MANONMANIAM SUNDARANAR UNIVERSITY, TIRUNELVELI

Department of Mathematics

SYLLABUS & SCHEME OF EXAMINATIONS M.Sc. MATHEMATICS (CBCS)

with MOOC and e-resources

(For those who join the programme during 2019-20 and onwards)

1. PRORAMME OBJECTIVES: Mathematics is one of the fundamental disciplines in science. It is the basic for all the disciplines. This two year program, consisting four semesters, aims at providing basic tools and exposure to students who intend to pursue Master Degree in Mathematics at the inter- national level.

- Elective courses in the fourth and fifth years are planned to suit competitive examinations like NET and SLET.
- Students undergoing this programme will have the opportunity of choosing research / teaching at leading research institutions or a career in corporate sectors.
- To enable the students to have a thorough exposure to the different branches of Mathematics so as to gain a comprehensive knowledge of Mathematics.
- To cultivate logical thinking and analytical skills which sharpens their concentration and provides patience to grapple with life outside the campus.

2. Eligibility and mode of Admission: Any graduate with an aggregate of 50% marks in Mathematics or Applied Mathematics is eligible to apply for admission to the course. Relaxation for SC/ST students will be given as per norms of the Government of Tamil Nadu.

An entrance examination (objective type questions) will be conducted for eligible applicants. The merit list will be prepared with 50% marks for entrance examination and 50% marks for Part III score in B.Sc. Then admission will be based on merit and reservation policy of the Government of Tamil Nadu.

3. SCHEME OF THE EXAMINATION

This program is under Choice Based Credit System of the University and a successful candidate should score a minimum of 90 credits in 4 semesters. Each paper is evaluated for 100 marks with Internal 25 marks and External 75 marks. The internal assessment comprises of 3 components -15 marks for written test (average of the best two of 3 tests), 5 marks for Seminar and 5 marks for Assignment.

The semester Question paper pattern for external examination is as follows :

Section A - 10 x 1 = 10 (no choice)

Section B - 5 x 5 = 25 (Internal choice questions)

Section C - 5 x 8 = 40 (Internal choice questions)

The duration of the examination is 3 hours. In order to train the students for National level examinations and Research, End semester examination question paper for each course shall contain 20% questions from problems and 80% questions from theory in Part B and Part C.

Passing minimum in the external examination is 50 % (38 out of 75). Passing minimum in the aggregate (internal and external marks put together) is 50% (50 out of 100). No passing minimum for the internal marks.

Examination, evaluation and classification will be made as per the rules and regulations of the University in force.

Semester	Course Code	Paper Title	Hours Per Week	Exam Hours	Credits	Marks		
						Internal	External	Total
I	1	Group theory	4	3	4	25	75	100
	2	Real Analysis I	4	3	4	25	75	100
	3	ORDINARY Differential Equations *	4	3	4	25	75	100
	4	Number Theory	4	3	4	25	75	100
	5	Elective I	3	3	3	25	75	100
	6	Practical	2	3	2	25	75	100
II	1	Rings and Modules	4	3	4	25	75	100
	2	Real Analysis II	4	3	4	25	75	100
	3	Graph Theory	4	3	4	25	75	100
	4	Mathematical statistics	4	3	4	25	75	100
	5	Elective II	3	3	3	25	75	100
	6	Supportive Course I	3	3	3	25	75	100
III	1	Topology	4	3	4	25	75	100
	2	Complex Analysis	4	3	4	25	75	100
	3	Linear Algebra	4	3	4	25	75	100
	4	Measure and integration	4	3	4	25	75	100
	5	Elective III	3	3	3	25	75	100
	6	Supportive Course II	3	3	3	25	75	100
IV	1	Functional Analysis*	4	3	4	25	75	100
	2	Differential Geometry	4	3	4	25	75	100
	3	Field theory	4	3	4	25	75	100
	4	COMBINATORIAL THEORY	4	3	4	25	75	100
	5	Elective IV	3	3	3	25	75	100
	6	Project	4	-	6	25	75	100
		Total			90			2400

INTERNAL - Continuous Internal Assessment External – End Semester Examination

* - COURSES WITH CONTENTS FROM E-PG PATHSHALA

.LIST OF ELECTIVE PAPERS

1. Programming in C++
2. Partial Differential Equations
3. Design and Analysis of Algorithms
4. Calculus of variations and Integral Equations
5. Mechanics
6. .Representation theory of finite groups
7. Coding Theory
6. Graph Algorithms
8. MATLAB Programming
9. Cryptography
10. Numerical Analysis
11. Fuzzy Theory and Their Applications
12. Operation Research

SUPPORTIVE COURSES FOR OTHER DEPARTMENT STUDENTS

(NPTEL – MOOC COURSES)

1. Mathematical Finance (For odd semester 2019-20 batch)

First Semester

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1. Group Theory (60 hours)

Preamble: *This paper aims to provide basic and fundamental training in Algebra, one of the primary subjects for the discipline of Mathematics. This course deals basic concepts of groups starting from the special groups viz., Dihedral groups and symmetric groups. It mainly deals the fundamental concepts of groups through the generalized tool of group actions and finally ends with structure of finite abelian groups. Through this course, every student shall get a good exposure in examples and counter examples of various concepts in group theory up to the direct product of groups.*

Unit I: Introduction to groups - Dihedral groups - Symmetric groups - Matrix groups - The Quaternion group - Homomorphisms and Isomorphisms - Group actions. **(12 hours)**

Unit II: Subgroups: Definition and Examples - Centralizers and Normalizer, Stabilizers and Kernels - Cyclic groups and Cyclic subgroups of a group - Subgroups generated by subsets of a group - Quotient Groups and Homomorphisms: Definitions and Examples - more on cosets and Lagrange's Theorem. **(12 hours)**

Unit III: The isomorphism theorems - Transpositions and the Alternating group - Group Actions: Group actions and permutation representations - Groups acting on themselves by left multiplication - Cayley's theorem. Groups acting on themselves by conjugation - The class equation **(12 hours)**

Unit IV: Automorphisms - The Sylow theorems - The simplicity of A_n **(12 hours)**

Unit V: Direct and semi-direct products and abelian groups: Direct Products - The fundamental theorem of finitely generated abelian groups - Table of groups of small order - semi direct products. **(12 hours)**

Text Book: David S. Dummit and Richard M. Foote, *Abstract Algebra (Second Edition)*, Wiley Student Edition (1999),

Unit 1: Chapter 1: (Sections 1.2, 1.3. 1.4, 1.5, 1.6, and 1.7)
Unit 2: Chapter 2: (Sections 2.1, 2.2, 2.3, 2.4) and Chapter 3: (Sections 3.1, 3.2)
Unit 3: Chapter 3: (Sections 3.3, 3.4) and Chapter 4: (Sections 4.1, 4.2, 4.3)
Unit 4: Chapter 4: (Sections 4.4, 4.5, 4.6)
Unit 5: Chapter 5: (Sections 5.1, 5.2, 5.3, 5.4, 5.5)

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2. Real Analysis – I (60 hours)

Preamble: *Analysis, Algebra and Geometry are the fundamentals on which most of Mathematical structures are built upon. Any post graduate in Mathematics is expected to have accomplished a basic knowledge of all these. In this direction, this course is a building block in Analysis for a budding mathematician. It deals with the topology of the real line, convergence of real sequences and continuity of real valued or vector valued functions of the real variable. It also teaches analysis of differentiation in all rigor. A student undergoing this course seriously will not only be able to pursue a research career in mathematics but will also find it simple to clear competitive examinations for teaching positions.*

Unit I: Basic Topology: Finite, Countable and uncountable sets - Metric Spaces - Compact Sets - Perfect sets - Connected Sets. **(12 hours)**

Unit II: Numerical sequences and series: Convergent sequences - Subsequences - Cauchy sequences - Upper and lower limits - Some special sequences - Series - Series of nonnegative terms. **(12 hours)**

Unit III: The number e - The root and ratio tests - Power series - Summation by parts - Absolute convergence - Addition and multiplication of series - Rearrangements. **(12 hours)**

Unit IV: Continuity: Limits of functions - Continuous functions - Continuity and compactness - Continuity and connectedness - Discontinuities - Monotonic functions - Infinite limits and limits at infinity. **(12 hours)**

Unit V: Differentiation: The Derivative of a real function - Mean value theorems - The continuity of derivatives - L'Hospital's rule - Derivatives of Higher order - Taylor's theorem - Differentiation of vector valued functions. **(12 hours)**

Text Book: Walter Rudin, *Principles of Mathematical Analysis (Third edition)*, McGraw Hill, 1976. Chapters 2, 3, 4 and 5.

3. Ordinary Differential Equations (60 hours)

Preamble: *Ordinary Differential Equations serve as Mathematical models for many real world problems. It has wider applications in Science and Technology, Economics, Defence, Biology etc. The present course is an attempt to make the students to understand the fundamental essences of the Theory of Ordinary Differential Equations and to motivate them to construct Mathematical modeling for real world problems.*

Unit I: Linear equations with constant co-efficients - Introduction - Second Order non-homogeneous Equations - Initial value problems - linear dependence and independence - formula for Wronskian. **(12 hours)**

Unit II: Nonhomogeneous equations of order two - Homogeneous and Non-homogeneous equations of order n - Initial value problems - annihilator method to solve anon-homogeneous equation. **(12 hours)**

Unit III: Linear equations with variable co-efficients - Initial value problems for the homogeneous equation - solution of the homogeneous equations - Wronskian and linear independence - reduction of the order of a homogeneous equation of first order. **(12 hours)**

Unit IV: Linear equations with regular singular points - Euler equation - Second order equations with regular singular points - solutions and properties of Legendre and Bessel's equation. **(12 hours)**

Unit V: Existence and uniqueness of solutions of first order equations - introduction - Equations with variables separated - Exact equations - method of successive approximations - Lipschitz condition - convergence of successive approximations. **(12 hours)**

Text Books

1. e-PG Pathshala Link: https://epgp.inflibnet.ac.in/view_f.php?category=1500

2. E.A.Codington, *An introduction to Ordinary Differential Equations,* Prentice Hall of India,

New Delhi, 2007.

Chapter 2 (Sections 1-8, 10 &11), Chapter 3 (Sections 1-5 & 8) Chapter 4 (Sections1-5) Chapter 5 (Sections 1-6)

4. Number Theory (60 hours)

Preamble: *This course was studied for its long and rich history, its wealth of easily accessible and fascinating questions, and its intellectual appeal. But, in recent years it has been studied for the reason that it has become essential for Cryptology. Upon successful completion of this course, the student will be able to construct mathematical proofs of statements and understand the logic and methods behind the major proofs in it and work effectively as part of a group to solve challenging problems in it.*

Unit I: Divisibility and Congruence: Divisibility, Primes, Congruence. **(12 hours)**

Unit II: Solutions of congruence - the Chinese Remainder theorem - Prime power moduli. **(12 hours)**

Unit III: Prime modulus - Primitive roots and Power Residues - congruence of degree two - Power Residues, prime modulus . **(12 hours)**

Unit IV: Quadratic residues - Quadratic reciprocity -The Jacobi symbol. **(12 hours)**

Unit V: Some functions of number theory: Greatest integer function - Arithmetic functions - The Moebius inversion formula- Recurrence functions. **(12 hours)**

Text Book : Content and treatment as in

Ivan Niven and H. S. Zuckerman, *An Introduction to the Theory of Numbers*, Fifth Edition, Wiley Eastern Limited, New Delhi,1994.

Chapter 1(Sections 1.1 to 1.3), Chapter 2 (Sections 2.1 to 2.3, 2.6 to 2.9), Chapter 3 (Sections 3.1 to 3.2) and Chapter 4 (Sections 4.1 to 4.4)

Elective – I

5. Practical

SECOND SEMESTER

1. Rings and modules (60 hours)

***Preamble**: This paper aims to provide good exposure on advanced concepts on rings and modules as part of Abstract Algebra. This course starts with basic concepts of rings and discuss about special rings viz., matrix rings, ring of quaternions etc. It shall discuss and analyze the properties and interlinks between the concepts of Euclidean ring, Principal Ideal Domain, Unique Factorization Domain and Integral Domain. Also it provides a basic on modules, a generalization of vector spaces.*

Unit I: Introduction to Rings - Examples - Polynomial rings - Matrix rings and group rings - Ring Homomorphisms and quotient rings - Properties of Ideals - Rings of fractions.

(12 hours)

Unit II: The Chinese remainder theorem - Euclidean domains, principal ideal domains and unique factorization domains: Euclidean domain - Principal ideal domains. **(12 hours)**

Unit III: Unique factorization domains - Polynomial rings: Definitions and basic properties - Polynomial rings over fields. **(12 hours)**

Unit IV: Polynomial rings that are unique factorization domains - Irreducibility criteria - Polynomial ring over fields. **(12 hours)**

Unit V: Introduction to Module Theory: Basics definitions and examples - Quotient modules and Module homomorphism - Generation of modules, Direct sums, and free modules. **(12 hours)**

Text Book: David S. Dummit and Richard M. Foote, *Abstract Algebra (Second Edition),* Wiley Student Edition (1999),

Chapter 7: (Sections 7.2, 7.3. 7.4, 7.5 and 1.6) for Unit 1
Chapter 7: (Sections 7.6) and Chapter 8: (Sections 8.1, 8.2) for Unit 2
Chapter 8: (Section 8.3) and Chapter 9: (Sections 9.1, 9.2) for Unit 3
Chapter 9: (Sections 9.3.5, 9.4, 9.5) for Unit 4
Chapter 10: (Sections 10.1, 10.2, 10.3) for Unit 5

2. Real Analysis – II (60 hours)

Preamble: *This is a continuation course for Analysis I. It covers the analysis of integration, uniform convergence of sequence and series of functions. Uniform convergence plays a key role in finding approximate solutions to theoretical and practical problems. Several variable calculus, particularly integration of differential forms, is rigorously done here. With the two courses in analysis, the student can come out with a sound background in analysis.*

Unit I: The Riemann-Stielitjes integral: Definition and existence of the integral - Properties of the integral - Integration and Differentiation - Integration of vector - Valued functions - Rectifiable Curves. **(12 hours)**

Unit II: Sequences and Series of functions: Discussion of Main problem - Uniform convergence - Uniform convergence and continuity-Uniform convergence and Integration. **(12 hours)**

Unit III: Uniform convergence and differentiation - Equicontinuous families of functions - The Stone - Weierstrass theorem. **(12 hours)**

Unit IV: Functions of Several Variables: Linear transformations - Differentiation - The Contraction Principle - The Inverse function theorem - The Implicit function theorem. **(12 hours)**

Unit V: Determinants - Derivatives of higher order - Differentiation of Integrals - Integration of Differential forms: Integration - Primitive Mappings - Partitions of unity - Change of Variables.

(12 hours)

Text Book: Walter Rudin, *Principles of Mathematical Analysis (Third Edition)*, Mc Graw Hill, 1976, Chapters 6, 7, 9 (except 9.1-9.5, 9.30, 9.31 and 9.32) and Chapter 10 (10.1 to 10.9 only).

3. Graph Theory (60 hours)

Preamble: *The objective of this course is two-fold: to formally study the basic definitions and concepts in Graph Theory and to use them to solve problems that can be modelled as graphs. The Syllabus is designed in such a way that the students are exposed to all the fundamental concepts in Graph theory with simple new proofs of many results. Knowledge of an under-graduate course in Graph theory is preferable. As Graph theory is applied in several other fields like Physics, Chemistry, Biology, Sociology, Electrical Engineering etc., this course facilitates the students to pursue interdisciplinary research.*

Unit – I : Bridges – Trees, cut vertices - blocks - - Geodetic sets. **(12 hours)**

Unit – II : Eulerian graphs - Hamiltonian graphs. Digraphs : strong digraphs - Tournaments. **(12 hours)**

Unit – III : Matchings - Factorization. **(12 hours)**

Unit – IV: Planar graphs - Embedding graphs on surfaces. Coloring -The four coloring problem - vertex coloring – Edge coloring - The Heawood Map Coloring theorem. **(12 hours)**

Unit V : Ramsey numbers: The Ramsey number of graphs - Turan's theorem . The centre of a graph - distant vertices. **(12 hours)**

Text Book: Gary Chartrand and Ping Zhang, *Introduction to graph theory,* Tata McGraw-Hill Publishing Company limited, New Delhi, Edition 2006

Chapter 4 (4.1, 4.2) and Chapter 5 (5.1-5.3, 5.5) for Unit I
Chapter 6 (6.1, 6.2) and Chapter 7 (7.1, 7.2) for Unit II
Chapter 8 (8.1, 8.2) for Unit III
Chapter 9 (9.1, 9.2) and Chapter 10 (10.1 – 10.4) for Unit IV
Chapter 11 (11.1, 11.2) and Chapter 12 (12.1, 12.2) for Unit V

4. Mathematical Statistics (60 hours)

Preamble: *This course is intended to study probability mass/density functions, mathematical expectations, moment generating functions, marginal and conditional distributions, some special distributions, limiting distribution and the Central Limit Theorem. The basic knowledge on statistics at UG level and Integral Calculus at PG level are required for studying this course. After completing this course, the student will be able qualified to join as statistical officer in department of survey and apply the concepts in data analysis.*

Unit I: The probability set function - Random variables - Probability density function - Distribution function - Mathematical expectation - Special mathematical expectations - Chebyshev's Inequality. **(12 hours)**

Unit II: Conditional probability - Marginal and conditional distributions - Stochastic independence Some special distributions: The Binomial, Trinomial and Multinomial distributions - The Poisson distribution. **(12 hours)**

Unit III: The Gamma and Chi-Square Distributions - The Normal distribution - The Bivariate normal distribution. Distributions of functions of random variables - Sampling theory - Transformations of variables of the discrete type - Transformations of variables of the continuous type. **(12 hours)**

Unit IV: The β, t and F distributions - Distributions of order statistics - The moment generating function technique. The distributions of $\bar{X}$ and nS^2/σ^2 - Expectations of functions of random variables. **(12 hours)**

Unit V: Limiting distributions, Stochastic convergence - Limiting moment generating functions - The Central limit theorem - Some theorems on limiting distributions. **(12 hours)**

Text Book: Robert V. Hogg and Allen T. Craig., *Introduction to Mathematical Statistics (Fourth Edition)* by Chapters 1, 2 (except 1.1, 1.2, 1.3, 1.8 and 2.3), Chapters 3, 4 (except 4.5) and Chapter 5.

5. Elective – II

6. Supportive course

THIRD SEMESTER

1. Topology (60 hours)

Preamble: *Topology has emerged as a major branch of Mathematics in the middle of 20th century as a result of the developments in Geometry and Set theory. The objective of this Course is to introduce the basic ideas of topology. The Syllabus is designed in such a way that many topics that are appropriate for a first course are included. Though there are no formal subject matter prerequisites, a bit of analysis, rigorous calculus and set theory are preferable. This Course lays the foundation for future study in analysis, geometry and algebraic topology.*

Unit I: Topological spaces - Basis for a topology - The order topology - The product topology on X x Y - The subspace topology - Closed sets and limit points - Continuous functions. **(12 hours)**

Unit II: The product topology - connected spaces, components and local connectedness. **(12 hours)**

Unit III: Compact spaces - Local compactness. **(12 hours)**

Unit IV: The Countability axioms - The Separation axioms - Normal spaces. **(12 hours)**

Unit V: The Urysohn lemma - The Tietze Extension theorem - Tychonoff theorem. **(12 hours)**

Text Book: J. R. Munkres , *Topology (second edition)*, Pearson Prentice hall, (2000), Sections 12 to 19, 23, 25, 26, 29 to 33, 35 and 37.

2. Complex Analysis (60 hours)

Preamble: *Complex numbers arose in the need of solving polynomial equations with real coefficients. Complex Analysis is the study about the complex valued functions of complex variables. This interesting theory has a wide applications in Integral, Differential equations, Functional Analysis, Fluid Dynamics. The objective of this course is to give fair introduction to the analyticity and the series representation of the given complex function. The students familiar with real analysis and basic Calculus may adopt this course.*

Unit I: Analytic Functions - Power Series. **(12 hours)**

Unit II: Conformality - Linear Transformation - Elementary Conformal mapping. **(12 hours)**

Unit III: Fundamental Theorems - Cauchy's Integral formula - Local properties of Analytic Functions. **(12 hours)**

Unit IV: General form of Cauchy's theorem (except proof of Cauchy's theorem) -Calculus of Residues. **(12 hours)**

Unit V: Power Series Expansions - Partial fractions and factorizations. **(12 hours)**

Text Book: Lars V. Ahlfors, *Complex Analysis (Third edition)*, McGraw Hill, 1979, Chapters 2 to 4 (except section 4.5) and Chapter 5 (Sections 5.1, 5.2.1).

3. Linear Algebra (60 hours)

Preamble: *Linear algebra is a branch of mathematics that studies systems of linear equations and the properties of matrices. The concepts of linear algebra are extremely useful in physics, economics and social sciences, natural sciences, and engineering. To understand the axiomatic structure of a modern mathematical subject and learn to construct simple proofs. To solve problems that apply Linear Algebra to Chemistry, Economics and Engineering.*

Unit I : Systems of linear Equations - Matrices and Elementary Row operations - Row - Reduced echelon Matrices - Matrix Multiplication - Invertible Matrices - Vector spaces - Subspaces - Bases and Dimension - Computations concerning Subspaces. **(12 hours)**

Unit II : The algebra of linear transformations - Isomorphism of Vector Spaces - Representations of Linear Transformations by Matrices - Linear Functionals - The Double Dual - The Transpose of a Linear Transformation. **(12 hours)**

Unit III : Commutative rings - Determinant functions - Permutations and the uniqueness of determinants - Classical Adjoint of a (Square) matrix - Inverse of an invertible matrix using determinants. **(12 hours)**

Unit IV: Characteristic values - Annihilating polynomials, Invariant subspaces. **(12 hours)**

Unit V: Simultaneous triangulation and simultaneous Diagonalization - Direct-sum Decompositions - Invariant Direct sums - The Primary Decomposition Theorem. **(12 hours)**

TEXT BOOK : Kenneth Hoffman and Ray Kunze, **Linear Algebra**, 2nd Edition, Prentice – Hall of India Private Limited, New Delhi :1975. Chapters 1 to 3, Chapter 5 (5.1 to 5.4) and Chapter 6.

4. Measure and Integration (60 hours)

Preamble : *This course is a basic necessity in many areas of pure and applied mathematics and takes the student to all the basics of measure and integration. The pre-requisite is the Real and Complex analysis courses which a post-graduate student of mathematics undergoes in earlier semesters. The course facilitates the students to undertake further studies in mathematics and also helps to face competitive examinations.*

Unit I : Lebesgue Measure: Introduction-Outer measure-Measurable sets and Lebesgue measure- The non-measurable set - Measurable functions - Littlewood's three principles. **(12 hours)**

Unit II: The Lebesgue Integral: The Riemann integral - The Lebesgue integral of a bounded function over a set of finite measure - The integral of a nonnegative function - The general Lebesgue integral. **(12 hours)**

Unit III: Differentiation and Integration: Differentiation of monotone functions-Functions of bounded variation - Differentiation of an integral - Absolute continuity. **(12 hours)**

Unit IV: Measure and Integration - Measure spaces - Measurable functions - Integration-Signed measures - The Radon-Nikodym theorem. **(12 hours)**

Unit V: Measure and Outer Measure: Outer measure and measurability-The Extension Theorem - Product measures. **(12 hours)**

Text Book: H.L. Royden, *Real Analysis*, Third Edition, Macmillan, New York, 1988

Chapters 3,4 (except 4.5),5 (except 5.5),11(except 11.4 and 11.7) and 12 (Sections 12.1, 12.2 and 12.4 only).

5. Elective – III

6. Supportive course – II

Fourth Semester

1. Functional Analysis (60 hours)

Preamble: *Functional Analysis is an important tool in Mathematics connecting both abstract and applied sciences. This introductory course provides essential concepts on vector space structure and the metric space structure for the development of the main objective so called bounded linear operators. Sufficient knowledge on Linear Algebra and basic Calculus are prerequisite. This course motivates the students to see fruitful applications of abstract Mathematics and provides fundamental tool for further research in Analysis.*

Unit I : Normed Spaces, Banach Spaces - Further properties of normed spaces - finite dimensional normed spaces and Compactness - Linear operators - bounded linear operators **(12 hours)**

Unit II : Linear functionals – linear operators and functionals on finite dimensional spaces - normed spaces of operators and dual spaces - Inner product space, Hilbert space - Further properties of inner product spaces. **(12 hours)**

Unit III : Orthogonal complements and direct sums - Orthonormal sets and sequences - series related to orthonormal sets and sequences - Total orthonormal sets and sequences - Representation of functionals on Hilbert spaces - Hilbert Adjoint operator - self adjoint operators, unitary and normal operators. **(12 hours)**

Unit IV : Hahn-Banach theorem for complex vector spaces and normed spaces - Adjoint operator - Self adjoint, Unitary and Normal operators - reflexive spaces - Uniform boundedness theorem. **(12 hours)**

Unit V : Strong and weak convergence - Convergence of sequences of operators and functional - Open mapping theorem - Closed graph theorem. **(12 hours)**

Text Books:

1. e-PG Pathshala: https://epgp.inflibnet.ac.in/view_f.php?category=1477

2. Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons Publication (2006). Chapter 2, Chapter 3 (except 3.7) and Chapter 4 (except 4.4, 4.10 and 4.11).

2. Differential Geometry (60 hours)

Preamble : *This is a subject which interrelates Differential analysis with Geometrical ideas. The pre-requisite for this course is the basic concepts of differential calculus and real analysis which is covered in an undergraduate programme in mathematics. This helps in advanced learning in mathematics, particularly for students who intend to pursue research.*

Unit I: Graphs and Level sets - Vector fields-Tangent space. **(12 hours)**

Unit II: Surfaces - Vector field on surfaces. **(12 hours)**

Unit III: Gauss map - Geodesics. **(12 hours)**

Unit IV: Parallel Transport - Weingarten map. **(12 hours)**

Unit V: Curvature of plane curves-Curvature of surface - Arc length and Line Integrals. **(12 hours)**

Text Book: A. Thorpe, *Elementary topics in Differential Geometry, First Indian Reprint* (2004), SpringerChapters 1 to 12.

3. Field Theory (60 hours)

Preamble: *This paper aims to an in depth knowledge about the algebraic structure of fields, which is vital in providing algebraic tools to find roots of equations.This course starts with basic concepts of fields, existence and properties of extension fields of polynomials. Also it aims to provide the use of Gaolis theory in discussing the existence of roots of polynomials. Further it also gives a fundamental knowledge about lattice theory and its applications to Boolean algebra.*

Unit I: Field theory: Basic Theory of field extensions - Algebraic Extensions. **(12 hours)**

Unit II: Splitting fields and Algebraic closures - Separable and inseparable extensions. **(12 hours)**

Unit III: Cyclotomic polynomials and extensions - Galois Theory: Basic definitions - The fundamental theorem of Galois Theory. **(12 hours)**

Unit IV: Finite Fields - Composite extensions and simple extensions. **(12 hours)**

Unit V: Cyclotomic extensions and abelian extensions over Q - Solvable and Radical Extensions - Insolvability of Quintic. **(12 hours)**

Text Book:

1. David S. Dummit and Richard M. Foote, *Abstract Algebra (Second Edition),* Wiley Student Edition (1999).

Chapter 13: (Sections 13.1, 13.2) for Unit I
Chapter 13: (Sections 13.4,13.5, 13.6) for Unit II
Chapter 14: (Sections 14.1,14.2, 14.3) for Unit III
Chapter 14: (Sections 14.4, 14.5) for Unit IV
Chapter 9: (Sections 9.1- 9.6) for Unit V

4. Combinatorial Theory (60 hours)

Preamble: *This objective of this course is to develop skills to apply the techniques of combinations and permutations for counting the number of certain configurations. The prerequisite are the basic ideas on classical algebra and trigonometry. After completing this course, the student will be able to solve problems involving the distributions of objects into cells, partitions of integers, generating functions, permutations with restrictions on relative positions, rook polynomials and Polya's theory.*

Unit I: Permutations and Combinations - rule of sum and product - distributions of distinct objects - Distributions of non-distinct objects. **(12 hours)**

Unit II: Generating functions for combinations - Enumerators for permutations - Distributions of distinct objects into non-distinct cells - partitions of integers - Ferrers graph - elementary relations. **(12 hours)**

Unit III: Recurrence relations - Linear recurrence relations with constant co-efficients - solution by the technique of generating functions - a special class of non-linear difference equation - recurrence relations with two indices. **(12 hours)**

Unit IV: The principle of inclusion and exclusion - general formula - derangements - rook polynomials - permutations with forbidden positions. **(12 hours)**

Unit V: Polya's theory of counting Equivalence classes under a permutation groups - Equivalence classes of functions - Weights and inventories of functions - Polya's fundamental theorem - Generalization of Polya's theorem. **(12 hours)** .

Text Book: Introduction to Combinatorial Mathematics by C.L. Liu, McGraw Hill(1968) Chapters 1 to 5.

5. Elective – IV

6. Project

Syllabus for Elective Papers

1. Programming in C++ (45 Hours)

Preamble: *To learn the basics of the programming language C++ such as tokens, expressions, classes and objects, constructors and destructors, inheritance, polymorphism and files. This course does not require any prerequisite except the basic ideas on the programming language C. After completing this course, the student will be able to identify/analyze/study the basic concept of control structures and functions in C++, classes and objects, constructors and destructors, pointers, virtual functions, polymorphism and practical course.*

Unit I: Tokens, Expressions and Control structures-Functions in C++. **(9 hours)**

Unit II: Classes and Objects. **(9 hours)**

Unit III: Constructors and Destructors- Operator overloading and type conversions. **(9 hours)**

Unit IV: Inheritance: Extending classes-Pointers, \virtual Functions and Polymorphism. **(9 hours)**

Unit V: Working with files. **(9 hours)**

Text Book: E. Balagurusamy, *Objected Oriented Programming with C++,* (Third Edition), (2007), Tata Mc Graw Hill, Chapters 3 to 9 and 11.

Practical (30 Hours)

List of programs for Practical (Programming in C++)

1. Programs to evaluate sin x, cos x, e^{-x} to 0.0001% accuracy.
2. Program to calculate the variance and standard deviation of a set of numbers.
3. Program to find product of matrices, inverse of a matrix using functions.
4. Macro that obtains largest of three numbers.
5. Define a class of students and prepare a statement containing name, total marks of Ranks (using functions).
6. Program to check whether a number/ string is a palindrome without using the corresponding standard function.
7. Define a class string and exhibit the use of string manipulations.
8. Create a class FLOAT that contains one float data. Overload all the four arithmetic

operators so that they operate on the objects of FLOAT.

9. Define a class String. Use overload = = operator to compare two strings.

10. Program to illustrate interpolation of constructors when the classes are inherited.

11. Program to illustrate multilevel and multiple inheritance.

12. Program using array of functions.

13. Program using function pointers.

14. Create a data file showing how to add a new item to the file, how to modify the details of an item and how to display the contents of the file.

15. Program that reads a text file and creates another file that is identical except that every sequence of consecutive blank spaces is replaced by a single space.

2. Partial Differential Equations (45 Hours)

Preamble: *This course in one of the important branches of Mathematics which provides techniques to solve operator equations in Fluid Mechanics. Partial Differential Equations arise when the dependent variable depends on more than one independent variables. The purpose of this course is to find the relation between the variables from the relation between the variables and its partial derivatives. Students are expected to have good knowledge of basic Calculus and the Theory of Ordinary Differential Equations.*

Unit I: Partial differential equations of first order. **(9 hours)**

Unit II: Fundamental concepts - Second order partial differential equations. **(9 hours)**

Unit III: Elliptic differential equations. **(9 hours)**

Unit IV: Parabolic differential equations. **(9 hours)**

Unit V: Hyperbolic differential equations. **(9 hours)**

Text Book: Sankara Rao K, *Introduction to Partial Differential Equations*, PHI Learning Private Limited, Third edition, 2017

Chapter 0 for Unit I, Chapter 1 for Unit II, Chapter 2 (2.1 – 2.9) for Unit III, Chapter 3 (3.1-3.8) for Unit IV, Chapter 4 (4.1 – 4.9) for Unit V

3. MATLAB Programming (45 Hours)

Unit I: MATLAB ENVIRONMENT: MATLAB windows - Variables - Working with Matrices - Saving Variables - Script M-files. PREDEFINED MATLAB FUNCTIONS: Elementary Math functions - Trigonometric functions - Data analysis functions - Defining matrices - Using the colon operator - Special values and functions. **(9 hours)**

Unit II: PLOTTING: Two dimensional plots - Basic plotting - Line, color, and mark style- Axes scaling - Other types of two dimensional plot - Three dimensional plotting - Three dimensional line plot - Surface plots. **(9 hours)**

Unit III: PROGRAMMING IN MATLAB: Problems with two variables - Input/output - User defined Input - Output options - Functions - Statement level control structures - Relational and logical operators - Loops. **(9 hours)**

Unit IV: MATRIX COMPUTATIONS: Matrix operations and functions -Solutions to system of linear equations - Special Matrices. SYMBOLIC MATHEMATICS: Symbolic Algebra - Equation Solving - Differentiation and Integration. **(9 hours)**

Unit V: NUMERICAL TECHNIQUES: Interpolation - Numerical Integration - Numerical Differentiation. **(9 hours)**

Text Books: Delores M. Etter, David C. Kuncicky and Holly Moore, *Introduction to MATLAB,* Dorling Kindersley (India) Pvt. Ltd. New Delhi (2009).

Sec. 1.1 - 1.5, Sec. 2.1 to 2.7, Sec. 3.1 - 3.9, Sec. 4.1 - 4.9Sec. 5.1 - 5.3, Sec. 6.1 - 6.3,Sec. 7.1 - 7.3.

4. Design and Analysis of Algorithms (45 Hours)

Preamble: *This elective course covers good principles of algorithm design, elementary analysis of algorithms, and fundamental data structures. The emphasis is on choosing appropriate data structures and designing correct and efficient algorithms to operate on these data structures. Through this course in data structures and algorithm design, students will learn good principles of algorithm design; learn how to analyse algorithms and estimate their worst-case and average-case behaviour (in easy cases); become familiar with fundamental data structures and with the manner in which these data structures can best be implemented; become accustomed to the description of algorithms in both functional and procedural styles; learn how to apply their theoretical knowledge in practice.*

Unit I: Growth of functions-Recurrences **(9 hours)**

Unit II: Heap sort- Quick sort. **(9 hours)**

Unit III: Elementary data structures-Binary search trees-Red black trees. **(9 hours)**

Unit IV: Elementary graph algorithms-Minimum spanning trees. **(9 hours)**

Unit V: Single source shortest paths - All-pairs shortest paths. **(9 hours)**

Text Book: Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, *Introduction to Algorithms*, 2nd Edition, 2007, Chapters 3 , 4, 6 (6.1 to6.4) 7 (7.1, 7.2), 10 (except 10.3), 12 (12.1-12.3), 13, 22, 23, 24 (except 24.5) and 25.

5. Numerical Analysis (45 Hours)

Preamble: *The objective of this course is to develop Numerical computational skills and to study their applications. This course focuses on the topics Interpolation by polynomials, the solution of nonlinear equations, Numerical differentiation and Numerical Integration. On the successful completion of the course, students will be able to learn various tools in solving numerical problems and prepare competitive examinations like CSIR-NET, SLET, etc.*

Unit I: Number Systems and Errors: The Representation of Integers -The Representation of Fractions - Floating point arithmetic- Loss of Significance and Error Propagation - Computational Methods for error estimation-Some comments on convergence of sequences-Some mathematical preliminaries. **(9 hours)**

Unit II: Interpolation by polynomials: Polynomial forms- Existence and Uniqueness of the Interpolating polynomial-The divided difference table- The error of the interpolating polynomial-Interpolation in a function table based on equally spaced points. **(9 hours)**

Unit III: The solution of nonlinear equations: A survey of iterative methods - Fixed point iteration - Polynomial Equations: Real roots - Complex roots and Muller's Method. **(9 hours)**

Unit IV: Matrices and Systems of Linear equations: The solution of linear systems by elimination -The pivoting strategy - The triangular factorization. **(9 hours)**

Unit V: Differentiation and Integration: Numerical differentiation - Numerical Integration: Some basic rules - Composite rules. **(9 hours)**

Text Book: Samuel D. Conte and Carl de Boor, *Elementary Numerical Analysis - An algorithmic approach*, Third Edition, Tata McGraw Hill Publishers (1980), Sections 1.1 to 1.7, 2.1 to 2.3, 2.5, 2.6, 3.1, 3.3, 3.6, 3.7, 4.2 to 4.4, 7.1, 7.2 and 7.4.

5. Mechanics (45 Hours)

Preamble: *The objective of the course is to prepare the students to understand basic concepts of Lagrangian and Hamiltonian approaches to classical mechanics and to study different applications of these concepts in the mechanical and electromagnetic problem. On the successful completion of the course, students will be able to understand the basic concepts and principles of Lagrangian and Hamiltonian, analyze the mechanism of solving the problem, and remember the postulates governing static and dynamic system and to study difference application of these concepts.*

Unit I: Statics in space. **(9 hours)**

Unit II: Kinematics, Kinetic Energy and Angular Momentum. **(9 hours)**

Unit III: Methods of Dynamics in space. **(9 hours)**

Unit IV: Applications in Dynamics in space-Motion of a particle. **(9 hours)**

Unit V: Applications in Dynamics in space-Motion of a rigid body. **(9 hours)**

Text Book: John A.Synge and Byron A.Griffith, *Principles of Mechanics*, Newyork Mc Graw Hill, (1949) Chapters 10 to 14.

6. Representation Theory of finite groups (45 Hours)

Preamble: *The aim to start with arbitrary field was to give the feeling that the theory is dependent on the base field and it gets considerably complicated if we move away from characteristic zero algebraically closed fields. Use the theory, methods and techniques of the course to solve mathematical problems.*

Unit I: Foundations: Introduction - Group characters - Representation modules - Regular representation. Representation theory of rings with identity: Some fundamental lemmas.

(9 hours)

Unit II: The principle indecomposable representations - The radical of a ring - Semi-simple rings - The Wedderburn structure theorems for semi-simple rings - Interwining numbers.

(9 hours)

Unit III: Multiplicities of the indecomposable representation - The generalized Burnside theorem. The representation theory of finite groups: The group algebra - The regular representation of a group - Semi-simplicity of the group algebra- The centre of the group algebra. **(9 hours)**

Unit IV: The number of in-equivalent irreducible representations - relations on the irreducible characters - The module of characters over the integers - The Kronecker product of two presentations - Linear characters - Induced representations and induced characters. **(9 hours)**

Unit V: Applications of the theory of characters: Algebraic numbers - Some results from the theory of characters - Normal subgroups and the character table - Some classical groups. **(9 hours)**

Text book: Martin Burrow, *Representation Theory of Finite groups*, Academic Press, (1965) Chapters 1(except section 4), 2, 3, and 4.

7. Coding Theory (45 Hours)

Preamble: *This course is the study of methods for efficient and accurate transfer of information from one place to another. This course is designed for students of engineering, computer science and mathematics. Knowledge of linear algebra is a prerequisite for this course. After completion of the course, the student will be an expert in coding and decoding messages.*

Unit I: Mathematical Background: Algebra - Krawtchouk Polynomials - Combinatorial theory- Shannon's Theorem: Introduction - Shannon's Theorem. **(9 hours)**

Unit II: Linear codes: Block codes - Linear codes - Hamming codes - Majority logic decoding - Weight Enumerators - The Lee metric. **(9 hours)**

Unit III: Some good codes: Hadamard codes and generalizations - The binary Golay code - The ternary Golay code - Constructing codes from other codes - Reed-Muller code - Kerdock codes. **(9 hours)**

Unit IV:. Bound on codes: The Gilbert bound - Upper bounds - Cyclic codes: Definitions - Generator matrix and check polynomial - Zeros of a cyclic code. **(9 hours)**

Unit V: The idempotent of a cyclic code - Other Representations of cyclic codes - BCH codes - Decoding BCH codes - Binary cyclic codes of length 2n (n odd). **(9 hours)**

Text Book: J. H. Van Lint, *Introduction to Coding Theory*, Cambridge University Press (2006), Chapters 1 (except 1.4), 2 (Sections 2.1 and 2.2 only), 3, 4, 5 (except 5.3), and Chapter 6 (except 6.8, 6.9 and 6.11)

8. Graph Algorithms (45 Hours)

Preamble: *Graph Algorithms are use to solve real world problems. In this course we train the students to find shortest paths, minimum weight spanning trees, matching's, planarity and maximum flows in net- works. The knowledge of graph theory at PG level must required for learning this course. After completing this course, the student will be able to identify/analyze the basic concept of trees and branching, matchings and depth-first search, the concept of strong connectivity and planarity, flows in networks and its applications and the algorithmic approach to know connectivity.*

Unit I: An introduction to algorithms: Algorithmic complexity. Trees: Depth-First search - DFS: a tool for finding blocks - Breath - First search. **(9 hours)**

Unit II: Minimum spanning tree problem - Paths and Distance in graphs: Distance in graphs - Distance in weighted graphs. **(9 hours)**

Unit III: Matchings and factorizations : An introduction to matching - Maximum Matchings in bipartite graphs - Maximum matchings in general graphs. **(9 hours)**

Unit IV: Eulerian graphs : An introduction to Eulerian graphs - Characterizing Eulerian graphs again - The Chinese Postman problem - Eulerian Digraphs. **(9 hours)**

Unit V: Hamiltonian graphs: An introduction to Hamiltonian graphs - Characterizing Hamiltonian graphs - The Travelling salesman problem. **(9 hours)**

Text Book: Gary Chartrand and Ortrud R. Oellermann, *Applied and Algorithmic Graph Theory*, Mc Graw Hill (1993), Sections 2.1, 3.2 - 3.6, 4.1, 4.2, 6.1 - 6.3, 7.1 - 7.4, 8.1 to 8.3.

9. Cryptography (45 Hours)

Preamble: *Cryptography is a key terminology in electronic security system. It has many uses such as to digitally sign documents, for access control, to implement electronic money and for copyright protection. This course provides modern cryptographic algorithms and their mathematical foundations. Undergraduate knowledge of number theory is the prerequisite for this course.*

Unit I: Euclidean Algorithm, Extended Euclidian Algorithm and itsefficiency for huge numbers. Factoring in primes. Congruences and Residue Class Rings, Order of group elements, Multiplicative group of residues mod n (large). Euler-FermatTheorem, Fast Exponentiation.(Chapter 1 & 2). **(9 hours)**

Unit II: Encryption, Symmetric and Asymmetric Cryptosystems, Linear Block Ciphers and its Crypto analysis.Probability and Perfect Secrecy, One-Time-Pad.Prime Number Generation with probabilistic algorithm for huge primes: Fermat Test, Carmichael Numbers, Miller-Rabin-Test. (Chapters 3, 4 & 7). **(9 hours)**

Unit III: Public Key Encryption: Idea, Security, RSA-Cryptosystem, Diffie-Hellmann Key Exchange. (Chapter 8). **(9 hours)**

Unit IV: Cryptographic Hash functions, Compression functions: Birthday attack, Message Authentification Code (MAC) (Chapter 11) **(9 hours)**

Unit V: Digital Signatures: Idea, Security, RSA signatures. Elliptic curves over a finite field. (Chapters 12 & 13). **(9 hours)**

Text Book : Johannes A. Buchmann, *Introduction to Cryptography*, Second edition, Springer, 2001.

9. Calculus of Variations and Integral Equations (45 Hours)

Preamble: *This is a field of mathematical analysis that uses variations, which are small changes in functions and functionals, to find maxima and minima of functional. Functionals are often expressed as definite integrals involving functions and their derivatives. Functions that maximize or minimize functionals may be found using the Euler–Lagrange equation of the calculus of variations. Many important problems involve functions of several variables. Solutions of boundary value problems for the Laplace equation satisfy the Dirichlet principle. In this paper, it is aimed to nurture the students to the tools and methods to solve variation problems and with this they can attempt to solve real life problems.*

Unit I: Calculus of Variations and Applications: Maxima and Minima - The Simplest case- Illustrative examples - Natural boundary conditions and transition conditions - The variational notation-The more general case. **(9 hours)**

Unit II: Constraints and Lagrange multipliers-Variable end points - Sturm- Liouville problems-Hamilton's principle - Lagrange's equations. **(9 hours)**

Unit III: Integral Equations: Introduction - Relations between differential and integral equations - The Green's function - Alternative definition of the Green's function. **(9 hours)**

Unit IV: Linear equation in cause and effect: The influence function - Fredholm equations with separable kernels - Illustrative example. **(9 hours)**

Unit V: Hilbert - Schmidt theory - Iterative methods for solving equations of the second kind - Fredholm theory. **(9 hours)**

Text Book: Francis B. Hildebrand, *Methods of Applied Mathematics* (Second Edition), Dover Publications, (1952) Sections 2.1 to 2.11, 3.1 to 3.9 and 3.11.

11. OPERATION RESEARCH (45hours)

PRE REQUISITES:
The learner should have basic knowledge from linear programming, simplex and dual simplex method and graphical method**.**

OBJECTIVES:
1. Use integer programming problem to solve system of linear equations.
2. To provide the depth knowledge about inventory control theory and make students to solve the inventory problems.
3. To introduce the concept of non–linear programming problems.
4. Using optimization techniques to solve many practical problems.

OUTCOME:
The learner will befall skillful in decision making, markov process, integer programming, enumeration algorithm, dynamic programming, stage coach and cargo leading problem, EOQ, inventory, queuing theory and acquire essential concepts in non linear programming.

UNIT I: Linear programming – Network problems: preliminary ideas – Network linear programme- ensuring total supply equals total demand – transportation problem – assignment problem – shortest route problem – maximum flow problem cuts in a network.

UNIT II: INTEGER PROGRAMMING: Introduction – Integer Programming Formulations – Gomory's construction–Fractional cut method(all integer)–The Cutting – Plane Algorithm – Branch–and–Bound Technique – Zero–One Implicit Enumeration Algorithm.

UNIT III: DYNAMIC PROGRAMMING: Introduction – Application of Dynamic Programming: Capital Budgeting Problem – Reliability Improvement Problem – Stage–coach Problem – Cargo Leading Problem – Minimizing Total Tardiness in Single Machine Scheduling Problem – Optimal Subdividing Problem – Solution of Linear Programming Problem through Dynamic Programming.

UNIT IV: INVENTORY AND QUEUING THEORY

Inventory

Introduction–Inventory Decisions–Cost Associated– with Inventories –Factors Affecting inventory–Economic Order Quantity–Deterministic Inventory Problems with No Shortages–Deterministic inventory Models with shortages–EOQ with Price Breaks–Multi Item Deterministic problems–Inventory Problems with Uncertain Demand.

Q**ueuing Theory**

Introduction–Queuing System–Elements Of Queuing System–Operating Characteristics of Queuing System–Classification of Queuing Models–Model–I(M/M/1):(∞/FIFO),Model–II(M/M/1) : (N/FIFO), Model–III(M/M/C):(∞/FIFO), Model–IV(M/M/C):(N/FIFO).Problems in above four models.

UNIT V: NON LINEAR PROGRAMMING: Introduction – Lagrangean Method –Jacobi Method– Kuhn–Tucker Method – Quadratic Programming – Separable Programming – Chance–Constrained Programming or Stochastic Programming.

REFERENCE BOOKS:

1. Hamdy A. Taha, Operations Research,(sixth edition)Prentice–Hall of India private Limited ,New Delhi,1997.

12. FUZZY SETS AND THEIR APPLICATIONS(45 hours)

SUBJECT OBJECTIVE: Fuzzy is one of the latesttopic in Mathematics that has real life applications. Hence it is essential for the students to learn this topic. This topic introduces the concept of uncertainty and fuzziness in logic that will enable the student to develop their intuitive mind further. The two years M.Sc. program is to prepare every student to face the competitive world outside.It will help them toacquire sufficient knowledge and skill in the subject that will make them competent in various areas of mathematics.

OUTCOME OF THE SUBJECT:

 To develop analytical mind so that the students can sharpen their mind better.

 To provide with sufficient practical oriented application thus the students can face the competitive world.

 To enable the students to have a thorough exposure to the different branches of Mathematics so as to gain a comprehensive knowledge of Mathematics.

 To mold the students in research/teaching or to find better placement in corporate sectors.

UNIT I: Crisp sets and fuzzy sets: Overview of Classical Sets, Membership Function, Height of a fuzzy set – Normal and sub normal fuzzy sets – Support – Level sets, fuzzy points, –cuts – Decomposition Theorems, Extension Principle.

UNIT II : Operation on fuzzy sets: Standard fuzzy operations – Union, intersection and complement – properties De. Morgan's laws - alpha–Cuts of fuzzy operations.

UNIT III : Fuzzy relations: CartesianProduct, Crisp relations – cardinality – operations and properties of Crisp and Fuzzy relations.Image and inverse image of fuzzy sets - Various definitions of fuzzy operations – Generalizations – Non interacting fuzzy sets, Tolerance and equivalence relations.

UNIT IV : Decision making in Fuzzy environments: General Discussion – Individual Decision making – multi person decision.making – multi criteria decision making – multi stage decision making – fuzzy ranking methods – fuzzy linear programming.

Unit V : Applications: Medicine – Economics – Fuzzy Systems and Genetic Algorithms – Fuzzy Regression – Interpersonal Communication – Other Applications.

REFERENCE BOOKS:

1. George J.Klir and Bo Yuan , Fuzzy sets and Fuzzy Logic Theory and Applications, PHI Leaning Private Limited, New Delhi (2009).

2. A. K. Bhargava; Fuzzy Set Theory, Fuzzy Logic and their Applications, published by S. Chand Pvt. Limited (2013).

3. K.Pundir and R.Pundir, Fuzzy sets and their application, Published by A Pragati edition (2012)

4. H.J.Zimmermann, Fuzzy set theory and its applications, Springer (2012).

Syllabus for Supportive Course

(for other Department students)

A suitable NPTEL – MOOC Course offered during the period.

For 2019-20 students of Odd semester the online course offered is

Mathematical Finance