POPES' COLLEGE (Autonomous)

(Accredited by NAAC-II with 'A' Grade (CGPA: 3.28)
C.S.I.-THOOTHUKUDI-NAZARETH DIOCESE

SAWYERPURAM-628251, Tamil Nadu

(Affiliated to Manonmaniam Sundaranar University)

Syllabus

M.Sc. Mathematics

(2021 onwards)

Learning Outcome Based Curriculum Framework

Vision

To buildup the students for critical thinking, analytical reasoning, professional practice engaging them to work out in diversified areas of research in cultivating innovations to the society.

Mission

- To impart quality education in Mathematics to the rural and economically weaker students.
- To develop logical thinking and skills among the students in supporting them for a better career.
- To promote effecting teaching for getting content knowledge and to explore mole applications in Mathematics.
- To provide an environment promoting the students for research work and professional Practice.

Eligibility for Admission:

Candidates with B.Sc degree in Mathematics/Applied Mathematics/ Mathematics and Computer Applications with 50% marks are eligible to be admitted into this course. Relaxation for SC, ST and MBC/DNC candidates is allowed as per the State Government norms.

Programme Outcome

PO1	Acquire an overview of concepts, fundamentals and advancements of science in different disciplines
PO2	Students will be able to apply disciplinary or interdisciplinary learning across multiple contexts, integrating knowledge and practice
PO3	Investigate, design and apply appropriate methods to solve problems in science, mathematics, technology
PO4	Think critically, work independently and focus in research oriented activities.
PO5	Inculcate an ability to engage in life-long learning to improve professional competency.
PO6	Employ highly developed conceptual, analytical, quantitative and technical skills and are adept with a range of technologies.
PO7	Communicate effectively on scientific achievements, basic concepts and recent developments with experts and with society at large
PO8	Engage in intellectual exchange of ideas with researchers of other disciplines to address important research issues

Programme Specific Outcomes

PSO1	Develop an appreciation of the basic concepts of Algebra, Analysis, Differential Equations, Combinatorics, Differential Geometry, Optimization techniques and Statistics.
PSO2	Develop a quest for knowledge which will pave way for doing Mathematics by students themselves.
PSO3	Develop an analytical thinking and knowledge for research.
PSO4	Learn many mathematical structures
PSO5	Gain the confidence to work in a team
PSO6	Construct and express logical arguments
PSO7	Develop generic skills that will pave way for their career
PSO8	Explore current research problems in mathematical sciences.

Course Structure:

I Semester					
S.No	**Subject status**	**Subject code**	**Subject Title**	**Hrs/ week**	**Credits**
1	Core -1	21PMAM11	Groups and Rings	6	5
2	Core - 2	21PMAM12	Real Analysis	6	5
3	Core -3	21PMAM13	Classical Mechanics	6	4
4	Core -4	21PMAM14	Ordinary Differential Equations	6	4
5	Discipline specific Elective-1	21PMAE11 21PMAE12	1. Numerical Methods 2. Programming with C++	6	4
		Self Study Course(MOOC)			2
	Subtotal			30	22+2
II Semester					
S.No	**Subject status**	**Subject code**	**Subject Title**	**Hrs/ week**	**Credits**
1	Core -5	21PMAM21	Linear Algebra	6	5
2	Core – 6	21PMAM22	Mathematical Analysis	6	5
3	Core -7	21PMAM23	Differential Geometry	6	4
4	Core -8	21PMAM24	Graph Theory	6	4
5	Discipline specific Elective-2	21PMAE21 21PMAE22	1.Operations Research 2. Fuzzy Mathematics	6	4
		Summer training programme			2
	Subtotal			30	22+2
III Semester					
S.No	**Subject status**	**Subject code**	**Subject Title**	**Hrs/ week**	**Credits**
1	Core -9	21PMAM31	Topology	6	5
2	Core – 10	21PMAM32	Measure Theory	6	5
3	Core -11	21PMAM33	Probability and Statistics	6	5
4	Core -12	21PMAM34	Analytic Number Theory	6	4
5	Discipline specific Elective-3	21PMAE31 21PMAE32	1. Combinatorial Mathematics 2.Discrete Mathematics	6	4
		Self Study Course			2
	Subtotal			30	23+2
IV Semester					
S.No	**Subject status**	**Subject code**	**Subject Title**	**Hrs/ week**	**Credits**
1	Core -13	21PMAM41	Complex Analysis	6	5
2	Core – 14	21PMAM42	Functional Analysis	6	5
3	Core -15	21PMAM43	Partial Differential Equations	6	4
4	Core -16	21PMAM44	Calculus of variations and Integral equations	6	4
5	Discipline specific Elective-4	21PMAE41	Project	6	5
	Subtotal			30	23

5.Question Pattern:

Duration:3 hours **Maximum marks:75**

Part A (10×1=10 marks)

Two questions from each unit

Part B(5×5=25 marks)

Either or type (one question from each unit)

Part C(5×8=40 marks)

Either or type (one question from each unit)

Project

Internal: 40 marks

External : 60 marks

SEMESTER I

Core	Sub Code		Hrs./Week	Credits
1	21PMAM11	Groups and Rings	6	5

Objective

- To acquire a thorough knowledge about algebraic concepts like Groups, Permutation groups and Direct products.
- To know the richness in the techniques of Mathematics by the way of studying Sylow's theorem and finite Abelian Groups
- To know that study of Euclidean Rings

Course Outcome

CO1	Determine the orbit for a set and make use of the counting principle technique to find algebraic descriptions for the size of each equivalence class.	K5
CO2	Explain Sylow's theorem for all finite groups.	K6
CO3	Develop all abelian groups generated by a finite set of elements and to find the root of unity for each element of a group.	K4
CO4	Analyze and demonstrate the examples of Ideals and Quotient Rings.	K4
CO5	Assess properties implied by the definition of Euclidean Rings and to illustrate and apply the concepts of Polynomial Rings.	K5

Unit I :

Cayley's Theorem - Permutation Groups - Another Counting Principle.

. (Chapter 2: Sections 2.9, 2.10, 2.11)

Unit II :

First part of Sylow's Theorem- Second part of Sylow's Theorem- Third part of Sylow's Theorem.

(Chapter 2: Sections 2.12)

Unit III

Direct Products - Internal direct product- Finite Abelian Groups-Invariants - Solvable.

(Chapter 2: Sections 2.13, 2.14)

Unit IV :

Ring Theory– Homomorphisms- Ideals and Quotient Rings – More Ideals and Quotient Rings -The Field of Quotients of an Integral Domain.

(Chapter 3: Sections 3.3, 3.4, 3.5, 3.6)

Unit V :

Euclidean Rings - A Particular Euclidean Ring - Polynomial Rings -Polynomial over the Rational Field.

(Chapter 3: Sections 3.7, 3.8, 3.9, 3.10)

Text Book : Topics in Algebra, Second Edition, I.N. Herstein, Wiley India Pvt.Ltd..

Reference Books

Garrett Birkhoff and Thomas C. Bartee: Modern Applied Algebra, CBS Publishers and Distributors, Delhi, 1987.

Core	Sub Code		Hrs./Week	Credits
2	21PMAM12	REAL ANALYSIS	6	5

Objective

- To make the students learn about main concepts of analysis.
- To provide deep understanding of the Metric space concepts
- To learn more about convergence, continuity and differentiation

Course Outcome

CO1	Recall and apply the concepts of continuity, discontinuity, compactness and connectedness in metric spaces.	K1, K3
CO2	Develop the knowledge of real functions, limit of functions and their properties	K6
CO3	Apply the concept of the series of real numbers and convergence.	K3

CO4	Analyze the concepts of continuous functions and their properties	K4
CO5	Construct the differentiation of functions of real variables.	K6

Unit I :

Metric Spaces – Compact Sets – Perfect Sets – The Cantor Set – Connected Sets.

Chapter 2 :Sec : 2.15 – 2.47

Unit II :

Convergent Sequences – Sub sequences – Cauchy Sequences – Upper and Lower limits – Some special sequences – Series – Series of non-negative terms.

Chapter 3 :Sec : 3.1 – 3.29

Unit III :

The Root and Ratio tests – Power Series – Summation by parts – Absolute Convergence – Addition and Multiplication of series.

Chapter 3 :Sec : 3.33 – 3.51.

Unit IV :

Continuity – Limits of functions –Continuous functions – Continuity and Compactness – Continuity and Connectedness.

Chapter 4 : Sec : 4.1 – 4.24.

Unit V :

Differentiation – The Derivative of a real function – Mean Value Theorems – The continuity of derivatives – L'Hospital's Rule – Derivatives of higher order – Taylor's Theorem.

Chapter 5 : Sec : 5.1 – 5.15

Text Book : Principles of Mathematical Analysis, Third Edition, Walter Rudin, McGraw-Hill International Editions.

Reference Books:

Mathematical Analysis, Apostol : Addition Wesley Publishing company, London ,1971.

Core	Sub Code		Hrs./Week	Credits
3	**21PMAM13**	**CLASSICAL MECHANICS**	**6**	**4**

Objective

- To learn more about of the mechanics of a particle, Lagrange's equations.
- To study the concepts and advantages of Hamilton's Principle
- To learn about Canonical transformations and its applications in Classical Mechanics.

Course Outcome

CO-1	Recall the definition and analyze the Lagrange's equations for Holonomic and non-Holonomic system	K1
CO-2	Describe variational principle and apply it to find the derivation	K1
CO-3	Understand the concepts of equation of motion and calculate the Eulerian angle and Euler equations for a rigid body	K2
CO-4	Distinguish the concept of the Hamiltonian equations of motion and the principle of least squares.	K4
CO-5	Analyze the canonical transformation and Hamilton Jacobi Theory	K4

Unit I

Some Definitions- Lagrange's Equations for a Holonomic system- Lagrange's Equations of Motion for Conservative, Non-Holonomic system- Physical Significance of λ_l

(Chapter 1: Sections 1.1, 1.2, 1.3, 1.4)

Unit II

Variational Principle- Calculus of Variations- Hamilton's Principle- Derivation of Hamilton's Principle from Lagrange's Equations- Derivation of Lagrange's Equations from Hamilton's Principle.

(Chapter 2:Sections 2.1, 2.2, 2.3, 2.4)

Unit III

Extension of Hamilton's Principle- Cyclic or Ignorable Coordinates- Conservation Theorem

(Chapter 2:Sections 2.5,2.6,2.7,2.8)

Unit IV

Derivation of Hamilton's Equations of Motion-Routh's procedure- Equations of motion-Derivation of Hamilton's equations from Hamilton's principle-Principle of least action.

(Chapter 4: Sections 4.1,4.2,4.3,4.4)

Unit V

Canonical coordinates and canonical transformations- Hamilton's Equations of Motion in Poisson's Bracket- Infinitesimal contact Transformation- Relation between Infinitesimal contact Transformation and Poisson's Bracket- Hamilton-Jacobi theory.

(Chapter 5 : Sections 5.1,5.2,5.3,5.4,5.5)

Text Book: Classical Mechanics, C.R.Mondal Prentice Hall of India, 2007

Reference Books:

Classical Mechanics, Second Edition, Herbert Goldstein:,Narosa, 1994.

Core	Sub Code	ORDINARY DIFFERENTIAL EQUATIONS	Hrs./Week	Credits
4	21PMAM14		6	4

Objectives

- To understand the various concepts in differential equations.
- To make the students to solve the Power series solutions.
- To understand the difference between ordinary and regular singular points.

Course Outcome

CO-1	Determine the solution of second order differential equations by variation of parameters.	K5
CO-2	Apply the concept of power series solutions to solve differential equations about ordinary points.	K3
CO-3	solve differential equations using Frobenius series method and study Lagendre Polynomials.	K3
CO-4	Analyze polynomials in terms of Legendre and Bessel equations.	K4
CO-5	solve the Homogenous linear system with constant co- efficient	K3

Unit I: Second Order linear equations : The General solution of the Homogeneous equation – The use of a known solution to find another – The method of variation of parameters.

Sections: 14 – 16, 19

Unit II: Power series solutions**:** A review of power series solutions – Series

solution of first order equations – Second order equations – Ordinary points.

Sections: 26 – 28.

Unit III: Regular singular points- Frobenius series – Legendre polynomials- Properties of Legendre polynomials

Sections: 29, 30, 44, 45.

Unit IV: Bessel functions – The Gamma functions – The general solution of Bessel's equation-Properties of Bessel functions.

Sections: 46, 47.

Unit V: Linear systems **:** Homogeneous linear systems with constant coefficients-Distinct real roots-Distinct complex roots.

Sections: 55, 56.

Text Book: Differential Equations with application and historical notes, G.F. Simmons, Second Edition, Tata McGraw Hill.

Reference Books:

Differential Equations, Second Edition, Richard Bronson: Schaum's Outlines,Tata McGraw Hill, 1989.

Discipline specific Elective	**Sub Code**	**Paper 1: NUMERICAL METHODS**	**Hrs./Week**	**Credits**
1	**21PMAE11**		**6**	**4**

Objectives

- To enable students develop their calculation skills.
- To apply various techniques in solving numerical problems.
- To understand the Runge Kutta method

Course Outcome:

CO1	Analyze the types of interpolation	K4
CO2	Use differentiation a in Newton's forward, backward and central difference formulae	K3
CO3	Explain Numerical intergration and Gaussian Quadrature formula	K3
CO4	Solve ordinary differential equations using different methods	K3
CO5	Calculate and solve Runge Kutta method and Milnes method	K3

Unit I: Interpolation : Newton's Interpolation Formula – Central difference Interpolation- Lagrange's Interpolation formula – Divided differences formula - Newton's Divided differences formula

Chapter 7: Sections 7.1 to 7.5.

Unit II: Numerical differentiation – Derivatives using Newton's forward , backward, central difference formulae - Maxima and minima of the interpolating polynomial

Chapter 8: Sections 8.1 to 8.4.

Unit III: Numerical Integration-Newton-Cote's quadrature formula –Weddle's rule-Romberg's method–Gaussian Quadrature formula-Two point and three point Gaussian quadrature formulae.

Chapter 8: Sections 8.5, 8.6.

Unit IV: Numerical solutions of ordinary differential equations – Taylor's series Method – Picard's Method – Euler's Method-Runge Kutta Methods.

Chapter 10: Sections 10.1 to 10.4.

Unit V: Predictor corrector Method – Milnes Method –Adams-Bashforth Method.

Chapter 10: Sections 10.5 to 10.7.

Text Book:

Numerical Methods , S.Arumugam , A.Thangapandi Issac & A.Soma Sundaram :

Scitech Publications (INDIA) Pvt.Ltd, Chennai, 2002.

Reference Book:

Numerical Analysis , S.Arumugam and Issac: New Gamma Publishing House Palayamkottai, 2013.

Discipline specific Elective	**Sub Code**	**Paper 2: Programming in C++**	**Hrs./Week**	**Credits**
1	21PMAE12		**6**	**4**

Objective

- To apply mathematical concepts in programming.
- To make the students to think and find solution to problems of real life situations.
- To study the C++ language as it plays an important role in the software area.

Course Outcome

CO1	Develop the Expressions and control structures	K4
CO2	Explain classes and objects	K6
CO3	Determine the Operator over loading and types of conversions	K5
CO4	Design virtual functions and polymorphismes	K4
CO5	Apply working with files	K4

Unit 1:

Token, Expressions and control structures-Functions in C++

Unit 2:

Classes and Objects.

Unit 3:

Constructors and Destructors-Operator over loading and Type Conversions.

Unit 4:

Inheritance-Extending Classes-Pointers- Virtual Functions and Polymorphisms.

Unit 5:

Working with files.

Text:

Object Oriented Programming with C++ (Third Edition), E.Balagurusamy Chapters 3 to 9 and11

SEMESTER II

Core	Sub Code		Hrs./Week	Credits
5	21PMAM21	Linear Algebra	6	5

Objective

- To acquire a detailed knowledge about algebraic concepts.
- To study the basic concepts of linear dependence, basis, homomorphisms of vector spaces and Inner product spaces
- To learn about Trace and Transpose, determinants and Transformations.

Course Outcome

CO1	Explain the concepts of field extensions and apply it to diverse situations in mathematical contexts.	K3
CO2	Demonstrate accurate and efficient use of field extension and Galois Theory.	K2
CO3	Determine Polynomial Rings and its effect in Galois Theory.	K5
CO4	Define and illustrate the concepts of various polynomials and represent a linear transformation by a matrix with respect to a given basis.	K4
CO5	Understand the significance of various canonical forms.	K2

Unit I:

Extension fields - Algebraic Extension - Finite Extension - Roots of polynomials - Remainder theorem - Factor theorem - Splitting field - More about Roots - Irreducible - Simple extension.

(Chapter 5: Sections 5.1, 5.3, 5.5)

Unit II:

Galois Group - Fixed Field - Automorphism - Normal Extension - Elements of Galois Theory - Fundamental Theorem - Solvability by Radicals - Commutators - Solvable - Abel's Theorem.

(Chapter 5: Sections 5.6, 5.7)

Unit III :

The Algebra of linear Transformations - Minimal Polynomial - Invertible - Singular - Regular - Rank - Characteristics Roots - Characteristics Vector

(Chapter 6: Sections 6.1, 6.2)

Unit IV:

Matrices -Matrix of linear Transformation– Canonical forms- Triangular form

(Chapter 6: Sections 6.3, 6.4)

Unit V:

Canonical forms: Nilpotent Transformations- invariants of linear transformations - Canonical forms: A decomposition of V: Jordan Form-minimal polynomial.

(Chapter 6: Sections 6.5, 6.6)

Text Book : Topics in Algebra, Second Edition, I.N. Herstein, Willey India Edition.

Reference Books

Garrett Birkhoff and Thomas C. Bartee: Modern Applied Algebra, CBS Publishers and Distributors, Delhi, 1987.

Core	Sub Code		Hrs./Week	Credits
6	21PMAM22	MATHEMATICAL ANALYSIS	6	5

Objective

- To make the students learn about main concepts of analysis such as differentiation, integration and some special functions.
- To enable the students to learn enough examples, theorems and techniques in analysis.
- To learn about Riemann integration, Sequence and series of functions

Course Outcome

CO-1	Define and analyze the properties of Riemann integration	K4
CO-2	Distinguish between point wise and uniform convergence of a sequence of functions.	K4
CO-3	Illustrate the effect of uniform convergence on the limit function with respect to continuity, differentiability and integrability.	K4
CO-4	Analyze the concepts of Fourier Series and Beta, Gamma functions.	K4
CO-5	Analyze the structure of fourier series and gamma function	K4

Unit I: Definition and Existence of the Integral- Properties of Integral – Integration and Differentiation.

Chapter 6: Section: 6.1 – 6.22.

Unit II: Integration of vector valued functions – Rectifiable curves, Sequence and Series of functions: Discussion of main problem – Uniform Convergence – Uniform Convergence and Continuity.

Chapter 6: Section: 6.23 – 6.27 & **Chapter 7 :** Section: 7.1 – 7.15.

Unit III: Uniform Convergence and Integration – Uniform Convergence and Differentiation – Equicontinuous families of functions.

Chapter 7: Section: 7.16 – 7.25.

Unit IV: The Stone Weierstrass Theorem - Power Series.

Chapter 7: Section: 7.26– 7.33 and **Chapter 8:** Section: 8.1 – 8.5.

Unit V: The algebraic completeness of the complex field – Fourier Series – Trigonometric series –Parseval's theorem- The Gamma function- Stirling's formula.

Chapter 8: Section: 8.8 – 8.22

Text Book: Principles of Mathematical Analysis, Third Edition, Walter Rudin – McGraw Hill International Book Company.

Reference Books

Mathematical Analysis ,Apostol : Addition Wesley Publishing company, London ,1971.

Core	Sub Code		Hrs./Week	Credits
7	21PMAM23	DIFFERENTIAL GEOMETRY	6	4

Objective:

- To acquire the essential ideas and methods of differential Geometry.
- To learn about the classical theory of curves, surfaces and vector methods.
- To study the Geodesic curvature and the Second Fundamental form

Course Outcome:

CO-1	Analyze the essential ideas about the theory of space curves.	K4
CO-2	Determine the concepts of the contact between curves and surfaces.	K5
CO-3	Explain the curves on surfaces and Helicoids	K3
CO-4	Apply the concept of families of curves and Geodesics	K3
CO-5	Compute the principal curvature and lines of curvature	K3

Unit I: The theory of space curves – Definitions , Arc length – Tangent – Normal and Binormal.

Chapter 1: Section: 1.1 – 1.4.

Unit II: Curvature and Torsion of a curve given as the intersection of two surfaces- Contact between curves and surfaces – Tangent Surface – Involutes and evolutes – Helices

Chapter 1: Section: 1.5, 1.6, 1.7 and 1.9

Unit III: The Metric: Local Intrinsic Properties of a Surface: Definition of a surface – Curves on a surface – Helicoids – Metric – Direction Coefficients.

Chapter 2: Section: 2.1, 2.2, 2.4, 2.5, 2.6

Unit IV: Families of curves-Orthoganal trajectories-Double family of curves – Geodesics , Canonical geodesic equation.

Chapter 2: Section: 2.7, 2.10, 2.11

Unit V: Geodesic curvature , The Second Fundamental form – Principal Curvature – Lines of Curvature (Dupin's indicatrix not included).

Chapter 2: Section: 2.15, **Chapter 3:** Section: 3.1 – 3.3.

Text book: An Introduction to Differential Geometry, T.J.Willmore, Oxford University Press, (17th Impresssion), New Delhi, 2002, (Indian Print).

Reference Books :

1. Differential Geometry A first course, D.Somasundaram, Narosa Publishing House.
2. Differential Geometry, William C.Graustein : Dover Publications , New York, 1962.

Core	Sub Code		Hrs./Week	Credits
8	21PMAM24	GRAPH THEORY	6	4

Objectives

- To acquire a detail knowledge about graph theory and its various concepts.
- To solve problems in communication network, railway network etc.,
- To learn about Edge Coloring and Vertex Coloring

Course Outcome

CO1	Analyze the properties of Trees and Connectivity	K4
CO2	Determine the Eulerian and Hamiltonian graphs.	K5
CO3	Discuss and understand the importance of the concepts Matchings and Colorings.	K2
CO4	Understand and apply the fundamental concepts of independent sets	K2, K3
CO5	Solve the problems involving vertex coloring	K3

Unit I :

Trees – cut Edges and Bonds- cut vertices-Cayley's formula-Connectivity – Blocks.

Chapter 2.Section 2.1 – 2.4. Chapter 3 : Sec : 3.1 – 3.2

Unit II :

Euler tours – Hamilton cycles – Applications -The Chinese Postman problem.

Chapter 4 : Sec : 4.1 – 4.3

Unit III :

Matchings – Matchings and coverings in Bipartite graphs - Perfect Matching – Edge colouring: Edge Chromatic Number-Vizing's theorem.

Chapter 5 : Sec : 5.1 – 5.3 & Chapter 6 : Sec : 6.1 & 6.2.

Unit IV :

Independent sets and Cliques: Independence sets-Ramsey's theorem –Turain's theorem.

Chapter 7 : Sec : 7.1 – 7.3.

Unit V :

Vertex Colouring: Chromatic Number- Brooks' theorem- Hajos' Conjecture- Chromatic polynomials- Girth and Chromatic number.

Chapter 8 : Sec : 8.1 – 8.5.

Text Book:

Graph theory with applications, J.A.Bondy and U.S.R.Murty, the MacMillan Press Limitted.

Reference Books:

Applications of Graph Theory , M.Murugan : Muthali Publishing House.

Discipline specific Elective	**Sub Code**	**Paper 1: Operations Research**	**Hrs./Week**	**Credits**

2	21PMAE21		**6**	**4**

Objectives

- To acquire a thorough knowledge of algorithms such as Branch and Bound algorithm, cutting plane algorithm etc.,
- To solve problems using O.R techniques.

Course Outcome

CO-1	Classify and formulate integer programming problems	K4
CO-2	Explain the concept of Gomory's cutting plane Algorithm	K3
CO-3	Formulate and solve mixed integer programming.	K6, K3
CO-4	Understand and solve problems regarding Queing Models.	K2, K3
CO-5	Formulate and solve inventory models and other related models.	K6, K3

Unit I:

Integer Programming Formulation-How to solve integer programming problems? - Types of integer programming problems. Zero- one problems- Solving Zero –one problems-Implicit Enumeration

Chapter 7 : sections 7.1 to 7.5

Unit II :

Integer programming-Gomory's cutting plane Algorithm – Branch and bound algorithm for integer programming.

Chapter 7 : sections 7.6, 7.7

Unit III :

All integer algorithms: All integer Dual Algorithm- All integer Primal algorithm- Mixed constraints infeasibility and unboundedness– Mixed integer programming: A cutting plane Algorithm for the MILP- Bender's partitioning Algorithm for MILP.

Chapter 7 : sections 7.8, 7.9

Unit IV :

Basic Queueing models: Single server infinite and finite Queae Length Model- Multiple server infinite and finite Queae Length Model.

Chapter 11: Sections 11.1 -11.4

Unit V :

Deterministic inventory models: Continuous Demand Instantaneous Replenishment Model- Considering Backordering- Production Consumption Model- Inventory Model with Discount- Multiple Items Inventory: Constraint on Total number of orders, Constraint on Inventory value, Constraint on space- Multiple items Inventory and multiple constraints.

Chapter 13: Sections 13.1 -13.9

Text Book: Operations Research Principles and Applications-G.Srinivasan-PHI learning private limited-New Delhi-EEE edition.

Reference Books

Operations Research, J.K.Sharma : Macmillan, Publishers, India Ltd, 2007.

Discipline specific Elective	**Sub Code**	**Paper 2: Fuzzy Mathematics**	**Hrs./Week**	**Credits**
2	21PMAE22		**6**	**4**

Objective

- To make the students to understand the various algebraic concepts in fuzzy.
- To study operations on Fuzzy sets
- To learn about Fuzzy arithmetic and Fuzzy relations.

Course Outcome

CO-1	Explain the concept of fuzzy sets and crisp sets in brief	K2, K3
CO-2	Define operations in fuzzy sets	K1
CO-3	Analyze the relationship in intersections and unions	K3
CO-4	Determine the concept of fuzzy arithmetic	K5

CO-5	Demonstrate the relations on fuzzy sets	K2

Unit I: Fuzzy sets: Basic concepts Fuzzy sets versus crisp sets. Additional Properties of α - cuts – Representation of fuzzy sets– Extension Principle for fuzzy sets.

Chapter 2: sections: 2.1 - 2.3.

Unit II: Operations on fuzzy sets –types of operations –fuzzy complements: boundary conditions, Monotonicity, continuous function and involutive - first and second Characterization theorem of fuzzy Complements.

Chapter 3: sections:3.1, 3.2.

Unit III: Fuzzy Intersections:t norms- Standard intersection, Algebraic product, Bounded difference and Drastic intersection-Characterization theorem of t-Norms- Fuzzy Unions: t-Conorms - Standard union, Algebraic sum, Bounded sum and Drastic union-Characterization theorem of t-Conorms.

Chapter 3: sections: 3.3, 3.4.

Unit IV: Fuzzy arithmetic: Fuzzy Numbers – Linguistic Variables – Arithmetic operations on Intervals – Arithmetic Operations on Fuzzy Numbers- Lattice of Fuzzy Numbers.

Chapter 4: sections:4.1 to 4.5.

Unit V: Fuzzy relations: Crisp versus Fuzzy Relations - Projections and Cylindric Extensions- Binary Fuzzy Relations – Binary Relations on a single set. .

Chapter 5: sections:5.1 to 5.4

Text Book: Fuzzy Sets and Fuzzy logic theory and applications, George J. Klir and Bo Yuan, Prentice Hall P.T.R, New Jersey.

SEMESTER –III

Core	Sub Code		Hrs./Week	Credits
9	21PMAM31	**Topology**	6	5

Objective

- To introduce basic concepts of Topology.
- To introduce product Topology and ordered Topology.
- To study the countability axioms and Urysohn Metrization theorem.

Course Outcome

CO1	Recall and construct various properties of topologies	K1
CO2	explain the concepts concerned with properties of continuous functions and product topology.	K3
CO3	define Connectedness and Compactness and prove the related theorems.	K1
CO4	Categorize separation axioms on different topological spaces	K4
CO5	Determine with the Uryshon lemma and the Tietze extension theorem	K5

Unit I :

Topological Spaces – Basis for a Topology – The Order Topology - The product Topology on XxY – The Subspace Topology– Closed sets and limit points.

Chapter 2 : Sec : 12 – 17.

Unit II :

Continuous Functions: Continuity of a Function – Homomorphisms – Constructing Continuous Functions – Pasting Lemma – Product Topology: Comparison of the box and product Topologies.

Chapter 2 : Sec : 18, 19.

Unit III :

Connected spaces -Compact Spaces: Open Covering – The Tube Lemma.

Chapter 3 : Sec : 23, 26.

Unit IV :

The Countability Axioms: First and second Countable, Dense – The Separation Axioms: Regular, Normal – Normal Spaces.

Chapter 4 : Sec : 30, 31, 32.

Unit V :

The Urysohn Lemma: Completely regular – The Urysohn Metrization Theorem-Imbedding theorem – The Tietze Extension Theorem.

Chapter 4 : Sec : 33 , 34, 35.

Text Book: Topology (Second Edition), James R Munkres, Prentice Hall of India Pvt. Ltd

Reference Books:

1. George McCarty: Topology, Tata McGraw Hill Publications, New Delhi, 1967.
2. G.F.Simmons: Topology and Modern Analysis ,McGraw – Hill International Editions, 1963.

Core	Sub Code		Hrs./Week	Credits
10	**21PMAM32**	**Measure Theory**	**6**	**5**

Objective

- To Introduce the Lebesgue Measure and Lebesgue Integrals, Measure and Integration.
- To understand the concept of measurable functions & some basic theorems on measurable functions
- To learn about measure spaces, signed measures and product measures.

Course Outcome

CO1	Define Lebesgue measure, Lebesgue measurable sets and measureable functions	K1
CO2	Analyze and make use of convergence and Decomposition theorems	K4
CO3	define Lebesgue integral and discuss its properties.	K1
CO4	Analyze the concept of functions of bounded variations	K4
CO5	List the properties of Signed measures	K1

Unit I: **LebesgueMeasure:** Lebesgue Measure – Lebesgue Outer Measure – The σ - Algebra of Lebesgue Measurable sets – Outer and Inner Approximation of Lebesgue Measurable sets – Countable Additivity, Continuity and the Borel – Cantelli Lemma.

Chapter 2 : Sec 2.1 – 2.5

Unit II: **Lebesgue Measurable functions&Sequential pointwise Limits and related Theorems**: Lebesgue Measurable functions – Sums, Products and Compositions. Sequential pointwise Limits and Simple Approximation – Littlewood's Three Principles, Egoroff's Theorem and Lusin's Theorem

Chapter 3 : Sec 3.1 - 3.3

Unit III: **Lebesgue Integration :**Lebesgue Integration – 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.

Chapter 4 : Sec 4.1 – 4.3

Unit IV: **Lebesgue Integral & Differentiablility**:The general Lebesgue Integral – Countable Additivity and Continuity of Integration. Differentiation and Integration – Continuity of monotone functions – Differentiability of monotone function: Lebesgue's theorem – Functions of bounded variations: Jordan's theorem.

Chapter 4 : Sec 4.4 & 4.5 **Chapter 6 :** Sec 6.1 - 6.3

Unit V: **Signed Measures:** Measure and Integration – Measures and Measurable sets – Signed Measures : The Hahn and Jordan Decompositions – The Caratheodory measure induced by an outer measure – The construction of outer measure

Chapter 17 : Sec : 17.1 - 17.4

Text Book: Real Analysis, Fourth Edition, **H.L.Royden**, P.M.Fitzpatrick, PHI

Learning Private Ltd.

Reference Book:

Munroe, M.E : Introduction to Measure and Integration , Addition–Wesley Publishing Company ,U.S.A 1959.

Core	Sub Code		Hrs./Week	Credits
11	**21PMAM33**	**Probability and Statistics**	**6**	**5**

Objectives:

- To understand the concept of Probability and Probability Distributions.
- To learn the basic concepts of Mathematical Statistics.
- To know about the theory of sampling.

Course Outcome

CO1	Explain conditional probability and stochastic independence	K3
CO2	Recall the different types of distributions	K1
CO3	Explain t and F distribution	K3
CO4	Analyze the change of variable technique	K4
CO5	state the central limit theorem, and apply it.	K1

Unit I :

Chebyshev's inequality-Conditional Probability and Stochastic Independence.

Chapter 1:Sec: 1.11 and Chapter 2.

Unit II :

Some Special Distributions : The Gamma and Chi-Square distribution – The normal distribution.

Chapter 3 : Sec : 3.3, 3.4

Unit III :

Sampling Theory : Transformation of variables – t & F distributions.

Chapter 4 : Sec : 4.1 – 4.4

Unit IV :

Change of variable technique – The MGF technique – Distributions of $\bar{X}$and $\frac{ns^2}{\sigma^2}$ - Expectations of functions of random variables.

Chapter 4 : Sec : 4.5 – 4.9

Unit V :

Limiting distributions, Stochastic, Convergence – Limiting moment generating functions – The Central Limit Theorem – Some theorems on Limiting Distributions.

Chapter 5 : Sec : 5.1 – 5.5

Text Book :

Introduction to Mathematical Statistics, Fourth Edition, Robert V. Hogg and Allen T.Craig, Pearson Education Asia.

Reference Book:

J.N.kapur , H.C. Saxena: Mathematical Statistics, S.Chand& co, 2013.

Core	Sub Code		Hrs./Week	Credits
12	**21PMAM34**	**Analytic Number Theory**	**6**	**4**

Objective

- To make the students to understand the various analytical concepts in numbers.
- To solve the arithmetic functions and arithmetic functions
- To study the concept of chebyshev's functions and shapiro's theorem

Course Outcome:

CO-1	Demonstrate and apply division algorithm in integers and define factorization using primes	K2
CO-2	Define and illustrate arithmetic functions and also analyze their properties	K1
CO-3	calculate and solve the arithmetic functions and Dirichlet multiplication.	K3
CO-4	Compute the averages of arithmetical functions	K3
CO-5	Analyze the concept of chebyshev's functions and shapiro's theorem	K4

Unit 1 : The fundamental Theorem of Arithmetic

Chapter 1

Unit 2 : Arithmetic functions

Chapter 2 : Sec : 2.1 – 2.8

Unit 3 : Multiplicative functions and Dirichlet Multiplication

Chapter 2 : Sec : 2.9 – 2.14

Unit 4 : Averages of Arithmetical functions

Chapter 3 : 3.1 – 3.9.

Unit 5 : Chebyshev's functions – equivalent forms of prime number theorem –Shapiro's theorem and its applications.

Chapter 4 : Sec : 4.1 – 4.7

Text Book : Introduction to Analytic Number Theory, Tom M. Apostol, Springer International Student Edition.

Reference Book:

1. Harriet Griffin: Elementary Theory of Numbers, McGraw-Hall Book company, INC 1954.
2. Ivan Niven and Herbert S. Zuckerman, An introduction to the theory of numbers – Third Edition, Wiley Eastern ltd (1976).

Discipline Specific Elective	**Sub Code**	**Paper 1: Combinatorial Mathematics**	**Hrs./Week**	**Credits**
3	**21PMAE31**		**6**	**4**

Objective:

- To introduce combinatorial techniques for solving enumeration problems
- To understand the concept of permutations and combinations
- To evaluate the concept of inclusion and exclusion principles

Course Outcome

CO-1	Develop the concept of permutations and combinations	K6
CO-2	Compute with the generating functions	K3
CO-3	Determine the recurrence relations	K5
CO-4	Analyze the concept of inclusion and exclusion principles	K4

CO-5	Develop the equivalence classes and permutation group	K6

Unit 1: Permutations and combinations.

Chapter 1 (sec 1.1 to 1.5, 1.7)

Unit 2: Generating Functions.

Chapter 2 (sec 2.1 to 2.5)

Unit 3: Recurrence Relations.

Chapter 3 (sec 3.1 to 3.3)

Unit 4: Principle of inclusion and exclusion.

Chapter 4 (sec 4.1 to 4.3)

Unit 5: Polya's Theory of counting.

Chapter 5 (sec 5.1 to 5.3)

Text: Introduction to Combinatorial Mathematics, C.L.Liu, TMH Publications.

Reference Books:

1. Normal L. Biggs, Discrete Mathematics, Oxford University Press, Oxford, 2002.
2. J.Hein, Discrete Structures, Logic and Computability, Jones and Barlett, 2002.
3. C.L.Liu, Elements of Discrete Mathematics, McGraw Hill, 1986.

Discipline Specific Elective	Sub Code	Paper 2: Discrete Mathematics	Hrs./Week	Credits
3	21PMAE32		6	4

Objectives:

- To acquire the detailed knowledge about various discrete Structures of mathematics.
- To study the concept of Pigeonhole principle, Generalized permutation and combination.
- To learn about Boolean functions and Representing Boolean functions

Course Outcome

CO1	Express a logic sentence in terms of predicates, quantifiers, and logical	K2

	connectives.	
CO2	Recall permutations and combinations	K1
CO3	Calculate Relation and their properties–n-ary relations and their applications	K3
CO4	Formulate and interpret Boolean Algebras	K6
CO5	Construct and classify logical sentence in terms of logical connectives, predicates	K6

Unit I:

Propositional Logic–Propositional equivalence-Predicates and quantifier

sections:1.1 - 1.3.

Unit II:

The Basics of counting –The Pigeonhole principle –Generalized permutation and combination.

Sections:5.1, 5.2 and 5.5

Unit III:

Relation and their properties–n-ary relations and their applications –representing relation –closures of relations.

Sections:7.1 –7.4 except Warshall's algorithm

Unit IV:

Boolean functions –Representing Boolean functions.

Sections:10.1 and 10.2

Unit V:

Logic Gates–Minimization.

Sections:10.3 and 10.4

Text Book:Discrete Mathematics and its Applications (SixthEdition)–Kenneth H. Rosen. WCB/ McGraw Hill Publications

Reference Books:

1. P. K. Mittal, Discrete Structures, Paragon International Publishers, New Delhi, 2007.

2. Gary Haggard, John Schlipf and Sue Whitesides, Discrete Mathematics for Computer Science, Thomson Brooks/Cole Publications.

Core	Sub Code		Hrs./Week	Credits
13	**21PMAM41**	**Complex Analysis**	**6**	**5**

Objectives:

- To learn the basic concepts of analytic functions and power series.
- To understand the concepts of Complex Integration using and Cauchy's integral formula and Residue theorem
- To acquire the knowledge of Harmonic functions.

Course Outcome

CO1	Recall and Analyze the concepts in complex analysis	K1, K3
CO2	Develop linear transformations and line integrable	K6
CO3	Apply the cauchy's theorem and ther higher derivatives	K3
CO4	Determine and Analyze the calculus of residues	K5
CO5	evaluate definite integrals and infinite series.	K5

Unit I : Analytic functions – Polynomials – Power series – Conformality.
Chapter 2 : Sec 1 : 1 – 4, Sec 2 : 4, 5, Chapter 3 : Sec 2 : 3, 4

Unit II : Linear transformations – Symmetry – Family of curves – line integrable – line integrable as functions of arc.
Chapter 3 : Sec 3 : 1 – 4, Chapter 4 : Sec 1 : 1 – 3.

Unit III : Cauchy's theorem for Rectangle – Cauchy's theorem in a disc, Cauchy's Integral formula, Index of a point – The integral formula – Higher derivatives.
Chapter 4 : Sec 1 : 4, 5, Sec 2 : 1 – 3

Unit IV : Taylor's Theorem – Zeros and Poles – The local mapping – The maximum principle of Calculus of Residues.
Chapter 4 : Sec 3 : 1 – 4, Sec 5 : 1.

Unit V : The Argument Principle – Evaluation of definite integrals .

Chapter 4 : Sec 5 : 2, 3.

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

Reference Book:

Foundations of Complex Analysis – S.Ponnusamy – Narosa Publishing House 2015 (Second Edition).

Core	Sub Code		Hrs./Week	Credits
14	**21PMAM42**	**Functional Analysis**	**6**	**5**

Objectives:

- To introduce the study of Banach spaces and its applications.
- To introduce the concept of Hilbert spaces, conjugate spaces, adjoint, self adjoint, normal and unitary operators.
- To introduce finite dimensional spectral theory.

Course Outcome

CO1	Develop the skills in analyzing the basic structure of Banach spaces	K3, K4
CO2	Explain the Natural Imbedding of N in N** andThe open mapping theorem	K3
CO3	Recall the results in Banach spaces and Hilbert spaces	K1
CO4	apply the spectral theorem for the Adjoint of an operator and Self adjoint operators	K3
CO5	Explain the operators and find the spectrum of operators	K5,K1

UNIT 1: **BanachSpaces:**Banach Spaces- The definition and some examples-Continuous linear transformations- The Hahn Banach Theorem

Chapter 9 Sections 46, 47, 48 .

UNIT 2: **Imbedding :**The Natural Imbedding of N in N**- The open mapping theorem

Chapter 9 Sections 49, 50

UNIT 3: **Hilbert Spaces:**Conjugate of an operator -Hilbert Spaces-The Definition and some simple properties- Orthogonal compliments

Chapter 9 Section 51, Chapter 10 Sections 52, 53

UNIT 4: **The Conjugate space and adjoint**: Orthonormal sets-The conjugate space H*- The Adjoint of an operator- Self adjoint operators

Chapter 10 Sections 54, 55, 56, 57

UNIT 5: **Spectral Theory:**Normal and Unitary operators- projections, Finite dimensional spectral theory- Determinants and the spectrum of an operator- The spectral theorem

Chapter 10 Sections 58, 59, Chapter 11 Sections 61, 62

Text Book: **Introduction to Topology and Modern Analysis- G.F. SIMMONS**-McGraw- Hill International Editions

Reference Books:

1. Functional Analysis - Second edition (2011), Tata MC Graw Hill Education Private Ltd. (New Delhi) – Walter Rudin.
2. Functional Analysis – K.ChandrasekaraRao, Narosa Publishing House (2009) New Delhi.

Core	Sub Code		Hrs./Week	Credits
15	21PMAM43	**Partial Differential Equations**	6	4

Objectives:

- To learn more about the concepts of first order partial differential equations.
- To understand the separation of variables in partial differential equations.
- To discuss about the linear partial differential equation with constant coefficients.

Course Outcome

CO1	Formulate partial differential equations and solve it	K3
CO2	Develop Origins of first order Partial Differential equations	K6
CO3	Explain and Solve different kinds of partial differential equations	K3
CO4	Match the physical situations with real world problems to construct mathematical models using partial differential equations	K1
CO5	Apply the Characteristics of Equations in three variables and Separation of variable	K3

Unit I: Simultaneous DE of First Order and First Degree in 3 variables – Methods of solutions of - $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$ - Orthogonal Trajectories of a system of curves on a surface .

Chapter 1: **Section:** Sec : 2 , 3,4.

Unit II : Partial Differential equations - Origins of first order Partial Differential equations - Linear equations of the first order - Integral surfaces passing through a given curve .

Chapter 2: **Section:** 1,2,4 and 5

Unit III: Cauchy's Method of Characteristics - Compatible systems of First order Equations - Charpit's Method.

Chapter 2: **Section:** 8 - 10

Unit IV: Second order equations in Physics - Linear Partial Differential equations with Constant Coefficients.

Chapter 3: **Section:** 2 and 4

Unit V: Characteristics of Equations in three variables - Separation of variables.

Chapter 3: **Section:** 7 and 9

Text Book: Elements Of Partial Differential Equations, IAN N. SNEDDON, McGraw Hill, New Delhi,1983.

Reference Book:

E. T. Copson: Partial Differential Equations Second edition, Cambridge University, 1975.

Core	Sub Code		Hrs./Week	Credits
16	**21PMAM44**	**Calculus Of Variations And Integral Equations**	**6**	**4**

Objectives:

- To study the basic concepts of maxima and minima in Calculus of Variations with its applications.
- To understand the relation between differential and integral equations and to study the concept of Green‟s function.
- To learn about Fredholm equations and Hilbert Schmidt theory.

Course Outcome

CO1	Explain the Euler - Lagrange equation for variational problems including the case of general variations.	K6
CO2	Determine the more general case, Constraints and Lagrange'sMultipliers	K5
CO3	Compare the relation between differential and integral equations.	K5
CO4	Calculate the Fredholm equations with separable kernels	K3
CO5	Apply Hilbert Schmidt theory and Iterative methods for solving equations of second kind.	K4

Unit I: **Maxima and Minima :**Calculus of Variations and Applications – Maxima and Minima – The simplest case – Illustrative examples.
Exercises problems: Chapter 2(2, 6, 8 and 18)
Sections: 2.1-2.4

Unit II: **Lagrange's Multipliers**:Thevariational notations – The more general case – Constraints and Lagrange'sMultipliers – Variable end points.
Exercises problems: Chapter 2(19, 20 and 21)
Sections: 2.5-2.8

Unit III: **Integral Equations:**Integral Equations – Introduction – Relation between differential and integral equations – The Green's function.
Exercises problems: Chapter 3(1,9, 11)
Sections: 3.1-3.3

Unit IV: **Fredholm equations:** Linear Equations in cause and effect- The influence function -Fredholm equations with separable kernels – Illustrative Examples. **Exercises problems:** Chapter 3(40 and 43)
Sections: 3.5-3.7

Unit V: **Hilbert Schmidt theory:**Hilbert Schmidt theory – Iterative methods for solving equations of second kind.
Exercises problems: Chapter 3(52 and 53)
Sections: 3.8-3.9

Text Book: **Methods of Applied Mathematics, Francis B. Hilde**

brand,

Prentice Hall of India, New Delhi.**Sections:** 2.1 to 2.8 and 3.1 to 3.3, 3.5-3.9

Reference Books:

Dr.M.K.Venkataraman, Higher Mathematics for Engineering and Sciences, The National Publishing Company, 2001.

Discipline specific Elective	Sub Code	Major Project	Hrs./Week	Credits
4	21PMAE41		6	5