3. Rosen K., Discrete Mathematics and its Applications, Tata Mc Graw Hill Pub. Com. Ltd, New Delhi, **2003**
4. Liu C.L., Elements of Discrete Mathematics, Mc Graw Hill Book Company, **1985**
5. Seymour Lepschutz, Finite Mathematics, Mc Graw Hill Book Com (Int. Edn), New York, **1983**
6. Wiitala: Discrete Mathematics (A unified Approach), Mc Graw Hill Book Company.
7. Harary F. , Graph Theory Addison, Wesley Reading Mass, **1969**
8. Wilson R.J., Introduction to Graph Theory, Oliver and Boyd, Edinburgh, **1972**

# M.Sc. Mathematics

## MATH-414 Topology
## (Hard Core- 4 Credits)

**Unit-I**

Revision of Sets - Functions - Product of Sets – Relations – Countable Sets – Uncountable sets – Partially ordered sets and lattices – Metric spaces – Definition and examples – Open sets and Closed sets in Metric Spaces – Open subsets of Real line.

**Unit -II**

Topological spaces -- Definitions and examples -- Closure and related concepts – Open bases and open sub bases – Separability and Second Countability - Lindloff's Theorem

**Unit-III**

Compactness – Basic Results -- Continuous Maps on Compact sets -- Characterization of Compactness by Basic and Sub basic open Covers – Tychonoff's Theorem - Generalized Heine – Borel Theorem.

**Unit – IV**

Compactness for metric spaces – Sequential Compactness -- Lebesgue covering lemma -- Sequential Compactness and Compactness Coincide on Metric Spaces -- $T_1$ Spaces -- Hausdorff Spaces.

**Unite -V**

Completely regular spaces and normal spaces – Urysohn's lemma and Tietze extension theorem- –Connected spaces – Components of a space .

**Text book**

G.F.Simmons , "An Introduction to Topology and Modern Analysis," McGraw-Hill Kogakusha, Tokyo, **1963**

Chapter 1 – Revision of Sections 1—3 , Section 4—8.
Chapter 2 – Sections 9 -- 12
Chapter 3 – Sections 16, 17 and 18
Chapter 4 – Sections 21 -- 24
Chapter 5 – Sections 26 -- 28
Chapter 6 – Sections 31 and 32

**Reference books**


1. J.R.Munkres, Toplogy, Pearson Education Inc., Second Edition, **(2000)**
2. Stephen Willard, General Topology, Dover Publication **(2004)**
3. J.Dugundgi, Toplogy, Allyn and Bacon, Boston, **(1966)**

# M.Sc. Mathematics

## HARD CORE : MATH-421 LINEAR ALGEBRA

**Unit-I**

The Algebra of Linear transformations, characteristic roots, Similarity of linear transformations, Invariant subspaces and Matrices.

**Unit-I**

Reduction to triangular forms, Nilpotent transformations, Index of nilpotency and Invariant of Nilpotent transformation.

**Unit-I**

Jordan blocks and Jordan forms, Modules - Cyclic modules - Fundamental theorem on modules over PID.

**Unit-I**

Rational canonical form, trace, transpose and Determinants.

**Unit-I**

Hermitian, Unitary and Normal transformations - Real quadratic forms.

I.N.Herstein, **Treatment and Contents as in** Topics in Algebra, Wiley Eastern Ltd., New Delhi, **(1975)**

Sections – 6.1,6.2 and 6.3
Sections – 6.4 and 6.5
Sections – 6.6 and 4.5
Sections - 6.7,6.8 and 6.9
Sections – 6.10 and 6.11

**Reference books**


1. M.Artin, Algebra, Prentice-Hall of India, **1991**
2. N.Jacobson, Basic Algebra, Volumes I & II, W.H.Freeman, **1980**
3. S.Lang, Algebra, 3rd edition, Addison-Wesley, **1993**
4. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul: Basic Abstract Algebra (2nd Edition) Cambridge University Press, Indian edition, **1997**

# M.Sc. Mathematics

## HARD CORE : MATH-422 LEBESGUE MEASURE THEORY

**Unit-I**

Ring and algebra of sets- $\sigma$- algebras- Examples- Algebras and $\sigma$ - algebras generated by a class of sets - Borel algebra and Borel sets.

Lebesgue outer measure on R - Countable sub-additivity - Measurable sets – Examples - $\sigma$ - algebra structure of measurable sets - Countable additivity of Lebesgue measure on R - Cantor set.

**Unit-II**

Construction of a non- measurable subset of [0, 1] - Measurable functions- Examples and basic properties - Approximation of measurable and bounded measurable functions by simple measurable functions - Approximation by step functions and continuous functions - Egorov's theorem.

**Unit-III**

Lusin's theorem - Lebesgue integral of non- negative measurable functions- Integrable functions and Lebesgue integral of integrable functions - Linearity- Monotone convergence theorem - Fatou's lemma - Dominated convergence theorem - Applications of convergence theorems.

**Unit-IV**

Comparison of Riemann and Lebesgue integration - Lebesgue integrability of Riemann integrable functions - Characterization of Riemann integrable functions – Improper Riemann integrals and their Lebesgue integrals - Riemann- Lebesgue lemma - Functions of bounded variation - Statement of Vitali's lemma and theorem on almost everywhere differentiability of monotone increasing functions.

**Unit-V**

Absolutely continuous functions - Examples and properties - Absolute continuity of indefinite integral of Lebesgue integrable functions - Differentiation of indefinite integrals - Characterization of absolutely continuous functions as indefinite integrals.

**Text books**


1. H.L. Royden, Real Analysis, Macmillan Publishing Company, **1988**
   (Units 1, 2, 4 and 5).
2. Walter Rudin, Real and Complex Analysis, McGraw Hill Publishing Co.Ltd New Delhi. $10^{th}$ Reprint, **1986**
   (Unit 3).


**Reference book**


P.R. Halmos, Measure Theory, D. Van Nostrand Company, Inc. Princeton, N.J., **1950**

# M.Sc. Mathematics

## HARD CORE : MATH-423 COMPLEX ANALYSIS

**Unit-I:** Introduction
Algebra of complex numbers, geometric representation of complex numbers, Riemann Sphere and stereographic projection, lines, circles, limit and continuity, Analytic functions, Cauchy-Riemann equations, Hormonic functions, Elementary theory of power series- Sequences, series, uniform convergence of power series, Abel's limit theorem, Topology of Complex plane

**Unit-II:** Complex Integration
Line integrals, Rectifiable arce, Cauchy's Theorem for rectangle, Cauchy's theorem for circular disk, Cauchy's integral formula, cauchy's inequality. Local properties of analytic function. - Liouville's theorem - Fundamental theorem of Algebra - Maximum modulus theorem - Morera's theorem.

**Unit-III:** Calculus of Residues
Singularities, counting zeros - the open mapping theorem - Goursat's theorem - Classification of singularities - Residue theorem, argument principle, Evaluation of definite integrals. The Maximum Modulus Theorem. Rouche's theorem - The maximum principle - Schwarz's Lemma, Power series expansions-The weierstrass Theorem, Taylor series, Laurant series.

**Unit-IV:** Harmonic Functions
Basic properties of harmonic functions - Mean value theorem - Harmonic functions on a disk - Harnack's inequality - Harnack's theorem, Poisson's formula, Schwarz's Theorem, reflection Principle.

**Unit-V:** Partial fractions and factorization
Partial fractions, Mittage-Leffer's theorem Infinite Products, Canonical Products, The Gamma and Beta functions, Sterling's formula, Entire functrions-Jenen's formula. Hadamard's Theorem

**Text book**
L.V. Ahlfors, Complex Analysis, McGraw-Hill, Kogakusha, **1979**

**References**
John B. Conway**:** Functions of One Complex Variable, Second edition, **1980**
R.P. Boas: Invitation to Complex Analysis, The Random House, **1987**
B.C Palka: An Introduction to the complex Function Theory, Springer**, 1991**
S. Ponnusamy: Foundations of Complex Analysis, Narosa**, 1995**

# M.Sc. Mathematics

## HARD CORE : MATH-424 ORDINARY DIFFERNTIAL EQUATIONS

**Unit-I**

Qulitative properties of Solutions – The Sturm Comparison Theorem – Eigen values and Eigen functions and Vibrating String.

**Unit-II**

Series Solutions of First Order Equations – Second Order Linear Equations – Ordinary points - Regular Singular Points – Gauss Hyper Geometric Equations.

**Unit-III**

Legendre Polynomials – Properties of Legendre Polynomials – Bessel Functions- The Gamma Function - Properties of Bessel Function.

**Unit-IV**

Linear Systems – Homogeneous Linear System with Constant Coefficients.

**Unit-V**

The Existence and Uniqueness of Solutions – The method of Successive Approximations – Picards's Theorem.

**Text book**

G.F.Simmons: **Treatment as in** Differential Equations with Applications and Historical Notes, McGraw Hill Book Company, **1972**

Sections 22-30, 32-35, 37-38 and 55-56.

**M. Sc. Mathematics**

**Hard Core- 4 credits**
**MATH-425: Real Analysis – II**

**Unit-I**
Improper Riemann integrals - Functions of Bounded variation – Basic properties - Completeness of Metric Spaces - Nowhere dense sets - Construction of Cantor set-Cantor set is uncountable and nowhere dense- Baire Category Theorem- Sequence and Series of functions - Examples - Uniform convergence.

**Unit-II**
Uniform convergence and Continuity - Uniform convergence and Integration - Uniform convergence and Differentiation - Double sequences and series - Iterated limits- Equicontinuous Families of Functions - Arzela – Ascoli Theorem

**Unit- III**
The Weierstrauss theorem for algebraic polynomials- The Stone - Weierstrass Theorem - Power Series - The Exponential and Logarithmic Functions - The Trigonometric Functions - Fourier Series - The Weierstauss theorem for the Trignometric polynomials- The Gamma Functions .

**Unit- IV**
Functions of Several Variables - Linear Transformation - Differentiation - The Contraction Principle.

**Unit- V**
The inverse function Theorem - The implicit Function Theorem - The Rank Theorem – Determinants .

**Text Book:**

Walter Rudin, Principles of Mathematical Analysis, McGraw Hill International Editions (1976)
Units 2-5 cover Chapters 7,8 and 9 , excluding last two sections of Chapter 9

**Reference Books:**


1. Patrick M. Fitzpatrick, "Advanced Calculu, Amer. Math. Soc. Pine and Applied Undergraduate Texts, Indian Edition, **2006**
2. Apostol, Mathematical Analysis, Narosa Publishing House, Indian edition, **1974**

**M. Sc. Mathematics**

## HARD CORE: MATH-511 FLUID MECHANICS

**Unit-I**

Equations of motion - Euler's Equation – Conservation of Mass – Balance of Momentum – Transport Theorem - Conservation of Energy – Incompressible Flows – Isentropic Fluids – Bernoulli's Theorem.

**Unit-II**

Rotations and Vorticity – Kelvin's Circulation Theorem – Helmboltz's Theorem.

**Unit-III**

Navier- Stokes Equations – Scaling Properties – Decomposition Theorem - Stokes Equations – Poiseuille Flow .

**Unit-IV**

Potential Flow – Complex Potential – Blasius Theorem - Kutta-Joukowski Theorem – D'Alembert's Paradox – Stokes Paradox.

**Unit-V**

Boundary Layers – Prandt Boundary Layer Equations –Steady Boundary Layer Flow on a Flat Plate of Infinite Width.

**Text book**

A.J.Chorin and J.E Marsden: 'A Mathematical Introduction to Fluid Mechanics', Texts in Applied Mathematics 4, Springer Verlag, **1999**

# M.Sc. Mathematics

## HARD CORE : MATH-512 DIFFERENTIAL GEOMETRY

**Unit-I**
Graphs and level sets - Vector fields - The tangent space

**Unit-II**
Surfaces - Vector fields on surfaces - Orientation - The Gauss map

**Unit-III**
Geodesics - Parallel transport

**Unit-IV**
The Weingantten map - Curvature of plane curves

**Unit-V**
Arc length and line integrals - Curvature of surfaces

J.A. Thorpe: **Treatment as** in Elementary Topics in Differential Geometry, Springer, **2004**

Chapters 1 to 12.

**M. Sc. Mathematics**
**Hard Core- 4 credits**
**MATH- 513: Functional Analysis**

**Unit-I**

Normed Linear Spaces – Examples of Sequence and Function Spaces including $c_o$, $l_p$ and $L_p[a,b]$, for $1 \le p \le \infty$ - Linear transformations –Continuity – Dual Spaces – Product and Quotient of Normed Linear Spaces – Completeness of Product and Quotient of Normed Linear Spaces – Completeness of the space of all bounded, linear transformations.

**Unit- II**

Equivalent norms -Completeness of finite dimensional normed linear spaces – Riesz's lemma - Characterization of finite dimensional normed linear spaces as those with compact unit sphere - Continuity of linear maps defined on finite dimensional normed linear spaces.

**Unit-III**

Hahn-Banach theorem for real vector spaces – Hahn-Banach theorem for real and complex normed linear spaces – Corollaries to Hahn-Banach theorem – The Principle of Uniform Boundedness – Banach – Steinhauss Theorem – Weakly Bounded Sets are Bounded.

**Unit-IV**

Closed and open maps – Maps with closed graph – Example of discontinuous, linear map with closed graph – Open mapping theorem and the closed graph theorem – Applications – Inner product spaces – Examples – Inner product spaces and parallelogram law for norm – Orthonormal sets – Bessel's inequality – Gram-Schmidt orthonormalization – Orthonormal basis-Examples.

**Unit- V**

Separable Hilbert spaces and countable orthonormal basis – Linear isometry onto $l_2$ - Example of a non-separable Hilbert space – Uncountable orthonormal basis and definition of convergence of Fourier series – Riesz-Fisher's theorem- Orthogonal projections – Closed subspaces are Chebychev - Riesz's representation theorem.

**Text book**

M. Thamban Nair, "Functional Analysis", Eastern Economy Edition , Prentice~ Hall of India Private Limited, New Delh, **2002**

**Reference book**

1. M. Fabian, P. Habala, P. Hakek, V. M Santalucia, J. Pelant and V. Zizler, "Functional Analysis and Infinite Dimensional Geometry", CMS Books in Mathematics, Springer, **2001**

2. B.V.Limaye, "Functional Analysis", Wiley Eastern , New Delhi, **1981**

**M. Sc. Mathematics**

## SOFT CORE : MATH-514 ANALYTICAL DYNAMICS

**Unit- I**
Generalized coordinates-Virtual displacements-D'Alembert's principle and derivation of the Lagrange equations.

**Unit -II**
Lagrange equation for non-holonomic constraints-Method of Lagrange multipliers-Velocity dependent potentials-Non-conservative forces and dissipation function- Non-holonomic systems and Lagrange multipliers.

**Unit- III**
Hamilton's equation-The Hamilton Principle - Variational – Principle

**Unit- IV**
Canonical transformations – Hamilton – Jacobi theory.

**Unit- V**
Dissipative systems – Attractors – Equilibrium solutions – Limit cycles – Flotquet's theory of Stability.

**Text book**

Walter Greiner, Classical Mechanics: Systems of Particles and Hamiltonian Dynamics, Springer, ISE, **2004**
Unit I: Sections 14-15(269-309); Unit II: Sections 16-17(314-37); Unit III: Sections 18 (341-364); Unit IV: Sections 19-20(30-399); Unit V: Sections 21-22(419-451).

**Reference books**

1**.** H. Goldstein, Classical Mechanics, Narosa Publishing House, New Delhi, **1985**
2. F. Scheck, Mechanics: From Newton's Laws to Deterministic Chaos, Springer**, 1999**

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**M. Sc. Mathematics**
**MATH-515: Title of Subject: Fuzzy Sets and its Application**
**Credits: 4**

**Unit-I** Crisp Sets
Basic Definitions - Operations on crisp sets – Properties of crisp set – Crisp relations- Operations on crisp relations – Properties of Crisp relations – Composition of Crisp relations - Characteristic Function-Exercises

**Unit – II** Fuzzy Sets
Definition of Fuzzy sets - examples - Fuzzy Numbers- Characteristics of a Fuzzy Set- Basic Operations on fuzzy Sets- Properties of Fuzzy Sets- Membership functions-Algebraic Product and Sum of Fuzzy Sets – Power and Related Operations on Fuzzy Sets – The Extension Principle- Exercise

**Unit-III** Fuzzy Relations
Definition of Fuzzy Relation – Basic Operations on Fuzzy Relations – Direct Product – Projections of a Fuzzy Relation – Max-Min and Min-Max Compositions – Fuzzy Relations and Approximate Reasoning – Exercise-Fuzzy Relational Equation-Problem Partitioning – Solution method – Use of Neural Network in Fuzzy Relation

**Unit-IV** Fuzzy control systems
Introduction – Fuzzy Control Structure - Modelling and Control Parameters – If….and….Then Rules – Rule Evaluation – Conflict Resolution – Defuzzification – Fuzzy Controller with Matrix Representation - Exercises.
.
**Unit-V** Applications
Fuzzy Control in Washing Machine – Fuzzy Decision Making in Forecasting – Fuzzy Decision Making in Industrial problems – Fuzzy control in Traffic control – Fuzzy Relational Equation in Medicine.

***Text Books***


1. George J. Klir/Bo Yuan, *Fuzzy Sets and Fuzzy Logic*, Prentice Hall of India, **2000**

2. George Bojadziev and Maria Bojadziev, *Fuzzy Sets, Fuzzy Logic, Applications*, World Scientific Publishing Co.Pte.Ltd, Singapore, **1995**


***Reference Books***


George J. Klir and Tina A. Folger, *Fuzzy Sets, Uncertainty and Information*, Prentice-Hall of India, **1993**

1. Witold Pedrycz & Fernando Gomide, *An introduction to Fuzzy Set*, Prentice-Hall of India, New Delhi, **2005**
2. James J. Buckely, Esfandiar Eslami, *An introduction to Fuzzy Logic and Fuzzy Sets*, Springer, **2002**
3. Abraham Kandel and Gideon Langholz, *Fuzzy Control Systems*, CRC Press, USA, **1994**

**M. Sc. Mathematics**

**SOFT CORE : MATH-516 NUMBER THEORY**

**1. Unit-I**

Divisibility : Introduction - Divisibility - Primes.

**2 Unit-II**

Congruences - Solution of Congruences - Congruences of higher degree - Prime power moduli - Prime Modulus - Congruences of degree two, prime modulus - Power residues - Number theory from an algebraic view point Multiplicative groups, rings and fields.

**Unit-III**

Quadratic Reciprocity: Quadratic Residues - Quadratic Reciprocity - The Jacobi Symbol.

**Unit-IV**

Some functions of Number Theory: Greatest Integer function - Arithmetic function s - The Moebius Inversion Formula - Multiplication of arithmetic functions – Recurrence functions.

**Unit-V**

Some Diophantine Equations: The equation $ax+by = c$ - Positive Solutions - Other linear equations - The equation $x^2 + y^2 = z^2$ - The Equation $x^4 + y^4 = z^2$ - Sum of fourth powers - Sum of two squares - The equation $4x^2 + y^2 = n$.

**Treatment as in** : Ivan Niven and S.Zuckerman, An Introduction to the Theory of Numbers, John Wiley, New York, **2000**

Chapter 1 : Sections 1.1 – 1.3
Chapter 2 : Sections 2.1 - 2.11
Chapter 3 : Sections 3.1 – 3.3
Chapter 4 : Sections 4.1 – 4.5
Chapter 5 : Sections 5.1 - 5.6, 5.10 and 5.11

**M. Sc. Mathematics**

## SOFT CORE : MATH-517 OPERATIONS RESEARCH

**Unit-I**

Hyperplanes and half-spaces – Supporting and separating hyper planes – Convex functions – Linear programming basic concepts – Convex sets – Linear programming problems – Examples of LPP – Feasible, basic feasible and optimal solutions – Extreme points.

**Unit-II**

Linear Programming – Graphical Method - Simplex Method.

**Unit-III**

Network models – Network definitions – Minimal spanning tree algorithm – Shortest route problem.

**Unit-IV**

Integer Programming – Cutting plane algorithm - Branch and Bound Technique.

**Unit-V**

Decisions under risk – Decision trees – Decision under uncertainty.
Game Theory - Two - Person, Zero - Sum Games - Games with Mixed Strategies - Graphical Solution - Solution by Linear Programming.

**Text books**

1. Hamdy A. Taha: Operations Research, Fourth Edition, **1971**
Chapter 8 – Sections 8.3, 8.4 and Chapter 11– Sections 11.1 to 11.4.

2. J.K.Sharma: Mathematical Models in Operations research, Tata McGraw Hill, **1990**
Chapter 2 – Sections 2.12 to 2.14 and Chapter 4 – Sections 4.3 to 4.4.

**M. Sc. Mathematics**

**SOFT CORE**
**MATH-518: ALGORITHMS USING C++**

**Objectives of the Course:**
To make the students familiar with certain mathematical algorithms and their implementation through C++ language and equip them well with hands-on experience to acquire skills in solving mathematical problems using computers.

**Unit-I** Fundamentals of algorithms
Introduction to algorithms – Steps in the development of algorithms – Examples of algorithms which are significant from computational point of view.

**Unit-II** Fundamentals of C++ language
Constants- Variables - Declaration of variables - Type conversions - Relational operators - Decision making, branching and looping. Functions - Simple functions - Passing arguments to functions - Returning values from functions - Reference arguments - Overloaded functions - Inline functions.

**Unit-III**
Defining classes - Creating objects - Constructors - Accessing class members - Member functions - Overloaded constructors - Static class data - Arrays and string functions..

**Unit-IV**
Operator overloading - Overloading unary and binary operators- Data conversion - Derived class- Class hierarchies – Inheritance - Public and private inheritance – Types of inheritance. Pointers - Pointer to objects - Memory management - New and delete functions.

**Unit-V** Applications of C++ in algorithms
Development of algorithms using C++ - Applications to solve mathematical problems.
Sorting algorithms - Bubble sort – Selection sort – Insertion sort. Searching algorithms- Binary search – Linear search.

**Reference books**


1. A.V.Aho, J.E.Hopcroft and J.D.Ullman, The Design and Analysis of Computer Algorithms, Addison-Wesley, Reading, Mass., **1974**

2. R.G.Dromey: How to solve it by computer Prentice-Hall of India Private Limited, New Delhi, **1999**

3. Robert Lafore: Object Oriented Programming in Turbo C++, Galgotia Publishers Private Ltd, **1997**

**M. Sc. Mathematics**

**SOFT CORE : MATH-522 GRAPH THEORY WITH APPLICATIONS**

**Treatment as in** J.A. Bondy and U.S.R. Murthy: Graph Theory with Applications,1976.

**Pre requisites**: Graphs and simple graphs - Special graphs (Complete graphs, Complement of graphs and null graphs) - Graph isomorphism – Sub graphs - Vertex degrees - Degree sequences and graphic sequences - walks, paths, Cycles - Graph connection and components - Bipartite graphs and their characterizations.
(Chapter 1. No questions from this chapter)

**Unit-I**

Connectivity and edge connectivity - Vertex cuts and edge cuts - Whitney's inequality (relating K,K and d) - Blocks and blocks of graphs - Characterization of 2 - connected graphs and blocks - Menger's theorem (without proof).
(Chapter 3 in which Section (3.3) is omitted).

**Unit-II**

Independent sets and their characterization - Matchings - Vertex as well as edge independence numbers, Covering numbers - Perfect matching – Konig's Theorem (with out proof) - Galli's theorem - Ramsey numbers - Theorems on the upper bounds and lower bounds for Ramsey numbers - Ramsey graphs - Erdos theorem.
(Chapter 7 - Sections (7.1) and (7.2) only).

**Unit-III**

Vertex colourings and chromatic numbers of graphs - Critical graphs and their properties - Brook's theorem - Hajo's conjecture and Dirac's theorem.
(Chapter 8 - Sections (8.1), (8.2) and (8.3) only)

**Unit-IV**

Chromatic polynomials - The five colour theorem - The four colour theorem (without proof) - Edge chromatic number - Vizing's theorem (statement only).
(Chapter 8 - Section (8.4) only; Chapter 9 - Section (9.6) only; Chapter 6 - Sections (6.1) and (6.2) only)

**Unit-V**

Directed graphs- Directed paths (Roy-Gallai Theorem) - Tournaments - Directed Hamilton paths and cycles (Moon's theorem, Ghouila - Houri theorem).
(Chapter 10 - Sections (10.2) and (10.3) only)

**Reference books**


1. F. Harary, Graph Theory, Addison –Wesley, **1969**
2. G Narasinga Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall of India Private Limited, New Delhi**, 2004**
3. I R.J. Wilson, Introduction to Graph Theory. Logman, **1972**
4. L.R. Foulds, Graph Theory Applications, Springer's, **1993**
5. S.A. Choudam, A First Course in Graph Theory, Mac Millan, **1987**

## M. Sc. Mathematics

## SOFT CORE : MATH-523 GRAPH THEORY WITH ALGORITHMS

**Unit-I**

Graphs – degrees – Isomorphism – subgraphs – Walks, paths, Circuits - connected graphs – components – Euler graphs – Operations on graphs – Hamiltonian paths and circuits – Traveling Salesman Problem
(Chapters 1 and 2 in which Sections (1.2),(1.6) and (2.3) are omitted).

**Unit-II**

Trees – some properties of trees – pendant vertices in a tree – distance and centers in a tree – Rooted and binary trees – On counting trees – Spanning trees – Fundamental circuits – finding all spanning trees of graph – spanning trees in a weighted graph.
(Chapter 3).

**Unit-III**

Cut sets – some properties of a cutest – All cut sets in a graph – Fundamental circuits and cut sets – connectivity and separability – Network flows – (1) Isomorphism – (2) Isomorphism.
(Chapter 4)

**Unit-IV**

Incidence matrix – Sub matrices - Circuit matrix – Fundamental Circuit matrix and rank – An application to a switching network – Cut set matrix – Relationships – path matrix .
(Chapter 7).

**Unit-V**

Algorithms – (Input) Computer representation of a graph – the out pat – some basic graph theoretic algorithms: connectedness and components, A spanning tree – A set of fundamental circuits, cut vertices and separability – shortest path algorithms: Shortest path either from a specified vertex to another specified vertex or among all pairs of vertices.

(Chapter 11 in which Sections (11.4) of Algorithm 5, (11.6) of Algorithm 8, (11.7), (11.8), (11.9) and (11.10) are omitted).

**Text book**

Narsingh Deo: Graph Theory with Applications to Engineering and Computer Science, Prentice Hall of India Private Limited, New Delhi, **2004**

**Reference books**

1. F. Harary, Graph Theory, Addison Wesley, **1969**
2. C.L.Liu, Elements of Discrete Mathematics, McGraw Hill Book Company, Second Edition, **1986**
3. R. Johnsonbaurgh, Discrete Mathematics, **1989**
4. L.R. Foulds: Graph Theory Applications, Narosa Publishing House, **1993**

**M. Sc. Mathematics**

**SOFT CORE : MATH-527 ALGEBRAIC NUMBER THEORY**

**Unit-I** Elementary Number Theory

Integers – Greatest common divisor – Infinitude of primes – Unique factorization in Z – Fermat's little theorem – Euler's $\Phi$ function and Euler's theorem – Multiplicative property of $\Phi$ function – Applications of unique factorization – The equation $x^2 + y^2 = z^2$ – The equation $x^4 + y^4 = z^2$ – The equation $x^4 – y^4 = z^2$ – Fermat numbers and their properties.

**Unit-II** Euclidean Rings

Preliminaries: Units, Associates, Irreducible elements, Norm map, Unique factorization domain, Principal ideal domain, Euclidean domain – Gauss' lemma – Gaussian integers – Units and primes in the ring of Gaussian integers – Eisenstein integers – Units in the ring of Eisenstein integers – Factorization of 3 – Order of $Z[\rho] / (\lambda)$.

**Unit-III** Algebraic Numbers and Integers

Basic concepts – Algebraic number – Algebraic integer – Minimal polynomial – Countability of algebraic numbers – Liouville's theorem for R – Algebraic number fields – Theorem of the primitive element – Liouville's theorem for C – Characterization of algebraic integers.

**Unit-IV** Integral Bases

The norm and the trace – Integral basis for an algebraic number field – Algebraic integers of $Q(\sqrt{-5})$ – Existence of an integral basis – Discriminant of an algebraic number field – Index – Determination of an integral basis for the ring of integers of a quadratic number field.

**Unit-V** Dedekind Domains

Integral closure – Integrally closed ring – Noetherian ring – Dedekind domain – Characterizing Dedekind domains.

**Text book**

J.Esmonde and M.Ram Murty, Problems in Algebraic Number Theory, Graduate Texts in Mathematics, Volume 190, Springer Verlag, New York, **1999**

Sections 1.1 and 1.2
Sections 2.1, 2.2 and 2.3
Sections 3.1, 3.2 and 3.3
Sections 4.1, 4.2 and 4.3
Sections 5.1 and 5.2

**M. Sc. Mathematics**

## SOFT CORE : MATH-528 ADVANCED ALGEBRAIC NUMBER THEORY

**Unit-I** The Ideal Class Group

Euclidean rings – Hurwitz constant – Fractional ideals – Finiteness of the ideal class group – The class number of an algebraic number field – The class number of $Q(\sqrt{-5})$ – The Diophantine equation $x^2 + 5 = y^3$.

**Unit-II** Quadratic Reciprocity

Preliminaries – Quadratic residues and quadratic non residues – The Legendre symbol – The quadratic character of -1 and 2 – Gauss sums – The law of quadratic reciprocity.

**Unit-III** The Structure of Units

Discrete subgroup of $R^m$ – Dirichlet's unit theorem – Units in real quadratic fields – Pell's equation.

**Unit-IV** Higher Reciprocity Laws

Cubic reciprocity – Eisenstein reciprocity.

**Unit-V** Analytic Methods

The Riemann and Dedekind zeta functions – Zeta functions of quadratic fields – Dirichlet's hyperbola method.

**Text book**

J.Esmonde and M.Ram Murty; Problems in Algebraic Number Theory, Graduate Texts in Mathematics, Volume 190, Springer Verlag, New York, **1999**

Sections 6.1, 6.2 and 6.3
Sections 7.1, 7.2 and 7.3
Sections 8.1 and 8.2
Sections 9.1 and 9.2
Sections 10.1 and 10.2

**M. Sc. Mathematics**

## SOFT CORE : MATH-529 THEORY OF FUZZY SETS

**Unit-I** Fuzzy sets

Basic definitions – Types of fuzzy sets – Basic concepts – $\alpha$ cuts and their properties – Representations of fuzzy sets – first and second decomposition theorems.

**Unit-II** Operations on fuzzy sets

Types of operations – Fuzzy complements – Fuzzy intersections: t norms – Fuzzy unions: t conorms – Combinations of operations.

**Unit-III** Elements of fuzzy arithmetic

Fuzzy numbers – Linguistic variables – Arithmetic operations on intervals – Arithmetic operations on fuzzy numbers – Fuzzy equations.

**Unit-IV** Fuzzy relations

Crisp and fuzzy relations – Projections and cylindric extensions – Binary fuzzy relations – Binary relations on a single set – Fuzzy equivalence relations – Fuzzy compatibility relations.

**Unit-V** Fuzzy logic

An overview of classical logic – multi valued logics – Fuzzy propositions – Fuzzy quantifiers – Linguistic hedges – Inference from conditional fuzzy propositions.

**Text book**

George J. Klir and Bo Yuan: Fuzzy sets and Fuzzy Logic: Theory and Applications, Prentice – Hall of India Private Limited, New Delhi, **2000**

**Reference book**

H.J. Zimmermann: Fuzzy set theory and its Applications, Allied Publishers Limited, New Delhi**, 1991**

**M. Sc. Mathematics**

## SOFT CORE : MATH-530 ALGEBRAIC CODING THEORY

**Unit-I** Error detection, Correction and decoding

Communication channels – Maximum likelihood decoding – Hamming distance – Nearest neighbourhood minimum distance decoding – Distance of a code.

**Unit-II** Linear codes

Linear codes – Self orthogonal codes – Self dual codes – Bases for linear codes – Generator matrix and parity check matrix – Enconding with a linear code – Decoding of linear codes – Syndrome decoding.

**Unit-III** Bounds in coding theory

Sphere covering bound – Gilbert Varshamov bound – Binary Hamming cores – q-ary Hamming codes – Golay codes – Singleton bound and MDS codes – Plotkin bound.

**Unit-IV** Cyclic codes

Definitions – Generator polynomials – Generator matrix and parity check matrix – Decoding of Cyclic codes.

**Unit-V** Special cyclic codes

BCH codes – Parameters of BCH codes – Decoding of BCH codes – Reed Solomon codes.

**Text book**

San Ling and Chaoping Xing; Coding Theory: A first course, Cambridge University Press, **2004**

**Reference book**

V. Pless: Introduction to the Theory of Error correcting codes, Wiley, New York, **1982**

**M. Sc. Mathematics**

## SOFT CORE : MATH-531 CRYPTOGRAPHY

**Unit-I** Basic concepts

Factoring and primality testing – Perfect numbers – Fermat's divisibility test – Fermat numbers – Base representation of integers – Computational complexity.

**Unit-II** Symmetric key crypto systems

An overview of congruences – Block ciphers – The DES key Schedule – The DES Cryptosystem

**Unit-III** Public key cryptosystems

Exponentiation, discrete logs and protocols – Public key cryptography – RSA system – Rabin system – Elgamal system.

**Unit-IV** Authentication and knapsack

Digital signatures – Signature schemes related to public key Crypto Systems – Knapsack problem – Merkle Hellman system – Chor Rivest system.

**Unit-V** Primality testing

Primitive roots – Gauss's algorithm – Primitive root theorem – Index calculus – Mersenne number – Pocklington's theorem – Proth's theorem – Pepin's primality test.

**Text book**

Richard A. Mollin: An Introduction to Cryptography, Chapman & Hall / CRC, Boca Raton, **2000**

**Reference book**

Dominic Walsh: Codes and Cryptography, Oxford Science Publications, Clarendon Press, Oxford, **1988**

**M. Sc. Mathematics**

**SOFT CORE : MATH-532 AUTOMATA THEORY**

**Unit-I** Introduction to the theory of computation
Three basic concepts: Languages, Grammars, Automata – Some application.

**Unit-II** Finite Automata
Deterministic finite accepters – Nondeterministic finite accepters – Equivalences of deterministic and nondeterministic finite accepters – Reduction of the number of states in finite automata.

**Unit-III** Regular Languages and Regular Grammars
Regular expression – Connection between regular expression and regular languages - Regular grammars.

**Unit-IV** Properties of Regular Languages
Closure properties of regular languages – Elementary questions about regular languages – Identifying non regular languages.

**Unit-V** Context-Free Languages
Context-free grammars – Parsing and ambiguity – Context – Free Grammars and programming languages.

**Treatment as in** : Peter Linz, "An Introduction to Formal Languages and Automata", Jones and Bartlett Publishers, Inc. **2006**

**M. Sc. Mathematics**

## SOFT CORE : MATH-533 ADVANCED TOPICS IN TOPOLOGY AND ANALYSIS

**Unit-I**

Quotient topology and quotient maps - Examples of quotient spaces - Path connectedness - Standard results - Example of a connected but not path connected space- Locally connected spaces.

**Unit-II**

The Uryshon's metrization theorem - One point compactification - Stone- Cech compactification - The Arzela - Ascoli theorem.

**Unit-III**

Local finiteness- Countably locally finite refinement of open coverings of metric spaces – Paracompactness - Standard results - Metric spaces are paracompact.

**Unit-IV**

Partition of unity - Lp- spaces – Completeness - Dual of Lp[a, b] for $1 \leq p < 1$.

**Unit-V**

Extreme points - Caratheodory's theorem - Krein- Milman theorem - Milman converse theorem - Extreme points of the closed unit ball of c, $l\infty$, C(Q), Q compact, Hausdorff and the dual of C(Q) - Stricly convex spaces - Examples.

**Reference books**


1. James R. Munkres, Topology, Prentice Hal, **2000**
2. James Dugundji, General Topology, Universal Book Stall, New Delhi, **1990**
3. John B. Conway, A course on Functional Analysis, Springer GTM, **1990**
4. M. Fabian, P.Habala, P. Hajek, V.M. Santalucia, J.Pelant and V. Zizler: Functional Analysis and Infinite dimensional geometry, CMS Books in Mathematics, Springer-Verlag, **2001**

**M. Sc. Mathematics**

## SOFT CORE : MATH-534 APPROXIMATION THEORY

**Unit-I**

Interpolation by polynomials - Lagrange interpolation - Vander Monde's determinant- Bernstein polynomials - Weierstrass approximation theorem.

**Unit-II**

Stone- Weierstrass theorem (Real and complex versions) - Weierstrass theorem as corollary - Approximation of continuous, periodic functions by trigonometric polynomials - Best approximation in C[a, b] with sup norm - Chebychev's Alternation theorem - Theorem of de La Vallee Poussin.

**Unit-III**

General linear families - Haar system and its characterizations - Uniqueness of polynomials of best approximation - Strong unicity theorem - Harr's unicity theorem.

**Unit-IV**

An algorithm of Remes and convergence under Haar condition - Strictly convex and uniformly convex Banach spaces - Approximation in inner product spaces – Approximation from closed, convex subsets - Approximation from subspaces of Hilbert spaces - Uniform convexity and continuity of metric projection.

**Unit-V**

Approximation from finite dimensional subspaces - Normal equations and Gram's determinant - approximation in L2[a, b] - Orthogonal polynomials - Legendre and Chebychev polynomials.

Best approximation by subspaces of Banach spaces - Duality formula - Spaces in which all closed subspaces are proximinal or Chebychev-proximinality of weak* closed subspaces - Approximation by closed hyperplanes.

**Reference books**


1. E.W.Cheney: An Introduction to Approximation theory, AMS Chelsea Publication, **1998**
2. B.V. Limaye: Functional Analysis, Wiley Eastein, New Delhi, **1981**
3. Frank Deutsch: Best approximation in inner product Spaces, Springer-Verlag New York Inc., **2001**
4. Serge Lang: Real Analysis, Addison-Wesley Publishing Company, **1983**
5. Ivan Singe: Best approximation in normed linear spaces by elements of linear subspaces, Springer-Verlag, **1970**

**M. Sc. Mathematics**

**SOFT CORE : MATH-536 DIFFERENCE EQUATIONS**

**Unit-I** The Difference Calculus
Definition, Derivation of Difference equation, Existence and uniqueness theorem. Operators and E. Elementary difference operators. Factorial polynomials. Operators and the sum calculus. Examples.

**Unit-II** First order difference equation
General Linear equation. Continued fraction. A general first-order equation – Expansion Techniques.

**Unit-III** Linear Difference equations
Introduction, Linearly Dependent functions. Fundamental Theorem for homogeneous equations.

**Unit-IV** Inhomogeneous equations
In homogeneous equations. Second order equations. Sturn Liouville Difference equations.

**Unit-V** Linear Difference equation with constant coefficients
Introduction, Homogeneous equation. Construction of a difference equation having specified solution. Relationship between Linear difference and differential equation.

**Text book**
Ronald E. Mickens: Difference equation - Theory and Application, Chapman & Hall, Second Edition, New York – London, **1990**

**M. Sc. Mathematics**

**Soft Core – MATH-537: Partial Differential Equations**

**Unit – I:** First Order PDEs
Genesis of First order PDE, Linear equations of first Order, Pfaffian Differential equations, Compatible systems, Charpit's method, Jacobi's method, Integral surfaces through a given curve, Quasi linear equations

**Unit – II:** Non-linear first order PDEs.
Cauchy's method of characteristics, Compatible systems, Special types of first order equations

**Unit – III**: Second Order PDEs
Genesis of Second order PDEs. Classification of second order pdes, One –dimensional wave equations, Vibrations of a string of Infinite length, semi-infinite length and finite length, Riemann's Method, Method of separation of variables

**Unit – IV:** Laplace equations
Boundary value problems, Maximum and minimum principles, Cauchy Problem, Dirichlet problem , Neumann problem, Harnack's theorem, Green's function

**Unit – V:**
Heat Conduction Problem in infinite rod case and finite rod case, Duhamel's Principle, Wave equation, Heat conduction equation, Classification in n-variables, Families of equi potential surfaces, Kelvin's Inversion Theorem

**TEXT BOOK:**


1. I. N. Sneddon, Elements of Partial DifferentiaI Equations, McGraw Hill, International Edition, Singapore**, (1986)**


**REFERENCE BOOKS**


1. T. Amarnath, An Elementary Course in Partial Differential Equations, Narosa Publishing House, **2010**
2. K. Shankara Rao, Introduction to Partial Differential Equations, PHI Publications, New Delhi, **2005**
3. F. John, Partial Differential Equations, Springer Verlag, **1975**
4. Lawrence C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, **1998**

**M. Sc. Mathematics**

## SOFT CORE : MATH-538 LIE GROUPS OF TRANSFORMATIONS AND DIFFERENTIAL EQUATIONS

**Unit-I**
Introduction–Lie groups of transformation – Infinitesimal transformations.

**Unit-II**
Extended group transformations and infinitesimal transformations (one independent – one dependent and two independent – two dependent).

**Unit-III**
Lie Algebras and Applications.

**Unit-IV**
Invariance of first and second order differential equations.

**Unit-V**
Invariance of a partial differential equations of first and second order – elementary examples.

**Treatment as in** G. W. Blueman and S. Kumei: Symmetries and Differential Equations Springer – Verlag, **1980**

1 – Chapter 2 (Sections 2.1 – 2.2);
2 – Chapter 2 (Sections 2.3.1 – 2.3.3) ;
3 – Chapter 2 (Sections 2.4.1 – 2.4.4);
4 – Chapter 3 (Sections 3.1.1 – 3.3.3);
5 – Chapter 4 (Sections 4.4.1 – 4.2.2).

**M. Sc. Mathematics**

## SOFT CORE : MATH-539 NUMERICAL ANALYSIS FOR ORDINARY DIFFERENTIAL EQUATIONS

**Unit-I**

Euler's method - trapezoidal rule - theta method.

**Unit-II**

Adams - Bashforth method - Order and convergence - Backward Differentiation Formula.

**Unit-III**

Gaussion Quadrature - Explicit Runge - Kutta scheme - Implicit Runge Kutta scheme - Collocation.

**Unit-IV**

Stiff equations - linear stability domain and A. Stability - A-stability of RK and multistep methods.

**Unit-V**

Error Contool - Milne Device - Embedded Runge Kutta method.

**Text book**

Arieh Iserles, A First Course in the Numerical Analysis of Differential Equations, Cambridge, **2009**

**M. Sc. Mathematics**

## SOFT CORE : MATH-540 ADVANCED FLUID MECHANICS

**Unit-I**

Characteristics - Wave equation - Examples - Riemann invariants - Hodograph transformation - Piston problem.

**Unit-II**

Shocks - Systems of conservation laws - Weak solution - Rankine - Hugoniot relations - Hugoniot relation - Prandtl's relation - Compressive shocks - Entropy condition.

**Unit-III**

Riemann problem - Centered waves - Solution of the Riemann problem - Courant – Fricdricts - Lewy condition.

**Unit-IV**

Combustion waves - Single conservation law - Convex conservation laws - Oleinik's condition – Non convex systems of conservation laws - Solution.

**Unit-V**

Numerical methods - Finite Difference Methods- Forward Difference - Backward Difference - Central Difference - Consistency - Order - Stability - Lax's Theorem – Von Neumann Analysis - Godunov scheme - l8 stability - $l_2$ stability - Lax – Fricdricks scheme - Lax Wendroff scheme - Crank - Nicolson scheme.

**Text Books**


1. Chorin and Marsden: A Mathematical Introduction to Fluid Mechanics, Texts in Applied Mathematics, Springer, Third Edition, **1993**
2. A Iserles: A First course in the Numerical Analysis of Differential Equations, Cambridge University Press, **2009**

**M. Sc. Mathematics**

## SOFT CORE : MATH-541 INTEGRAL EQUATIONS

**Unit-I**

Introduction - classification of integral equation - examples - IVP for ODE.

**Unit-II**

BVP for ODE - BVP for elliptic PDE - Abel's problem.

**Unit-III**

Second order ODE and integral equations -Differential equation theory - initial value problems - Boundary value problems - Singular Boundary value problems.

**Unit-IV**

Integral equations of the second kind - Introduction - Degenerate kernels - a different approach.

**Unit-V**

Operators - Newmann series.

**Book**

Porter and Stirling, Integral equations, Cambridge, pp 1-94.

A practical treatment from spectral theory to applications. - Cambridge: Cambridge University Press, **1996**

**M. Sc. Mathematics**

## SOFT CORE : MATH-542 ADVANCED MATHEMATICAL ANALYSIS

**Unit-I** Spaces of functions

Families of functions like periodic functions - Continuous functions, C1- functions, rapidly decreasing functions on Rn which separate points, closed subsets - Partition of unity.

**Unit-II**

Topology on the spaces functions

Uniform convergence - Uniform convergence on compact on polynomials (with emphasis on power series), Ck-functions, C1-functions on Rn – holomorphic functions on C - Completeness of various spaces of functions under uniform metric, Lp-metric and under uniformly on compact topology.

**Unit-III** Compact subsets

Arzela - Ascoli theorem - Normal families of holomorphic functions - Hilbert spaces of holomorphic functions - Reproducing kernels.

**Unit-IV** Fourier analysis

Convolutions - Fourier transform - Approximate identities in L1(Rn) given by classical kernels like Fejer's kernel.

**Unit-V** Density

Approximation through convolutions - Density theorems of Weierstrass and Stone, Korovkin – Density of C1c -functions in Lp.

**Reference books**


1. R. Beals: Advanced mathematical analysis, Springer Verlag, New York, **1973**
2. J.B. Conway: Functions of one complex variable, Narosa Publishing House, **1980**
3. E.H. Lieb and M. Loss: Analysis, Narosa Book House, New Delhi, **1997**
4. W. Rudin: Real and complex analysis, 2nd ed., TMH Edition, **1962**
5. K. Yosida: Functional analysis, Springer - Verlag, New York, **1968**

**M. Sc. Mathematics**

## SOFT CORE : MATH-543 REPRESENTATION THEORY OF COMPACT GROUPS

**Unit-I**

Locally compact groups - Examples of various matrix groups. - Existence of Haar measure (without proof) - Computation of Haar measure on R, T, SU(2), SO(3) and some simple matrix groups. Convolution - The Banach algebra L1(G).

**Unit-II**

General properties of representations of a locally compact group - Complete reducibility - Basic operations on representations – Irreducible representations.

**Unit-III**

Representations of finite groups - Decomposition of regular representations – Orthogonal relations - Irreducible representations of the symmetry group. Representations of compact groups - Matrix coefficients - Schur's orthogonality relations - Finite dimensionality of irreducible representations of compact groups.

**Unit-IV**

Arzela - Ascoli Theorem - Compact operators - Various forms of Peter- Weyl theorem.

**Unit-V**

Character of a representation. Schur's orthogonality relations among characters - Weyl's chracter formula - Computing all the irreducible representations of SU(2), SO(3).

**Reference books**


1. T. Brocker and T. Dieck: Representations of compact lie groups, Springer Verlag, **1985**
2. J. L. Clerc, Les repr´esentatios des groupes compacts, Analyse harmonique (J.L.Clerc et al. ed.), C.I.M.P.A, **1982**
3. M. Sigiura, Unitary representations and harmonic analysis: An introduction, John Wiley, **1975**
4. B. Vinberg, Linear representations of groups, A series of advanced textbooks in Mathematics, Brikauser Verlag, Berlin - Boston, **1989**

**M. Sc. Mathematics**

## SOFT CORE : MATH-544 ELEMENTS OF HARMONIC ANALYSIS

**Unit-I**

Basic properties of topological groups, subgroups, quotient groups - Examples of various matrix groups.

**Unit-II**

Connected groups - Existence of Haar measure (without proof) - Computation of Haar measure on R, T, Z and some simple matrix groups - Convolution, the Banach algebra L1(G) and convolution with special emphasis on L1(R), L1(T) and L1(Z).

**Unit-III**

Fourier transform and its properties - Approximate identities in L1(G).

**Unit-IV**

The Dual group of a locally compact abelian group - Computation of dual groups for R, T, Z.

**5. Unit-V**

Classical kernels on R - The Fourier inversion Theorem - Plancherel theorem on R - Plancherel measure on R, T, Z - Discussion on Plancherel theorem on a general locally compact abelian group.

**Reference books**


1. G. Folland: A course in abstarct harmonic analysis, CRC Press, **1994**
2. H. Helson: Harmonic analysis, Trim Series, Hindustan Book Agency, 2nd Edition, **1995**
3. Y. Katznelson: Introduction to harmonic analysis, J. Wiley and Sons, **1968**
4. L.H. Loomis: An introduction to abstract harmonic analysis, van Nostrand, New York, **1953**
5. E. Hewitt & K.A. Ross: Abstract harmonic analysis, Vol. I, Springer – Verlag, **1963**
6. W. Rudin: Real and complex analysis, Tata Mc Graw Hill, 2nd Edition, **1962**

**M. Sc. Mathematics**

## SOFT CORE : MATH-545 LINEAR LIE GROUPS

**Unit-I**

Basic properties of topological groups, subgroups, quotient groups and connected groups.

**Unit-II**

Linear Lie groups like GL(n,R), GL(n,C), Orthogonal groups, Unitary groups, Motion groups, Heisenberg groups and various properties of them.

**Unit-III**

Computation of Haar measure for the above groups - The exponential map and the Lie algebras of the above groups.

**Unit-IV**

Representations of a locally compact group - Adjoint representation - Irreducible representations of SU(2) and SO(3).

**Unit-V**

Induced representation - Irreducible representations of Motion group M(2) and Heisenberg groups.

**Reference books**


1. J. L. Clerc: Les repr´esentatios des groupes compacts, Analyse harmonique (J.L.Clerc et al., ed.), C.I.M.P.A**., 1982**
2. G. Folland: A course in abstract harmonic analysis, CRC Press, **1994**
3. S. Kumaresan: A course in differential geometry and lie groups, Trim 22, Hindustan Book Agency, **2002**
4. M. Sigiura: Unitary representations and harmonic analysis: An introduction, John - Wiley, **1975**

**M. Sc. Mathematics**

**SOFT CORE : MATH-546 GRAPH THEORY**
**4 Credits**

**Unit-I**
Vertex cuts – Connectivity – Edge cuts – Edge connectivity – Whitney's Theorem – Blocks – Cyclical Edge connectivity.

**Unit-II**
Independent sets – Coverings – Matchings – Factors – Matching in bipartite graphs – Hall's theorem – Perfect Matchings – covering numbers – Gallai's Theorem.

**Unit-III**
Chromatic number of graphs – critical graphs – Brooks theorem – Hajos conjecture –Chromatic polynomials – Girth and chromatic number of graphs.

**Unit-IV**
Plane and Planar graphs – Dual graphs – Euler's Formula – Bridges – Kuratowski's Theorem – Five color Theorem – Four color theorem.

**Unit- V**
Directed graphs – Directed paths – Roy and Gallai's Theorem – Directed Hamilton paths – Directed Hamilton cycles – Moon's theorem – k partite tournaments.

**Reference books:**


1. R. Balakrishnan and K. Ranganathan, A textbook of Graph Theory, Springer Publication, **2000**
2. J.A. Bondy and U.S.R Murty, Graph theory with applications, Springer Publication, **2008**

**M. Sc. Mathematics**

## SOFT CORE : MATH-547 ADVANCED FUNCTIONAL ANALYSIS

**Unit-I**

Topological vector spaces-balanced and absorbing sets - Locally convex spaces – Examples- Weak and weak* topologies.

**Unit-II**

Finite dimensional topological vector spaces -Minkowski functional - bounded and totally bounded sets - Metrizable topological vector spaces - Characterization of normable locally convex spaces.

**Unit-III**

Continuous linear functionals and dual of locally convex spaces - Hahn- Banach separation theorems - Weak topology induced by a subset of the dual polar set – Bipolar theorem.

**Unit-IV**

Weak* continuous linear functionals on dual normed linear spaces - Goldstein's theorem - Banach -Alaoglu's theorem - Characterization of reflexive spaces as spaces with weakly compact unit balls.

**Unit-V**

Linear operators – Examples - Integral operators - Inverse and adjoint operators - Adjoint operators in Hilbert spaces - Normal and unitary operators.

**Reference books**


1. John B. Conway: A Course on Functional Analysis, Springer GTM, **1990**
2. H.H. Schefer: Topological Vector Spaces, Springer-Verlag, GTM, **1980**
3. M. Fabian, P. Habala, P. Hajek, V.M. Santalucia, J.Pelant and V. Zizle: Functional Analysis and Infinite Dimensional Geometry, CMS Books in Mathematics, Springer-Verlag, 2**001**
4. B.V. Limaye: Functional Analysis, Wiley Eastern, New Delhi, **1981**
5. Thamban Nair: Functional Analysis, Easten Economy Edition, Prentice Hall of India Pvt Ltd, New Delhi, **2002**

**M. Sc. Mathematics**

## SOFT CORE : MATH-548 ADVANCED TOPICS IN DISCRETE MATHEMATICS

**Unit-I**

Applications of Boolean algebra to Switching Theory using AND, OR and NOT gates - The Karnaugh Method.

**Unit-II**

Definition of (undirected) graphs - Paths - Circuits and Cycles - Subgraphs and induced subgraphs - Degree of a vertex -Connectivity - Complete graphs bipartite graphs - Matrix representations of graphs - Weighted graphs - Dijkstra's Algorithm.

**Unit-III**

Trees and their properties- Spanning trees - Minimal spanning trees - Kruskal's Algorithm – Euler graphs and paths - Euler's theorem on the existence of Euler paths and circuits.

**Unit-IV**

Fundamental cycles - Cutsets - Fundamental cutsets - Plane and planar graphs - Dual graphs - Euler's formula for connected plane graphs - Kuratowski's theorem (statement only) and its applications.

**Unit-V**

Directed graphs - Indegree and outdegree of a vertex - Strong connectivity - Matrix representation of directed graphs - Warshall's Algorithm - Directed trees. Search trees - Tree traversals- Notions of syntax analysis- Polish notations - Conversion of infix expressions to Polish notations - The reverse Polish Notation.

**Reference books**


1. J.P. Tremblay and R. Manohar: Discrete Mathematical Structures with Applications to Computer Science, McGraw Hill Book Company**, 1997**
2. J.L. Gersting: Mathematical Structures for Computer Science (3rd edn), Computer Science Press, New York, **1993**
3. Seymour Lepschutz: Finite Mathematics, McGraw - Hill Book Company, New York, International Edition, **1983**
4. S. Wiitala: Discrete Mathematics - A Unified Approach, McGraw Hill Book Company, **1987**
5. C.L. Liu: Elements of Discrete Mathematics, McGraw-Hill Book Company, **2000**
6. N. Deo: Graph Theory with Applications to Engineering and Computer Sciences, Prentice Hall of India, **2004**

**M. Sc. Mathematics**

## SOFT CORE : MATH-549 LABORATORY PRACTICAL IN MATHEMATICS

### Objective of the Course:

To introduce to the students certain important software packages in Mathematics and train them for practical applications so as to augment the skills of the students.

Course contents: Any **five units** from the following topics:
Kash
Latex
Maple
Mathematica
Mathcad
Mathlab
Octave
Pari
Reduce
Scilab

Methodology of teaching:

(i) Lectures
(ii) Computer Practicals
(iii) Assignments

Methodology of evaluation: Practicals

### Reference books


1. Adre Heck : Introduction to Maple, Springer, **2003**
2. Batut C, Bernardi D, Cohen H and Olivier M: User's Guide to PARI – GP, University of Bordeaux I, France, **1995**
3. Eugene Don, Schaum's Outlines, Mathematica, Tata McGraw Hill Edition, **2004**

**M. Sc. Mathematics**

## SOFT CORE: MATH 550 TOPICS IN TOPOLOGY AND ANALYSIS

**Unit-I** Connected topological spaces

Connected topological spaces- Path connectedness- -Components-Example of a connected but not path connected space- Locally connected spaces- Continuous images of connected, path connected and locally connected spaces

**Unit-II** Locally compact spaces and Completely regular spaces

Locally compact spaces-One point compactification -Completely regular spaces- Imbedding theorem for completely regular spaces-The Uryshon's metrization theorem

**Unit-III** Stone- Cech compactification

Stone- Cech compactification- equicontinuity- Arzela- Ascoli theorem- Stone-Weierstrass theorem

**Unit-IV** Interpolation

Lagrange interpolation-Bernstein polynomials- Monotone operator theorem- Weierstrass theorem

**Unit-V** Completeness

Completeness of Lp[a; b]-Product measures- Fubini's theorem

**Reference books**


1. James R Munkres: Topology, Prentice Hall**, 2000**
2. Walter Rudin,: Real and Complex Analysis, Mc Graw-Hill Pupblizhing Co. Ltd., New Delhi, $10^{th}$ Reprint, **1986**
3. H.L.Royden: Real Analysis, Macmillan Publishing Company, **1988**
4. E.W.Cheney: An Introduction to Approximation Theory, AMS Chelsea Publications **1998**

## SOFT CORE: MATH 551 FUNCTIONAL ANALYSIS - II

**Unit-I** Normed linear spaces
Separation theorem and strict separation theorem in normed linear spaces-Applications-Weak and weak* topologies on normed linear spaces, both finite and infinite dimensional

**Unit-II** Weak and weak* topologies
Conditions for metrizability of weak and weak* topologies on bounded sets-Weak and weak* continuous linear functionals-Separation theorem for spaces with weak or weak* topologies

**Unit-III** Dual-polar set
Weak topology induced by a subset of the dual-polar set - Bipolar theorem - Goldstein's theorem- Banach -Alaoglu's theorem- Reflexivity and weak convergence.

**Unit-IV** Operators - I
Linear operators-Examples-Integral operators- Inverse and adjoint operators- Range and null spaces- Adjoint operators in Hilbert spaces- Normal and unitary Operators

**Unit-V** Operators - II
Compact operators on Banach spaces- Definition, examples and basic properties- Hilbert Schmidt operators

**Reference books**


1. M. Fabian, P.Habala, P. Hajek, V.M. Santalucia, J.Pelant and V. Zizler: Functional Analysis and Infinite Dimensional Geometry, CMS Books in Mathematics, Springer-Verlag, 2**001**
2. M. Thamban Nair: Functional Analysis - A First Course, Prentice-Hall of India Private Ltd, New Delhi**, 2002**
3. B. V. Limaye: Functional Analysis, Wiley Eastern, **1981**
4. John B. Conway: A Course on Functional Analysis, Springer (GTM), **1990**

## SOFT CORE: MATH 552 OPERATOR THEORY

**Unit-I**

Banach algebras – Involutive Banach algebras – Various examples including Group algebras – Spectrum – Spctral mapping theorem – Spectral radius formula.

**Unit-II**

Maximal ideal space for commutative Banach algebras – Gelfand - Naimark theory for commutative Banach algebras – C*- algebras, Examples- Commutative C*- algebras.

**Unit-III**

Representations of C*-algebras – Von Neumann's density theorem – Double commutant theorem - GNS constructions.

**Unit-IV**

Functional calculus – The spectral theorem for normal operators – Spectral theorem for unitary operators – Polar decomposition.

**Unit-V**

Compact operators – Examples and properties – Spectral theorem for compact operators – Hilbert – Schmidt operators.

**Reference books**


1. Sunder, V.S: Functional Analysis – Spectral Theory, Trim Series, Hindustan Book Agency, **1997**
2. Takesaki, M: Theory of Operator Algebras I, Springer Verlag, **1979**
3. Yosida, K: Functional Analysis, Springer Verlag, **1968**

**M. Sc. Mathematics**

## SOFT CORE: MATH - 554 NON-COMMUTATIVE RINGS AND REPRESENTATIONS

**Unit-I** Modules

Modules - Artinian and Notherian modules - Tensor products - Restricted and induced modules - Indecomposable modules – Completely reducible module - Schur Lemma.

**Unit-II** Radical

Semi simple rings - The radical of a rings - The Jacabson radical – Group algebras - Maschke's Theorem.

**Unit-III** Structure theory

Structure theory of ring - Density Theorem - Widderburn-Artin theorem for semi simple rings.

**Unit-IV** Representations - I

Representations - linear representation - Matrix representation - Equivalent representation - Invariant subspaces - Irreducible representations

**Unit-V** Representations - II

Direct sum of representations - Induced representation – restricted representation - tensor product of representations - Inner products of representation.

**Text book**

Charles W. Curtis and Irving Reiner: Representation Theory of Finite Groups and Associative Algebras, Inter Science Publishers, 1962. (Chapters 2 and 4).

**Reference books**


1. William Fulton and Joe Harris: Representation Theory - A First Course, Springer International Edition, Springer-Verlag, New York, **2004**
2. Jacobson: Basic Algebra II, Hindustan Publishing Corporation (India), **1983**
3. I.N Herstein: Non-Commutative Rings, The Mathematical Association of America, **1968**

## M. Sc. Mathematics

## SOFT CORE: MATH-555: ADVANCED COMPLEX ANALYSIS

**Unit-I**
The space of continuous functions - Spaces of analytic functions - Spaces of meromorphic functions - The Riemann Mapping Theorem.

**Unit-II**
Weierstrass factorization theorem - Factorization of sine function - The gamma function - The Reimann zeta function.

**Unit-III**
Schwarz Reflection Principle - Analytic continuation along a path - Monmodromy theorem.

**Unit-IV**
Subharmonic and superharmonic functions - The Dirichlet problem - Green's function.

**Unit-V**
Jensen's formula - The genus and order of an entire function.

**Text book**
John B. Conway: Functions of One Complex Variable, Second edition, 1980.

**Reference Book:**
L.V. Ahlfers, Complex Analysis, Mc-Grow Hill, Kogakush, **1979**

**M. Sc. Mathematics**

## SOFT CORE: MATH-557 ALGORITHMS WITH JAVA

**Unit-I**

ALGORITHMS: Introduction : Data structure concepts-List, Stacks, Queues, Trees, Heaps, Sets, Graphs, Design of Efficient Algorithms and their Computational Complexities . Searching and sorting techniques.

**Unit-II**

JAVA: Data types – Constants, variables – Declaration of variables – Scope of variables-Types casting –operator expressions- Decision making , branching and looping , creating arrays, variable size arrays, Strings.

**Unit-III**

Defining classes-Creating objects-Accessing class members – Methods overloading, Creating inheritance – Abstract methods and classes.

**Unit-IV**

Multi threading programming – creating threads, Extending the thread class – Starting , Stopping and blocking threads-Managing errors and exceptions-Types of errors exceptions-Catch statements-Throwing customized Exceptions.

**Unit-V**

Applet programming-Building Applet codes-Adding Applet to HTML file – passing parameters to Applet.

**Text Books**


1. Alhred V. Aho, Jellrey D. Ullman, John E.Hop Croft: "Data Structures and Algorithms, Addison Wesley Series, **1983**
2. ", E.Balagurusamy : "Programming with Java: A PrimerTata McGraws Hill, **1998**


**Reference Books**


1. Gilles Brassard and Paul Bratley, "Fundamentals of Algorithms", Prentice Hall of India Pvt. Ltd**., 1997**

**M. Sc. Mathematics**

## MATH-558: FUNCTIONAL ANALYSIS – III
## (Soft Core - 4 Credits)

**Unit-I**

Nets and sequences-convergence of nets-unconditional summability of series in Banach Space-Review of Hilbert spaces – sesquilinear forms-adjoint and self-adjoint operators in Hilbert spaces.

**Unit-II**

Normal and unitary operators – weak topology – strong and weak convergence of operators – orthogonal direct sums.

**Unit-III**

Compact operators of Banach spaces-integral operators – adjoint operator – Fredholm alternative.

**Unit-IV**

Invertible operators – eigenvalues and sepectrum related results – spectrum of a compact operator – self adjoint operators.

**Unit-V**

Compact operators of Hilbert spaces – Numerical range – spectral theorem for compact, self adjoint operators.

**Text Books:**


1. V.S. Sunder: Functional Analysis TRIM Series 13, Hindustan Book Agency, **1997** (For units 1 and 2)

2. M.Fabian, P.Habala, P.Hajek, V.M. Santalucia, J.Pelant and V.Zizler: Functional Analysis and Infinite dimensional geometry CMS books in Mathematics, Springer, **2001** (For units 3-5)

**M. Sc. Mathematics**

**Math-559 Mathematica Practical**
**Soft Core**

**Unit-I**

Basic concepts: Constants- Built-In Functions. Basic Arithmetic Operations Strings-Assignment,Replacement, and Logical relations -
Loops.

**Unit-II**

Two dimensional graphics and Three dimensional Graphics: Plotting Functions of Single variables and Two Variables - Graphic commands.

**Unit- III**

Lists: Generating Lists- List Manipulation - Set Theory - Tables and Matrices. Equations- Algebra and Trigonometry- Polynomials.

**Unit- IV**

Differential Calculus - Integral Calculus - Multivariable Calculus

**Unit-V**

Ordinary Differential Equations - Linear Algebra.

Reference:


1. Eugene Don, Schaum's Outlines: Mathematica, Tata McGraw-Hill Edition, **2004**
2. Bruce F. Torrence and Eve A. Torrence, A Students Introductions to Mathematica, Cambridge University Press, **2009**

**M. Sc. Mathematics**

**SOFT CORE: MATH -560 - Mathematical Softwares**
**(Credits: 4)**

**Unit-I:**
LATeX introduction- Installation – Math symbols and tables – TeX symbol and tables – Matrix and lists – Typing Math and text – Text environments.

**Unit-II:**
Document structure – Latex Documents – The AMS articles document class – Bemer Presentation and PDF documents – Long Documents – BibteX – Make index – Books in LateX-Colours and Graphics – TeXCAD – LATeX CAD.

**Unit-III:**
Starting with MATLAB- Variables Vectors, Matrices – Creating Array in MATLAB –Menu, Workspace, working Directory, Command window, Diary, Printing- Built_in function, User defined functions, Script M-files- Complex Arithmatic, Figen values and Eigen vectors – Two and three dimensional Plots.

**Unit-IV:**
Getting around with maple – Maple input and output - Programming in Maple.

**Unit-V:**
Maple: Abstract Algebra – Linear algebra – Calculus on Numbers – Variables- Complex Arithmatic, Eigen values and Eigen vectors – Two and three dimensional Plots.

**Text Books**:
G. Gratzer: More Math Into LATEX, 4th edition, Springer, **2007**
AMOS Gila: MATLAB an introduction with application, WILEY India Edition, **2009**
Brain R Hunt, Ronald L Lipsman: A Guide to MATLAB for beginners and Experienced users, Cambridge University Press, **2003**
Ander Hec: Introduction in Maple, Springer, **2007**

**M. Sc. Mathematics**

**MATH-561: Computational Algebra**
**(Soft core)**

**Unit- I**

Fundamental Algorithms: Representation, Addition and Multiplication of Numbers and Polynomials - Division with Remainder- Euclidean Domain - The Extended Euclidean Algorithm

**Unit- II**

Modular Arithmetic - Modular Inverses via Euclid -Repeated Squaring - Modular Inverses via Euclid

**Unit-III**

Modular Algorithms and Interpolation: Change or Representation - Evaluation and Interpolation - The Chinese Remainder Algorithm

**Unit- IV**

Fast Multiplication - Karatsuba's Multiplication Algorithm - The Discrete Fourier Transform and the Fast Fourier Transform -Newton Iteration -Solving Polynomial Equations via Newtons Iteration

**Unit -V**

Factoring Polynomial over Finite Fields: - Factorization of Polynomials -Distinct-Degree Factorization - Equal -Degree Factorization - Squarefree Factorization - Factoring in }[x] and Q[x] - A Factoring Algorithm.

**Reference:**

1. Joachim von zur Gathen and J\"{u}rgen Gerhand: Modern Computer Algebra, Cambridge University Press, **1999**

**M. Sc. Mathematics**

**Soft Core- MATH-562: Numerical Analysis**

**Unit-I:** Nonlinear Equations in One Variable**:**

Fixed point iterative method – convergence Criterion -Aitken's $\Delta 2$- process - Sturm sequence method to identify the number of real roots – Newton - Raphson's methods convergence criterion Ramanujan's Method - Bairstow's Method.

**Unit-II:** Linear and Nonlinear system of Equations**:**

Gauss Eliminations with Pivotal Strategy Jacobi and Gauss Seidel Itervative Methods with convergence criterion. LU - decomposition methods – (Crout's, Choleky and DeLittle methods) – consistency and ill conditioned system of equations - Tri-diagonal system of equations – Thomas Algorithm. Iterative methods for Nonlinear system of equations, Newton Raphson, Quasi Newton and Over Relaxation methods for Nonlinear system of Equations.

**Unit-III:** Interpolation:

Lagrange, Hermite, Cubic-spline's (Natural, Not a Knot and Clamped)- with uniqueness and error term, for polynomial interpolation. Bivariate interpolation. Orthogonal polynomials Grams Schmidth Orthogoralization procedure and least square, Chebyshev and Rational function approximation.

**Unit -IV:** Numerical Integration**:**

Gaussian quadrature, Gauss-Legendre, Gauss-Chebeshev formulas, Gauss Leguree, Gauss Hermite and Spline intergation – Integration over rectangular and general quadrilateral areas and multiple integration with variable limits.

**Unit-V:** Numerical solution of ordinary differential equations**:**

Initial value problems- Picard's and Taylor series methods – Euler's Method- Higher order Taylor methods - Modified Euler's method - Runge Kutta methods of second and fourth order – Multistep method - The Adams - Moulton method - stability - (Convergence and Truncation error for the above methods). Boundary - Value problems – Second order finite difference and cubic spline methods.

**TEXT BOOKS**


1. M. K. Jain, S. R. K. Iyengar and R.K. Jain: Numerical methods for scientific and engineering computation, Wiley Eastern Ltd. Third Edition, **1993**
2. C.F. Gerald and P.O. Wheatley : Applied Numerical Methods, Low- priced edition, Pearson Education Asia, Sixth Edition, **2002**
3. M.K. Jain: Numerical solution of differential equations,: Wiley Eastern, Second Edition, **1979**


**REFERENCE BOOKS**


1. S.C. Chapra and P.C. Raymond: Numerical Methods for Engineers, Tata McGraw Hill, New Delhi, **2000**
2. S.S. Sastry: Introductory methods of Numerical analysis, Prentice - Hall of India, New Delhi, **1998**

## M.Sc. Mathematics

### MATH-563: INTEGRAL TRANSFORMS
### SOFTCORE COURSE-4 CREDITS

### SYLLABUS

**Unit- I**

Laplace transforms ,Important properties, Simple Applications, Asymptotic Properties, Watson's Lemma.

**Unit- II**

Inversion Integral, The Riemann-Lebesgue Lemma, Dirichlet Integrals, The Inversion, Watson's Lemma for loop integrals, Heaviside Series Expansion.

**Unit- III**

Application to Ordinary Differential Equations, Elementary Examples, Higher Order Equations, Partial Differential Equations, Heat Diffusion Integral Equations.

**Unit-IV**

Fourier Transform, Exponential, Sine and Cosine Transforms, Important Properties, Spectral Analysis .

**Unit- V**

Partial Differential Equations, Potential Problems, Water Waves-Basic Equations, Waves Generated by a Surface Displacement.

**TEXT BOOK**

B.Davies: Integral Transforms and Their Applications, Springer, Texts in Applied Mathematics, 41 Third Edition, **2002**