

M Sc MATHEMATICS

PROGRAM STRUCTURE AND SYLLABUS 2019-20 ADMISSIONS ONWARDS

(UNDER MAHATMA GANDHI UNIVERSITY PGCSS REGULATIONS 2019)



BOARD OF STUDIES IN MATHEMATICS (PG)
MAHATMA GANDHI UNIVERSITY

2019

M Sc MATHEMATICS Degree Program

(Mahatma Gandhi University Regulations PGCSS2019 from 2019-20 Academic Year)

1. Aim of the Program

Aims and objective:

- To improve the perspective of students on mathematics as per modern requirement.
- To enhance the logical, reasoning, analytical and problem solving skills of students.
- To orient students towards relating Mathematics to applications.
- To help the student build interest and confidence in learning the subject.
- To cultivate a research culture in young minds.
- To encourage students for pursuing higher studies in mathematics.
- To ultimately see that the learning of mathematics becomes more alive, vibrant, relevant and meaningful; a program that paves the way to seek and understand the world around them.
- To motivate students to uphold scientific integrity and objectivity in professional endeavours.

2. Eligibility for Admissions

As per the rules and regulation of PG admission of M G University, 2019

3. Medium of Instruction and Assessment

English

4. Faculty under which the Degree is Awarded

Science

5. Note on compliance with the UGC Minimum Standards for the conduct and award of Post Graduate Degrees

The programme is offered in accordance with the UGC minimum standards for the conduct and award of Post Graduate Degrees. The students have to secure 80 credits to complete the programme successfully.

THE PROGRAM STRUCTURE

Course Code	Title of the Course	Type of the Course	Hours per week	Credits
FIRST SEMESTER				
ME010101	Abstract Algebra	Theory	5	4
ME010102	Linear Algebra	Theory	5	4
ME010103	Basic Topology	Theory	5	4
ME010104	Real Analysis	Theory	5	4
ME010105	Graph Theory	Theory	5	4
SECOND SEMESTER				
ME010201	Advanced Abstract Algebra	Theory	5	4
ME010202	Advanced Topology	Theory	5	4
ME010203	Numerical Analysis with Python	Theory	5	4
ME010204	Complex Analysis	Theory	5	4
ME010205	Measure and Integration	Theory	5	4
THIRD SEMESTER				
ME010301	Advanced Complex Analysis	Theory	5	4
ME010302	Partial Differential Equations	Theory	5	4
ME010303	Multivariate Calculus and Integral Transforms	Theory	5	4
ME010304	Functional Analysis	Theory	5	4
ME010305	Optimization Technique	Theory	5	4
FOURTH SEMESTER				
ME010401	Spectral Theory	Theory	5	4
ME010402	Analytic Number Theory	Theory	5	4
	Elective 1	Theory	5	3
	Elective 2	Theory	5	3
	Elective 3	Theory	5	3
Dissertation				1
Comprehensive Viva				2
Total Credits				80
ME800401	Differential Geometry	Group A	5	3
ME800402	Algorithmic Graph Theory		5	3
ME800403	Combinatorics		5	3
ME810401	Probability Theory	Group B	5	3
ME810402	Operations Research		5	3
ME810403	Coding Theory		5	3
ME820401	Commutative Algebra	Group C	5	3
ME820402	Ordinary Differential Equations		5	3
ME820403	Classical Mechanics		5	3

FIRST SEMESTER COURSES

ME010101	Abstract Algebra
ME010102	Linear Algebra
ME010103	Basic Topology
ME010104	Real Analysis
ME010105	Graph Theory

ME010101 - ABSTRACT ALGEBRA

5 Hours/Week (Total Hours : 90)

4 Credits

Text Book: John B. Fraleigh, A First Course in Abstract Algebra, 7th edition, Pearson Education.

- Module 1:** Direct products and finitely generated Abelian groups, fundamental theorem, Applications
Factor groups, Fundamental homomorphism theorem, normal subgroups and inner automorphisms.
Group action on a set, Isotropy subgroups, Applications of G- sets to counting.
(Part II – Sections 11, 14, 16 & 17) (25 hours)
- Module 2:** Isomorphism theorems, Sylow theorems , Applications of the Sylow theory.
(Part VII Sections 34, 36 & 37) (25 hours)
- Module 3:** Fermat's and Euler Theorems, The field of quotients of an integral domain, Rings of polynomials, Factorisation of polynomials over a field.
(Part IV – Sections 20, 21, 22 & 23) (20 hours)
- Module 4:** Non commutative examples, Homeomorphisms and factor rings, Prime and Maximal Ideals
(Part V – Sections 24, 26 & 27) (20 hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	3	2	1
Module II	3	2	1
Module III	2	2	1
Module IV	2	2	1
Total	10	8	4

References:-

1. I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
2. Thomas W. Hungerford, Algebra (Graduate texts in Mathematics), Springer
3. M. Artin, Algebra, Prentice -Hall of India, 1991
4. N. Jacobson, Basic Algebra Vol. I, Hindustan Publishing Corporation
5. P.B. Bhattacharya, S.K. Jain, S.R. Nagapaul, Basic Abstract Algebra, 2nd edition, Cambridge University Press, Indian Edition, 1997.
6. David S Dummit, Richard M Foote, Abstract Algebra, Third Edition, Wiley.

ME010102 - LINEAR ALGEBRA

5 Hours/Week (Total Hours : 90)

4 Credits

Text Book: Kenneth Hoffman / Ray Kunze (Second Edition), *Linear Algebra*,
Prentice-Hall of India Pvt. Ltd., New Delhi, 1992.

Review : Chapter 1 of text

- Module 1:** Vector spaces, subspaces, basis and dimension
Co-ordinates, summary of row-equivalence, Computations concerning
subspaces
(Chapter 2- 2.1, 2.2, 2.3,2.4 2.5& 2.6 of the text) (20 hours)
- Module 2:** Linear transformations, the algebra of linear transformations, isomorphism,
representation of transformations by matrices, linear functional, double dual,
transpose of a linear transformation.
(Chapter 3 - 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 & 3.7 of the text) (25 hours)
- Module 3:** Determinants: Commutative Rings, Determinant functions, Permutation and
uniqueness of determinants, Additional properties of determinants.
(Chapter 5 - 5.1, 5.2, 5.3 & 5.4 of the text) (20 hours)
- Module 4:** Introduction to elementary canonical forms, characteristic values, annihilatory
Polynomials, invariant subspaces, Direct sum Decompositions
(Chapter 6 - 6.1, 6.2, 6.3, 6.4,6.6of the text)
(25 hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	2	2	1
Module II	3	3	1
Module III	3	1	1
Module IV	2	2	1
Total	10	8	4

References:

1. Klaus Jonich. Linear Algebra, Springer Verlag.
2. Paul R. Halmos, Linear Algebra Problem Book, The Mathematical Association of America.
3. S. Lang, Algebra, 3rd edition, Addison-Wesley, 1993.
4. K.B. Datta, Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
5. S. Kumaresan, Linear Algebra A Geometrical Approach, Prentice Hall of India, 2000.

ME010103 - BASIC TOPOLOGY

5 Hours/Week (Total Hours : 90)

4 Credits

Text Book : K.D Joshi , Introduction to General Topology , Wiley Eastern Ltd, 1984

Module I : Topological Spaces: Definition of a topological space – Examples of topological spaces-Bases and subbases – subspaces.

(Chapter 4: Sections 1, 2, 3, and 4 of the text) (25 hours)

Module II : Basic concepts: Closed sets and Closures – Neighbourhoods, Interior and Accumulation points – Continuity and Related Concepts – Making functions continuous , Quotient spaces

(Chapter 5: Section 1;1. To 1.7 , Section 2; 2.1 to 2.10 and 2.13, Section3; 3.1 to 3.11, Theorem 3.2 condition 4 (25 hours)

Module III : Spaces with special properties :- Smallness conditions on a space, Connectedness

(Chapter 6 : Section 1; 1.1 to 1.16, Section 2; 2.1 to 2.15 (20 hours)

Module IV : Spaces with special properties :- Local connectedness and Paths

Separation axioms:- Hierarchy of separation axioms

(Chapter 6 : Sections 3.1 to 3.8, Chapter 7 : Sections 1.1 to 1.17(20 hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	3	2	1
Module II	3	2	1
Module III	2	2	1
Module IV	2	2	1
Total	10	8	4

Reference:

- 1) George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963
- 2) I.M. Singer & J.A. Thorpe ,Lecture Notes on Elementary Topology & Geometry, Springer Verlag 2004

ME010104 - REAL ANALYSIS

5 Hours/Week (Total Hours : 90)

4 Credits

Text 1: Tom Apostol, *Mathematical Analysis (Second edition)*, Narosa Publishing House.

Text 2: Walter Rudin, *Principles of Mathematical Analysis (Third edition)*, McGraw Hill Book Company, International Editions.

Module 1: Functions of bounded variation and 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 functions 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 parameter.

(Chapter 6, Section: 6.1 - 6.12. of Text 1) (20 hours.)

Module 2: The Riemann-Stieltjes Integral

Definition and existence of the integral, properties of the integral, integration and differentiation, integration of vector valued functions.

(Chapter 6 - Section 6.1 to 6.25 of Text 2) (20 hours.)

Module 3: Sequence and Series of Functions

Discussion of main problem, Uniform convergence, Uniform convergence and Continuity, Uniform convergence and Integration, Uniform convergence and Differentiation.

(Chapter 7 Section. 7.1 to 7.18 of Text 2) (25 hours.)

Module 4: Weierstrass Approximation & Some Special Functions

Equicontinuous families of functions, the Stone - Weierstrass theorem, Power series, the exponential and logarithmic functions, the trigonometric functions, the algebraic completeness of complex field.

(Chapter 7 – Sections 7.19 to 7.27, Chapter 8 - Section 8.1 to 8.8 of Text 2) (25 hours.)

Sections 3.1 to 3.8, Chapter 7 : Sections 1.1 to 1.17(20 hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	2	2	1
Module II	3	2	1
Module III	3	2	1
Module IV	2	2	1
Total	10	8	4

References:-

1. Robert G. Bartle Donald R. Sherbert, Introduction to Real Analysis, 4th Edition, John Wiley and Sons, New York.
2. Gerald B. Folland, Real Analysis: Modern Techniques and Their Applications, 2nd Edition, Wiley-Interscience Publication, John Wiley and Sons, New York.
3. Royden H.L, Real Analysis, 2nd edition, Macmillan, New York.
4. Kenneth A. Ross, Elementary Analysis - The Theory of Calculus Second Edition, Springer International
5. ShantiNarayan & M.D. Raisinghania, Elements of Real Analysis, 7th Edition, S. Chand Publishing, New Delhi

ME010105 – GRAPH THEORY

5 Hours/Week (Total Hours : 90)

4 Credits

Text : R. Balakrishnan and K. Ranganathan , A Text book of Graph Theory, Second edition Springer.

Module I: Introduction, _Basic concepts. Sub graphs. Degrees of vertices. Paths and Connectedness, Automorphism of a simple graph, line graphs, Operations on graphs, Graph Products.

Directed Graphs : Introduction, basic concepts and tournaments.

(Chapter 1 Sections 1.1 – 1.7(Upto 1.7.3 including) 1.8, 1.9)

(Chapter 1 Sections 2.1, 2.2, 2.3) (20Hours)

Module II: Connectivity : Introduction, Vertex cuts and edge cuts, connectivity and edge connectivity, blocks, Cyclical edge Connectivity of a graph.

Trees; Introduction, Definition, characterization and simple properties, centres and cancroids, counting the number of spanning trees, Cayley’s formula. Applications

(Chapter 3 Sections 3.1, 3.2 , 3.3, 3.4 and 3.5)

(Chapter 4 Sections4.1, 4.2, 4.3, 4.4 (Up to 4.4.3 including) and 4.5, 4.7)

(25Hours)

Module III: Eulerian and Hamiltonian Graphs: Introduction, Eulereian graphs, Hamiltonian Graphs, Hamiltonian around’ the world’ game

Graph Colorings: Introduction, Vertex Colorings, Applications of Graph Coloring, Critical Graphs, Brooks’ Theorem

(Chapter 6 Sections 6.1, 6.2 and 6.3)

(Chapter 7 Sections 7.1, 7.2 and7.3(Up to 7.3.1 including) (20Hours)

Module IV: Planarity: Introduction, Planar and Nonplanar Graphs, Euler Formula and Its Consequences, K_5 and $K_{3,3}$ are Nonplanar Graphs, Dual of a Plane Graph, The Four-Color Theorem and the Heawood Five-Color Theorem .

Spectral Properties of Graphs: Introduction, The Spectrum of a Graph, Spectrum of the Complete Graph K_n , Spectrum of the Cycle C_n ,

(Chapter 8 Sections 8.1, 8.2 , 8.3, 8.4, 8.5 and 8.6)

(Chapter 11 Sections 11.1, 11.2 , 11.3 and 11.4) (25Hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	2	2	1
Module II	3	2	1
Module III	3	2	1
Module IV	2	2	1
Total	10	8	4

References:

1. John Clark and Derek Allan Holton, A First Look at Graph Theory, Allied Publishers.
2. Douglas B West, Introduction to Graph Theory, Prentice Hall of India.
3. Sheldon Axler, Linear algebra done right, Second edition ,Springer.

SECOND SEMESTER COURSES

ME010201	Advanced Abstract Algebra
ME010202	Advanced Topology
ME010203	Numerical Analysis with Python
ME010204	Complex Analysis
ME010205	Measure and Integration

ME010201 - ADVANCED ABSTRACT ALGEBRA

5 Hours/Week (Total Hours : 90)

4 Credits

Text Book : John B. Fraleigh, A First Course in Abstract Algebra, 7th edition, Pearson Education.

- Module 1:** Introduction to extension fields, algebraic extensions, Geometric Constructions Finite fields.
(Part VI – Section 29, 31 – 31.1 to 31.18, 32, 33 of the text) (20 hours)
- Module 2:** Unique factorization domains, Euclidean domains. Gaussian integers and multiplicative norms
(Part IX – Sections 45,46 & 47 of the text) (20 hours)
- Module 3:** Automorphism of fields, the isomorphism extension theorem , Splitting fields.
(Part X – Sections 48 & 49, 50 of the text) (25 hours)
- Module 4:** Separable extensions, Galois Theory, Illustrations of Galois Theory, Cyclotomic Extensions. (mention the insolubility of the quintic)
(Sections 51, 53, 54, 55 - 55.1 to 55.6 of the text) (25 hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	2	2	1
Module II	3	2	1
Module III	3	2	1
Module IV	2	2	1
Total	10	8	4

References:-

1. David S Dummit, Richard M Foote, Abstract Algebra, Third Edition, Wiley.
2. I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.
3. M. Artin, Algebra, Prentice -Hall of India, 1991.
4. Charles Lanski, Concepts in Abstract Algebra, American Mathematical Society, 2004.
5. Klaus Jonich. Linear Algebra, Springer Verlag.
6. Paul R. Halmos, Linear Algebra Problem Book, The Mathematical Association of America.
7. S. Lang, Algebra, 3rd edition, Addison-Wesley, 1993.
8. K.B. Datta, Matrix and Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2000.
9. Roger A. Horn, Charles R. Johnson, Matrix Analysis, Second Edition, Cambridge University press.

ME010202 - ADVANCED TOPOLOGY

5 Hours/Week (Total Hours : 90)

4 Credits

Text 1 : K.D Joshi , Introduction to General Topology , Wiley Eastern Ltd, 1984

Text 2 : James R. Munkres , Topology(second edition) , Pearson

Module I : Separation axioms:- Compactness and Separation axioms , The Urysohn Characterisation of normality –Tietze Characterisation of normality .
(Chapter 7: Sections 2; 2.1 to 2.10 Section 3; 3.1 to 3.6 – Proof of Lemma 3.4 excluded Section 4; 4.1 to 4.7 of text 1) (20hours)

Module II : Products and Co-products:- Cartesian products of families of sets – The product topology -Productive properties.
(Chapter 8 : Section 1; 1.1 to 1.9 Section 2; 2.1 to 2.8 , Section 3 – 3.1 to 3.6 of text 1) (25hours)

Module III : Embedding and Metrisation;- Evaluation functions into products – Embedding lemma and Tychonoff Embedding – The Urysohn Metrisation Theorem
(Chapter 9: Section 1; 1.1 1.5, Section 2; 2.1 to 2.5 Section, 3; 3.1 to 3.4 Variation of compactness (Chapter 11:Sections 1.1 to 1.11 of text 1)
(25 hours)

Module IV : Definition and convergence of nets, Homotopy of paths.
(Chapter 10: Section 1 of text 1; Chapter 9 : Section 1 of text 2) (20hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	2	2	1
Module II	3	2	1
Module III	3	2	1
Module IV	2	2	1
Total	10	8	4

References:

- 3) George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company,1963
- 4) I.M. Singer &J.A. Thorpe ,Lecture Notes on Elementary Topology &Geometry, Springer Verlag 2004

ME010203 Numerical Analysis with Python3

5 Hours/Week (Total Hours : 90)

4 Credits

- Text 1** Jason R Briggs , Python for kids – a playful introduction to programming, No Starch Press
- Text 2** Amit Saha, Doing Math with Python, No Starch Press, 2015.
- Text 3** Jaan Kiusalaas, Numerical Methods in Engineering with Python3, Cambridge University Press.

Though any distribution of Python 3 software can be used for practical sessions, to avoid difficulty in getting and installing required modules like numpy, scipy etc, and for uniformity, the Python3 package *Anaconda 2018.x* (<https://www.anaconda.com/distribution/#download-section>) may be installed and used for the practical sessions. However, a brief introduction on how to use Python IDLE 3 also should be given.

BASICS OF PYTHON

Before going into mathematics programming part, an introduction to Python should be given. No questions should be included in the end semester examination from this unit. Internal examinations may test the knowledge of concepts from this section.

From Text 1, Chapter 2 full – calculations and variables,

Chapter 3 – creating strings, lists are more powerful than strings, tuples,

Chapter 5- If statements, if-then-else statements, if and elif statements, combining conditions, the difference between strings and numbers,

Chapter 6 – using for loops, while we are talking about looping,

Chapter 7 – using functions, parts of a function, using modules

Chapter 9 – The functions abs, float, int, len, max, min, range, sum

From Text 2 Chapter 1 - section complex numbers

Unit I -

Module I : Defining Symbols and Symbolic Operations, Working with Expressions, Solving Equations and Plotting Using SymPy, problems on factor finder, summing a series and solving single variable inequalities

Chapter 4 - From text 2

Unit II

Module II : Finding the limit of functions, finding the derivative of functions, higher-order derivatives and finding the maxima and minima and finding the integrals of functions are to be done. In the section programming challenges, the following problems - verify the continuity of a function at a point, area between two curves and finding the length of a curve

Chapter 7 from text 2

Unit III

Module III : Interpolation and Curve Fitting - Polynomial Interpolation - Lagrange's Method, Newton's Method and Limitations of Polynomial Interpolation,

Roots of Equations - Method of Bisection and Newton-Raphson Method.

Chapter 3, sections 3.1, 3.2 Chapter 4, sections 4.1, 4.3, 4.5 From Text 3, -

Unit IV-

Module III : Gauss Elimination Method (excluding Multiple Sets of Equations), Doolittle's Decomposition Method only from LU Decomposition Methods

Numerical Integration, Newton-Cotes Formulas, Trapezoidal rule, Simpson's rule and Simpson's 3/8 rule.

Chapter 2, sections 2.2, 2.3 , Chapter 6, sections 6.1, 6.2 From Text 3.

1. Instead of assignments, a practical record book should be maintained by the students. At least 15 programmes should be included in this record book.
2. Internal assessment examinations should be conducted as practical lab examinations by the faculty handling the paper.
3. End semester examination should focus on questions including concepts from theory and programming. However, more importance should be given to theory in the end semester examinations as internal examinations will be giving more focus on programming sessions.

Question Paper Pattern

	Section A	Section B	Section C
Module I	2	2	1
Module II	3	2	1
Module III	3	2	1
Module IV	2	2	1
Total	10	8	4

References

1. A primer on scientific programming with python, 3rd edition, Hans Petter Langtangen, Springer
2. Vernon L. Ceder, The Quick Python Book, Second Edition, Manning.
3. NumPy Reference Release 1.12.0, Written by the NumPy community. (available for free download at <https://docs.scipy.org/doc/numpy-dev/numpy-ref.pdf>)
4. S. D. Conte and Carl de Boor, Elementary Numerical Analysis – An algorithmic approach, Third Edition, McGraw-Hill Book Company.
5. S.S. Sastry, Introductory Methods of Numerical Analysis, Fifth Edition, PHI.

ME010204 COMPLEX ANALYSIS

5 Hours/Week (Total Hours : 90)

4 Credits

Text Book : Lars V. Ahlfors, Complex Analysis, Third edition, McGraw Hill Internationals

Module-1 The spherical representation of complex numbers , Riemann Sphere, Stereographic projection, Distance between the stereographic projections

Elementary Theory of power series, Abel's Theorem on convergence of the power series, Hadamard's formula, Abel's limit Theorem

Arcs and closed curves, Analytic functions in regions, Conformal mappings, Length and area ,Linear transformations , The cross ratio, Symmetry, Oriented circles, Families of circles.

Chapter – 1 Section .Chapter – 2 Sections.2.1 to 2.5,Chapter – 3 Sections 2.1, 2.2, 2.3,2.4and ,3.1 to 3.4 of the text (25 hours)

Module-2 Fundamental theorems on complex integration: line integrals, rectifiable arcs, line integrals as functions of arcs, Cauchy's theorem for a rectangle, Cauchy's theorem in a disk,

Cauchy's integral formula: the index of a point with respect to a closed curve, the integral formula.

(Chapter 4 – Sections 1 , 2.1 and 2.2 of the text.) (20 hours.)

Module-3 Higher derivatives. Differentiation under the sign of integration, Morera's Theorem, Liouville's Theorem, Fundamental Theorem, Cauchy's estimate

Local properties of analytical functions: removable singularities, Taylor's theorem, zeroes and poles, Weierstrass Theorem on essential singularity, the local mapping, the maximum principle. Schwarz lemma

Chapter-4 sections 2.3, 3.1,3.2,3.3, and 3.4 of the text (20 hours)

Module-4 The general form of Cauchy's theorem: chains and cycles, simple connectivity, homology, general statement of Cauchy's theorem, proof of Cauchy's theorem, locally exact differentiation, multiply connected regions

Calculus of Residues: the residue theorem, the argument principle, evaluation of definite integrals.

Chapter-4 Sections 4 and 5 of the text (25 hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	2	2	1
Module II	3	2	1
Module III	3	2	1
Module IV	2	2	1
Total	10	8	4

References:-

1. Chaudhary. B, The elements of Complex Analysis, Wiley Eastern.
2. Cartan. H (1973), Elementary theory of Analytic functions of one or several variable, Addison Wesley.
3. Conway .J.B, Functions of one Complex variable, Narosa publishing.
4. Lang. S, Complex Analysis, Springer.
5. H.A. Priestly, Introduction to Complex Analysis, Clarendon press, Oxford, 1990

ME010205 - MEASURE THEORY AND INTEGRATION

5 Hours/Week (Total Hours : 90)

4 Credits

Text Book: H. L. Royden, P.M. Fitzpatrick, Real Analysis Fourth Edition, Pearson Education

Module 1: Lebesgue Measure: Introduction, Lebesgue outer measure, The σ algebra of Lebesgue measurable sets, Outer and inner approximation of Lebesgue measurable sets, Countable additivity, continuity and Borel-Cantelli Lemma - Non measurable sets - The Cantor set and Cantor Lebesgue function

Chapter 2; Sections 2.1 to 2.7 (25 Hours)

Module 2: Lebesgue Measurable Functions and Lebesgue Integration: Sums, products and compositions – Sequential pointwise limits and simple approximation – The Riemann Integral – The Lebesgue integral of a bounded measurable function over a set of finite measure – The Lebesgue integral of a measurable non negative function – The general Lebesgue integral.

Chapter 3; Sections 3.1 to 3.2, Chapter 4; Sections 4.1 to 4.4(25 Hours)

Module 3: General Measure Space and Measurable Functions: Measures and measurable sets – Signed Measures: The Hahn and Jordan decompositions – The Caratheodory measure induced by an outer measure – Measurable functions

Chapter 17; Sections 17.1 to 17.3, Chapter 18; Section 18.1 upto corollary 7 (20 Hours)

Module 4: Integration over General Measure Space and Product Measures: Integration of non negative measurable functions – Integration of general measurable functions – The Radon Nikodym Theorem – Product measure: The theorems of Fubini and Tonelli

Chapter 18; Sections 18.2 to 18.4, Chapter 20; Section 20.1 (20 Hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	3	2	1
Module II	3	2	1
Module III	2	2	1
Module IV	2	2	1
Total	10	8	4

References:

1. G. de Barra : Measure Theory and integration , New Age International (P) Ltd., New DelhiNew Age International (P) Ltd., New Delhi,
- 2.Halmos P.R, Measure Theory, D.vanNostrand Co.
3. P.K. Jain and V.P. Gupta, Lebesgue Measure and Integration, New Age International (P) Ltd., New Delhi, 1986(Reprint 2000).
4. R.G. Bartle, The Elements of Integration, John Wiley & Sons, Inc New York, 1966.

THIRD SEMESTER COURSES

ME010301	Advanced Complex Analysis
ME010302	Partial Differential Equations
ME010303	Multivariate Calculus
ME010304	Functional Analysis
ME010305	Optimization Technique

ME010301 - Advanced Complex Analysis

5 Hours/Week (Total Hours : 90)

4 Credits

Text book : Complex Analysis – Lars V. Ahlfors (Third Edition), McGraw Hill Book Company

Module 1: Harmonic Functions – Definitions and Basic Properties, The Mean-Value Property, Poisson’s Formula, Schwarz’s Theorem, The Reflection Principle. A closer look at Harmonic Functions – Functions with Mean Value Property, Harnack’s Principle.

The Dirichlet’s Problem – Subharmonic Functions, Solution of Dirichlet’s Problem (Proof of Dirichlet’s Problem and Proofs of Lemma 1 and 2 excluded)

(Chapter 4 : Section 6: 6.1 - 6.5, Chapter 6 : Section 3 : 3.1 - 3.2 , Section 4 : 4.1 - 4.2)

Module 2: Power Series Expansions – Weierstrass’s theorem, The Taylor Series, The Laurent Series Partial Fractions and Factorization – Partial Fractions, Infinite Products, Canonical Products, The Gamma Function. Entire Functions – Jensen’s Formula, Hadamard’s Theorem (Hadamard’s theorem - proof excluded)

(Chapter 5 : Section 1 : 1.1 - 1.3, Section 2 : 2.1 – 2.4, Section 3 : 3.1 – 3.2)

Module 3: The Riemann Zeta Function – The Product Development, The Extension of $\zeta(s)$ to the Whole Plane, The Functional Equation, The Zeroes of the Zeta Function

Normal Families – Normality and Compactness, Arzela’s Theorem

(Chapter 5 : Section 4 : 4.1 – 4.4, Section 5 : 5.2 - 5.3)

Module 4: The Riemann Mapping Theorem – Statement and Proof, Boundary Behaviour, Use of the Reflection Principle

The Weierstrass’s Theory – The Weierstrass’s ρ - function, The functions $\zeta(s)$ and $\sigma(z)$, The Differential Equation

(Chapter 6 : Section 1: 1.1-1.3, Chapter 7 : Section 3 : 3.1 – 3.3)

Question Paper Pattern

	Section A	Section B	Section C
Module I	2	2	1
Module II	3	2	1
Module III	3	2	1
Module IV	2	2	1
Total	10	8	4

References:

1. Chaudhary B., The Elements of Complex Analysis, Wiley Eastern.
2. Cartan H., Elementary theory of Analytic Functions of one or several variable, Addison Wesley, 1973.
3. Conway J. B., Functions of one complex variable, Narosa publishing.
4. Lang S., Complex Analysis, Springer.
5. H. A. Priestly, Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.
6. Ponnuswamy S., Silverman H., Complex Variables with Applicatio

ME010302 - PARTIAL DIFFERENTIAL EQUATIONS

5 Hours/Week (Total Hours: 90)

4 Credits

Text Book: Ian Sneddon , Elements of Partial Differential Equations, Mc Graw Hill Book Company

Module 1: Methods of solutions of $dx/P = dy/Q = dz/R$. Orthogonal trajectories of a system of curves on a surface. Pfaffian differential forms and equations. Solution of Pfaffian differential equations in three variables, Partial differential equations. Origins of first order partial differential equation.
(20 hours)

Module 2: Linear equations of first order. Integral surfaces passing through a given curve. Surfaces orthogonal to a given system of surfaces. Nonlinear partial differential equation of the first order . Compatible systems of first order equations . Charpits Method. Special types of first order equations. Solutions satisfying given conditions.
(25 hours)

Module 3: Jacobi' s method The origin of second order equations. Linear partial differential equations with constant coefficients. Equations with variable coefficients.
(20 hours)

Module 4.: Separation of variables. Non linear equations of the second order . Elementary solutions of Laplace equation. Families of equipotential surfaces. The two dimensional Laplace Equation Relation of the Logarithmic potential to the Theory of Functions.
(25 hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	2	2	1
Module II	3	2	1
Module III	3	2	1
Module IV	2	2	1
Total	10	8	4

References:

1. Phoolan Prasad and Renuka Ravindran, Partial Differential Equations, New Age International
2. K Sankara Rao, Introduction to Partial Differential Equations, Prentice Hall of India
3. E T Copson, Partial Differential Equations, S Chand and Co

ME010303 - MULTIVARIATE CALCULUS AND INTEGRAL TRANSFORMS

5 Hours/Week (Total Hours : 90)

4 Credits

Text 1: Tom Apostol, *Mathematical Analysis, Second edition*, Narosa Publishing House.

Text 2: Walter Rudin, *Principles of Mathematical Analysis, Third edition – International Student Edition*.

Module 1: The Weirstrass theorem, other forms of Fourier series, the Fourier integral theorem, the exponential form of the Fourier integral theorem, integral transforms and convolutions, the convolution theorem for Fourier transforms.

(Chapter 11 Sections 11.15 to 11.21 of Text 1) (20 hours.)

Module 2: Multivariable Differential Calculus

The directional derivative, directional derivatives and continuity, the total derivative, the total derivative expressed in terms of partial derivatives, An application of complex- valued functions, the matrix of a linear function, the Jacobian matrix, the matrix form of the chain rule. Implicit functions and extremum problems, the mean value theorem for differentiable functions,

(Chapter 12 Sections. 12.1 to 12.11 of Text 1) (22 hours.)

Module 3: A sufficient condition for differentiability, a sufficient condition for equality of mixed partial derivatives, functions with non-zero Jacobian determinant, the inverse function theorem ,the implicit function theorem, extrema of real- valued functions of one variable, extrema of real- valued functions of several variables.

Chapter 12 Sections-. 12.12 to 12.13 of Text 1

Chapter 13 Sections-. 13.1 to 13.6 of Text 1 (28 hours.)

Module 4: Integration of Differential Forms

Integration, primitive mappings, partitions of unity, change of variables, differential forms.

(Chapter 10 Sections. 10.1 to 10.14 of Text 2) (20 hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	2	2	1
Module II	3	2	1
Module III	3	2	1
Module IV	2	2	1
Total	10	8	4

References:-

1. Limaye Balmohan Vishnu, Multivariate Analysis, Springer.
2. Satish Shirali and Harikrishnan, Multivariable Analysis, Springer

ME010304 - FUNCTIONAL ANALYSIS

5 Hours/Week (Total Hours : 90)

4 Credits

Text Book: Erwin Kreyszig, **Introductory Functional Analysis with applications**, John Wiley and sons, New York

Module 1: Examples, Completeness proofs, Completion of Metric Spaces, Vector Space, Normed Space, Banach space, Further Properties of Normed Spaces, Finite Dimensional Normed spaces and Subspaces, Compactness and Finite Dimension

(Chapter 1 – Sections 1.5, 1.6; Chapter 2 - Sections 2.1 to 2.5)

Module 2: Linear Operators, Bounded and Continuous Linear Operators, Linear Functionals, Linear Operators and Functionals on Finite dimensional spaces, Normed spaces of operators, Dual space

(Chapter 2 - Section 2.6 to 2.10)

Module 3: Inner Product Space, Hilbert space, Further properties of Inner Product Space, Orthogonal Complements and Direct Sums, Orthonormal sets and sequences, Series related to Orthonormal sequences and sets, Total Orthonormal sets and sequences, Representation of Functionals on Hilbert Spaces

(Chapter 3 - Sections 3.1 to 3.6, 3.8)

Module 4: Hilbert-Adjoint Operator, Self-Adjoint, Unitary and Normal Operators, Zorn's lemma, Hahn- Banach theorem, Hahn- Banach theorem for Complex Vector Spaces and Normed Spaces, Adjoint Operators

(Chapter 3 - Sections 3.9, 3.10; Chapter 4 - Sections 4.1 to 4.3, 4.5)

Question Paper Pattern

	Section A	Section B	Section C
Module I	2	2	1
Module II	3	2	1
Module III	3	2	1
Module IV	2	2	1
Total	10	8	4

References

1. Limaye, B.V, Functional Analysis, New Age International (P) LTD, New Delhi, 2004
2. Simmons, G.F, Introduction to Topology and Modern Analysis, McGraw –Hill, New York, 1963
3. Siddiqi, A.H, Functional Analysis with Applications, Tata McGraw –Hill, New Delhi, 1989

4. Somasundaram. D, Functional Analysis, S.Viswanathan Pvt. Ltd, Madras, 1994
5. Vasistha, A.R and Sharma I.N, Functional analysis, Krishnan Prakasan Media (P) Ltd, Meerut: 1995-96
6. M. Thamban Nair, Functional Analysis, A First Course, Prentice – Hall of India Pvt. Ltd, 2008
7. Walter Rudin, Functional Analysis, TMH Edition, 1974.

ME010305 OPTIMIZATION TECHNIQUES

5 hours/week (Total Hours : 90)

4 credits

Text -1 K.V. Mital and C. Mohan, **Optimization Methods in Operation Research and Systems Analysis**, 3rd edition.

Text -2 Ravindran, Philips and Solberg. **Operations Research Principle and Practice**, 2nd edition, John Wiley and Sons.

Module I: LINEAR PROGRAMMING

Simplex Method, Canonical form of equations, Simplex Method (Numerical Example), Simplex Tableau, Finding the first BFS and artificial variables, Degeneracy, Simplex multipliers, Revised simplex method, Duality in LPP, Duality theorems, Applications of Duality, Dual simplex method, Summary of simplex methods.

(Chapter 3; sections: 9 – 21 of text – 1) (25 hours)

Module II: INTEGER PROGRAMMING

I.L.P in two dimensional space – General I.L.P. and M.I.L.P problems – cutting planes – remarks on cutting plane methods – branch and bound method – examples – general description – the 0 – 1 variable.

(Chapter 6; sections: 6.1 – 6.10 of text – 1) (25 hours)

Module III: GOAL PROGRAMMING , FLOW AND POTENTIALS IN NETWORKS

Goal programming. Graphs- definitions and notation – minimum path problem – spanning tree of minimum length – problem of minimum potential difference – scheduling of sequential activities – maximum flow problem – duality in the maximum flow problem – generalized problem of maximum flow.

(Chapter – 5 & 7 Sections 5.9 & 7.1 to 7.9, 7.15 of text - 1) (15 hours)

Module IV: NON- LINEAR PROGRAMMING

Basic concepts – Taylor’s series expansion – Fibonacci Search - golden section search– Hooke and Jeeves search algorithm – gradient projection search – Lagrange multipliers – equality constraint optimization, constrained derivatives – non-linear optimization: Kuhn-Tucker conditions – complimentary Pivot algorithms.

(Chapter 11; Sections: 11.1 – 11.7, 11.9- 11.11 of text – 2) (25 hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	3	2	1
Module II	2	2	1
Module III	2	2	1
Module IV	3	2	1
Total	10	8	4

Reference:-

1. S.S. Rao, Optimization Theory and Applications, 2nd edition, New Age International Pvt.
2. J.K. Sharma, Operations Research: Theory and Applications, 3rd edition, Macmillan India Ltd.
3. Hamdy A. Thaha, Operations Research – An Introduction, 6th edition, Prentice Hall of India Pvt. Ltd.

FOURTH SEMESTER COURSES

ME010401	Spectral Theory
ME010402	Analytic Number Theory
Elective Group A	
ME800401	Differential Geometry
ME800402	Algorithmic Graph Theory
ME800403	Combinatorics
Elective Group B	
ME810401	Probability Theory
ME810402	Operations Research
ME810403	Coding Theory
Elective Group C	
ME820401	Commutate Algebra
ME820402	Ordinary Differential Equations
ME820403	Classical Mechanics

ME010401 - SPECTRAL THEORY

5 Hours/Week (Total Hours : 90)

4 Credits

Text Book: Erwin Kreyszig, **Introductory Functional Analysis with applications**, John Wiley and sons, New York

Module I: Reflexive Spaces, Category theorem(statement only), Uniform Boundedness theorem (applications excluded), Strong and Weak Convergence, Convergence of Sequences of Operators and Functionals, Open Mapping Theorem, Closed Linear Operators, Closed Graph Theorem

(Chapter 4 - Sections 4.6 to 4.9, 4.12, 4.13) (20 Hours)

Module 2: Banach Fixed point theorem, Spectral theory in Finite Dimensional Normed Spaces, Basic Concepts, Spectral Properties of Bounded Linear Operators, Further Properties of Resolvent and Spectrum, Use of Complex Analysis in Spectral Theory

(Chapter 5 – Section 5.1; Chapter 7 - Sections 7.1 to 7.5) (25 Hours)

Module 3: Banach Algebras, Further Properties of Banach Algebras, Compact Linear Operators on Normed spaces, Further Properties of Compact Linear Operators, Spectral Properties of compact Linear Operators on Normed spaces, Further Spectral Properties of Compact Linear Operators

(Chapter 7 - Sections 7.6, 7.7; Chapter 8 - Sections 8.1 to 8.4)

(25 Hours)

Module 4: Spectral Properties of Bounded Self adjoint linear operators, Further Spectral Properties of Bounded Self Adjoint Linear Operators, Positive Operators, Projection Operators, Further Properties of Projections

(Chapter 9 - Sections 9.1 to 9.3, 9.5, 9.6) (20 Hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	2	2	1
Module II	3	2	1
Module III	3	2	1
Module IV	2	2	1
Total	10	8	4

References

1. Limaye, B.V, Functional Analysis, New Age International (P) LTD, New Delhi, 2004
2. Simmons, G.F, Introduction to Topology and Modern Analysis, McGraw –Hill, New York, 1963
3. Siddiqi, A.H, Functional Analysis with Applications, Tata McGraw –Hill, New Delhi, 1989
4. Somasundaram. D, Functional Analysis, S.Viswanathan Pvt. Ltd, Madras, 1994
5. Vasistha, A.R and Sharma I.N, Functional analysis, Krishnan Prakasan Media (P) Ltd, Meerut: 1995-96
6. M. Thamban Nair, Functional Analysis, A First Course, Prentice – Hall of India Pvt. Ltd, 2008
7. Walter Rudin, Functional Analysis, TMH Edition, 1974.

ME010402 - ANALYTIC NUMBER THEORY

5 Hours/Week (Total Hours : 90)

4 Credits

Text: Tom M. Apostol, *Introduction to Analytic Number Theory*, Springer International Student Edition, Narosa Publishing House

Module I: Arithmetic Functions, Dirichlet Multiplication and Averages of Arithmetical functions Arithmetic Functions, Dirichlet Multiplication: Introduction, The Möbius function $\mu(n)$, The Euler totient function $\phi(n)$, a relation connecting μ and ϕ , a product formula for $\phi(n)$, The Dirichlet product of arithmetical functions, Dirichlet inverses and the Möbius inversion formula, The Mangoldt function $\Lambda(n)$, Multiplicative functions, Multiplicative functions and Dirichlet Multiplication, The inverse of a completely multiplicative function, The Liouville's function $\lambda(n)$, The divisor function $\sigma_\alpha(n)$, Generalized convolutions

Averages of Arithmetical functions: Introduction, The big oh notation, Asymptotic equality of functions, Euler's summation formula, Some elementary asymptotic formulas, The average order of $d(n)$, The average order of the divisor functions $\sigma_\alpha(n)$, The average order of $\phi(n)$, An application to the distribution of lattice points visible from the origin, The average order of $\mu(n)$ and of $\Lambda(n)$, The partial sums of a Dirichlet product, Applications to $\mu(n)$ and of $\Lambda(n)$.

(Chapter 2: sections 2.1 to 2.14, Chapter 3: 3.1 to 3.11) (30 hours)

Module II: Some Elementary Theorems on the Distribution of Prime Numbers Introduction, Chebyshev's functions $\psi(x)$ and $\vartheta(x)$, Relation connecting $\vartheta(x)$ and $\pi(x)$, Some equivalent forms of the prime number theorem, Inequalities for $\pi(n)$ and P_n , Shapiro's tauberian theorem, Applications of Shapiro's theorem, An asymptotic formula for the partial sum $\sum_{p \leq x} \frac{1}{p}$.

(chapter 4: sections 4.1 to 4.8) (15 hours)

Module III: Congruences: Definitions and basic properties of congruences, Residue classes and complete residue system, Linear congruences, Reduced residue systems and Euler-Fermat theorem, Polynomial congruences modulo p , Lagrange's theorem, Applications of Lagrange's theorem, Simultaneous linear congruences, The Chinese remainder theorem, Applications of the Chinese remainder theorem.

(chapter 5: 5.1 to 5.8) (25 hours)

Module IV: Quadratic Residues, The Quadratic Reciprocity Law and Primitive Roots, Quadratic Residues, The Quadratic Reciprocity Law: Quadratic residues, Legendre's symbol and its properties, evaluation of $(-1|p)$ and $(2|p)$, Gauss' Lemma, The quadratic reciprocity law, Applications of the reciprocity law. **(Chapter 9; 9.1 to 9.6)**

Primitive Roots: The exponent of a number mod m , Primitive roots, Primitive roots and reduced residue systems, The nonexistence of primitive roots mod 2^α for $\alpha \geq 3$, The existence of primitive root mod p for odd primes p , Primitive roots and quadratic residues.

(chapter 10: 10.1 to 10.5) (20 hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	3	2	1
Module II	2	2	1
Module III	3	2	1
Module IV	2	2	1
Total	10	8	4

References:

1. David M. Burton, Elementary number Theory, Seventh edition, Tata McGraw-Hill Edition 2012
2. Kenneth H. Rosen, Elementary Number Theory and its Applications, sixth edition, 2011
3. Hardy G.H. and Wright E.M., Introduction to the Theory of Numbers, Oxford, 1981
4. Leveque W.J., Topics in Number Theory, Addison Wesley, 1961.
5. J.P. Serre, A Course in Arithmetic, GTM Vol.7, Springer-Verlag, 1973.

Elective Group A

ME800401 - DIFFERENTIAL GEOMETRY

5 Hours/Week (Total Hours : 90)

3 Credits

Text Book: John A. Thorpe, Elementary Topics in Differential Geometry

- Module 1:** Graphs and level sets, vector fields, the tangent space, surfaces, vector fields on surfaces, orientation.
(Chapters 1 to 5 of the text) (20 hours)
- Module 2:** The Gauss map, geodesics, Parallel transport,
(Chapters 6, 7 & 8 of the text) (20 hours)
- Module 3:** The Weingarten map, curvature of plane curves, Arc length and line integrals
(Chapters 9, 10 & 11 of the text) (25 hours)
- Module 4:** Curvature of surfaces and Parametrized surfaces
(Chapters 12 & 14 of the text). (25 hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	2	2	1
Module II	3	2	1
Module III	3	2	1
Module IV	2	2	1
Total	10	8	4

References:-

1. Serge Lang, Differential Manifolds
2. I.M. Siger, J.A Thorpe, Lecture notes on Elementary topology and Geometry, Springer – Verlag, 1967.
3. S. Sternberg, Lectures on Differential Geometry, Prentice-Hall, 1964.
4. M. DoCarmo, Differential Geometry of curves and surfaces.
5. Goursat, Mathematical Analysis, Vol – 1(last two chapters)

ME800402: ALGORITHMIC GRAPH THEORY

5 hours/week (Total Hours : 90)

3 credits

Text Book: Gray Chartrand and O.R Oellermann , Applied and Algorithmic Graph Theory, Tata McGraw- Hill Companies Inc

Module I: Introduction to Graphs and Algorithms

What is graph? The degree of a vertex. isomorphic graphs. subgraphs, degree sequences. connected graphs. cutvertices and blocks. special graphs. digraphs. algorithmic complexity. Search algorithms, sorting algorithms. greedy algorithms., representing graphs in a computer.

(Chapter 1 Sections 1.1 to 1.9, Chapter 2 Sections 2.1, 2.2 , 2.3, 2.5 and 2.6 of the text) (24 hours)

Module II: Trees, paths and distances

Properties of trees, rooted trees. Depth-first search,. breadth – first search, . the minimum spanning tree problem

Distance in a graphs, distance in weighted graphs, .the centre and median of a graph. Activity digraphs and critical paths.

(Chapter 3 sections 3.1 to 3.3.3.4 and 3.5 , Chapter 4 sections 4.1 to 4.4 of the text) (22 hours)

Module III: Networks

An introduction to networks. the max-flow min-cut theorem. the max-flow min-cut algorithm . Connectivity and edge connectivity . Mengers theorem.

(Chapter 5 sections 5.1 , 5.2 , 5.3 and 5.5 of the text) (22 hours)

Module IV: Matchings and Factorizations

An introduction to matchings . maximum matchings in a bipartite graph,. Factorizations. Block Designs.

(Chapter 6 sections 6.1 , 6.2 , 6.4 and 6.5 of the text) (22 hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	3	2	1
Module II	3	2	1
Module III	2	2	1
Module IV	2	2	1
Total	10	8	4

Reference:-

1. Alan Gibbons, Algorithmic Graph Theory, Cambridge University Press, 1985
 2. Mchugh. J.A, Algorithmic Graph Theory, Prentice-Hall, 1990
- Golumbic. M, Algorithmic Graph Theory and Perfect Graphs, Academic press.

ME800403 COMBINATORICS

5 Hours/Week (Total Hours : 90)

3 Credits

Text : Chen Chuan Chong , Koh Khee Meng , Principles and Techniques in Combinatorics., World Scientific Publishing, 2007

Module I Permutations and combinations: Two basic counting principles, Permutations, Circular permutations, Combinations, The injection and bijection principles, Arrangements and selections with repetitions, Distribution Problems
(Chapter 1 of the text Sections 1.1 – 1.7) (22 hours)

Module II The Pigeonhole Principle and Ramsey numbers: Introduction, The Pigeonhole principle, More examples, Ramsey Type problems and Ramsey numbers, Bounds for Ramsey numbers
(Chapter 3 of the text Sections 3.1 - 3.5) (18 hours)

Module III The Principle of Inclusion and Exclusion: Introduction, The principle, A generalization , Integer solutions and shortest routes, Surjective mappings and Stirling Numbers of second kind, Derangements and A Generalization.
(Chapter 4 of the text Sections 4.1 – 4.6) (25 hours)

Module IV Generating Functions & Recurrence relations: Generating Functions: Ordinary generating functions, Some modeling Problems, Partition of Integers, Exponential generating functions
Recurrence Relations: Introduction, Two examples, Linear homogeneous recurrence relations, General Linear recurrence relations.
(Chapter 5 & Chapter 6 of the text Sections 6.1- 6.4) (25 hours)

Question Paper Pattern

	Section A	Section B	Section C
Module I	3	2	1
Module II	2	2	1
Module III	3	2	1
Module IV	2	2	1
Total	10	8	4

References:-

1. V Krishnamoorthy, Combinatorics theory and applications, E. Hoewood, 1986
2. Hall,Jr, Combinatorial Theory, Wiley- Interscinice, 1998.
3. .Brualdi, R A, Introductory Combinatorics, Prentice Hall,1992