KERALA UNIVERSITY
SYLLABUS FOR M.Sc. MATHEMATICS
SEMESTER PATTERN IN AFFILIATEDCOLLEGES
2017 ADMISSIONWARDS

M.Sc. MATHEMATICS COURSE STRUCTURE & MARK DISTRIBUTION

Semester	Paper Code	Title of the paper	Distribution hrs per semester	Instructional hrs./ week		Dur ESA hrs.	Maximum Marks		
				L	P		CA	ESA	Total
I	MM 211	Linear Algebra	108	6	-	3 hrs	25	75	100
	MM 212	Real Analysis - I	108	6	-	“	25	75	100
	MM 213	Diff. Equation	108	6	-	“	25	75	100
	MM 214	Topology - I	126	7	-	“	25	75	100
II	MM 221	Abstract Algebra	108	6	-	3 hrs	25	75	100
	MM 222	Real Analysis-II	108	6	-	“	25	75	100
	MM 223	Topology-II	126	7	-	“	25	75	100
	MM 224	Scientific Programming with Python	108	6		“	25	75	100
III	MM 231	Complex Analysis-I	126	7	-	3 hrs	25	75	100
	MM 232	Functional Analysis-I	108	6	-	“	25	75	100
	MM 233	Elective-I	108	6	-	“	25	75	100
	MM 234	Elective-II	108	6	-	“	25	75	100
IV	MM 241	Complex Analysis-II	126	7	-	3 hrs	25	75	100
	MM 242	Functional Analysis-II	108	6	-	“	25	75	100
	MM 243	Elective-III	108	6	-	“	25	75	100
	MM 244	Elective-IV	108	6	-	“	25	75	100
	MM 245	Dissertation/ Project						80+20	100
		Comprehensive Viva							100
		GRAND TOTAL	**1800**						**1800**
L: Lecture; P: Practical; CA: Continuous Assessment; ESA: End Semester Examination									

M.Sc MATHEMATICS
(Revised Syllabus from 2017 Admissions)
LIST OF PAPERS

SEMESTER– I

MM211 Linear Algebra(Revised Syllabus)
MM212 Real Analysis - I (Revised Syllabus)
MM213 Differential Equations(Previous Syllabus)
MM214 Topology – I (Revised Syllabus)

SEMESTER – II

MM221 Abstract Algebra (Revised Syllabus)
MM222 Real Analysis - II(Revised Syllabus)
MM223 Topology – II (Revised Syllabus)
MM224 Scientific Programming with Python (New Syllabus)

SEMESTER– III

MM231 Complex Analysis – I (Previous Syllabus)
MM232 Functional Analysis – I (Revised Syllabus)
MM233 Elective (One among the following)
- Automata Theory (Previous Syllabus)
- Probability(Previous Syllabus)
- Operations Research (Previous Syllabus)
- Algebraic Topology (New Syllabus)

MM234 Elective (One among the following)
- Geometry of Numbers (Previous Syllabus)
- Differential Geometry (Revised Syllabus)
- Graph Theory (Revised Syllabus)
- Approximation Theory (Previous Syllabus)

SEMESTER – IV

MM241 Complex Analysis – II (Previous Syllabus)
MM242 Functional Analysis – II (Revised Syllabus)
MM243 Elective (One among the following)
- Mathematical Statistics (Revised Syllabus)
- Integral equations and Calculus of Variation (New Syllabus)
- Theory of Wavelets (Previous Syllabus)
- Coding Theory (Previous Syllabus)
- Field Theory (Previous Syllabus)
- Difference Equations (New Syllabus)

MM244 Elective (One among the following)
- Representation Theory of Finite Groups (Previous Syllabus)
- Category Theory (Previous Syllabus)
- Advanced Graph Theory (Previous Syllabus)
- Analytic Number Theory (Previous Syllabus)
- Mechanics (Revised Syllabus)
- Commutative Algebra (Previous Syllabus)

MM 211 Linear Algebra

Text

Sheldon Axler, Linear Algebra Done Right 2nd Edition, Springer.

Unit I

Vector spaces: Definition, Examples and properties, Subspaces, Sum and Direct sum of subspaces, Span and linear independence of vectors, Definition of finite dimensional vector spaces, Bases: Definition and existence, Dimension Theorems.
[Chapters 1,2 of Text]

Unit II

Linear maps, their null spaces and ranges, Operations on linear maps in the set of all linear maps from one space to another , Rank-Nullity Theorem , Matrix of linear map, its invetibilty. [Chapter 3 of Text]

Unit III

Invariant subspaces, Definition of eigen values and vectors, Polynomials of operators, Upper triangular matrices of linear operators, Equivalent condition for a set of vectors to give an upper triangular operator, Diagonal matrices, Invariant subspaces on real vector spaces. [Chapter 5 of Text]

Unit IV

Concept of generalized eigen vectors, Nilpotent operators, Characteristic polynomial of an operator, Cayley-Hamilton theorem, Condition for an operator to have a basis consisting of generalized eigen vectors, Minimal polynomial. Jordan form of an operator (General case of Cayley-Hamilton Theorem may be briefly sketched from the reference text) [Chapter 8 of Text]

Unit V

Change of basis, trace of an operator, Showing that trace of an operator is equal to the trace if its matrix, determinant of an operator, invertibilty of an operator and its determinant, relation between characteristic polynomial and determinant, determinant of matrices of an operator w.r.t. two base are the same. Determinant of a matrix (The section volumes may be omitted) [Chapter 10 of Text]

References

1. Kenneth Hoffman and Ray Kunze, Linear Algebra, Prentice Hall, 1981.
2. I.N Herstein, Linear Algebra, Wiley Eastern.
3. S. Kumaresan, Linear Algebra, Prentice Hal, 2000.

MM 212 REAL ANALYSIS-I

Texts: (1) Tom M. Apostol, Mathematical Analysis, Second Edition, Narosa 1974
(2) Sudhir R.Ghorpade and Balmohan V. Limaye, A course in Multivariate Calculus and Analysis, Springer, 2010

UNIT I

Functions of Bounded Variation and Rectifiable Curves: 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, Function of bounded variation expressed as the difference of increasing functions, Continuous functions of bounded variation, Curves and paths, Rectifiable paths and arc-length, Additive and continuity of arc length, Equivalence of paths, Change of parameter.
[Chapter 6 of Text 1]

UNIT II

The Riemann-Stieltjles Integral: The definition of Riemann-Steiltjles integral, Linear properties, Integration by parts, Change of variable in a Riemann –Stieltjes integral, Reduction to a Riemann integral, Step functions as integrators, Reduction of a Riemann-Stieltjes integral to a finite sum, Euler's summation formula, Monotonically increasing integrators, Upper and lower integrals, Additive and linearity properties of upper and lower integrals, Riemann's condition, Comparison Theorems, Integrators of bounded variation, Sufficient conditions for the existence of Riemann-Stieltjes integrals, Differentiation under the integral sign.
[Chapter 7, Sections 7.1-7.16,7.24 of Text 1]

UNIT III

Sequences of Functions: Point-wise convergence of sequences of functions, Examples of sequences of real-valued functions, Definition of uniform convergence, Uniform convergence and continuity. The Cauchy condition for uniform convergence, Uniform convergence of infinite series of functions, Uniform convergence and Riemann-Stieltjes integration, Non-uniformly convergent series that can be integrated term by term, Uniform convergence and differentiation, Sufficient conditions for uniform convergence of a series.
[Chapter 9, Sections 9.1-9.9 except 9.7 of text 1. Do suficient problems to study the uniform convergence of sequences and series]

UNIT IV

Multivariate Calculus: Sequences, continuity and limits. Sequences in R^2 , Sub-sequences and Cauchysequences, Compositions of continuous functions, Piecewise continuous functions on overlapping subsets, Characterizations of continuity, Continuity and boundedness, Continuity and convexity, Continuity and intermediate value property , Uniform continuity, Limits and continuity.
[Text 2. Sections 2.1, 2.2 (excluding Continuity and monotonicity, Continuity, Bounded Variation, Bounded Bivariation, implicit function theorem), 2.3 (Excluding Limits from a quadrant, Approaching Infinity)

UNIT V

Partial and Total Differentiation: Partial derivative, Directional derivatives, Higher order partial derivatives, Higher order directional derivatives, Differentiability
[Text2. Section 3.1 and 3.2 excluding subsection on Implicit Differentiation]

References:

1. **J.A Dieudonne, Foundations of Modern Analysis, Academic Press**
2. **W.Rudin, Principles of Mathematical Analysis, Third Edition**
3. **Tom M Apostol, Calculus, Volume 1, Wiley Edition.**
4. **Tom M Apostol, Calculus, Volume 2, Wiley Edition.**

MM 213 DIFFERENTIAL EQUATIONS

Texts (1) G.F Simmons, *Differential Equations (with Applications and Historical Notes)*, Tata Mc Graw-Hill
(2) T.Amarnath, *An elementary Course in Partial Differential Equations*, Narosa

UNIT 1

Solving second order Linear Equations- The method of undetermined coefficients, The method of variation of parameters, The method of successive approximations and Picards Theorem.
[Chapter 3: Sections 18,19; Chapter11: Sections 55, 56, 57 of Text 1]

UNIT II

Series solutions of first order equations - ordinary point - regular singular point - Gauss's Hype geometric equations-The point at infinity, Chebyshev polynomials.
[Chapter 5: Sections 25,26,27,28,29,30,31 and appendix D, excluding min max property of Text 1]

UNIT III

Special functions - Legendre polynomials - Bessel's functions - Gamma functions.
[Chapter 6: Sections 32,33,34,35 of Text 1]

UNIT IV

First Order PDE - Curves and Surfaces, Genesis of first order PDE, Classifications of integrals-Linear equation of first order- Pfaffian Differential Equations- Compatible systems- Charpits equations, Jacobi's method.
[Chapter 1: Section 1.1 to 1.8 of Text2]

UNIT V

Second order PDE - Classification of second order PDE - One dimensional wave equations-Vibration of finite string - Vibration of semi infinite string - Vibrations of infinite string, Laplace equations - Boundary value problem, Maximum and minimum principles.
[Chapter 2: Sections 2.1, 2.2, 2.3.1, 2.3.2, 2.3.3, 2.4.1, 2.4.2 of Text 2]

References

1] Iat Sneddon,*Elements of Partial Differential Equations* (MC Graw-Hill)
2] Phoolan Prasad, Renuka Raveendran, *Partial Differential Equations* (Wiley Eastern)
3] Zahir Ahsan, *Differential Equations and their Applications* (Prentice Hall 1999)
4] Earl A Coddington, Norman Levinson, *Theory of Ordinary Differential Equations* (Tata Mc Graw Hill)
5] G.Birkoff and G.C Rota, *Ordinary Differential Equations* (Wiley and Sons- 3rd Edn (1978)).
6] M.Ram Mohan Rao, *Ordinary Differential Equations and Applications.*

MM 214: Topology I

Text book:
Principles of Topology by Fred H. Croom, Baba Barkha Nath Printers (India), Third Reprint 2009.

In this course we discuss the basics of topology , based on chapters 3and 6. Students should be motivated as discussed in the first two chapters of the Text book.

Unit I

Metric Spaces:-Definition, Examples, Open sets, Closed sets, Interior, closure and boundary
Sections 3.1, 3.2, 3.3

Unit II

Continuous functions, Equivalence of metric spaces, Complete metric spaces-Cantor's Intersection Theorem.
Sections 3.4, 3.5, 3.7, Exercise 3.7(3).

Unit III

Topological spaces:-Definition, Examples, Interior, Closure, Boundary, Base, Sub base, Continuity, Topological Equivalence, Subspaces.
Sections 4.1, 4.2, 4.3, 4.4, 4.5

Unit IV

Connectedness and disconnected spaces, Theorems on connectedness, Connected subsets of real line, Applications of connectedness, Path connected spaces.
Sections 5.1, 5.2, 5.3, 5.4, 5.5

Unit V

Compact spaces, compactness and continuity, Properties related to compactness, One point compactification.
Sections 6.1, 6.2, 6.3,6.4

References

1. Gerald Buskes, Arnoud van Rooiji, Topological Spaces from Distance to Neighbourhood

2.James R. Munkres, Topology, PHI Learning Private Limited, Second Edition, 2009.

3. Stephen Willard, General Topology, Addison-Wesley, Reading, 1970.
4. G.F. Simmons, Topology and Modern Analysis, Mc Graw-Hill, New York, 13th reprint, 2010.

5. J Arthur Seebach, Lynn Arthur Steen, Counter Examples in Topology, Dover Publications, 1995.

6. Sheldon W. Davis, Topology, Tata Mc Graw-Hill Edition, 2006.

MM221 Abstract Algebra

Text: J A Gallian, Contemporary Abstract Algebra, 8thEdition, Cengage Learning.

Students are introduced to some basic ideas of abstract algebra in their previous course. Now in this course, we discuss more advanced topics of abstract algebra based on chapters 8, 9, 11, 14, 16, 17, 18, 20, 21, 32 and 33 of text. Students and teachers are advised to review the topics of group theory based on the chapters 1 to 7, 10, 12, 13 and 14 of text.

Unit I

Groups, Cyclic groups, Permutation groups, Cayley theorem, Cosets, Langrange Theorem, Isomorphism, Homomorphism – Definition and examples only. (Proof of theorems in chapters 1 to 7 may be omitted)(Chapter 1, 2, 3, 4, 5, 6 and 7). External direct product of groups – Definition and examples, properties, representing groups of units modulo n as external direct product, applications. Normal subgroups and factor groups, Application of factor groups, internal direct products(Chapter 8 and 9)

Unit II

Fundamental theorem of abelian groups, Isomorphism classes, proof of the fundamental theorem(Chapter 11). Sylow theorems, Conjugacy classes, the class equation, The Sylow theorems and Applications. Simple groups, examples, Non simplicity tests.(Chapter 24 and 25). Theorems 25.1, 25.2 and 25.3 and corollary 1(Index Theorem), corollary 2 (embedding Theorem)may be discussed without proof.

Unit III

Rings, Fields, Integral Domain, Characteristic of a ring, Homomorphism - Definition and Examples (chapter 12 and 13) (Proof of theorems in chapters 12 and 13 may be omitted). Ideals, Factor rings, Prime ideals and Maximal ideals, Construction of field of Quotients, Factorization of polynomials, Reducibility tests, Unique factorization in Z[x](Chapters 14, 15, 17 – irreducibility tests and proof of theorem 17.6 of chapter 17 may be omitted)

Unit IV

Divisibility in Integral domains-Irreducibles, Primes, Historical Discussion of Fermat’s Last Theorem, Unique Factorization domains, Euclidean domains. Extension fields, Fundamental Theorem of Field Theory, Splitting fields, Zeros of irreducible polynomial.(chapters 18 and 20)

Unit V

Algebraic extensions, Characterization of extensions, Finite extensions, Properties of algebraic extensions, Fundamental theorem of Galois Theory(without proof), Solvability of polynomials by radicals, Insolvability of Quintic.(Chapters 21, 32(proof of theorems 32.4 and 32.5 may be omitted),

References:

1. **J B Fraleigh, A first course in Abstract Algebra, Seventh Edition, Pearson Education Inc.**
2. **I N Herstein, Topics in Algebra, Second Edition, Wiley**
3. **Neal H McCoy, Gerald J Janusz, Introduction to Abstract Algebra, sixth edition, Academic Press**
4. **Hungerford, Algebra, Springer**

MM 222 REAL ANALYSIS-II

Texts: (1) G.de.Barra, Measure Theory and Integration, New Age International Publishers, New Delhi, 1981.

UNIT I

Lebesgue Outer Measure, Measurable sets, Regularity, Measurable functions, Borel and Lebesque Measurability

(Chapter 2, 2.1-2.5 of Text)

UNIT II

Integration of Non-negative functions, The General Integral, Integration of Series, Riemann and Lebesgue Integrals, The Four Derivatives, Lebesgue's Differentiation Theorem, Differentiations and Integration.

(Chapter 3, 3.1 to 3.4, Chapter 4, 4.1, 4.4 (statements only),4.5 of the Text)

UNIT III

Abstract Measure Spaces: Measures and Outer Measures, Extension of a measure, Uniqueness of the Extension, Completion of the Measure, Measure spaces, Integration with respect to a Measure (Chapter 5, 5.1-5.6 of Text)

UNIT IV

The L^p Spaces, Convex Functions, Jensen's Inequality, The Inequalities of Holder and Minkowski, Completeness of L^p (μ).

(Chapter 6, 6.1-6.5 of Text)

UNIT V

Convergence in Measure, Signed Measures and the Hahn Decomposition, The Jordan Decomposition, The Radon-Nikodym Theorem, Some Applications of the Radon-Nikodym Theorem. (Chapter 7,7.1 Chapter 8,8.1-8.4 of Text)

References:

(1) H.L.Roydon, Real Analysis, Third Edition, Mac-Millan

(2) W. Rudin, Real and Complex analysis, Tata Mc-Graw Hill Edition

(3) P.R Halmos, Measure Theory, Springer

MM 223: Topology II

Text book I: Principles of Topology by Fred H. Croom, Baba Barkha Nath Printers (India), Third Reprint 2009.

Text book II: Topology by Sheldon W. Davis, Tata Mc Graw-Hill Edition, 2006.

Unit I Product and Quotient spaces:- Finite and arbitrary products, Comparison of topologies, Quotient spaces.
Sections 7.1, 7.2, 7.3, 7.4 of Text I, (Alexander sub basis theorem and Theorem 7.11 excluded).

Unit II Separation axioms:-T_0;T_1 and T_2-spaces, Regular spaces, Normal spaces, Separation by continuous functions
Sections 8.1, 8.2, 8.3, 8.4 of Text I

Unit III Convergence, Tychnoff 's Theorem
Chapter 16, Theorem 18.21 and Theorem 18.22 of Text II

Unit IV Algebraic topology:- The fundamental group, The fundamental group of S^1.
Sections 9.1, 9.2, 9.3 of Text I

Unit V Examples of fundamental groups, The Brouwer Fixed Point Theorem.
Sections 9.4 and 9.5 of Text I

References

1. **Gerald Buskes, Arnoud van Rooiji, Topological Spaces from Distance to Neighbourhood**
2. **2.James R. Munkres, Topology, PHI Learning Private Limited, Second Edition, 2009.**
3. **Stephen Willard, General Topology, Addison-Wesley, Reading, 1970.**
4. **G.F. Simmons, Topology and Modern Analysis, Mc Graw-Hill, New York, 13th reprint, 2010.**
5. **J Arthur Seebach, Lynn Arthur Steen, Counter Examples in Topology, Dover Publications, 1995.**
6. **Sheldon W. Davis, Topology, Tata Mc Graw-Hill Edition, 2006.**

MM 224 Scientific Programming with Python

Text books:

1. Jaan Kiusalaas, ***Numerical Methods in Engineering with Python3***, Camdbridge University Press.
2. Amit Saha, ***Doing Math with Python***, No Starch Press, 2015.

Unit I

This unit is based on sections 1.1 to 1.5 of text 1. Even though some of the materials may be familiar to students, a quick review should be given as in the sections. For a detailed review it is recommended to consider chapters 4,5,6,8 and 9 of reference text 1. Importance should be given for defining functions and importing functions from modules.

Unit II

Visualizing Data with Graphs - learn a powerful way to present numerical data: by drawing graphs with Python. The unit is based on Chapter 2 of Text 2. The sections Creating Graphs with Matplotlib and Plotting with Formulas must be done in full. In the section Programming Challenges, the problems Exploring a Quadratic Function Visually, Visualizing Your Expenses and Exploring the Relationship Between the Fibonacci Sequence and the Golden Ratio must also be discussed.

Unit III

The unit is based on chapters 4 and 7 of Text 2. Here we discuss Algebra and Symbolic Math with SymPy and Solving Calculus Problems. In Chapter 4 the sections Defining Symbols and Symbolic Operations, Working with Expressions, Solving Equations and Plotting Using SymPy should be done in full. In the section Programming Challenges, the problems Factor Finder, Graphical Equation Solver, Summing a Series and Solving Single-Variable Inequalities also should be discussed.

In chapter 7, some problems discussed namely, 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 problems Verify the Continuity of a Function at a Point, Area Between Two Curves and Finding the Length of a Curve also should be discussed.

Unit IV

Gauss Elimination Method (excluding Multiple Sets of Equations), LU Decomposition Methods (Doolittle's Decomposition Method only).
[Sections 2.2, 2.3 of Text 1]

Interpolation and Curve Fitting - Polynomial Interpolation - Lagrange's Method, Newton's Method and Limitations of Polynomial Interpolation.
[Sections 3.1 and 3.2 of Text 1]

Roots of Equations - Method of Bisection and Newton-Raphson Method. [Sections 4.1, 4.3 and 4.5 of Text 1]

Unit V

Numerical Integration - Newton-Cotes Formulas - Trapezoidal rule, Simpson's rule and Simpson's 3/8 rule.
[Sections 6.1 and 6.2 of Text 1]

Initial Value Problems - Euler's Method and Runge-Kutta Methods
[Sections 7.1, 7.2 and 7.3 of Text 1]

(For more problems visit https://www.nostarch.com/doingmathwithpython/, https://doingmathwithpython.github.io/author/amit-saha.html and https://projecteuler.net/.)

1. The course is aimed to give an introduction to mathematical computing, with Python as tool for computation.
2. The students should be encouraged to write programs to solve the problems given in the sections as well as in the exercises.
3. The end semester evaluation should contain a theory and a practical examinations.
4. The duration of the theory examination will be 3 hours, with a maximum of 50 marks. One question out of two from each unit has to be answered. Each question carries 10 marks.
5. In the question papers for the theory examination, importance should be given to the definition, concepts and methods discussed in each units, and not for writing long programs.
6. Practical examination shall also be of 2 hours duration for a maximum of 25 marks with 5 questions carrying equal marks.
7. Continuous evaluation follows the pattern - 5 marks for attendence, 10 marks for the internal examination(theory) and 10 marks for the practical record. The record should contain at least 20 programs.
8. Practice of writing the record should be maintained by each student throughout the course and it should be dually certified by the teacher-in-charge/internal examiner and evaluated by the external examiner of practical examination.

References

1. Vernon L. Ceder, ***The Quick Python Book***, Second Edition, Manning.
2. ***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)
3. S. D. Conte and Carl de Boor, ***ELEMENTARY NUMERICAL ANALYSIS An Algorithmic Approach***, Third Edition, McGraw-Hill Book Company.
4. S.S. Sastry, ***Introductory Methods of Numerical Analysis***, Fifth Edition, PHI.

MM 231 COMPLEX ANALYSIS – I

Text: John. B. Conway, Functions of Complex Variables, Springer-Verlag, New York, 1973. (Indian Edition: Narosa)

UNIT I

Elementary properties and examples of analytic functions, Power series, Analytic function, Riemann- Stieltjes integrals.

(Chapter 3- Sections 1, 2 and Chapter 4- Section 1 of Text)

UNIT II

Power series representation of an analytic function, Zeros of an analytic function, The index of a closed curve.

(Chapter 4 – Sections 2, 3 and 4 of Text)

UNIT III

Cauchy's Theorem and integral formula, Homotopic version of Cauchy's Theorem, Simple connectivity, Counting zeros: The open Mapping Theorem, Goursat's Theorem.

(Chapter 4 - Sections 5, 6, 7 and 8 of Text)

UNIT IV

Singularities: Classification, Residues, The argument principle.

(Chapter 5 Sections 1, 2, and 3 of Text)

UNIT V

The extended plane and its spherical representation, Analytic function as mapping, Mobius transformations, The maximum principle, Schwarz's Lemma.

(Chapter 1- Section 6, Chapter 3- Section 3, Chapter 6- Section 1 and 2 of Text)

References:

1. **L.V. Ahlfors, Complex Analysis, Mc-Graw Hill (1966)**
2. **S. Lang, Complex Analysis, Mc-Graw Hill (1998).**
3. **S. Ponnusamy & H. Silverman, Complex Variables with Applications, Birkhauser**
4. **H. A. Priestley, Introduction to Complex Analysis, Oxford University Press Tristan Needham, Visual Complex Analysis, Oxford University Press(1999)**
5. **V. Karunakaran, Complex Analysis, Narosa Publishing House,**

MM 232: FUNCTIONAL ANALYSIS- I

Text: B. V. Limaye, FUNCTIONAL ANALYSIS (3rd Edition)

A quick review of chapter I of the Text is to be done as a prerequisite to the Functional Analysis course.

UNIT I

Normed spaces and continuity of linear maps. (Section 5 and 6 of the Text, Except 6.5 (d) and Theorem 6.8).

UNIT II

Hahn-Banach theorems and Banach spaces. (Section 7 and 8 of the Text,Theorem7.12 statement only).

UNIT III

Uniform boundedness principle, closed graph and open mapping theorems (Section 9.1, 9.2, 9.3 and 10 of the Text).

UNIT IV

Bounded inverse theorem, spectrum of a bounded operator (Section 11.1, 11.3, 12 (Except 12.4) and 13.1 of the Text,).

UNIT V

Weak convergence, reflexivity and compact linear maps (Sections 15.1, 15.2 (a), 16.1, 16.2, 17.1, 17.2 and 17.3, 17.4 (a) of the Text).

References

1. **Bryan Rynne, M.A. Youngson, Linear Functional Analysis, Publisher: Springer.**
2. **Rajendra Bhatia, Notes on Functional Analysis, Publisher: Hindustan Book Agency.**
3. **M. Tamban Nair, Functional Analysis: A first course, Publisher: Prentice Hall of India Pvt. Ltd.**
4. **Walter Rudin, Functional Analysis, 2nd Edition, Publisher: Tata Mc Graw-Hill.**
5. **B. V. Limaye, Linear Functional Analysis for Scientists and Engineers, Springer Singapore, 2016.**

MM 233 AUTOMATA THEORY (Elective)

Text: J.E. Hoporoft and J.D. Uliman, *Introduction to Automata Theory Languages and Computation,* Narosa, 1999

UNITI
Strings,AlphabetsandLanguages (Section 1.1 of the Text)
Finite Automata (Chapters 2, Sections 2.1 to 2.4)

UNIT II
Regular expressions and Properties of Regular sets.(Sections 2.5 to 2.8 and 3.1 to 3.4)

UNIT III
Context Free grammars (Section 4.1 to 4.5)

UNIT IV
Pushdown Automata & properties of Context free languages
Theorem 5.3, 5.4 (without proof), (Section is 5.1 to 5.3 and 6.1 to 6.3)

UNIT V
Turning Machine and Chomski hierarchy, (Sections 7.1 to 7.3 and 9.2 to 9.4)

References

1. **G.ERevesz,*Introduction to Formal Languages***
2. **P.Linz,*Introduction to Forma Languages and Automata,*Narosa2000**
3. **G.Lallment, *Semigroups and Applications***

MM 233 PROBABILITY (Elective)

Texts:

(1) **Laha R.G and Rohatgi V.K ,“ *Probability Theory*”, JohnWiley, New York (1979)**
(2) **Johnson N.L and Kotz S “*Distributions in Statistics: Discrete Distributions*”, John Wiley, New York (1969)**
(3) **Johnson N.L, and Kotz S “ *Distributions in Statistics: Continuous Univariate Distributions*”, Vol 1 and 2 ,John Wiley, New York (Paperback, 1970)**

UNITI

Probability,liminf,limsup,and limitofsequence of events, Monotone and continuity property of probability measure, Addition Theorem, Independence of finite number of events, Sequence of events, Borel Cantalls Lemma, Borel Zero one law

UNIT II

Random variable, Its probability distribution function, Properties of distribution function, Discrete and continues type random variables, Discrete, Continuous and other types of distributions, Expectation and moments of random variables, Inequalities of Liaponov (for moments) , Random vectors, Independence of random variables and sequence of random variables, Markov and Chebychev’s inequalities.

UNIT III

Standard distributions and their propertiesBernoulli, Binomial, Geometric, Negative Binomial, Hyper geometric, Beta, Cauchy, Chi square, Double Exponential, Exponential, Fisher’s F, Gamma, Log Normal, Normal,, Parents, Students’s t, Uniform and Heibull.

UNIT IV

Characteristic functions and their elementary properties, Uniform continuity and non negative definiteness of characteristic functions, Characteristic functions and moments, Statement (without proof) and application of each of the three theorems Inversion Theorem, Continuity Theorem and Bochner Khintchine Theorem of characteristic functions, Statement and proof of Fourier Inversion Theorem.

UNIT V

Stochastic convergence of sequence of random variables, Convergence in distributions, Convergence in probability, Almost sure convergence and convergence in the rth mean, Their inter-relation ship - Examples and counter examples, Slutsky’s Theorem.

References:

(1). Ash R.B- “*Basic Probability Theory*”, John wiley, New York (1970)
(2). Bhat B.R-“*Modern Probability Theory: An Introduction Text Book*”, Wiley Eastern (Second Edition) 1985
(3). Gnedenko B.V-“*The Theory of Probability*”, Mir Publishers Moscow (1969)
(4). Luckacs.E-“*Characteristic Functions*”, Hafner, New York (Second Edition, 1970)
(5). Luckacs. E- “*Stochastic Convergence*”, Academic Press (Second Edition, 1975)
(6). Johnson N.L, Kots,S and Balakrishnan.N-“*Continuos Univariate Distribution*”, *Vol.1 and 2* , John Wiley, New York (Second Edition, 194 vol.1 1995 Vol.2)
(7). Johnson N.L, Kots.S and Kemp A.W-“*Univariate Discrete Distributions*”, JohnWiley, New York” Second Edition 1992)

MM 233 OPERATIONS RESEARCH (Elective)

Texts: 1) Ravindran, Philips, Solberg, *Operations Research, Principles and Practice*, Second Edition, John Wiley & Sons

2) K. V. Mital, C. Mohan. *Optimization Methods in Operations Research and Systems Analysis*, Third Edition, New Age International Publishers, New Delhi

UNIT I

Linear Programming : Formulation of Linear Programming Models, Graphical solution of Linear Programs in two variables, Linear programs in standard form, basic variable, basic solution, basic feasible solution,Solution ofLinear Programming problem usingsimplex method, Big-M simplex method, The two phase simplex method.
[Chapter 2 of text 1 , sections 2.1 to 2,9]

UNIT II

Transportation Problems: Linear programming formulation, Initial basic feasible solution, degeneracy in basic feasible solution, Modified distribution method, Optimality test.
Assignment Problems:
Standard assignment problems, Hungarian method for solving an assignment problem.
[Chapter 3 of text 1, sections 3.1 to 3.3]

UNIT III

Project management; Programme Evaluation and Review Technique (PERT), Critical Path Method (CPM)
[Chapter 3 of text 1, section 3.7]

UNIT IV

Kuhn Tucker Theory and Nonlinear Programming: Lagrangian function, saddle point, Kuhn Tucker conditions, Primal and dual problems, Quadratic Programming.

[Chapter8 of text 2, sections 1 to 6]

UNIT V

Dynamic Programming: Minimum path, Dynamic Programming problems, Computational eco nomy in DP, serial multistage model, Examples of failure, Decomposition, Backward recursion.
[Chapter 10 of text 2, sections 1 to 10]

Reference:

Hamdy A. Taha, *Operations Research*, Fifth edition, PHI

MM 233 ALGEBRAIC TOPOLOGY (Elective)

Text Book : **Basic Concepts of Algebraic Topology, Fred H. Croom**

Springer – Verlang

Unit I

Introduction, Examples, Geometric Complexes and Polyhedra, Orientation of Geometric complexes. (Sections 1.1, 1.2, 1.3, 1.4 of Chapter 1)

Unit II

SImplicial Homology Groups - Chains, cycles, Boundaries, Homology groups, examples of Homology Groups, The structure of Homology Groups, The Euler Poincare Theorem, Psudo manifolds and the Homology Groups of $S^{n.}$ (Sections 2.1, 2.2, 2.3, 2.4, 2.5 of chapter 2).

Unit III

Simplicial Approximation- Introduction, Simplicial Approximation, Induced Homomorphisms on the Homology groups, the Browerfixed point theorem and related results . (Sections 3.1, 3.2, 3.3, 3.4 of Chapter 3)

Unit IV

The Fundamental group - Introduction, Homotopic paths and the fundamental group, the covering homotopy property for $S^{1,}$ Examples of Fundamental group, the relation between $H_1(K)$ and $\pi_1([K])$.

(Sections 4.1,4.2,4.3, 4.4 and 4.5 of chapter 4)

Unit V

Covering Spaces – Definition and examples, basic properties of Covering spaces, Classification of covering spaces, Universal covering spaces, and applications

(Section 5.1, 5.2, 5.3, 5.4 and 5.5 of Chapter 5)

References :

(1) I.M Singer, J.A Thorpe, Lecture Notes on Elementary Topology and Geometry, Springer International Edition, Springer (India) Private Limited, New Delhi, 2004

(2) Satya Deo, Algebraic Topology A Primer, Hindustan Book Agency, New Delhi, 2003.

(3) Allen Hatcher, Algebraic Topology , Published 2001 by Cambridge University Press

MM 234 APPROXIMATION THEORY (Elective)

Text: EW Cheney, "*Introduction to Approximation Theory*", Mc Graw Hill

UNIT 1

Metric spaces- An existence Theorem for best approximation from a compact subset; Convexity- Caratheodory's Theorem- Theorem on linear inequalities; Normed linear spaces - An existence T heorem
for best approximation from finite dimensional subspaces - Uniform convexity - Strict convexity
(Sections 1,2,5,6 of Chapter 1)

UNIT 2

The Tchebycheff solution of inconsistent linear equations -Systems of equations with one unkno wn-
Three algebraic algorithms; Characterization of best approximate solution for m equations in n unknowns- The special case m=n+1; Poly's algorithm.
(Section 1,2,3,4,5 of Chapter 2)

UNIT 3

Interpolation- The Lagrange formula-Vandermonde's matrix- The error formula- Hermite interpo lation;
The Weierstrass Theorem- Bernstein polynomials- Monotone operators- Fejer's Theorem; Gener al linear
families- Characterization Theorem- Haar conditions- Alternation Theorem.
(Sections 1,2,3,4, of Chapter 3)

UNIT 4

Rational approximation- Conversion or rational functions to continued fractions; Existence of be st
rational approximation- Extension of the classical Theorem; Generalized rational approximation- the characterization of best approximation- An alternation Theorem- The special case of ordinary rational functions; Unicity of generalized rational approximation.
(Sections 1,2,3,4 of Chapter 5)

UNIT 5

The Stone Approximation Theorem, The Muntz Theorem - Gram's lemma, Approximation in the mean-
Jackson's Unicity Theorem- Characterization Theorem, Marksoff's Therem.
(Section 1,2,6 of Chapter 6)

Reference:

P.J Davis. "*Interpolation and Approximation*", Blaisdell Publications.

MM 234 GEOMETRY OF NUMBERS (Elective)

Text Book: D.D Olds,Anneli Lax and Guiliana P. Davidoff, *The Geometry of Numbers,* The Mathematical Association of America 2000

UNIT 1

Lattice points and straight lines, Counting of lattice points (Chapters 1 and 2)

UNIT 2

Lattice points and area of polygons, Lattice points in circles (Chapter 3 and 4)

UNIT 3

Minkowski fundamental Theorem and Applications (Chapters 5 and 6)

UNIT 4

Linear transformation and integral lattices, Geometric interpretations of Quadratic forms (Chapters 7 and 8)

UNIT 5

Blichfieldts and applications, Tchebychev's and consequences (Chapter 9 and 10)

References

1. **J.W.S Cassells, *Introduction to Geometry of Numbers,* Springer Verlag 1997**
2. **C.I Siegel, *Lectures in Geometry of Numbers,* Springer Verlag 1989.**

MM 234 DIFFERENTIAL GEOMETRY (Elective)

Text: John.A. Thorpe, *Elementary Topics in Differential Geometry,* Springer Verlag

UNIT I
Graphs and level sets, Vector fields, Tangent Spaces . (Chapter 1,2,3 of Text)

UNIT II
Surfaces, Vector fields on surfaces, Orientation, The Gauss map (Chapter 4,5 6 of Text)

UNIT III
Geodesics, Parallel transport (Chapter 7,8 Text)

UNIT IV
The Weingarten map, Curvature of plane curve. (Chapter 9.10 of Text)

UNIT V
Arc length, Line integral, Curvature of surfaces (Chapter 11,12 of Text, except the proofs of Theorem 1, Theorem 2 of Chapter 11 and Theorem 1 of Chapter 12)

References:

[1] I Singer and J.A Thorpe, *Lecture notes on Elementary Topology and Geometry,* Springer-Verlag
[2] M Spivak*, Comprehensive introduction to Differential Geometry (Vols 1 to 5),* Publish or Perish Boston.

MM 234 GRAPH THEORY (Elective)

Text: Gary Chartrand and Ping Zhang , *Introduction to Graph Theory,* Tata Mc Graw Hill, Edition 2006

An overview of the concepts-Graphs, Connected graphs, Multi graphs, Degree of a vertex, Degree Sequence, Trees.

UNIT I

Definition of isomorphism, Isomorphism as a relation, Graphs and groups, Cut-vertices, Blocks, Connectivity.
(Sections 3.1, 3.2, 3.3, 5.1, 5.2 and 5.3)

UNIT II

Eulerian graphs, Hamilton graphs, Hamilton walks and numbers
(Sections 6.1, 6.2 and 6.3)

UNIT III

Strong diagraphs, Tournaments, matching, Factorization.
(Sections 7.1, 7.2, 8.1,8.2)

UNIT IV

The Four colour problem, Vertex colouring, The Ramsey number of graphs, Turan's Theorem.
(Sections 10.1, 10.2, 10.3, 11.1 and 11.2)

UNIT V

The centre of a graph, Distant vertices, Locating numbers, Detour and Directed distance.
(Sections 12.1, 12.2, 12.3, 12.4)

References:

1. **Bondy J.A and Murthy U.S.R, *"Graph Theory with Applications",* the Macmillan Press Limited.**
2. **Hararay F.,*"Graph Theory"*, Addison-Wesley**
3. **Suesh Singh G.,*"Graph Theory"*, PHI Learning Private Limited**
4. **Vasudev.C , *"Graph Theory Applications"*.**
5. **West D.B,*"Introduction to Graph Theory",* PHI Learning Private Limited**

MM 242: COMPLEX ANALYSIS II

Text: John. B. Conway, Functions of Complex Variables, Springer-Verlag, New York, 1973. (Indian Edition: Narosa)

UNIT I

Compactness and Convergence in the space of Analytic functions, The space C(G,Ω), Space of Analytic functions, Riemann Mapping Theorem.

(Chapter 7- Sections 1, 2 and 4 of the Text)

UNIT II

Wierstrass factorization Theorem, Factorization of sin function, The Gamma function.

(Chapter 7- Sections 5,6 and 7 of the Text)

UNIT III

Riemann Zeta function, Runge's Theorem, Simple connectedness, Mittag-Leffler's Theorem.

(Chapter 7- Section 8 and Chapter 8 of the Text)

UNIT IV

Analytic continuation and Riemann surfaces, Schwarz Reflexion Principle, Analytic continuation along a path, Monodromy Theorem.

(Chapter 9- Sections 1, 2 and 3 of the Text)

UNIT V

Basic properties of Harmonic functions, Harmonic function on a disc, Jensen's formula, The genus and order of an entire function, Hadamard factorization Theorem.

(Chapter 10- Sections 1, 2 and Chapter 11 of the Text)

References:

1. L.V. Ahlfors, Complex Analysis, Mc-Graw Hill (1966)

2. S. Lang, Complex Analysis, Mc-Graw Hill (1998).

3. S. Ponnusamy & H. Silverman, Complex Variables with Applications, Birkhauser.

4. H. A. Priestley, Introduction to Complex Analysis, Oxford University Press Tristan Needham, Visual Complex Analysis, Oxford University Press(1999)

5. V. Karunakaran, Complex Analysis, Narosa Publishing House,

MM 242: FUNCTIONAL ANALYSIS II

Text: **B. V. Limaye, FUNCTIONAL ANALYSIS (3rd Edition)**

UNIT I

Spectrum of a compact operator (Section 18.1, 18.2, 18.3, 18.4, 18.5 and 18.7 (a) only).

UNIT II

Inner product spaces, orthonormal sets (Section 21 and 22 of the Text, omitting 21.3 (d), 22.3 (b), 22.8 (b), 22.8 (c), 22.8 (d), 22.8 (e)).

UNIT III

Approximation and optimization, projection and Riesz representation theorems. (Section 23 and 24 of the Text, omitting 23.6).

UNIT IV

Bounded operators and adjoints, normal, unitary and self-adjoint operators (Section 25 and 26.1, 26.5 of the Text omitting 25.4 (b)).

UNIT V

Spectrum and numerical range, compact self-adjoint operators (Section 27.1, 27.5, 27.7, 28.1, 28.4, 28.5, 28.6 of the Text).

References

1. **Bryan Rynne, M.A. Youngson, Linear Functional Analysis, Publisher: Springer.**
2. **Rajendra Bhatia, Notes on Functional Analysis, Publisher: Hindustan Book Agency.**
3. **M. Tamban Nair, Functional Analysis: A first course, Publisher: Prentice Hall of India Pvt. Ltd.**
4. **Walter Rudin, Functional Analysis, 2nd Edition, Publisher: Tata Mc Graw-Hill.**
5. B. V. Limaye, Linear Functional Analysis for Scientists and Engineers, Springer Singapore, 2016.

MM 243 Mathematical Statistics (Elective)

Text: **V.K.Rohatgi**, *An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern Ltd.

Unit I: The theory of point estimation:

The problem of point estimation, properties of estimates, unbiased estimation, unbiased estimation (continued): A lower bound for the variance of an estimate, the method of moments, maximum likelihood estimates.(Chapter 8 (Sec 8.2 – sec 8.7) of text)

Unit II: Neyman – Pearson theory of testing of hypothesis:

Introduction, some fundamental notions of hypothesis testing, the Neyman – Pearson Lemma, families with monotone likelihood ration, unbiased and invariant tests.(Chapter 9 of text)

Unit III: Some further result on hypothesis testing:

Introduction, the likelihood ratio tests, the Chi-square tests, the t-tests, the F-tests, Bayes and minimax procedure.(Chapter 10 of text)

Unit IV: Confidence estimation:

Introduction, Some fundamental notions of confidence estimation, shortest length confidence intervals, relation between confidence estimation and hypothesis testing, unbiased confidence intervals, Bayes confidence intervals(Chapter 11 of text)

Unit V: Nonparametric statistical inference:

Introduction, nonparametric estimation, some single – sample problems, some two – sample problems, tests of independence.(Chapter 13 (Sec 13.1 – 13.5) of text)

References:

Lehmann. E.L, "*Theory of Point Estimation*", John Wiley, New York, 1983.

1. **Lehmann E.L**, "*Testing of Statistical Hypothesis*", John Wiley, New York (Second Ed.), 1986.
2. **Randles R H and Wolf D A**, "*Introduction to the Theory of Non parametric Statistics*", Wiley, New York, 1979.
3. **Kendall M G and Stuart A**, "*The Advanced Theory of Statistics*", Vol 2, Mac Millan, New York (Fourth Ed.), 1979.
4. **Mood Ali, Gray Bill, Fhardoes D C**, "*Introduction to the Theory of Satistics*", McGraw Hill International, New York (Third Ed.), 1972.

MM 243 Difference Equations (Elective)

Unit – I: Linear Difference Equations of Higher Order
Difference calculus – General theory of linear difference equations – Linear homogenous equations with constant coefficients – Linear non-homogenous equations – Method of undetermined coefficients. (Chapter 2: Sections: 2.1 to 2.4)

Unit – II: System of Linear Difference Equation
Autonomous (time invariant) systems –The basic theory –The Jordan form: Autonomous (time-invariant) systems - Linear Periodic Systems. (Chapter 3: Sections: 3.1 to 3.4)

Unit – III: The Z-Transform Method
Definitions and examples – Properties of Z-Transform – The inverse Z-Transform and solutions of difference equations - Power series method - Partial fraction method – Inversion integral method. (Chapter 6: Sections: 6.1,6.2)

Unit – IV: Oscillation Theory
Three-term difference equations – Self-adjoint second order equations –Nonlinear difference equations. (Chapter 7: Sections: 7.1 to 7.3)

Unit – V: Asymptotic Behaviour of Difference Equations
Tools of approximations - Poincare’s theorem – Asymptotically diagonal systems. (Chapter 8: Sections: 8.1 to 8.3)

Book for Study
Saber N.Elaydi, An Introduction to Difference Equations, Third Edition, Springer International Edition, First Indian Reprint, New Delhi, 2008.

Books for Reference

1. S.Goldberg, Introduction to Difference Equations, Dover Publications, 1986.
2. Walter G.Kelley, Allan C.Peterson, Difference Equations An Introduction with Applications, Academic Press, Indian Reprint, New Delhi, 2006.
3. V.Lakshmikantham, DonatoTrigiante, Theory of Difference Equations: Numerical Methods and Applications, Second Edition, Marcel Dekker, Inc, New York, 2002.
4. Ronald E.Mickens, Difference Equations, Van Nostrand Reinhold Company, New York, 1987.
5. Sudhir K.Pundir, Rimple Pundir, Difference Equations (UGC Model Curriculum), Pragati Prakashan, First Edition, Meerut, 2006.

E – Learning source:

MM 243 Integral equations and Calculus of Variations (Elective)

Text 1: Ram P. Kanwal, Linear Integral Equations, Second Edition

Text 2: Gelfand ,Fomin , Calculus of variations, Dover books

Unit 1

Introduction and Integral equations with Separable kernels

(Chapter 1 and 2 of text 1)

Unit 2

Method of successive approximations and Classical Fredholm theory

(Chapter 3 and 4 of text 1)

Unit 3

Applications to ordinary differential equations

(Chapter 5 of text 1)

Unit 4

Calculus of Variations: Basic concepts of the calculus of variations such as functionals, extremum, variations, function spaces, the brachistochrone problem. Necessary condition for an extremum

Unit 5

Euler`s equation with the cases of one variable and several variables, Variational derivative. Invariance of Euler`s equations. Variational problem in parametric form

References:

Weinstock R, Calculus of variations with applications to Physics and engineering, Dover Publications

Jerry A.J , Introduction to integral equations with Applications , Wiley publishers

MM 243 THEORY OF WAVELETS (Elective)

Text Book:
Michael Frazier, *An Introduction to Wavelets through Linear Algebra,* Springer

Prerequisites: Linear Algebra, Discrete Fourier Transforms, elementary Hilbert Space Theorems (No questions from the pre-requisites)

UNIT I
Construction of Wavelets on ZN the first stage. (Section 3.1)

UNIT II
Construction of Wavelets on Zn the iteration sets, Examples - Shamon, Daubiehie and Haar (Sections: 3.2 and 3.3)

UNIT III
ɩ2 (Z), Complete Orthonormal sets, L2[-π,π] and Fourier Series.
(Sections: 4.1,4.2 and 4.3)

UNIT IV
Fourier Transforms and convolution on ɩ2 (Z), First stage wavelets on Z.
(Section: 4.4 and 4.5)

UNIT V
The iteration step for wavelets on Z, Examples, Shamon Haar and Daubiehie

References:

Mayor (1993), *Wavelets and Operators,* Cambridge University Press
Chui. C(1992), *An Intrioduction to Wavelets,* Academic Press, Boston

MM 243 CODING THEORY (Elective)

Text: D.J Hoffman etal., ***Coding Theory The Essentials,*** **Published by Marcel Dekker Inc 1991**

UNIT I

Detecting and correcting error patterns, Information rate, The effects of error detection and correction, Finding the most likely code word transmitted, Weight and distance, MLD, Error detecting and correcting codes.
(Chapter 1 of the Text)

UNIT II

Linear codes, bases for C = <S> and $C^{\perp}$, generating and parity check matrices, Equivalent codes ,Distance of a linear code, MLD for a linear code, Reliability of IMLD for linear codes.
(Chapter 2 of the Text)

UNIT III

Perfect codes, Hamming code, Extended codes, Golay code and extended Golay code, Red Hulles Codes.
(Chapter 3 sections: 1 to 8of the Text)

UNIT IV

Cyclic linear codes, Polynomial encoding and decoding, Dual cyclic codes.
(Chapter 4 and Appendix A of the Text)

UNIT V

BCH Codes, Cyclic Hamming Code, Decoding 2 error correcting BCH codes
(Chapter 5 of text)

References

1. **E.R Berlekamp,** ***Algebriac Coding Theory,*** **Mc Graw-Hill, 1968**
2. **P.J Cameron and J.H Van Lint,** ***Graphs,*** **Coded and Designs CUP**
3. **H. Hill,** ***A First Course in Coding Theory,*** **OUP 1986.**

MM 243 FIELD THEORY (Elective)

Text: Joseph Rotman, *Galois Theory,* Second Edition, Springer, 1998.

UNIT 1

Solvable groups (Appendix B of the text): Isomorphism Theorems, Correspondence Theorem , Sylowp-subgroup, commutator subgroups and Higher subgroups, S5 is not solvable.
(The following results are included: G5 , G6 , G7 , G8 , G9 , G14 , G15 , G16 , G17 , G18 , G1 9 , G20 , G21, G22, G23, G31 , G34 , G36 , G37 , G38 ,G39)

UNIT 2

Polynomial Rings over Fields: Principal ideal, Greatest common divisor, LCM, Remainder Theorem, Prime and maximal ideals, Splitting, prime fields, Characteristic, Irreducible and primitive polynomials, Content, Eisenstein Criterion, Cyclotomic polynomial.
(The following results are included: Theorem 13 to Theorem 22, Theorem 24 to Theorem 33, Theorem 35to Corollary 42)

UNIT 3

Splitting Fields: Degree of an extension, Simple extension, Algebraic extension and transcend ental ex-tension, Splitting field, Seperable extension, Galois field, Galois group.
(The following results are included: Lemma 44 to Corollary 53, Lemma 54 to Theorem 58)

UNIT 4

Roots of Unity and Solvability by Radicals: Cyclic group of nth roots of unity, Primitive element, Frobenius automorphism, Radical extension, Solvability by radicals, Unsolvable quintic.
(The following results are included: Theorem 62 to Corollary 72, Lemma 73 to Theorem 75)

UNIT 5

Fundamental Theorem of Galois Theory: Galois extensions, Fundamental Theorem, Fundamental Theorem of algebra, Galois Theorem on solvability.
(The following results are included: Theorem 81 to Corollary 93, Lemma 94 to Theorem 98)

References:

1. Harold M. Edwards, *Galois Theory,* Springer, 1984.
2. Joseph . A. Gallian, *Contemporary Abstract Algebra,* 7th Edition, Brooks/Cole.
3. J. B. Fraleigh, *A First Course in Abstract Algebra,* 7th Edition, PHI.
4. T. W. Hungerford, *Algebra,* Springer 2005.
5. O. Zariski and P. Samuel, Commutative Algebra, Vol. I, Springer – Verlag

MM 244 Mechanics (Elective)

Text: Herbert Goldstein, Charles P. Poole and John Safko, *Classical Mechanics*, Third Edition, Pearson, 2011.

Unit I: Mechanics of a particle, Mechanics of a system of particles, Constraints, D'Alembert's principle and Lagrange's equations, Velocity dependent potentials and the dissipation function, Simple applications of the lagrangian formulation.(Chapter 1 of text)

Unit II: Hamilton's principle, Some techniques of the calculus of variations, derivation of Lagrange's equation from Hamilton's principle, Extending Hamilton's principle to systems with constraints, Conservation theorems and symmetry properties. (Sections 2.1, 2.2, 2.3, 2.4 and 2.6)

Unit III: 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, the differential equation for the orbits and integrable power law potentials, the Kepler problem: Inverse square law of force.(Sections 3.1, 3.2, 3.3, 3.4, 3.5 and 3.7)

Unit IV: The independent coordinates of a rigid body, orthogonal transformation, the Euler angles, the Cayley – Klein parameters and related quantities, Euler's theorem on the motion of a rigid body, the coriolis effect. (Sections 4.1, 4.2, 4.4, 4.5, 4.6, 4.10)

Unit V: Angular momentum and kinetic energy of motion about a point, tensors, the inertial tensor and the moment of inertia, the eigen values of the inertial tensor and the principal axis transformation, solving rigid body problems and the Euler equations of motion.

(Sections 5.1 to 5.5)

References:

Synge J.L and Griffith B.A, *Principles of Mechanics,* McGraw – Hill.

MM 244 ADVANCED GRAPH THEORY (Elective)

Text:
Fred Buckley, Frank Harary, *Distance in Graphs,* Addison-Wesley Publishing Company

UNIT 1
Graphs: Graphs as Models, Paths and connectedness, Cutnodes and Blocks, Graph Classes and Graph Operations, Polynomial Algorithms and NP-Completeness
(Chapter 1 and Section 11.1 of Text)

UNIT II
The Center and Eccentricity, Self Centered Graphs, The Median, Central Paths Path Algorithms and Spanning Trees, Centers.
(Chapter 2, Sections 2.1, 2.2, 2.2; Chapter 11, Sections 11.2, 11.3)

UNIT III
External Distance Problems: Radius, Small Diameter, Diameter, Long Paths and Long Cycles
(Chapter 5 of Text)

UNIT IV
Convexity: Closure in variants, Metrics on Graphs, Geodetic Graphs, Distance Hereditary Graphs.
Diagraphs: Diagraphs and Connectedness, Acyclic diagraphs
(Chapter 7 and sections 10.1, 10.2 of Text)

UNIT V
Distance Sequences: The eccentric sequences, Distance sequence, The Distance distribution, Long Paths in Diagraphs, Tournaments
(Sections 9.1, 9.2,9.3,10.3,10.4 of Text)

References:

(1) **Bondy and Murthy, *Graph Theory with Applications,* The Macmillan Press Limited, 1976**
(2) **Chartrand G and L.Lesniak, *Graphs and Diagraphs,* Prindle, Weber and Schmidt, Boston, 1986**
(3) **Garey M.R, D.S Johnson , *Computers and Intractability,* A Guide to the Theory of NP-Completeness, Freeman, San Francisco 1979.**
(4) **Harary. F, *Graph Theory,* Addison Wesley Reading Mass 1969 (Indian Edition, Narosa)**
(5) **K.R Parthasarathy, *Basic Graph Theory,* Tata Mc Graw-Hill, Publishing Co, New Delhi, 1994.**

MM 244 ANALYTIC NUMBER THEORY (Elective)

Text: Tom.M. Apostol; *Introduction to Analytical Number Theory,* Springer-Verlag

UNIT I
The Fundamental Theorem of Arithmetic (chapter 1 of Text)

UNIT II
Arithmetical function and Dirichlet multiplication
(Section 2.1 to 2.17 of Text)

UNIT III
Congruences, Chinese Remainder Theorem
(Sections 5.1 to 5.10 of Text)

UNIT IV
Quadratic residues, Reciprocity law, Jacobi symbol
(Sections 9.1 to 9.8 of Text)

UNIT V
Primitive roots, Existence and number of primitive roots.
(Sections 10.1 to 10.9 of text)

References

[1] Emd Groswald, *Topics from the Theory of Numbers,* Birkhause
[2] G.H Hardy and E.M Wright , *Introduction to the Theory of Numbers,* OxCalculus, Volume 1
ford

MM 244 COMMUTATIVE ALGEBRA (Elective)

Text: N.S Gopalakrishan, *Commutative Algebra,* Oxonian Press

UNIT I
Modules, Free projective, Tenser product of modules, Flat modules
(Chapter 1 of Text)

UNIT II
Ideals, Local rings, Localization and applications
(Chapter 2 of Text)

UNIT III
Noetherian rings, modules, Primary decomposition, Artinian modules
(Chapter 3 of Text)

UNIT IV
Integral domains, Integral extensions, Integrally closed domain, Finiteness of integral closure
(Chapter 4 of Text)

UNIT V
Valuation rings, Dedikind domain
(Chapter 5 of Text, Theorems 4 and 5 omitted)

References:

[1] M.F Atiyah and I.G Mac Donald, *Introduction to Communication Algebra,* Addison Wesley
[2] T.W Hungerford, *Algebra,* Springer-Verlag

MM 244 REPRESENATION THEORY OF FINITE GROUPS
(Elective)

Text: Walter Ledermann, *Introduction to Group Characters,* Cambridge University Press

UNIT I
G-module, Characters, Reducibility, Permutation representations, Complete reducibility, Schur's Lemma
(Sections 1.1 to 1.7 of Text)

UNIT II
The commutant algebra, Orthogonality relations, The groups algebra
(Section 1.8, 2.1, 2.2 of Text)

UNIT III
Character table, Character of finite abelian groups, The lifting process, Linear characters
(Section 2.3, 2.4, 2.5, 2.6 of Text)

UNIT IV
Induced representations, Reciprocity law, A_5, Normal subgroups, Transitive groups, Induced characters of S_n
(Sections 3.1, 3.2, 3.3, 3.4, 4.1, 4.2, 4.3 of Text)

UNIT V
Group theoretical applications, Brunside's (p,q) Theorem, Frobenius groups
(Chapter 5 of Text)

Reference: S.Lang, *Algebra,* Addison Wesley

MM 244 CATEGORY THEORY (Elective)

Text Book: S. Maclane, *Categories for the working Mathematician,* Springer, 1971

UNIT-I
Categories, Functors and Natural Transformations - Axioms for categories, categories, Fun ctors.
Natural Transformations, Mobics, Epis and Zeros Foundations, Large Categories, Hom-sets.

UNIT II
Constructions on categories - Duality Contravariance and opposites, Products of Categories. F unctor
Categories, The category of all categories, Comma categories, Graphs and Free categories, Quotient Categories.

UNIT III
Universals and Limits - Universal Arrows, Yoneda Lemma Coproduces and Colimits, Product s and Limits, Categories with Finite products, Groups in categories.

UNIT IV
Adjoints – Adjunctions, Examples of Adjoints, Reflective subcategories, Equivalence of categ ories,
Adjoints for pre orders, Cartesian closed categories, Transformations of Adjoints, Compositions of
Adjoints.

UNIT –V
Limits – Creation of Limits by products and Equalizers, Limits with parameters, Preservation o f Limits,
Adjoints on Limits, Freyd’s Adjoint Functor Theorem, Subobjects and Generation,
The Special Adjoint Functor Theorem, Adjoint in Topology.

References:

1. **M.A. Arbib and E.G Maneswarrows, *Structures and Functors,* The categorical Imperative, Avademic Press-1975**
2. **H. Herrlich and G.E Strecker, *Category Theory,* Allyn & Bacon, 1973**
3. **M. Barmand, C. Wells, *Category Theory for Computer Science,* Prentice Hall , 1990**
4. **F. Borceux, *Handbook of Categorical Algebra,* Vol. I, II, III, Cambridge, University Press, 1994**
5. **P. Frevd, *Abelian Categories,* Harper & Row, 1964**
6. **R.F,C Walters, *Categories and Computer Science,* Cambridge University Press, 1991**