

**APPENDIX – AY**  
**MADURAI KAMARAJ UNIVERSITY**  
**(University with Potential for Excellence)**  
**M.Sc. Mathematics (Semester)**  
**REVISED SYLLABUS**  
**(With effect from the academic year 2018-19 onwards)**

**1. Introduction of the Programme**

The M.Sc., Mathematics programme is expected to be highly beneficial to the student community. The programme introduces new ideas slowly and carefully in such a manner so as to give the students a good instinctive feeling for the subject and develops an interest in the subject to pursue their studies further. It would also prove to be a great asset for those preparing for NET, SET and other competitive exams. One of the amazing features of the twentieth century mathematics has been its recognition of the power of the abstract approach. This has given rise to a large body of new results for problems and has in fact led us to emerging trends in mathematics.

**2. Eligibility for admission**

A candidate with a pass in B.Sc., Mathematics degree or any other degree accepted by Madurai Kamaraj University as equivalent to B.Sc., Mathematics is eligible to join the course.

**2.1 Duration of the Programme : 2 Years**

**2.2 Medium of Instructions : English**

**3. Objective of the Programme**

To Develop knowledge in basic Mathematics and Mathematical theories so that the students are able to develop skills which enable them to apply mathematical techniques for solving problems and help them to appreciate the depth of mathematical ideas that are useful in other areas. Students undergoing this course will make them serve as good teachers at the U:G level and will also prepare them for pursuing research in areas related to Mathematical Science.

**4. Outcome of the Programme**

The syllabi for M.Sc., Mathematics have been designed in such a way that the students, When they go out, will be capable of facing the competitive situation prevailing now and getting placement with developed Mathematical Knowledge.

**5. Core subject papers**

M.Sc., Mathematics programme consist of number of subjects. The following are the various categories of the courses suggested for the M.Sc., Mathematics Programme.

Core Subjects (CS) – 16,

Elective Subjects (ES) – 4,

Non-Major Subject Elective (NMSE) – 3. (For other major students)

**6. Subject Elective Papers**

The University shall provide all information related to the Elective subject in M.Sc., Mathematics to all the students so as to enable them to choose their Elective Subject in each semester. The list of elective papers in each semester is displayed under the Programme structure.

## 7. Non-Major Elective papers

The University shall provide all informations relating to the Non-Major Elective Subjects wise is related to competitive examinations in M.Sc., Mathematics, to all the students so as to enable them to choose their Elective Subjects in third semester. The list of elective papers of third semester is displayed under the Programme structure.

## 8. Unitization

Each subject contain five units which are interrelated each other. Not only core subjects, but elective and non-major elective also contain the same.

## 9. Pattern of semester exam

Internal	-	25Marks
External	-	75 Marks
Total	-	100 Marks

## 10. Scheme for Internal Assessment

For the M.Sc., Mathematics Degree, the internal assessment marks will be given as below

Tests	-	10 Marks(average of best two tests)
Assessment	-	5 Marks
Seminar/Group Discussion	-	5 Marks
Peer-Team-Teaching	-	25 Marks
<b>Total</b>	<b>-</b>	<b>100 Marks</b>

## 11. External Exam

- There Shall be external Examination at the end of each semester, odd semester in the month of October / November and even semester in April / May.
- A candidate, who has not passed the examination, may be permitted to appear in such failed subjects in the subsequent examination to be held in October / November or April / May. A candidate should get registered for the first semester examination. If registration is not possible, owing to shortage of attendance beyond condonation limit / regulation prescribed OR belated joining OR on medical grounds, The candidates are permitted to move to the next semester. Such candidates shall re-do the missed semester after the completion of the programme.
- Students must have earned 75% of attendance in each course for appearing for the examination. Students who have earned 74% to 70% of attendance have to apply for condonation in the prescribed form with the prescribed fee. Students who have earned 69% to 60% of attendance have to apply for condonation in the prescribed form with the prescribed fee along with the Medical Certificate.
- Students who have below 60% of attendance are not eligible to appear for the examination. They shall re-do the semester(s) after the completion of the programme.
- The result of all the examination will be published through the controller of examination where the students underwent the course as well as through University website. In the case of private candidates, the results will be published through the Controller of University examination in which they took the examination as well as University Website.

## 12. Question paper pattern

### Part – A

Ten Questions (NO Choice) 10 X 1 = 10 Marks  
Two Questions from each Unit (Objective type Questions)

### Part – B

Five Questions (either or type) 5 X 7 = 35 Marks  
One question from each unit

### Part – C

Three Questions out of five 3 X 10 = 30 Marks  
One question from each unit

## 13. Scheme of Evaluation

The performance of a student in each course is evaluated in terms of percentage of marks with a provision of conversion to grade points. Evaluation of each course shall be done by a continuous internal assessment by the concerned Course Teacher as well as by an end semester examination and both will be consolidated at the end of the course.

A mark statement with

$$CCPC = \frac{\sum(\text{Marks} \times \text{Credits})}{\sum(\text{Credits})}$$

Where the summation cover all the papers appeared up to the current semester.

## 14. Passing Minimum

A candidate passes the M.Sc., Mathematics by scoring a minimum of 50% (internal + external) in each paper of the course. No minimum marks for internal assessment . External minimum for external assessment is 45% and the external minimum is 34 out of 75.

### 14.1. Classification

S.No.	Range of CGPA	Class
1.	40 & above but below 50	III
2.	50 & above but below 60	II
3	60 & above	I

## 15. Model Questions

One model question paper is displayed at the end of the regulation.

## 16. Teaching Methodology

Each subject is designed with Lectures/tutorials/seminar/Peer-Team-Teaching/ PPT Presentation/assignment etc., to meet the effective teaching and the learning requirements.

## 17. Text Books

List of all the text books is quoted at the end of the syllabus of each subject.

## 18. Reference Books

The list of all the reference books is followed by the list of text books. This list contains at least two books for each subject.

## 19. Retotaling and Revaluation Provision

Candidate may apply for retotaling and revaluation within ten days from the date of the result published in the university website along with the required forms and fees.

## 20. Transitory provision

The candidate of previous scheme may be permitted to write exams in their own schemes up to the examinations of April 2020 as a transitory provisions.

## Subjects and Paper related websites

All the subject details along with syllabus may be downloaded from the university website [www.mkuniversity.org](http://www.mkuniversity.org)

### SCHEME OF EXAMINATIONS

S.No	Title of the Paper	Credits	Contact hours	Duration of Exams (in hours)	Marks		
					External	Internal	Total
I	Groups and Rings	5	6	3	75	25	100
	Theory of Riemann Integrations	5	6	3	75	25	100
	Ordinary Differential Equations	4	6	3	75	25	100
	Differential Geometry	4	6	3	75	25	100
	Elective I (From list I)	4	6	3	75	25	100
II	Linear Algebra	5	6	3	75	25	100
	Real Analysis	5	6	3	75	25	100
	Classical Mechanics	4	6	3	75	25	100
	Partial differential equations	4	6	3	75	25	100
	Elective II (From list II)	4	6	3	75	25	100
III	Topology	5	6	3	75	25	100
	Measure Theory	5	6	3	75	25	100
	Graph Theory	5	6	3	75	25	100
	Probability and Statistics	4	6	3	75	25	100
	Non-Major Elective III (from list III)	5	6	3	75	25	100
IV	Functional Analysis	5	6	3	75	25	100
	Number Theory and Cryptography	5	6	3	75	25	100
	Complex Analysis	5	6	3	75	25	100
	Operations Research	4	6	3	75	25	100
	Elective IV (From list IV)	4	6	3	75	25	100

### Elective Subject for M.Sc., Mathematics

Sem	S.No	Course Title	Credits
I List I	1	Automata Theory	4
	2	Discrete Mathematics	4
	3	Calculus of variations	4
II List II	4	Galois Theory	4
	5	Integral Transforms	4
	6	Numerical Methods	4
IV List IV	7	Fluid Dynamics	4
	8	Fuzzy sets and Logic	4
	9	Financial Mathematics	4

### Non-Major Elective Subjects for M.Sc., Mathematics

Sem	S.No.	Course Title	Credits
III List III	1	Statistical Methods	5
	2	Quantitative Aptitude	5
	3	Competitive Mathematics	5
Semester	Subject Code	Course Title	Credits
<b>Major Elective</b>			
I		Automata Theory	4
		Discrete Mathematics	4
		Calculus of variations	4
<b>Major Elective</b>			
II		Galois Theory	4
		Integral Transforms	4
		Numerical Methods	4
<b>Non Major Elective</b>			
III		Statistical Methods	5
		Quantitative Aptitude	5
		Competitive Mathematics	5
<b>Major Elective</b>			
IV		Fluid Dynamics	4
		Fuzzy sets and Logic	4
		Financial Mathematics	4

### FIRST YEAR / SEMESTER I CORE SUBJECT 1 GROUPS AND RINGS – (5 Credits) / 90Hrs

**Subject Objective:** To study the advance ideas in Group theory like fundamental theorem on finite Abelian groups and polynomial Rings in Ring theory.

**Outcome of the subject:** This subject helps the students to know about the algebraic structure, develops thinking and improve the mathematical ability.

**Unit I:** A Counting Principle – Normal subgroups and quotient groups – homomorphism – Automorphism – Cayley’s theorem – permutation groups – another counting principle – Sylow’s Theorem ( Sections 2.5-2.12 of Chapter-2)

**Unit II :** Direct Products – Finite Abelian Groups (Sections 2.13-2.14 of Chapter -2) – Solvable groups – Nilpotent groups (Text book No.2, Chapter 1, Sections 1.13 and 1.14)

**Unit III :** Ideals and Quotient Rings – More Ideals and Quotient Rings – The Field of Quotients of an Integral Domain (Sections 3.4-3.6 of Chapter-3)

**Unit IV :** Euclidean Rings – A particular Euclidean Ring (Sections 3.7-3.8 of Chapter-3)

**Unit V :** Polynomial Rings – Polynomials over the rational fields – Polynomial rings over commutative rings. (Sections 3.9-3.11 of Chapter-3)

**Text book:**

1. I.N. Herstein, Topics in Algebra – John Wiley and Sons, Second Edition (2013)
2. N.S. Gopala Krishna, University Algebra – New Age International (P) Limited, Second Edition

**Reference Books :**

1. Vijay K Khanna and S.K. Bhambri Vikas; A course in Abstract Algebra, Publishing House Pvt, Ltd., 3<sup>rd</sup> Edition, Reprint 2011.
2. Richard M. Foote and David S. Dummit; abstract Algebra, John Wiley Publication, 2011.

**CORE SUBJECT – 2****THEORY OF RIEMANN INTEGRATION – (5 Credits) / 90Hrs**

**Subject objective :** To make the students familiar with the concept of the construction of real number system, metric space and the analytical rudiments such as continuity, differentiability and Riemann integrations in the real life.

**Outcome of the subject:** Students will get a comprehensive idea about the underlying principles of real analysis and Riemann integrations.

**Unit I :Metric Spaces:** Basic properties of complete metric spaces-countable-uncountable sets – Compact Sets – Perfect Sets – Connected Sets-construction of cantor sets (Chapter-2, Text Book-1)

**Unit II :** Some special sequences, addition and multiplication of series, rearrangements. (Rest as in existing syllabus)-Limits of Functions – Continuous Function – Continuity and Compactness – Continuity and connectedness – discontinuities – Monotonic Functions – Infinite Limits and Limits at Infinity.(Chapters 3 and 4 of Text Book-1)

**Unit III:** The Derivatives of a real Function – Mean Value Theorem – The Continuity of Derivatives – L-Hospital's Rule – Derivatives of Higher Order – Taylor's Theorem – Derivatives of Vector – Valued Functions. (Chapter-5 of Text Book -1)

**Unit IV :** The Riemann – Stieltjes Integral – Definition and Existence of the Integral – Properties of the Integral – Integration and Differentiation – Integration of Vector – valued functions. (Chapter-6 of Text Book-1)

**Unit V:** Functions of bounded variation, Rectifiable curves:Introduction-Properties of monotonic functions-Functions of bounded variation-Total variation-Additive property of total variation-total variation on  $[a,x]$  as a function of  $x$ - Functions of bounded variation expressed as the difference of increasing functions-Continuous functions of bounded variation curves and paths-Rectifiable path and arc length- Additive and continuity properties of arc length-Equivalence of paths, Change of parameters. (Chapter-6 of Text Book-2)

**Text Book:**

1. Walter Rudin, Principles of Mathematical Analysis – McGraw Hill International Editions, Mathematics series, Third Edition (1964)**Units 1 to 4**
2. Apostol, Mathematical Analysis, Narosa Publishing House, Indian edition, 1974

**Reference Books:**

1. Patrick M. Fitzpatrick, Advanced Calculus, AMS, Pine and Applied Undergraduate Texts, Indian Edition, 2006
2. Robert G. Bartle, The elements of Real Analysis, John Willy & Sons.

**CORE SUBJECT – 3****ORDINARY DIFFERENTIAL EQUATIONS –(5 Credits) / 90Hrs**

**Subject objective:** To provide knowledge of ODE's, power series solution, special function, existence and uniqueness of solutions of ODE's.

**Outcome of the subject:** Distinguish between linear, non linear, partial and ordinary differential equations and state the basic existence theorem for 1<sup>st</sup> order ODE's and use the theorem to determine a solution interval.

**Unit I:** Second order homogeneous equations, Initial value problems, Linear dependence and Independence, Wronskian and a formula for Wronskian, Non-homogeneous equations of order two. (Sections 2.1-2.6 of Chapter-2)

**Unit II:** Homogeneous and Non-Homogeneous equations of order n, Initial value problems, Annihilator method to solve non-homogeneous equations, Algebra of constant coefficient operators. (Sections 2.7-2.12 of Chapter-2)

**Unit III:** Initial value problems for homogeneous equation, Solutions of the homogeneous equation, The Wronskian and linear independence, Reduction of the order of a homogeneous equation, The non-homogeneous equation, Homogeneous equation with analytic coefficients, The Legendre equation. (Chapter-3)

**Unit IV:** The Euler equation, second order equations with regular singular points- an example, second order equations with regular singular points-the general case, A convergence proof, The exceptional cases, The Bessel equation, The Bessel equation (Continued). (Chapter-4)

**Unit V:** Equations with variables separated, Exact Equations, The method of successive approximations, The Lipschitz condition, Convergence of the successive approximations, Non-local existence solutions, Approximations and uniqueness of solutions. (Chapter-5)

**Text Book:**

**E.A.Coddington**, An Introduction to Ordinary Differential Equations, Prentice Hall of India, 1987.

**Reference Books:**

1. G.F. Simmons, Differential Equations with Applications and Historical notes, Tata McGraw-Hill, 2006.
2. S.G. Deo and Raghavendra, Ordinary Differential Equations and Stability Theory, Tata McGraw Hill, 1980.

**CORE SUBJECT – 4**  
**DIFFERENTIAL GEOMETRY – (5 Credits) / 90Hrs**

**Subject Objective:** To introduce the curve in space and to find curvature, torsion of a curve and various applications in differential geometry.

**Outcome of the subject:** Students will get new ideas and techniques which play a prominent role in current research in global differential geometry.

**Unit I:** Introductory remarks about space curves, Definition, Arc length, Tangent, Normal and binomial, Curvature and torsion of a curve given as the intersection of two surfaces, contact between curves and surfaces, Tangent surfaces, involutes and evolutes. (Sections 1.1-1.7, Chapter-1)

**Unit II:** Intrinsic equations, fundamental existence theorem for space curves, Helices and definition of a surface, Curves on a surface, Surfaces of revolution, Helicoids. (Sections 1.8 & 1.9 of Chapter-1; Sections 2.1-2.4 of Chapter-2)

**Unit III:** Metric – Direction coefficients, Families of curves, isometric correspondence, Intrinsic properties, Geodesics, canonical geodesic equations, Normal property of geodesics. (Sections 2.5-2.12 of Chapter-2)

**Unit IV:** Existence theorems, geodesic parallels, Geodesic curvature, Gauss-Bonnet theorem Gaussian curvature, Surface of constant curvature. (Sections 2.13-2.18 of Chapter-2)

**Unit V:** The second fundamental form, principal curvatures, Lines of curvature Developable, Developable associated with space curves, Developable associated with curves on surfaces, Minimal surfaces, Ruled surfaces. (Sections 3.1-3.8 of Chapter-3)

**Text Book:**

T.G. Willmore, An Introduction to Differential Geometry, Oxford University Press 23<sup>rd</sup> Impression 2008.

**Reference Book:**

1. C.E. Weatherburn, Differential Geometry of Three Dimensions, The University Press 1998
2. D. Somasundaram, Differential Geometry, Narosa Publishing House, 2008.



**FIRST YEAR / SEMESTER II**  
**CORE SUBJECT – 5**  
**LINEAR ALGEBRA – (5 Credits) / 90Hrs**

**Subject objective:** To study the advance ideas in Vector Space, Linear Transformations and inner product space.

**Outcome of the subject:** Students will know more concepts in linear algebra and they will help them to develop thinking and improve mathematical ability.

**Unit-I:** Vector spaces – Subspaces – Bases and Dimension – Coordinates – Linear transformations – The Algebra of Linear transformations. (Sections 2.1-2.4 of Chapter-2 and Sections 3.1-3.2 of Chapter-3)

**Unit-II:** Isomorphism – Representation of transformation by matrices – Linear functional – Annihilators – The transpose of linear transformation. (Sections 3.3-3.7 of Chapter-3)

**Unit-III:** Determinants – Commutative rings – Determinant functions – Permutations and uniqueness of determinants – Properties of determinants. (Sections 5.1-5.4 of Chapter-5)

**Unit-IV:** Characteristic values and characteristic vectors – Annihilators polynomials – Invariant subspaces. (Sections 6.1-6.4 of Chapter-6)

**Unit-V:** Inner product – Inner product spaces – Linear functional and adjoints, Modules. (Sections 8.1-8.3 of Chapter 8 and Section 5.5 of chapter-5 )

**Text Books:**

Kenneth Hoffman and Ray Kunze, Linear Algebra, Pearson Ed, Second Edition first Indian reprint 2003.

**Reference books:**

1. Jin Ho Kwak and Sungpyo Hong, Linear Algebra, Birkhauser Boston, 1997.
2. Stephen H. Friesberg, Arnold J. Insel and Lawrence E. Spence, Linear Algebra, Prentice-Hall, 1989.

**CORE SUBJECT – 6**  
**REAL ANALYSIS – (5 Credits) / 90Hrs**

**Subject objective:** To make the students familiar with the concept of uniform convergence of sequence, double convergence and series, theorems of implicit functions, inverse function and Stokes.

**Outcome of the subject:** Students will have enriched knowledge of the concepts of real analysis and they will get more knowledge in Weierstrauss theorem for algebraic polynomials.

**Unit-I:** Uniform convergence and continuity – Uniform convergence and Integration – Uniform convergence and Differentiation – Double sequence and series – Iterated limits – Equicontinuous Families of Functions. (Chapter-7)

**Unit-II:** The Weierstrass theorem for algebraic polynomials – The Stone-Weierstrass theorem – Power series – The exponential and Logarithmic Functions – the Trigonometric Functions – Fourier series – The Weierstrass theorem for trigonometric polynomials – The Gamma Functions.(Chapter-8)

**Unit-III:** Functions of several variables – Linear Transformations – Differentiation – The Contraction Principle.(Chapter-9)

**Unit-IV:** The inverse function theorem – The Implicit Function Theorem – The Rank Theorem – Determinants.(Chapter-9)

**Unit-V:** Integrations of Differential forms – Primitive mappings – partition of unity – change of variables – differential forms, Simplexes and chain and Stokes's theorem.(Chapter-10)

**Text Book:**

Walter Rudin, Principles of Mathematical Analysis, McGraw Hill International Editions (1976).

**Reference Books:**

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

**CORE SUBJECT - 7**

**CLASSICAL MECHANICS (5 Credits) / 90Hrs**

**Subject objective:** To understand the basic concepts of Lagrangian and Hamiltonian approaches to classical mechanics and to study different applications of these concepts in the mechanics.

**Outcome of the subject:** This concept introduces the methods of solving partial differential equation. Students will become familiar with the first order and second order linear partial differential equation. a selection of analytical techniques for solving some partial differential equation that frequently occur in applications and students will understand Bertrand theorem and Kepler problem in mechanics.

**Unit I:** Mechanics of particle, Mechanics of a system of particles, Constraints(Sections 1.1 - 1.3 of Chapter-1)

**Unit II:** D'Alembert's principle and Lagrange's equation, Velocity - dependent potentials and the dissipation function, Hamilton's principle, Some techniques of the Calculus of variations.(Sections 1.4-1.5 of Chapter-1 and Sections 2.1-2.2 of Chapter-2)

**Unit III:** Derivation of Lagrange's equation from Hamilton's principle, Extension of Hamilton's principle to nonholomorphic systems, Advantage of a variational principle, formulation, conservation theorems and symmetry properties.(Sections 2.3-2.6 of Chapter-6)

**Unit IV:**Reduction to the equivalent one-body problem, The equations of motion and first integrals, The equivalent one-dimensional problem and classification of orbits, The virial theorem.(Sections 3.1-3.4 of Chapter-3)

**Unit V:** The differential equation for the orbit and integrable power - law potentials, Conditions for closed orbits (Bertrand's theorem), The Kepler problem: Inverse square law of force, The motion in time in the Kepler problem, The Laplace - Runge - Lenz vector.(Sections 3.5-3.9 of Chapter-3)

**Text Books:**

H.Goldstein; Classical Mechanics, Second edition, Addison Wesley, New York, 1980.

**Reference Books:**

1. D.T. Greenwood; Classical Mechanics, Prentice Hall of India Pvt. Ltd.New Delhi, 1979.
2. D. Rutherford; Classical Mechanics, Oliver and Boyd, 1987.

**CORE SUBJECT - 8**

**PARTIAL DIFFERENTIAL EQUATIONS - (5 Credits) / 90Hrs**

**Subject objective:**To provide knowledge of PDE and it's various kinds of solving methods.

**Outcome of the subject:** Students will be able to solve partial differential equations which arise in geometry, physics and applied mathematics

**Unit-I:**Formation of PDEs - solution of PDEs of first order - Integral surfaces passing through a given curve - The Cauchy problem - Cauchy method of characteristics to first order nonlinear equations - Compatible systems of first order PDEs - Charpit's method (Sections 0.4-0.11 of Chapter-0)

**Unit-II:** Classification of second order PDEs into canonical forms - Adjoint operators - Riemann's method - CF of homogeneous linear PDEs - Methods for finding PI.(Sections 1.2-1.7 of Chapter-1)

**Unit-III:** Derivation of Laplace equation - The spherical mean - Maximum-Minimum principle - Separation of variables - Dirichlet problem for a rectangle - Neumann problem for a rectangle - Laplace equation in cylindrical coordinates - Laplace equation in spherical coordinates. (Sections 2.1.1, 2.4-2.7, 2.11-2.12 of Chapter-2)

**Unit-IV:** Derivation of the diffusion equation - The elementary solution - Dirac delta function - Separation of variables - Diffusion equation in cylindrical coordinates - Diffusion equation in spherical coordinates - Maximum-Minimum principle.(Sections 3.1-3.8 of Chapter-3)

**Unit-V:** Derivation of the one-dimensional wave equation - solution of the one-dimensional wave equation in canonical form - D'Alembert's solution - Separation of variables for vibrating string - periodic solution of the wave equation in cylindrical coordinates - periodic solution of the wave equation in spherical polar coordinates.(Sections 4.1-4.5, 4.8-4.9 of Chapter-4)

**Text Book:**

K. SankaraRao: Introduction to Partial Differential Equations, Third Edition, PHI Learning, New Delhi, 2011.

**References:**

1. Ian Sneddon; Elements of Partial Differential Equations, International Student Edition, McGraw-Hill, New Delhi, 1957.
2. W.E.Williams; Partial Differential Equations, Oxford Applied Mathematics and Computing Sciences Series, Clarendon Press, Oxford, 1980.
3. K.F.Riley and M.P.Hobson; Essential Mathematical Methods for physical Sciences, Cambridge University Press, Delhi, 2011.

**SECOND YEAR / SEMESTER III**  
**CORE SUBJECT – 9**  
**TOPOLOGY – (5 Credits) / 90Hrs**

**Subject objective:** To study the concepts of Topological spaces and the theorems of Uryshon's and Tychonoff.

**Outcome of the subject:** It will clear the extended concepts of Analysis and the students will be able to enrich their knowledge of Topology and be able to apply for various areas of mathematics.

**Unit I:** Types of Topological Spaces and Examples – Basics for a topology – The order topology – The product Topology on  $X \times Y$  – The subspace topology – Closed sets and limits points – Continuous functions. (Sections 12-18 of Chapter 2)

**Unit II:** The Product Topology – The metric topology – Connected Spaces – Connected subspaces of the real line – Components.(Sections 19-21 of Chapter-2 and sections 23-26 of chapter 3)

**Unit III:** Compact spaces – Compact subspaces of the real line – Limit Point Compactness.(Sections 27-28 of chapter 3)

**Unit IV:**Countability axioms – The separation axioms – Normal spaces – The Uryshon's lemma (Sections 30-33 of chapter-4)

**Unit V:** The Uryshonmetrization Theorem – Tietz Extension Theorem – The Tychonoff theorem.(Sections 34-35 of chapter-4 and sections 37 of chapter-5)

**Text Book:**

James R.Munkers; Topology (Second Edition), Prentice – Hall of India, Private Ltd, New Delhi, 2006.

**References:**

1. G.F.Simmons; Introduction to Topology and Modern Analysis, Tata McGraw – Hill Edition, New Delhi (2004).
2. S.T.Hu; Introduction to Topology, Tata McGraw – Hill, New Delhi 1979.

## CORE SUBJECT-10

### MEASURE THEORY- (5 Credits)/90Hrs

**Subject objective:** To give the comprehensive idea about the underlying principles of Lebesgue measure and its property.

**Outcome of the subject:** Students will be enriched with Lebesgue outer measure, signed measure and its different types of decompositions.

**UNIT I :**Lebesgue Outer Measure, Measurable Sets, Regularity, Measurable Functions , Borel and Lebesgue Measurability. (Sections 2.1-2.5 of chapter-2)

**UNIT II:** Integration of Non-negative functions, The General Integral, Integration of Series, Riemann and Lebesgue Integrals .(Sections 3.1-3.4 of chapter-3)

**UNIT III :** Abstract Measure Spaces, Measures and Outer Measures, Extension of a Measure, Uniqueness of Extension, Completion of a Measure . (Sections 5.1-5.4 of chapter-5)

**UNIT IV :** Measure Spaces, Integration with respect to a measure, the  $L^p$  spaces , The inequalities of Holder and Minkowski, Completeness of  $L^p$  .(Sections 5.5-5.6 of chapter-5 and sections 6.1, 6.4-6.5 of chapter-6)

**UNIT V :** Signed Measures, Hahn decomposition, The Jordan decomposition , Measurability in a product space, The product measure and Fubini's theorem (Sections 8.1-8.2 of chapter-8 and sections 10.1-10.2 of chapter-10)

#### Text book :

G. de Barra, Measure Theory and Integration, New Age International Publishers, 1981

#### Reference :

1. Inder K. Rana, An Introduction to Measure and integration, Narosa, 2007 .
2. H. L. Royden, P. M. Fitzpatrick, Real Analysis – Fourth edition, PHI, 2011.

## CORE SUBJECT- 11

### GRAPH THEORY\_(5 CREDITS) /90Hrs

**SUBJECT OBJECT:** To study the graph theoretical concepts and algorithms that help to model real life situations.

**OUTCOME OF THE SUBJECT:** students will gather the graph theoretical knowledge and its application through algorithm.

**Unit I:** Graphs and simple graphs, Graph isomorphism- The incidence and adjacency matrices, Sub graphs, Vertex degrees, Paths and connection cycles - The shortest problem, Sperner's lemma. (Sections 1.1-1.9 of chapter-1)

**Unit II:** Trees, cut edges and Bonds, Cut vertices, Cayley's formula -The connector Problem, Connectivity, Blocks, Construction of Reliable Communication Networks. (Sections 2.1-2.5 of chapter-2 and sections 3.1-3.3 of chapter-3)

**Unit III:** Euler tours, Hamiltonian cycles- The Chinese postman problem, The travelling salesman problem.(Sections 4.1-4.4 of chapter-4)

**Unit IV:** Matchings, Matchings and coverings in Bipartite graphs, Perfect matching- The Personnel assignment problem, The optimal assignment problem. (Sections 5.1-5.5 of chapter-5)

**Unit V:** Chromatic number, Brook's theorem, Hajo's conjecture, chromatic polynomials, girth and chromatic number, Astorage problem. (Sections 8.1-8.6 of chapter-6)

**Text Book:**

J.A Bondy and U.S.R Murthy, Graph theory with applications, North Holland, 1976.

**References:**

1. John Clark and D. Allan Holton; Graph theory World Scientific Publishing Co. Pvt.Ltd, 1991.
2. NarsinghDeo; Graph Theory with Applications to Engineering and Computer Science, Prentice Hall, 1974.

**CORE SUBJECT-12**

**PROBABILITY AND STATISTICS-(5 Credits /90 Hrs)**

**Subject objective :** To develop the skills of the students to understand more concepts in probability and statistics .

**Outcome of the subject :** Students can improve their problem solving skills by using probability and statistics

**Unit I :** Probability Set function – Conditional Probability and Independence - Random variables of Discrete type and continuous type – distribution function - its properties- Expectation of a random variable – moment generating function - Chebeshev 's inequality (Sections 3-10 of chapter-1)

**Unit II :** Two random variables – joint density - marginal probability density – conditional distribution , expectation and variance, Independence of two random variables mutual independence and pairwise independence . (Chapter-2)

**Unit III :** Discrete distribution Bernoulli, Binomial and related distribution Poisson distribution continuous distributions exponential, gamma and chi square normal bivariate normal distributions .(Chapter-3)

**Unit IV :** Sample statistic and parameter concepts Transformation of variables of discrete and continuous types- methods of distribution function, change of variable (its extension)(Chapter-4)

**Unit V:** Order statistics-distribution of order statistics-distributions of  $X$  and  $S^2$ - expectation of function of random variables limiting distributions-convergence in Probability and in distribution-limiting MGF central limit theorem important results on limiting distribution (Chapter-5)

**Text Book:**

Robert V. Hogg and Allen T. Craig: Introduction to Mathematics Statistics, 7<sup>th</sup> edition, Pearson Education, 2002.

**References:**

1. I. Miller and M. Miller; Mathematics Statistics with Applications, Seventh Edition, Pearson Education, 2004.
2. Jun Shao; Mathematics Statistics- Second Edition, Springer-2003.
3. Vijay K. Rohatgi, A.K. Md. Ehsanes Saleh; An introduction to probability and Statistics-Second edition, Wiley, 2008.

**SECOND YEAR/SEMESTER IV****CORE SUBJECT-13****FUNCTIONAL ANALYSIS-(5 Credits)/ 90Hrs**

**Subject objective:** To study about the Banach space and Hilbert space with its properties.

**Outcome of the subject:** Students will obtain more skills analyzing the basic structure of normed spaces and get knowledge in using classes of functions rather than individual functions.

**Unit I:** Normed spaces-continuity of linear maps-Hahn Banach theorems (sections 5-7 of chapter-2)

**Unit II:** Banach spaces-Uniform boundedness principle-closed graph theorem –open mapping theorem. (Sections 8 of chapter-2 and Sections 9-10 of chapter-3)

**Unit III:** Bounded inverse theorem-Spectrum of a bounded operator-duals and transposes-duals of  $L^p(a,b)$  and  $C[a,b]$ . (Sections 11-12 of chapter-3 and sections 13-14 of chapter-4)

**Unit IV:** Weak and weak convergence- reflexivity-Compact linear maps-Spectrum of compact operator. (Sections 15-16 of chapter -4 and sections 17-18 of chapter-5)

**Unit V:** Inner product spaces-orthogonal sets-Bounded operators and Adjoints –normal, unitary and self-adjoint operators. (Sections 21-22 of chapter-6 and sections 25-26 of chapter-7)

**Text Book:**

B.V. Limaye; Functional Analysis, New age International Limited publishers, New Delhi, (3<sup>rd</sup> edition) 2017.

**Reference Books:**

1. J.B. Conway; A Course in Functional Analysis, 2<sup>nd</sup> edition, Springer, Berlin, 1990.
2. C. Goffman and G. Pedrick; A First course in Functional Analysis, Perentice-Hall 1974.
3. E. Kreyzig; Introduction to Functional Analysis with Applications, John Wiley & Sons, New York, 1978.

## CORE SUBJECT-14

### NUMBER THEORY AND CRYPTOGRAPHY -(5 Credits) / 90 Hrs

**Subject objective:** To provide an introduction to analytic number theory and recent topics of Cryptography with applications.

**Outcome of the subject :**The outgoing students will know more about numbers and enrich their knowledge for doing research in number theory.

**Unit I :**Introduction – Well Ordering – Induction- Binomial Coefficients- Greatest integer functions- Divisibility- Greatest Common Divisor (GCD) – Euclid ‘s algorithm –GCD via Euclid ‘s algorithm- Least Common Multiple (LCM)- representation of integers. (Sections 1.1-1.6 of chapter-1 and sections 2.2-2.4 of chapter-2)

**Unit II:**Introduction –primes counting function - prime number theorem- test of primality - canonical factorization \_ fundamental theorem of arithmetic \_ Seive of Eratosthenes \_ Determining factorization- fundamental theorem of arithmetic- Seive of Eratosthenes- determining canonical factorization of a natural number. (Sections 3.1-3.3 of chapter-3)

**Unit III :**Congruence- equivalence relations-linear congruences -linear Diophantine equations-Chinese remainder theorem- polynomial congruences – modular arithmetic- Fermat’s theorem –Wilson’s theorem- Fermat number. (Sections 4.2-4.7 of chapter-4 )

**Unit IV:**Arithmetic functions- tau functions- Dirichlet product – quadratic residues- Legendre symbols- Gauss lemma- Law of reciprocity.(Sections 5.1-5.2 of chapter-5 and sections 7.2-7.3 of chapter-7 )

**Unit V:** Cryptography: Introduction- Some simple crypto systems-Enciphering Matrices- The idea of Public key Cryptography – RSA - Discrete log- Knapsack (Chapter 3 Sections 1-2, Chapter 4 Sections 1-4, Text book -2)

#### **Text Book:**

1. Neville Robbins; Beginning Number Theory, second Edition, Narosa, 2006.
2. Neal Koblitz: A Course in Number Theory and Cryptography, Second edition, Springer-Verlag Newyork-1994.

#### **Reference Books:**

1. Tom. M. Apostol; Introduction to analytic Number theory, Narosa Publishing House,1998.
2. Ivan Nivan, H.S.Zuckerman and H.L.Montgomery; An introduction to the theory of Number, 5<sup>th</sup> Ed paperback- International Edition, 1991.



**CORE SUBJECT – 15**  
**COMPLEX ANALYSIS –(5 Credits) / 90 Hrs**

**Subject objective:** To provide the knowledge of Analytic functions, conformal Mapping and related formulas.

**Outcome of the subject:** Students will get more ideas about analytic functions, complex integration and Riemann mapping theorem.

**Unit I :** Analytic functions as mappings – Conformality – Linear Transformation – Elementary Conformal mappings – Line integrals – Rectifiable arcs – Line integrals as functions of arcs - Cauchy's theorem for a rectangle – Cauchy's theorem in a circular disc(Chapter 3 sections 2, 3, 4, Chapter 4 section 1)

**Unit II :** Cauchy's integral formula – Local Properties of Analytic functions – The general form of Cauchy's theorem –The calculus of Residues – Harmonic functions (Chapter 4, Sections 2,3,4,5,6)

**Unit III :** Power series expansions – Weierstrass's theorem – Taylor's series – Laurent's series – Partial fractions and factorization (Chapter 5 Sections 1,2)

**Unit IV :** Entire functions – Normal families – Riemann mapping theorem (Chapter 5, sections 3, 4)

**Unit V:** Conformal mappings of polygons – Functions with mean value properties – Harnack's Principle – Sub harmonic functions – Dirichlet's Problem (Chapter 6, Sections 2,3,4)

**Text Book:**

Lars V. Ahlfors; Complex Analysis, McGraw Hill International, Third Edition, 1979.

**References:**

1. Conway J. B.; Functions of one Complex variables, Springer International Student Edition, Second Edition, 2000.
2. Matthias Beck, Gerald Marchesi, Dennis Pixton, Lucas Sabalka, A First course in Complex Analysis, Orthogonal Publishing House, 2015.
3. Jerrold E. Marsden, Michael J. Hoffman, Basic complex analysis, 3<sup>rd</sup> Edition, W.H.Freeman, New York (1999), 5<sup>th</sup> reprint.

**CORE SUBJECT – 16**  
**OPERATION RESEARCH-(5 Credits) / 90 Hrs**

**Subject objectives:** To study about the networking models and the game theory with its solving methods.

**Outcome of the subject:** Students will be familiar with linear and non-linear programming concepts.

**Unit I:** Network models- Minimal spanningtree algorithm- shortest route algorithms- maximal flow problems- critical path calculation- tree and total floats.(Chapter-6)

**Unit II:**Advanced Linear Programming, simplex method using the restricted basis- banded variables algorithm- revised simplex method.(Chapter-7)

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**Unit III:**Game theory- Optimal solution of two-person zero sum games- solution of mixed strategy games- linear programming solution of games.(Chapter-13)

**Unit IV:**classical optimization theory- Jacobian method-Lagrangian method- The Newton Raphson- Kahn Tucker conditions.(Chapter-18 )

**Unit V:**Nonlinear Programming Algorithms- separable programming-quadratic programming- geometric programming. (Chapter-19)

**Text Book:**

H.A. Taha, Operations Research 8<sup>th</sup> edition, Prentice Hall, New Delhi, 1998.

**References:**

1. F.S.Hiller and G.J. Lieberman; An introduction to operations research, Holden-Day, Inc.SanFransisco, 1973.

2. L. Cooper and D. Steiberg, Introduction to methods of optimization, W.B. Saunders company, Philedelphia, 1970.

**Major Elective List I**

**AUTOMATA THEORY (4 Credits) / 90 Hrs**

**Subject objective:** To understand the notion of effective computability by studying Finite Automata, Grammars, Push Down Automata and Languages of PDA

**Outcome of the subject:**Students will be familiar with various applications of mathematics in practical situation.

**Unit I:**Why study Automata theory ? Introduction to formal proof, Additional forms of proof , Inductive proofs, The concepts of Automata theory.

**Unit II:** An informal picture of finite automata, Deterministic finite automata, Non-deterministic finite automata, An application: text search , Finite automata with epsilon transitions.

**Unit III:** Regular expression, Finite automata and regular expression, Application of regular expressions, Algebraic laws of regular expressions.

**Unit IV:** Proving languages are not regular, Closure properties of regular languages, Decision properties of regular languages, Equivalence and Minimization of automata.

**Unit V:**Context-free grammars, Parse trees, Application of context-free grammar, Ambiguity in grammars and languages, Definitions of Push Down Automata, Languages of PDA , Equivalence of PDA's and CFG's, Deterministic PDA.

**Text Book:**

J.E.Hopcroft, R.Motwani and J.D. Ullman; Introduction to Automata theory, Cambridge University press, 2007.

**Reference Book:**

1.P.K. Srimani and S.F.B. Nasir; A text book on Automata theory, Cambridge University press, 2007.

2. J.P. Tremblay and R. Manohar ; Discrete Mathematical Structures with Applications to Computer Science, McGraw Hill Education (India) Pvt Ltd,2017.

**DISCRETE MATHEMATICS – (4 Credits) / 90 Hrs**

**Subject objective:**To understand the basic foundation about permutation, relations and groups and dominating sets in graph theory.

**Outcome of the subject:** Students will gather the enumerators for permutation aspects in combinatorial theory, graph theoretical knowledge and its applications.

**Unit I:**The rules of sum and product – permutations – combinations – distributions of distinct objects – distributions of non-distinct objects – Stirling's formula.

**Unit II:**Generating functions of combinations – Enumerators for permutations – distributions of distinct objects into non-distinct cells – partitions of integers.

**Unit III:** Linear recurrence relations with constant coefficients – solution by the technique of generating functions – a special class of non-linear difference equations – recurrence relations with two indices.

**Unit IV:**Sets – relations and groups – equivalence classes of functions – weight and inventories of functions – Polya's fundamentals theorem.

**Unit V:** The principle of inclusion and exclusion - the general formula – de arrangements – permutations with restrictions on relative positions.

**Text Book:**

C.L. Liu, Introduction to Combinatorial Mathematics, McGraw hill, 1968.

**References:**

1.RalphP.Grimaldi,Discrete and Combinatorial Mathematics,Pearson Education 2011

2. S. Lipschutz and M.L. Lipson; Discrete Mathematics, McGraw hill Education (India) Private limited, revised third edition 2016.

## CALCULUS OF VARIATIONS – (4 Credits) / 90 Hrs

**Subject objective:** To Acquire knowledge about Euler equations, functional dependent on higher order derivatives and variational problems in parametric form.

**Outcome of the subject:** Students will get more ideas about moving boundary value problem and their properties.

**Unit I:** Variations and its properties, Euler's Equations and functional of the form  $\int_{x_0}^{x_1} F(x, y_1, y_2, \dots, y_n, y_1', y_2', \dots, y_n') dx$

**Unit II:** Functional dependent on higher-order derivatives and functions of several independent variables, variational problems in parametric form.

**Unit III:** Elementary problem with moving boundaries, Moving boundary problem for a functional of the form  $\int_{x_0}^{x_1} F(x, y, z, y', z') dx$ , extremals with corners, one-sided variations

**Unit IV:** Field of extremals, the function  $E(x, y, p, y')$ , transforming the Euler equations to the canonical form.

**Unit V:** Constraints of the forms  $\phi(x, y_1, \dots, y_n) = 0$  and  $\phi(x, y_1, \dots, y_n, y_1', \dots, y_n') = 0$ , isoperimetric problems.

### Text Book:

Lev Elsgolts; Differential equations of the calculus of variations, University Press of the Pacific, 2003.

### Reference:

1. Robert Weinstock; Calculus of variations with applications to Physics and Engineering, Dover Books on Mathematics, 1975.
2. Izrail M. Geifand, S.V. Fomin; Calculus of variations, Dover Books on Mathematics, 2003

## Major Elective List II

### GALOIS THEORY – (4 Credits) / 90 Hrs

**Subject objective:** To introduce the idea connected to Galois theory and its application.

**Outcome of the subject:** Students will get more ideas about field theory and extension fields.

**Unit I:** Extension fields and transcendence of  $e$  (Text book 1 Section 5.1 & 5.2)

**Unit II:** Roots of polynomials, more about roots, solvable roots and Nilpotent roots. (Text book 1, Sections 5.3 & 5.5)

**Unit III:** Separable and inseparable extensions- Cyclotomic polynomials and extensions (Text book 2, Chapter 13, sections 13.5 & 13.6)

**Unit IV:**Galois Theory, (Sections 5.6, 5.7 -Text book 1)

**Unit V:**Galois Fields over the rationals (Section 5.8- Text book 1 and Section 14.9 -Text book 2).

**Text Book:**

1. I.N.Herstein: Topics in Algebra-second edition, John Wiley & Sons, New York,1999
- 2.David S Dummit,Richard M Foote; Abstract Algebra - Third edition Wiley,2011

**References:**

1. John B.Fraleigh; A First Course in Abstract Algebra – Seventh edition, Pearson Education; 2014
2. J.J.Gallian; Contemporary Abstract Algebra, Eighth edition, Cengage; 2013

**INTEGRAL TRANSFORMS – (4 Credits) / 90 Hrs**

**Subject objective:**To provide the students an understanding of the basic properties of Laplace and Fourier Transforms.

**Outcome of the subject:**Students will get different technique to solve difficult integral problems using various transformation.

**Unit I:** Calculation of the Laplace transforms of some elementary functions – Rules of manipulation of the Laplace transform – Laplace transforms of derivatives – Periodic functions – The convolution of two functions.

**Unit II:** The diffusion equation in a semi-infinite line – The wave equation in the semi-infinite strip.

**Unit III:** Fourier transforms – Fourier cosine transforms – Fourier sine transforms of derivatives

**Unit IV:** The calculation of the Fourier transforms of some simple functions (Lemma 1 and Lemma 2 are excluded ) – The Fourier transforms of rational functions – The Convolution integral – Parseval's theorem for cosine and sine transforms.

**Unit V:** Laplace's equation in a half plane – Laplace's equation in an infinite strip – The linear diffusion equation on a semi-infinite line

**Text Book:**

Ian Sneddon; The uses of integral transforms,McGraw Hill, Delhi ,1972

**References:**

1. D. Zwillinger; Handbook of Differential Equations, Academic Press, Boston, 1997 (3<sup>rd</sup> edition)
2. LokenathDebnath and DambaruBhatta; Integral Transforms and their Application, Chapman and Hall/ CRC Chapman and Hall/CRC, Second Edition.

## NUMERICAL METHODS – (4 Credits) / 90 Hrs

**Subject objective:** To develop the skills of solving algebraic, transcendental, differential and integral equations numerically.

**Outcome of the subject:** The outgoing students will know more about Eigen values and Eigen vectors, Lagrange and Newton Interpolation formula.

**Unit I:** Introduction – Bisection method – iteration methods based on first degree equation – iteration methods based on second degree equation – methods for complex roots – polynomial equations.

**Unit II:** Introduction – Direct methods – Error analysis for direct methods – iteration methods – Eigen values and Eigen vectors – Bounds on Eigen Values.

**Unit III:** Introduction – Lagrange and Newton Interpolations – Finite difference operators – Interpolating polynomials using finite differences – Hermite interpolations – piecewise and spline interpolation.

**Unit IV:** Introduction - Numerical Differentiation – Extrapolation methods – partial differentiation – Numerical integration – methods based on interpolation – composite integration methods – Romberg method.

**Unit V:** Introduction – Difference equation – Numerical methods – Single step methods.

### Text Book:

M.K.Jain ,S.R.K.Iyengar and R.K.Jain; Numerical Methods for Scientific and Engineering Computation, New Age International Publishers, Fourth Edition, 2013.

### Reference :

C.F.Gerald and P.O.Wheatly ; Applied Numerical Analysis, Addison Wesley, Fifth Edition, 1998.

## Non- Major Elective Subject List III

### Statistical Methods (5 Credits) / 90 Hrs

**Subject Objective:** To enable the students to learn statistical techniques and to apply statistical techniques to the data collected, analyze and interpret them.

**Outcome of the subject:** Students will be able to understand important and various concept in applied statistics. They will also be able to assess articulate what type of statistical techniques appropriate for a given data and compose the finding from the methods applied for the data.

**Unit I:** Definition – Importance – Application – Collection of data – Primary and Secondary Data – Sampling design – Types of samples – Statistical errors – Classification of data – Tabulation – Presentation of data – Diagrams (15 hrs)

**Unit II:** Measures of Central tendency – Mean – Median – Mode – Geometric Mean – Harmonic Mean – Measures of dispersion – Range – Quartile deviation – Mean deviation – Standard deviation.

**Unit III:** Correlation – Meaning – Types – Scatter diagram – Karl Pearson’s coefficient of correlation – Rank correlation – Concurrent deviation method - Bi-variate frequency distribution. Regression analysis – Uses – Methods of studying regression – Regression lines.

**Unit IV:** Index numbers – Meaning – Construction of index number – Problems – Methods of construction – Test of consistency – Fixed base – Chain base – Base conversion and shifting – Consumer price index – Formula.

**Unit V:** Time series – Components – Moving average – Methods of least squares – Measurement of seasonal variations – Simple average, Ratio-to-trend method, Ratio-to-moving average method – Link relative method.

**Text Book:**

R.S.N. Pillai and Bagavathi; Statistics, Theory and Practice, published by S.Chand and Company New Delhi, 2010.

**References:**

1. Dr. S. P. Gupta; Statistical methods, published by S. Chand & sons, New Delhi, 2014.
2. G.C. Beri; Business Statistics, Tata McGraw Hill Edition, 1978.

**Quantitative Aptitude (5 Credits) / 90 Hrs**

**Subject Objective:** To enable the students to learn basic mathematical concepts required for quantitative aptitude and to solve a question in a fraction of minute by using short-cut methods.

**Outcome of the Subject:** Students will be able to solve questions asked in quantitative aptitude in a fraction of minute.

**Unit I:** HCF and LCM of numbers.

**Unit II:** Problems on numbers

**Unit III:** Problems on Ages

**Unit IV:** Percentage

**Unit V:** Profit and Loss

**Text Book:**

Dr. R.S. Aggarwal Quantitative Aptitude S.Chand & Company Pvt. Ltd, 2015

**References:**

1. U. Mohan Rao, Quantitative Aptitude Scitech Publication (India) Pvt Ltd, 2016
2. Arun Sharma; How to prepare for Quantitative Aptitude for the CAT, McGraw Hill Education, 2014.

## **Competitive Mathematics (5 Credits) / 90 Hrs**

**Subject objective:** To enable the students to learn basic mathematical concepts required for quantitative aptitude and to solve a question easily by using short-cut methods.

**Outcome of the Subject:** Students will be able to solve questions asked in quantitative aptitude in a fraction of minute and their Intelligent Quotient(IQ) of the students will be increased.

**Unit 1:** Time and distance

**Unit 2:** Problems on trains

**Unit 3:** Simple interest and compound interest

**Unit 4:** Area

**Unit 5:** Permutations and combinations

### **Text Book:**

Dr. R. S. Aggarwal Quantitative Aptitude S.Chand & Company Pvt.Ltd, 2015

### **Reference Book:**

1. U.MohanRao, Quantitative Aptitude Scitech Publication (India) Pvt Ltd, 2016
2. Arun Sharma; How to prepare for Quantitative Aptitude for the CAT, McGraw Hill Education , 2014

## **Major Elective List IV**

### **Fluid Dynamics(4 Credits) / 90 Hrs**

**Subject objective:** To develop an appreciation for the properties of Newtonian fluids and to study analytical solution for variety of simplified problems

**Outcome of the Subject:** Students will get the knowledge of basic principles of fluid mechanics and they get the ability to analyze the fluid flow problems with the application of Bernoulli's theorem.

**Unit I:** Real fluids and Ideal fluids – Velocity of a fluid at a point – streamlines pathlines – Velocity potential – Vorticity Vector – Equation of continuity – acceleration of a fluid.

**Unit II:** Equation of motion of a fluid: Pressure at a point in a fluid at rest – pressure at a point in a moving fluid – Euler's equations of motion – Bernoulli's Equation, Bernoulli's theorem.

**Unit III:** Some two – dimensional flows: meaning of two – dimensional flow – stream function - two – dimensional image systems – Milne-Thomson circle theorem - Theorem of Blasius.

**Unit IV:** Elements of Thermodynamics: the equation of state of a substance – the first law of thermodynamics – internal energy of a gas – specific heats of a gas – function of state; Entropy – Maxwell's thermodynamics relation.



**Unit V:** Shock waves: formation of shock waves – elementary analysis of normal shock waves – elementary analysis of oblique shock waves – the method of characteristics for two – dimensional, homentropic, irrotational flow.

**Text Book:**

F. Chorlton; Text book of Fluid Dynamics, CBS publishers and Distributors Pvt. Limited, 2004.

**References**

1. M.D. Raisinghania; Fluid Dynamics, published by S. Chand, 2003.
2. Michel Rieutord; Fluid Dynamics, Springer International Publishing, 2015.

**FUZZY SETS AND FUZZY LOGIC APPLICATIONS(4 credits)**

**Subject objective:** To introduce the concept of uncertainty and fuzziness in logic and to Study fuzzy arithmetic, fuzzy relations and construction of fuzzy sets.

**Outcome of the subject:** Students will acquire the knowledge of basic ideas of fuzzy sets and fuzzy logic.

**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,  $\alpha$ -cuts – Decomposition Theorems, Extension Principle. (Chapter1 and Chapter-2)

**Unit II: Operation on fuzzy sets:** Standard fuzzy operations – Union, intersection and complement – properties De. Morgan's laws -  $\alpha$  - Cuts of fuzzy operations. (Chapter-3)

**Unit III: Fuzzy relations:** Cartesian product, 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. (Chapter-5)

**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 . (chapter-15)

**Unit V: Applications:** Medicine – Economics – Fuzzy Systems and Genetic Algorithms – Fuzzy Regression – Interpersonal Communication – Other Applications.(Chapter-17)

**Text Book:**

George J. Klir and Bo Yuan, Fuzzy sets and Fuzzy Logic Theory and Applications, PHI Learning Private Limited, New delhi, 2015.

**Reference books:**

1. A.K. Bhargava; Fuzzy Set Theory, Fuzzy Logic and their Applications, published by S. Chand Pvt.
2. S. Rajasekaran & Y.A. Vijayalakshmi Pai, Neural Networks, Fuzzy logic and Genetic Algorithms, Prentice Hall of India.

## **FINANCIAL MATHEMATICS – (4 credits)**

**Subject objective:** To impart the knowledge of active and practical use of mathematics which includes stochastic integrals, binomial model, Black-Scholes models and the multi-dimensional Black Scholes models.

**Outcome of the subjects:** Students will get more examples of asset pricing both from complete and incomplete models.

**Unit I:** Brownian motion, stochastic integrals, Ito process, Ito formula, Girsanov transformation and martingale representation theorem.

**Unit II:** Financial markets, derivatives, Binomial model, pricing European and American Contingent claim.

**Unit III:** Definition of the finite market model, first and second fundamental theorems of asset pricing, pricing European contingent claims, incomplete markets, separating hyper plane theorem

**Unit IV:** Black-Scholes model, equivalent martingale measure, European contingent claims, European contingent claims, pricing European contingent claims, Europeans call options – Black-Scholes formula, American contingent claims and American call and put options.

**Unit V:** Multi-dimensional Black- Scholes model, first and second fundamental theorem of asset pricing, from of equivalent local martingale measures, pricing European contingent claims and incomplete markets.

### **Text Book:**

R.J. Williams, Introduction to the mathematics of Finance, American Mathematical society, 2006.

### **References:**

1. Stephen Garrett, An Introduction to the mathematics of Finance: A Deterministic Approach, Butterworth-Heinemann Ltd; 2<sup>nd</sup> Revised edition, 2013.
2. S.M. Ross, An Elementary Introduction to Mathematical Finance, Cambridge University Press; 3<sup>rd</sup> edition, 2011.
3. Marek Capinski, Tomasz Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering Springer; 2<sup>nd</sup> edition 2011.s

**MODEL QUESTION PAPER**

**M.Sc. Mathematics**

**TOPOLOGY**

**Time: 3 hours**

**Maximum Mark: 75**

**SECTION - A**

**Answer all Questions**

- Name the topology generated by  $B = \{x: a < x < b\}$ .  
(A) Usual topology  
(B) Upper limit topology  
(C) Lower limit topology  
(D) Digital topology
- Which of the following subset is connected ?  
(A)  $A = \{(x, y): |x^2 - y^2| \geq 4\}$  of  $R^2$   
(B)  $A = (a, d, e)$  subset of a topological space  $(X, \tau)$   
(C) Real line  $R$  With Usual topology  
(D)  $A = \{x \in R: |x| > 2\}$  as a subset of the real line with usual topology.
- If  $A$  is open set and  $B$  is closed set  
(A)  $A-B$  is open set  
(B)  $A-B$  is closed set  
(C)  $B-A$  is open set  
(D)  $B-A$  is not closed set
- If  $Y$  is a subset of a topological space  $(X, \tau)$ , the collection  $\tau_y = \{Y \cap U / U \in \tau\}$  is called the  
(A) Subspace topology (C) order topology  
(B) Product topology (D) discrete topology
- The lower limit topology  $T'$  on real line  $R$  is  
(A) Strictly finer than standard topology  
(B) Inferior than the standard topology  
(C) Finer than the standard topology  
(D) Same as standard topology
- If  $X$  is a topological space and  $f, g: X \rightarrow R$  are continuous functions. Then,  
(A)  $f + g$  is continuous  
(B)  $f - g$  is continuous  
(C)  $f \cdot g$  continuous  
(D)  $\frac{f}{g}$  is continuous provided  $g(x) \neq 0, \forall x$ .
- If  $Y$  is a subspace of  $X$ ,  $A$  is closed in  $Y$  and  $Y$  is closed in  $X$  then,  
(A)  $A$  is semi-closed in  $X$   
(B)  $A$  is not closed in  $X$   
(C)  $A$  is not open in  $X$   
(D) None of the above
- Let  $X = \{1, 2, 3, 4, 5\}$ ,  $\tau = \{\emptyset, X, \{2\}, \{3, 4\}, \{1, 3, 4\}, \{2, 3, 4\}, \{1, 2, 3, 4\}\}$  then  $\text{Fr}\{3\}$  is  
(A)  $\{2, 3, 4, 5\}$  (C)  $\{1, 3, 4, 5\}$   
(B)  $\{1, 2, 3, 4\}$  (D)  $\{1, 2, 4, 5\}$
- Let  $A$  subset of a topological space  $X$  and  $A'$  be set of all limits. The closure of  $A$   
(A)  $\bar{A} = A \cup A'$  (C)  $\bar{A} = A - A'$   
(B)  $\bar{A} = A \cap A'$  (D)  $\bar{A} = A'$

10. Let  $A$  be a connected subset of a topological space  $X$ . If  $A \subset B \subset \bar{A}$ , then  $B$  is

- (A) Connected (C) Separable  
(B) Disconnected (D) Dense

**SECTION : B**

**Answer all questions (5x7=35 Marks)**

11.(a). Prove that  $\bar{A} = A \cup A'$

(or)

(b). Let  $X$  be a topological space and let  $B$  be basis for a topology on  $X$ . Prove that  $\tau$  equals the collection of all union of elements of  $B$ .

12.(a) State and prove Uniform limit theorem.

(or)

(b) State and prove Pasting lemma

13. (a) Prove that a topological space  $X$  is locally connected iff each component of each open subset of  $X$  is open.

(or)

(b) Prove that the union of a collection of connected subspaces of  $X$  have a point in common is connected.

14. (a) A subset of  $\mathbb{R}$  is compact iff it is bounded and closed-prove.

(or)

(b) Prove that every metric space having the Balzano-Weierstrass property is sequentially compact.

15. (a) Prove that a closed subspace of a Lindeloff space is Lindeloff.

(or)

(b) Prove that the property of being regular is a hereditary property.

**SECTION C**

**Answer any three questions**

16. Let  $X$  and  $Y$  be topological spaces, let  $f: X \rightarrow Y$ . Prove that the following are equivalent:

(a)  $f$  is continuous

(b) For every subset  $A$  of  $X$  then  $f(\bar{A}) \subset \bar{f(A)}$

(c) Inverse image of closed set is closed.

17. Prove that  $\mathbb{R}$  is connected

18. Show that every regular space with countable basis is normal.

19. (a) Prove that continuous image of a compact space is compact.

(b) Prove that every compact subspace of Hausdorff space is closed.

20. State and prove Urysohn lemma.