M Sc – Mathematics (Admissions 2022 onwards)

Program Outcomes

PO1 **Knowledge in Mathematical Science**: Understand the basic concepts, fundamental principles and the scientific theories related to mathematical sciences.

PO2 **Abstract thinking**: Ability to absorb and understand the abstract concepts that lead to various advanced theories in mathematical sciences.

PO3 **Modelling and solving**: Ability in modelling and solving problems by identifying and employing the appropriate existing theories and methods.

PO4 **Advanced theories and methods**: Understand advanced theories and methods to design solutions for complex mathematical problems

PO5 **Applications in Engineering and Sciences**: Understand the role of mathematical sciences and apply the same to solve the real life problems in various fields of study.

PO6 **Modern software tool usage:** Acquire the skills in handling scientific tools towards solving problems and solution analysis.

PO7 **Environment and sustainability**: Understand the significance of preserving the environment towards sustainable development.

PO8 **Ethics**: Imbibe ethical, moral and social values in personal and social life leading to highly cultured and civilized personality. Continue to enhance the knowledge and skills in mathematical sciences for constructive activities and demonstrate highest standards of professional ethics.

PO9 **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

PO10 **Communication:** Develop various communication skills such as reading, listening, and speaking which will help in expressing ideas and views clearly and effectively.

PO11 **Project management and Research**: Demonstrate knowledge, understand the scientific and management principles and apply these to one's own work, as a member/ leader in a team to manage projects and multidisciplinary research environments. Also use the research-based knowledge to analyse and solve advanced problems in mathematical sciences.

PO12 **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Curriculum (2022)

Course Code	Course Title	L T P	Cr	ES	Course Code	Course Title	L T P	Cr	ES
SEMESTER I					**SEMESTER II**				
22MAT501	Advanced Algebra	3 1 0	4	A	22MAT511	Advanced Complex Analysis	3 1 0	4	A
22MAT502	Advanced Real Analysis	3 1 0	4	B	22MAT512	Advanced Topology	3 1 0	4	A
22MAT503	Ordinary Differential Equations	3 0 2	4	C	22MAT513	Partial Differential Equations	3 0 2	4	B
22MAT504	Functional Analysis-I	3 1 0	4	C	22MAT514	Measure Theory	4 0 0	4	C
22MAT581	Mathematics Lab	0 0 2	1	L1		Elective I	3 0 0	3	E
22MAT505	Data Structures and Algorithms	3 0 2	4	E		Elective II	3 0 0	3	L
21CUL501	Cultural Education	2 0 0	P/F		21AVP501	Amria Value Programme	1 0 0	1	
					22AVP103	Mastery Over Mind	1 0 2	2	
	TOTAL		**21**			TOTAL		**25**	
SEMESTER III					**SEMESTER IV**				
22MAT601	Advanced Graph Theory	3 0 2	4	A		Elective VI	3 0 0	3	E
22MAT602	Functional Analysis-II	3 1 0	4	B	22MAT699	Dissertation		10	P
22MAT603	Mathematical Foundations of Incompressible Fluid Flow	3 1 0	4	C					
	Elective III	3 0 0	3	D					
	Elective IV	3 0 0	3	E		TOTAL		**13**	
	Elective V	3 0 0	3	F					
22MAT690	Seminar	0 0 2	1	G					
	TOTAL		**22**			**TOTAL**	**81**		

ELECTIVES (any one Stream)

Course Code	Course Title	L T P	Cr	ES	Course Code	Course Title	L T P	Cr	ES
	ALGEBRA STREAM					**ANALYSIS STREAM**			
22MAT631	Algebraic Geometry	3 0 0	3	D/E	22MAT641	Fixed Point Theory	3 0 0	3	D/E
22MAT632	Algebraic Topology	3 0 0	3	D/E	22MAT642	Fractals	3 0 0	3	D/E
22MAT633	Commutative Algebra	3 0 0	3	D/E	22MAT643	Harmonic Analysis	3 0 0	3	D/E
22MAT634	Finite Field	3 0 0	3	D/E	22MAT644	Nonlinear Partial	3 0 0	3	D/E
22MAT635	Information and Coding Theory	3 0 0	3	D/E	22MAT645	Wavelet Analysis	3 0 0	3	D/E
22MAT636	Lie Algebra	3 0 0	3	D/E	22MAT646	Mathematical Physics	3 0 0	3	D/E
22MAT637	Linear Algebra (for M.Sc	3 0 0	3	D/E	22MAT647	Operator Theory	3 0 0	3	D/E
22MAT638	Representation Theory	3 0 0	3	D/E	22MAT648	Fourier transform and Distribution Theory	3 0 0	3	D/E
22MAT639	Semi group Theory	3 0 0	3	D/E					
22MAT640	Theory of Manifolds	3 0 0	3	D/E					
	STATISTICS STREAM					**DIFFENTIAL EQUATIONS AND ITS APPLICATIONS STREAM**			
22MAT671	Queuing Theory and Inventory Control Theory	3 0 0	3	D/E	22MAT651	Advance Boundary Layer Theory	3 0 0	3	D/E
22MAT672	Statistical Pattern Classifications	3 0 0	3	D/E	22MAT652	Computational Fluid Dynamics	3 0 0	3	D/E

	22MAT673	Statistical Quality Control and Six Sigma Quality Analysis	3 0 0	3	D/E		22MAT653	Finite Element Method	3 0 0	3	D/E	
	22MAT674	Theory of Sampling and Design of Experiments	3 0 0	3	D/E		22MAT654	Magneto-Hydro Dynamics	3 0 0	3	D/E	
	22MAT675	Time Series Analysis	3 0 0	3	D/E		22MAT655	Advanced Numerical Analysis	3 0 0	3	D/E	
	22MAT676	Statistical Techniques For Data Analytics	3 0 0	3	D/E		22MAT656	Hemodynamics	3 0 0	3	D/E	
	22MAT677	Mathematical Finance	3 0 0	3	D/E		22MAT657	Stochastic Differential Equations	3 0 0	3	D/E	
							22MAT658	Singular Perturbation Theory	3 0 0	3	D/E	
							22MAT659	Nonlinear Dynamics and Chaos	3 0 0	3	D/E	
		COMPUTER STREAM										
	22MAT660	Machine Learning	3 0 0	3	D/E							
	22MAT661	Algorithms For Advanced Computing	3 0 0	3	D/E							
	22MAT662	Computer Aided Design for VLSI Circuits	3 0 0	3	D/E							
	22MAT663	Cryptography	3 0 0	3	D/E							
	22MAT664	Fuzzy Sets and its Applications	3 0 0	3	D/E							
	22MAT665	Introduction to Soft Computing	3 0 0	3	D/E							
	22MAT666	Object-Oriented Programming and Python	3 0 0	3	D/E							
	22MAT667	Graph Analytics and Applications	3 0 0	3	D/E							
	22MAT668	Social Network Analysis	3 0 0	3	D/E							
	22MAT669	Computer Aided Drug Design	3 0 0	3	D/E							
	22MAT670	Evolutionary Game Dynamics	3 0 0	3	D/E							

SEMESTER I

22MAT501 Advanced Algebra 3 1 0 4

CO-1: To derive the class equation and use it in various counting problems. To derive Cauchy's/ Sylow's theorem for general groups.

CO-2: To understand direct product concept and the application of Sylow's theorem to Classify finite abelian Groups.

CO-3: To study the cyclotomic polynomials and cyclotomic extension fields and their properties

CO-4: To familiarize Galois theory and its use in analysing the solvability by radicals of polynomial equations.

CO-5: To understand group representation theory and the concepts of indecomposable modules, irreducible modules and completely irreducible modules

Review: Groups and Rings

Unit 1

Groups

Conjugate Elements, Normalizer of an Element, Index of Normalizer, Center of a Group, Cauchy's Theorem on Prime Order, the Number of Conjugate Classes $p(n)$ for a Permutation Group, p-Sylow subgroups, Sylow's Theorems. **(Sec. 2.11and 2.12)** **(11 hrs)**

Unit 2

Groups (contd)

Normal Subgroups, Isomorphic Groups, External and Internal Direct Products, Cyclic Groups, Abelian Groups, Invariants of a Group, Fundamental Theorem on Finite Abelian Groups **(Sec. 2.13 and 2.14)** **(11 hrs)**

Unit 3

Cyclotomic Polynomial and Extensions of Fields. (Ref. Book-1, Sec. 13.6) (8 hrs)

Unit 4

Galois Theory

The Elements of Galois Theory, Group of Automorphisms and its fixed field, Galois Group, The Fundamental Theorem of Galois Theory, Solvable Groups, Solvability by Radicals **(Sec. 5.6 to 5.8).** (13 hrs)

Unit 5

Introduction to the Representation Theory. Linear Actions and Modules over group rings. (Reg. Book-1, Sec. 18.1) (10 hrs)

REFERENCES

1. D.S. Dummit and R. M. Foote, 'Abstract Algebra', 2nd Ed., John Wiley, 2002.
2. John B. Fraleigh, 'A First Course in Abstract Algebra', Narosa Publishing House, 2003.
3. Joseph A. Gallian, 'Contemporary Abstract Algebra', Cengage Learning., 2013.
4. M.Artin, 'Algebra', Prentice Hall inc 1994.
5. Joseph Rotman,'Galois Theory', 2nd Ed., Springer, 2001

Note: The Problems are to be referred from Reference Book 1.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	3	-	-	-	-	-	2
CO2	3	3	2	3	3	3	-	-	-	-	-	2
CO3	2	2	3	3	3	3	-	-	-	-	-	2
CO4	3	3	3	3	3	3	-	-	-	-	-	3
CO5	3	3	3	3	3	3	-	-	-	-	-	2

22MAT502 **Advanced Real Analysis** **3-1-0-4**

Course Outcomes:

CO1- Understanding the sequences and series of functions and uniform convergence.

CO2- Understanding some special functions like exponential, logarithmic and trigonometric functions.
CO3- Understanding special functions and algebraic completeness of the complex field and Fourier series.
CO4- Applying the concept of derivatives in functions of several variables.
CO5- Understanding Contraction principle, The inverse function theorem, The implicit function theorem.

Unit 1

Sequences and Series of Functions: Sequence of functions and its point-wise limit, Discussion of main problems, Uniform convergence, Uniform convergence and continuity, Uniform convergence and Integration, Uniform convergence and Differentiation, Equicontinuous Families of Functions, The Stone-Weierstrass Theorem.

(Chapter 7)

Unit 2

Some Special Functions: Introduction to power series, The Exponential and Logarithmic Functions, The Trigonometric Functions.

(Chapter 8)

Unit 3

Some Special Functions :The Algebraic Completeness of the Complex Field, Fourier series, Gamma function and its properties.

(Chapter 8)

Unit 4

Functions of Several Variables: Linear Transformation, Differentiation, Partial derivatives and problems.

(Chapter 9)

Unit 5

The Contraction principle, The inverse function theorem, The implicit function theorem and problems.

(Chapter 9)

TEXTBOOK:

1. *Rudin. W, "Principles of Mathematical Analysis", McGraw-Hill International Editions, Third Edition, 1976.*

REFERENCE BOOKS:

1. *H.L. Royden and P.M.Fitzpatrick, "Real Analysis", Pearson Education Asia Limited, Fourth Edition, 2010.*
2. *Tom M. Apostol, "Mathematical Analysis", Narosa publishing house, New Delhi, Second Edition, 1989.*

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	3	-	-	-	-	-	2
CO2	3	3	2	3	3	3	-	-	-	-	-	2
CO3	2	2	3	3	3	3	-	-	-	-	-	2
CO4	3	3	3	3	3	3	-	-	-	-	-	3
CO5	3	3	3	3	3	3	-	-	-	-	-	2

22MAT503 ORDINARY DIFFERENTIAL EQUATIONS 3 0 2 4

Prerequisite: The students must know the basic concepts on ordinary differential equation.

Course Outcomes:

CO-1: Understand the existence - uniqueness conditions of solutions to first order equations and apply various methods to solve the initial value problems.
CO-2: Understand the concepts of the existence and uniqueness theorem, fundamental matrix, homogenous/nonhomogenous linear systems with constant coefficients and solve the problems involving central forces, planetary motion and some special equations.
CO-3: Understand the concepts of a complex n-dimensional space, the systems as vector equations, existence and uniqueness of solutions to systems.
CO-4: Understand the concepts of nonlinear equations, autonomous systems, the phase plane and its phenomena and stability for linear and nonlinear systems.
CO-5: Understand the concepts of periodic and oscillatory behaviours of a differential equation.

Unit 1
Linear differential equations: Introduction, initial value problems, the wronskian and linear independence, reduction of order of a homogeneous equation, non-homogeneous equation.

TB2 (3.1-3.6)(4 hours)

Existence - Uniqueness of Solutions to First Order Equations: Equations with variable separated, Exact equations, the method of successive approximations, Lipschitz condition, Convergence of successive approximations, Non–local existence of solutions, Approximations to, and uniqueness, of solutions.

TB2 (5.2- 5.8)(10hours)

Unit 2
Systems of first order equations, Existence and uniqueness theorem, fundamental matrix, nonhomogenous linear systems, linear systems with constant coefficients. **TB3 (4.2-4.7)(10 hours)**

An example – central forces and planetary motion, Some special equations.
TB2 (6.2- 6.3)(4 hours)

Unit 3

Complex n-dimensional space, Systems as vector equations, Existence and uniqueness of solutions to systems, Existence and Uniqueness of linear systems, Equations of order n.
TB2 (6.4- 6.8) (10 hours)

Unit 4
Nonlinear equations: Autonomous Systems, The Phase plane and its phenomena, Types of critical points. Stability, critical points and stability for linear systems, Stability by Liapunov's Direct method, stability by eigen values, Simple critical points of nonlinear systems.**TB1 (11.58- 11.62) (10 hours)**

Unit 5
Nonlinear mechanics, Conservative systems, Periodic solutions, The Poincaré–Bendixson theorem. Oscillations and the Sturm Separation theorem, The Sturm comparison theorem.
TB1 (11.63- 11.64), (4.24-4.25) (7 hours)

TEXT BOOKS:
1. George F. Simmons and John S Robertson, Differential equations with applications and historical notes, Tata McGraw Hill Education Private Limited, Second Edition, 2003.
2. E.A. Coddington, An introduction to ordinary differential equations, PHI learning, 1999.
3. S. G. Deo, V. Lakshmikantham and V Raghavendra, Text book of Ordinary differential equations, McGraw Hill Education Private Limited, second edition, 2013.

REFERENCE:

1. William E. Boyce and Richard C. DiPrima, Elementary differential equations and boundary value problems Wiley india, 9th edition, 2012.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	3	3	3	-	-	-	-	1	3
CO2	3	3	2	3	3	3	-	-	-	-	1	3
CO3	3	2	3	3	3	3	-	-	-	-	1	3
CO4	3	3	3	2	3	3	-	-	-	-	1	2
CO5	3	3	3	2	3	3	-	-	-	-	1	2

22MAT504 FUNCTIONAL ANALYSIS-I 3 1 0 4

Course Outcomes:

CO1: To understand the basic concepts of normed linear and banach spaces.
CO2: To understand finite dimensional normed spaces and compactness of unit ball.
CO3: To understand uniform boundedness principle, bounded inverse theorem and open mapping theorem.
CO4: To understand bounded linear functionals, dual space of classical spaces, reflexivity of the banach space and Hilbert spaces.
CO5: To understand separable Hilbert space and Riesz Representation Theorem.

Unit 1

Normed linear spaces, Banach spaces, Classical examples: $C[0,1], l_p, C, C_0, C_{00}, L^p[0,1]$, Continuity of Linear Operator and bounded linear operator, Quotient spaces

Unit 2

Finite dimensional normed spaces, Riesz lemma, (non) compactness of unit ball, Hahn Banach theorem and Its consequences.

Unit 3

Uniform Boundedness principle, Closed Graph Theorem, Bounded Inverse Theorem, Open Mapping Theorem, Banach Steinhauss Theorem

Unit 4

Bounded Linear Functionals, Dual space of classical spaces, Reflexivity of the Banach Space, Hilbert spaces, Projection theorem, Orthonormal basis, Bessel inequality, Parseval's equality

Unit 5

Seperable Hilbert spaces and Countable orthonormal basis, example of non seperable spaces, Uncountable orthonormal basis and definition of convergence of Fourier series – Riesz-Fisher‘s theorem, Riesz representation theorem

REFERENCES BOOKS:

1. *. Linear Analysis by Bela Bollobas, Cambridge University Press, 1999*

2. Functional Analysis by Balmohan V Limaye, New Age International Publishers, Third Ed, Reprint 2014.
3. Introduction to Topology and Modern Analysis by G. F. Simmons, McGraw Hill Education, 2004
4. Thamban Nair, Functional Analysis: A First Course, PHI, 2001.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	3	-	-	-	-	-	2	2
CO2	3	3	3	3	3	-	-	-	-	-	2	2
CO3	3	2	3	3	3	-	-	-	-	-	1	2
CO4	3	3	3	3	3	-	-	-	-	-	1	2
CO5	3	3	3	3	3	-	-	-	-	-	1	2

22MAT505 Data Structures and Algorithms 3 0 24

Course Outcomes:

CO-1: Understand the basic concepts of growth functions and various sortings.
CO-2: Understand and the concept of divide and conquer for various sortings.
CO-3: Understand and apply the greedy method for various problems.
CO-4: Understand various definitions of graphs and apply to some algorithms.
CO-5: Understand the concepts of various computational complexity classes.

Unit 1 Introduction: growth functions – recurrence relation – methods – master method. Sorting: bubble – insertion sort – selection sort.

Unit 2 Divide and conquer: quick sort – merge sort – bucket sort – lower bounds – heap sort – comparisons of sorting.

Unit 3 Greedy algorithm: fractional knapsack problem – task scheduling problem. Dynamic programming: matrix multiplication problem – 0-1 knapsack.

Unit 4 Graph algorithms: graph traversal (DFS, BFS with analysis) – biconnected components – strong connectivity; shortest path algorithms (along with analysis) – Dijkstra – Bellman Ford – Floyd Warshall. All pairs shortest path algorithm – minimum spanning tree (with analysis) – Kruskal – Prim's – Baruvka's.

Unit 5
NP problems: definition, P, NP, NP complete, NP hard & co-NP, examples – P, NP.

TEXT BOOK

Goodrich M T and Tamassia R, Algorithm Design Foundations, Analysis, and Internet Examples, John Wiley and Sons, 2002.

REFERENCES

1. Baase S and Gelder A V, ``Computer Algorithms – Introduction to Design and Analysis, Pearson Education Asia, 2002.
2. Cormen T H, Leiserson C E, Rivest R L and Stein C, Introduction to Algorithms, Prentice Hall of India Private Limited, 2001.
3. Dasgupta S, Papadimitriou C and Vazirani U, Algorithms, Tata McGraw-Hill, 2009.
4. Horowitz E, Sahni S and Rajasekaran S, Fundamentals of Computer Algorithms, Galgotia, 1998.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	1	2	-	-	-	-		1
CO2	2	2	2	2	1	2	-	-	-	-		1
CO3	2	2	2	1	1	2	-	-	-	-		1
CO4	2	2	2	1	-	2	-	-	-	-		1
CO5	2	2	2	1	-	2	-	-	-	-		1

22MAT581 Mathematics Lab 0 0 2 1

Course Outcomes:

CO 1 Introduction to a Mathematical software
CO2 Explorations of various applications
CO3 Implementation of Mathematical techniques.

- Introduction to a Mathematical software
- Explorations of various applications
- Implementation of Mathematical techniques.
- Introduction to Latex

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	1	3	-	-	-	-	2	3
CO2	3	3	2	2	1	3	-	-	-	-	2	3
CO3	2	2	3	2	1	3	-	-	-	-	2	3

SEMESTER II

22MAT511 ADVANCED COMPLEX ANALYSIS 3 1 0 4

Course Outcomes:

CO1: Understand the concept of the Schwarz Reflection by complex conjugation, and its Applications
CO2:Understand the Riemann Mapping theorem
CO3:Understand the Analytic Continuation
CO4:To understand about the entire function and meromorphic function
CO5:Understand about the Elliptic functions

Unit 1:
Schwarz Reflection: Schwarz Reflection by complex conjugation, Reflection along analytic Arcs, Application of Schwarz Reflection (Chapter 9)

Unit 2
The Riemann Mapping Theorem: Compact sets in Function Spaces, Statement and Proof of the the Riemann Mapping Theorem, Behaviour at the Boundary (Chapter 10).

Unit 3
Analytic Continuation: Analytic Continuation along a curve, Monodromy Theorem, the Dilogrithm, Bloch-Wigner Function, Picard's Theorem and its Application (Chapter 11)

Unit 4
Entire and Meromorphic Functions: Infinite Products, Absolute Convergence, Weierstrass Products, Functions of Finite Order, Canonical product, Minimum Modulus Theorem, Hadamard's Theorem, Mittag-Leffler Theorem (Chapter 13) .

Unit 5
Elliptic Functions: Liouville Theorem, Fundamental Parallelogram, Elliptic Function, Weierstrass Function, Addition Theorem, Sigma and Zeta Functions (Chapter 14)

TEXTBOOK
Serge Lang, 'Complex Analysis' Springer, 4th Edition, First Indian Reprint 2005.

REFERENCES
1. S. Ponnusamy and H. Silverman, Complex Variables with Applications, Springer, 2006.

2. R. Roopkumar, Complex Analysis, Pearson Education, 2014, Chennai

3. Lars V. Ahlfors, Complex Analysis, 2ndEdition, McGrawHill, New York, 1966

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	3	-	-	-	-	-	1	1

CO2	3	3	2	3	3	-	-	-	-	-	1	1
CO3	3	3	3	3	3	-	-	-	-	-	1	1
CO4	3	3	3	3	3	-	-	-	-	-	1	1
CO5	3	3	3	3	3	-	-	-	-	-	1	1

22MAT512 **Advanced Topology** **3 1 0 4**

Course Outcomes:

CO-1: To understand the basic definitions of metric topology, countability and separation axioms.
CO-2: To understand the normal spaces, Urysohn lemma and Urysohn metrization Theorem.
CO-3:.To understand the cTychnoff theorem and other metrization theorems.
CO-4: To study the complete metric spaces and compactness.
CO-5: Understand and the basic concepts of homotopy of paths and fundamental groups.

Unit – 1: The Metric Topology, The Countability Axioms, The Separation Axioms. (Text Book : 20, 21, 30 & 31)

Unit – 2: Normal Spaces. The Urysohn Lemma, The Urysohn Metrization Theorem, The Tietze Extension Theorem. (Text Book : 32 - 35)

Unit – 3: The Tychonoff Theorem, Local Finiteness, The Nagata-Smirnov Metrization Theorem, Para-compactness, The Smirnov Metrization Theorem. (Text Book : 37 & 39 - 42)

Unit – 4: Complete Metric Spaces, Compactness in Metric Spaces, Pointwise and Compact Convergence, Ascoli's Theorem, Baire Space. (Text Book : 43, 45 - 48)

Unit – 5: Homotopy of Paths, The Fundamental Group, Covering Spaces. (Text Book : 51 - 53)

<u>Text Book</u>

1. J. Munkres, “Topology”; Prentice Hall, 2002, Second edition

<u>Reference Books:</u>

1. S. Kumaresan, “Topology of Metric Spaces”; Narosa Publishing House, New Delhi, 2011 Second Reprint.

2. J. Dugundji, “ Topology” Allyn and Bacon, Boston-1966.
3. Fred H. Croom, “Principles of Topology”, Cengage Learning.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	2	3
CO2	3	3	2	3	3	-	-	-	-	-	2	3
CO3	2	2	3	3	3	-	-	-	-	-	2	3
CO4	3	3	3	3	3	-	-	-	-	-	2	3
CO5	3	3	3	3	3	-	-	-	-	-	2	3

22MAT513 PARTIAL DIFFERENTIAL EQUATIONS 3 0 2 4

Prerequisite: The students must know the basic concepts on Calculus (both differential and integral), Differential Equations (ODE and PDE at UG Level), either metric space or topology to understand the words open set, closed set, compact, connected, region, continuous function, Vector Calculus in which the notion of curves, surfaces, tangent plane, normal, surface integral and volume integral and their evaluation, Fourier series and Fourier transforms.

Course Outcomes:

CO-1: Understand the geometrical interpretation, characteristics and general solutions of a first-order pde, and solve it by various methods.
CO-2: Understand the concepts of a second-order pde, its canonical forms and the procedure for obtaining the general solutions.
CO-3: Understand the concepts of the Cauchy problem, initial & boundary-value problems and homogeneous/ nonhomogeneous wave equations..
CO-4: Understand the various types of boundary-value problems, maximum/minimum principles and uniqueness and continuity theorems.
CO-5: Understand the concepts of the heat equation, its solutions and the initial and boundary value problems with time- dependent and time-independent boundary conditions.

Unit 1

Geometrical interpretation of a first-order pde, method of characteristics and general solutions, Monge cone, Lagrange’s equations, canonical forms of first-order linear equations, method of separation of variables.

Tb1:(2.4-2.8)

Unit 2

Second-order equations in two independent variables, canonical forms, equations with constant coefficients, general solutions.

Tb1: (4.1-4.6)

Unit 3

The Cauchy problem, the Cauchy-Kowalewskaya theorem, homogeneous wave equations, the D'Alembert solution of wave equation, initial boundary-value problems, equations with nonhomogeneous boundary conditions, vibration of finite string with fixed ends,.(review) nonhomogeneous wave equations.

Tb1:(5.1-5.7)

Unit 4

Basic concepts, types of boundary-value problems, maximum and minimum principles, uniqueness and continuity theorems. Dirichlet problem for a circle, Dirichlet problem for a circular annulus, Neumann problem for a circle, Dirichlet problem for a rectangle, Dirichlet problem involving the Poisson equation, the Neumann problem for a rectangle

Tb1:(9.1-9.10)

Unit 5

Derivation of the heat equation and solutions of the standard initial and boundary value problems, uniqueness and the maximum principle, time-independent boundary conditions, time-dependent boundary conditions.**TB2: (3.1-3.4) (10 hours)**

TEXTBOOKS:

1. Tyn Myint-U, Lokenath Debnath, Linear Partial Differential Equations for Scientists and Engineers,
   Birkhauser, Boston, Fourth Edition, 2007.
2. D. Bleecker, G. Csordas, Basic Partial Differential Equations, Van Nostrand Reinhold, New York, 1992.

REFERENCES:

1. L.C. Evans, Partial Differrential Equations, Graduate Studies in Mathematics, Vol. 19, AMS, Providence, 1998.
2. I.N. Sneddon, Elements of partial differential equations, McGraw Hill, New York, 1986.
3. E. Zauderer, Partial Differrential Equations of Applied Mathematics, John Wileys & Sons, New York, 2^{nd} edition, 1989.
4. E. C. Zachmanoglou and D. W. Thoe, Introduction to Partial Differential Equations with Applications, Dover Publication, New York, 1986.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	3	3	3	-	-	-	-	1	3
CO2	3	3	2	3	3	3	-	-	-	-	1	3
CO3	3	2	3	3	3	3	-	-	-	-	1	3
CO4	3	3	3	2	3	3	-	-	-	-	1	2
CO5	3	3	3	2	3	3	-	-	-	-	1	2

22MAT514 **MEASURE THEORY** **4 0 0 4**

Course Outcomes:

CO -01: To understand the notion of measure of a set on the real line and to understand the measurable sets and functions

CO-02: To understand and appreciate the notion of Lebesgue Integrals as a generalization of Riemann Integrals
CO-03: To understand abstract measure spaces and integration with respect to a measure
CO-04: To understand and apply various inequalities to establish the completeness of
CO-05: To understand and apply Raydon-Nikodym Theorem

Unit 1 (Sections: 2.1 to 2.5 of [1])
Measure on the Real Line: Lebesgue Outer Measure - Measurable Sets – Regularity - Measurable Functions - Borel and Lebesgue Measurability

Unit 2 (Sections: 3.1 to 3.4 of [1])
Integration of Functions of a Real Variable: Integration of Non-Negative Functions - The General Integral - Integration of Series - Riemann and Lebesgue Integrals.

Unit 3 (Sections: 5.1 to 5.6 of [1])
Abstract Measure Spaces: Measures and Outer Measures - Extension of a Measure - Uniqueness of the Extension - Completion of a Measure - Measure Spaces - Integration with Respect to a Measure.

Unit 4 (Sections: 6.1 to 6.5 of [1])
Inequalities and the L^p Spaces: The L^p Spaces - Convex Functions - Jensen's Inequality - The Inequalities of Holder and Minkowski - Completenessof$L^p(\mu)$.

Unit 5 (Sections: 8.1 to 8.4 of [1])
Signed Measures and their Derivatives: Signed Measures and the Decomposition - The Jordan Decomposition - The Radon-Nikodym Theorem - Some Applications of the Radon-Nikodym Theorem.

TEXTBOOK:

1. Measure Theory and Integration by G.de Barra. First Edition. New Age International Publishers, Reprint 2000.

Reference Book:

1. Real Analysis by H.L. Royden and P.M.Fitzpatrick. Fourth Edition. Pearson Education Asia Limited, 2010.
2. Elias M. Stein & Rami Shakarchi**,** Real Analysis Measure Theory, Integration, and Hilbert Spaces (Princeton Lectures in Analysis), Princeton university press, 2007.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	3	3	3	-	-	-	-	1	3
CO2	3	3	2	3	3	3	-	-	-	-	1	3
CO3	3	2	3	3	3	3	-	-	-	-	1	3
CO4	3	3	3	2	3	3	-	-	-	-	1	2
CO5	3	3	3	2	3	3	-	-	-	-	1	2

SEMESTER III

22MAT601 **Advanced Graph Theory** **3 0 2 4**

Course Outcomes:

CO-1: Understand the basic concepts of graphs and trees.	
CO-2: Understand the concepts of matchings and coverings.	
CO-3: Understand the graph coloring problems.	
CO-4: Understand the concepts of planar graphs and dual graphs.	
CO-5: Understand the basics of spectral graph theory.	

Review of Graphs: Graphs and Sub graphs, isomorphism, matrices associated with graphs, degrees, walks, connected graphs, shortest path algorithm.

Unit 1

Trees: Trees, cut-edges and cut-vertices, spanning trees, minimum spanning trees.
Connectivity: Graph connectivity, k-connected graphs and blocks.
Euler and Hamilton Graphs: Euler graphs, Euler's theorem. Fleury's algorithm for Eulerian trails. Necessary / sufficient conditions for the existence of Hamilton cycles, Chinese-postman problem, approximate solutions of traveling salesman problem.

Unit 2

Matching: Matchings, maximal matchings. Coverings and minimal coverings. Berge's theorem, Hall's theorem, Tutte's perfect matching theorem, Job assignment problem. Coverings, Independent Sets and Cliques; Basic Relations. Graph dominations and coverings.

Unit 3

Colorings: Vertex colorings, greedy algorithm and its consequences, Brooks' theorem. Chromatic polynomials. Edge-colorings, Vizing theorem on edge-colorings.

Unit 4

Planar graphs: Euler formula. Crossing number Kuratowaski's Characterization, Planarity testing algorithm. Spear Embedding. Dual graphs

Unit 5 Graph Spectrum:

Adjacency matrix of a graph and its eigenvalues, Spectral radius of graphs, Regular graphs and Line graphs, Strongly regular graphs, Cycles and Cuts, Laplacian matrix of a graph, Algebraic connectivity, Laplacian spectral radius of graphs.

TEXTBOOKS

1. *J.A. Bondy and U.S.R. Murty, Graph Theory and Applications, Springer, 2008.*
2. *D.B. West, Introduction to Graph Theory, P.H.I. 2010.*

REFERENCES BOOKS

1. *Frank Harary, Graph Theory, New York Academy of Sciences, 1979.*
2. *Balakrishnan and Ranganathan, Graph Theory, springer.*
3. *Russel Merris, Graph Theory, John Wiley, 2011.*
4. C. Godsil, G. Royle, "Algebraic Graph Theory", Graduate Texts in Mathematics 207, Springer-Verlag, 2001.

5. R. B. Bapat, “Graphs and Matrices”, Universitext, Springer, Hindustan Book Agency, New Delhi, 2010.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	-	-	-	-	2	2
CO2	3	3	2	3	3	1	-	-	-	-	2	2
CO3	2	2	3	3	3	1	-	-	-	-	2	2
CO4	3	3	3	3	3	1	-	-	-	-	2	2
CO5	3	3	3	3	3	1	-	-	-	-	2	2

22MAT602 FUNCTIONAL ANALYSIS-II 3 1 0 4

Course Outcomes:

CO1: To understand the concepts of weak and weak*topologies..
CO2: To understand linear and other operators..
CO3: To understand compact operators on banach spaces. .
CO4: To understand invertibility and spectrum, properties of spectrum, Gelfand theorem.
CO5: To understand basis of commutative banach algebra.

Unit-I

Weak topology, weak* topology, weak convergence, weak* convergence, Banach Alaglou Theorem

Unit-2

Linear operators-Examples-Integral operators- Inverse and adjoint operators- Range and null spaces- Adjoint operators in Hilbert spaces- Normal and unitary Operators

Unit-3

Compact operators on Banach spaces- Definition, examples and basic properties- Hilbert Schmidt operators

Unit-4

Banach Algebras, examples, ideals and quotients, invertibility and Spectrum, Properties of Spectrum, Gelfand theorem.

Unit-5

Spectral Radius Formula, Commutative Banach algebra, Gelfand Representation Theorem

REFERENCES BOOKS:

1. Introduction to Topology and Modern Analysis by G. F. Simmons, McGraw Hill Education, 2004
2 Introductory functional analysis with applications by Kreysig E, John Wiley and sons, 1989.
3.Topics in Functional Analysis and applications by S.Kesavan, John Wiley and sons, 1989
4. C- Algebras and Operator Theory by Gerald J. Murphy, Academic Press Limited, 1990.*
5. Functional Analysis and Infinite Dimensional Geometry by . M. Fabian, P.Habala, P. Hajek, V.M. Santalucia, J.Pelant and V. Zizler, CMS Books in Mathematics, Springer-Verlag, 2001

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	3	2	-	-	-	-	-	1	1
CO2	3	3	2	3	2	-	-	-	-	-	1	1
CO3	2	2	3	3	2	-	-	-	-	-	1	1
CO4	3	3	3	3	2	-	-	-	-	-	1	1
CO5	3	3	3	3	2	-	-	-	-	-	1	1

22MAT603 Mathematical Foundations of Incompressible Fluid Flow 3 1 0 4

Course Outcomes:
CO1: To understand and the significance of Lagrangean and Eulerian frames of reference, the material derivative, equation of continuity in these two frames and their equivalence and analyze the kinematics of fluid flow

CO2: To understand and analyze the inviscid fluid flow theory by using Euler's Equation,the simplified form of energy equation, Lamb's, Lagrange's and Helmholtz's equations and appreciate the permanence of irrotational motion.

CO3: To understand the significance of Bernoulli's equation and its applications, the stream function, velocity potential and complex potential in two-dimensional flow, the image system of source and doublet and associated conformal transformations.

CO4) To understand the general theory of irrotational motion and associated theorems like Kelvin's theorem on permanence of irrotational motion, Minimum Kinetic Energy Theorem and the basic theorems on acyclic irrotational motion.

CO5) To understand the basic ideas of symmetry of stress and rate of strain tensor, invariant functions of components of these tensors in viscous fluid flow to develop the Navier-Stokes Equation of motion and to model and solve simple flow problems having exact solution.

Unit 1:

Review of gradient, divergence, curl, Laplacian and vector identities in curvilinear orthogonal systems. (Appropriate sections from Chapter – 1)

Kinematics of Fluids in motion – Lagrangian and Eulerian methods – Material Derivative - Equation of continuity in Lagrangian and Eulerian Methods – their equivalnence – Boundary conditions – Kinematic and physical – condition for a moving surface to be a boundary of fluid flow - steam line, path line and streak line – vorticity – angular velocity - rotational and irrotational motion – vortex lines. (Appropriate sections from Chapter – 2)

Unit 2

Euler's Equations of Equation of Motion of inviscid fluid flow – Lamb's hydrodynamical equations –Impulsive Motion – The energy equation – (inviscid flow) - Lagrange's hydrodynamical equations – Cauchy's Integrals – Helmohtz equations – Permancence of irrotational motion. (Chapter 3)

Unit 3

Bernoulli's equation – Bernoulli's Theorem – Applications – Toricelli's Theorem – Trajectory of a free jet – Euler's Momentum Theorem – D'Alembert's paradox - Motion in two-dimensions – Stream function – Physical significance - irrotational motion in two-dimensions – complex potential – source, sink and doublet – Image of a system – Image of a source, sink and doublet with respect to a line – Conformal transformation & preservation of Kinetic Energy – Transformation of source, sink & doublet – conformal transformation of uniform line source and vortex – Image of a source and a doublet with regard to circle - Milne-Thomson circle theorem – Blasius theorem. (appropriate sections from Chapter 4 & 5)

Unit 4

General theory of irrotational motion – flow and circulation – Stoke's theorem – Kelvin's Circulation theorem – Permanence of irrotational motion – Green's Theorem – Kinetic Energy of Infinite liquid – Acylic and cyclic motion – Some uniqueness theorems related to acyclic irrotational motion - Kelvin's minimum energy theorem – Mean of a potential function over a spherical surface- Maxima and minima of velocity and pressure - Mean value of velocity potential in a region with internal boundaries. (Appropriate sections from Chapter 6)

Unit 5

Newtonian & Non-Newtonian fluids – state of stress at a point – symmetry of stress at a point – transformation of stress components – the three invariant functions – principal stresses – principal directions – Nature of strain – transformation of rate of strain components – the three invariant functions –Relation between stress and rates of strain – Stoke's law of viscosity – Stoke's Hypothesis – The Navier-Stoke's equations of motion of a viscous fluid – vorticity transport equation.
Exact Solutions of Navier Stokes Equations – Steady flows: Plane Couete flow – Generalized Plane Couette Flow – Plane Poiseuille Flow – Hagen-Poiseuille Flow – Unsteady flows: flow over a suddenly accelerated flat plate – flow over an oscillating plate – flow between two parallel plates – flow in a pipe, starting from rest. (Appropriate sections in Chapter 13 and 14)

TEXT BOOK:

1. M.D. Raisinghania, Fluid Dynamics, (9^{th} revised & enlarged edition), S.Chand & Company Limited, 2010.

Reference Books:

1. F. Chorlton, Text Book of Fluid Dynamics, G. K. Publishers, 2009.
2. G.K.Batchelor, "An Introduction to Fluid Dynamics", Cambridge University Press, 1997.
3. L.M. Milne-Thompson, "Theoretical Hydrodynamics", Dover Publications, 1968.
4. S.W. Yuan, "Foundations of Fluid Mechanics", Prentice Hall, New Jersey, 1970.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	1	3	-	-	-	-	-	-	2
CO2	3	3	3	2	3	-	-	-	-	-	1	2
CO3	3	3	3	3	3	-	-	-	-	-	2	2
CO4	3	3	3	3	3	-	-	-	-	-	2	2
CO5	3	3	3	3	3	-	-	-	-	-	3	3

SEMESTER IV

22MAT699 DISSERTATION 10 credits

CO-01: Identify and understand some open problem
CO-02 : Use various mathematical concepts /theorems for research problems
CO - 03: New proofs/methods/algorithms/solutions of the research problems
CO-04:Presentation and documentation of the research findings

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	3	2	2			1	-	-	-	-	3	1
CO2	3	3	2			1	-	-	-	-	3	1
CO3	3	2	3			1	-	-	-	-	3	1
CO4	3	3	3			1	-	-	-	-	3	1
CO5	3	3	3			1	-	-	-	-	3	1

Electives

22MAT631 ALGEBRAIC GEOMETRY 3 0 0 3

Course Outcomes:

CO 1: To understand the various structures introduced in Algebraic geometry and to prove the standard theorems due to Hilbert/Krull/Noether which give correspondence between algebraic varieties and ideals, rings and fields.
CO 2: To understands properties of morphisms and its applications
CO 3: To familiarize the concept of rational maps
CO 4: To identify nonsingualrity through various criteria and understand the process of desingularisation
CO 5: To familiarize the idea of multiplicity and intersection with examples

Unit 1 AFFINE AND PROJECTIVE VARIETIES

Noetherian rings and modules; Emmy Noether's theorem and Hilbert's Basissatz; Hilbert's Nullstellensatz; Affine and Projective algebraic sets; Krull's Hauptidealsatz; topological irreducibility, Noetherian decomposition; local ring, function field, transcendence degree and dimension theory; Quasi-Compactness and Hausdorffness; Prime and maximal spectra; Example: linear varieties, hypersurfaces, curves.

Unit 2 MORPHISMS

Morphisms in the category of commutative algebras over a commutative ring; behaviour under localization; morphisms of local rings; tensor products; Product varieties; standard embeddings like the segre- and the d-uple embedding.

Unit 3 RATIONAL MAPS

Relevance to function fields and birational classification; Example: Classification of curves; blowing-up.

Unit 4 NONSINGULAR VARIETIES

Nonsingularity; Jacobian Criterion; singular locus; Regular local rings; Normal rings; normal varieties; Normalization; concept of desingularisation and its relevance to Classification Problems; Jacobian Conjecture; relationships between a ring and its completion; nonsingular curves.

Unit 5 INTERSECTIONS IN PROJECTIVE SPACE

Notions of multiplicity and intersection with examples.

TEXTBOOKS / REFERENCES BOOKS

1. *Robin Hartshorne, Algebraic Geometry, Graduate Texts in Mathematics (GTM) 8th Printing, Springer, 1997.*
2. *C. Musili, Algebraic Geometry for Beginners, Texts and Readings in Mathematics 20, Hindustan Book Agency, 2001.*

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT632 ALGEBRAIC TOPOLOGY 3 0 0 3

Course Outcomes:

CO 1: To understand the concept complexes define homology groups
CO 2: To obtain homology groups for various pseudo manifolds
CO 3: To prove Brouwer fixed point theorem and understand its uses
CO 4: To familiarise the concept of homotopy theory and its role in topological spaces
Co 5: To find out the fundamental groups of various spaces and anayse the topological structures.

Unit 1

Geometric Complexes and Polyhedra: Introduction. Examples. Geometric Complexes and Polyhedra; Orientation of geometric complexes.

Simplicial Homology Groups: Chains, cycles, Boundaries and homology groups, Examples of homology groups; The structure of homology groups.

Unit 2

The Euler Poincare's Theorem; Pseudomanifolds and the homology groups of Sn. [Chapter 1 Sections 1.1 to 1.4 & Chapter 2 Sections 2.1 to 2.5 from the text].

Unit 3

Simplicial Approximation: Introduction; Simplicial approximation; Induced homomorphisms on the Homology groups; The Brouwer fixed point theorem and related results;

Unit 4

The Fundamental Group: Introduction; Homotopic Paths and the Fundamental Group; The Covering Homotopy Property for S1;

[Chapter 3 Sectins 3.1 to 3.4; Chapter 4 Sections 4.1 to 4.3]

Unit 5

Examples of Fundamental Groups; The Relation Between H1(K) and p1(iKi); Covering Spaces: The definition and some examples. Basic properties of covering spaces. Classification of covering spaces. Universal covering spaces. Applications.

[Chapter 4: Sections 4.4, 4.5; Chapter 5 Sections 5.1 to 5.5 from the text]

TEXT BOOK
Fred H. Croom: Basic Concepts of Algebraic Topology, UTM, Springer, NY, 1978.

REFERENCES BOOKS:

1. Eilenberg S and Steenrod N: Foundations of Algebraic Topology, Princetion Univ. Press, 1952.
2. S.T. Hu: Homology Theory, Holden-Day, 1965.
3. S.T. Hu: Homology Theory, Academic Press, 1959.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT635 Information and Coding Theory 3 0 0 3

Course Outcomes:

CO-1: To understand the basic concepts of linear/error correcting codes and apply the concepts to encode and decode the information.
CO-2: To understand the concepts of dual /Hamming codes and apply the concept to find the parameters of given codes and their dual codes using standard matrix and polynomial operations .
CO-3: To familiarise the concepts of cyclic/BCH codes with required properties.
CO-4: To understand the concepts of weight enumerators and apply to find the weight information of the code. To familiarise the concept of MDS code.
CO-5: Apply the basic concepts of linear codes to solve problems .

Information Theory: Entropy, Huffman coding, Shannon-Fano coding, entropy of Markov process, channel and mutual information, channel capacity; Error correcting codes: Maximum likelihood decoding, nearest neighbour decoding, linear codes, generator matrix and parity-check matrix, Hamming bound, Gilbert-Varshamov bound, binary Hamming codes, Plotkin bound, nonlinear codes, Reed-Muller codes, Cyclic codes, BCH codes, Reed-Solomon codes, Algebraic codes.

Reference Books:

1. R. W. Hamming, "Coding and Information Theory", Prentice-Hall, 1986.
2. N. J. A. Sloane, F. J. MacWilliams, "Theory of Error Correcting Codes", North-Holland Mathematical Library 16, North-Holland, 2007.
3. S. Ling, C. Xing, "Coding Theory: A First Course", Cambridge University Press, 2004.
4. V. Pless, "Introduction to the Theory of Error-Correcting Codes", Wiley-Interscience Publication, John Wiley & Sons, 1998.
5. S. Lin, "An Introduction to Error-Correcting Codes", Prentice-Hall, 1970.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT633 COMMUTATIVE ALGEBRA 3 0 0 3

Course Outcomes:

CO-1: To understand the basic definitions of rings, ideals and modules through examples; To construct new modules by tensor product, Hom, direct sum/product.
CO-2: To understand the fractions of modules and apply the fractions to construct the field from integral domain. To familiarize the decomposition of rings/modules.
CO-3: To familiarize the concept of integral dependence of extension ring and chain conditions of modules. To understand the definitions of valuations / Noetherian / Artin rings through examples.
CO-4: To study the basic properties of Noetherian/Artin rings; use the basic properties to characterize/decompose the Noetherian/Artin rings.
CO-5: To understand the basic definitions of discrete valuation rings and Dedekind domains. To familiarize the concept of dimension theory of rings/modules.

Unit 1 Rings and ideals, modules and operations on them (tensor product, Hom, direct sum and product).

Unit 2 Rings and modules of Fractions, primary decomposition.

Unit 3 Integral dependence and Valuations, Chain Conditions.

Unit 4 Noetherian Rings and Artin Rings.

Unit 5 Discrete valuation Rings and Dedekind Domains, Dimension theory.

TEXT BOOKS / REFERENCES

1. Atiyah-Macdonald, Commutative Algebra, Westview Press, 1994.
2. Zariski and Samuel, Commutative Algebra I, II , Springer, 1991.
3. Eisenbud, Commutative Algebra with a View Towards Algebraic Geometry, Springer, 1995.
4. Bourbaki, Commutative Algebra, Springer, 1989.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	

CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT636 LIE ALGEBRA 3 0 0 3

Course Outcomes:

CO 1: To understand the concept of Lie algebra and to know the substructures and operations on them.
CO 2: To familiarize nilpotent and solvable Lie algebras and prove the Engel's theorem
CO 3: To understand theorems on Semi simple Lie algebras and their applications .
CO 4: To derive various decomposition theorems on Lie algebras
Co 5: To understand the classification of Lie algebras through Dynkin diagrams.

Unit 1 Basic Concepts - Definition and Examples, Lie Algebra of Derivations, Adjoint Representation, Structure Constants, Direct Sums, Homomorphism and Isomorphisms, Ideals, Centre and Derived Algebra of a Lie Algebra, Simple Lie Algebras, The Normalizer of a Subalgebra and Centralizer of a Subset in Lie Algebras, Automorphism and Inner Automorphism of a Lie Algebra. (Book 1, Chapters 1 and 2).

Unit 2 Descending Central Series of a Lie Algebra, Nilpotent Lie Algebras. Derived Series of a Lie Algebra, Radical of a Lie Algebra, Solvable Lie Algebras, Engel's Theorem. (Book 1, Chapter 3).

Unit 3 Semi simple Lie Algebras - Theorems of Lie and Cartan, Jordan-Chevalley Decomposition, Cartan's Criterion. (Book 1, Chapter 4)

Unit 4 Killing Form, Inner Derivations, Abstract Jordan Decomposition, Complete Reducibility of Lie algebras. (Book 1, Chapter 5)

Unit 5 The Weyl Group, Root Systems. (Book 1, Chapter 10)

TEXT BOOKS / REFERENCES BOOKS

1. Jacobson, Lie Algebras, Dover, 1979.
2. J.P. Serre, Lie Algebras and Lie Groups, Benjamin, 1965 (Translated from French).
3. J.E. Humphreys, Introduction to Lie Algebras and Representation Theory, Springer-Verlag, 1980.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT640 THEORY OF MANIFOLDS 3 0 0 3

Course Outcomes:

CO 1: To familiarize the concept of manifolds and learn their properties
CO 2: To understand the concept of tangent spaces and its properties
CO 3: To generalize the ideas of curves/derivatives to manifolds
CO 4: To prove the inverse /implicit function theorems in manifolds
Co 5: To understand Riemannian manifolds and their relevance

Unit 1

Definition of Manifolds, Differentiable and Analytic Manifolds, Examples of Manifolds, Product of Manifolds, Mappings between Manifolds, Sub manifolds, Tangent Vectors.

Unit 2

Differentials, The Differential of a Function, Infinitesimal Transformation, Tangent Space, Tangent Vector.

Unit 3

Cotangent Space, Vector Fields, Smooth Curve in a Manifold. Differential Forms– k-forms, Exterior Differential, its Existence and Uniqueness.

Unit 4

Exact Differential Forms. De Rham Cohomology Group, Betti Number, Poincare's Lemma, Inverse Function Theorem, Implicit Function Theorem and its Applications, Integral Curve of a Smooth Vector Field.

Unit 5

Orientable Manifolds– Definition and Examples. Smooth Partition of Unity– Definition and Existence. Riemannian Manifolds– Definition and Examples.

TEXTBOOKS / REFERENCES:

1. *P.M.Cohn, "Lie Groups", Cambridge University Press, 1965.*
2. *Claude Chevalley, "Theory of Lie Groups", Fifteenth Reprint, Princeton University Press, 1999.*

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT639 Semigroup Theory 3 0 0 3

Course Outcomes:

CO1: To understand the basics of semigroups.

CO2: To understand the concepts of classes of semigroups like regular semigroups.

CO3: To understand the simple and semi simple semigroups.

CO4: To understand the Clifford semigroups and free bands.

CO5: To understand the inverse of the semi simple groups.

Unit I: - Basic Definitions- Monogenic Semigroups- Ordered Sets, Semi lattices and lattices- Binary relations; equivalences- Congruences- Free semigroups- Ideals and Rees Congruences.(Chapter I Section 1.1-1.7)
Unit II: - Greens Relations- Structure of D- classes- regular D- classes- regular semigroups- The
sandwich Sets (Chapter II Section 2.1 – 2.5)
Unit III: - Simple and 0-simple semigroups- principal factors, Rees Theorem- Completely simple
semigroups- Isomorphism and normalization (Chapter III Section 3.1 – 3.4)
Unit IV: -Completely Regular Semigroups- Clifford Decomposition- Clifford semigroups- Bands- Free Bands- Varieties of Bands(Chapter IV Section 4.1- 4.6)
Unit V: -Inverse semigroups- Preliminaries- The Natural partial order relation on an inverse semigroup- Congruences on Inverse semigroups- -The Munn Semigroup(Chapter V Section 5.1
– 5.4)

Text Books / Reference Books:

1. Fundamentals of Semigroup theory, J. M. Howie, Clarendon Press, Oxford ISBN0- 19- 851194-9
2. The Algebraic Theory of Semigroups- A. H. Clifford and G. B. Preston, American Mathematical Society 1961
3. Semigroups: An Introduction to the Structure Theory- P. A. Grillet, Marcel Decker INC. 1995
4. Techniques of Semigroup Theory- Peter M. Higgins, Clarendon press

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT638 Representation Theory 3 0 0 3

Course Outcomes:

CO1: To understand the basic notions of representation theory.
CO2: To understand the irreducible and indecomposable representations.
CO3: To understand the characters of representations and extensions of representations.
CO4: To understand the Maschke’s theorem and dual representations.

1. Basic objects and notions of representation theory: Associative algebras. Algebras defined by generators and relations. Group algebras. Quivers and path algebras. Lie algebras and enveloping algebras. Representations. Irreducible and indecomposable representations. Schur's lemma. Representations of sl(2).
2. Basic general results of representation theory. The density theorem. Representations of finite dimensional algebras. Semisimple algebras. Characters of representations. Jordan-Holder and Krull-Schmidt theorems. Extensions of representations.
3. Representations of finite groups, basic results. Maschke's theorem. Sum of squares formula. Duals and tensor products of representations. Orthogonality of characters.

Orthogonality of matrix elements. Character tables, examples. Unitary representations. Computation of tensor product and restriction multiplicities from character tables. Applications of representation theory of finite groups.

4. Representations of finite groups, further results: Frobenius-Schur indicator. Frobenius determinant. Algebraic integers and Frobenius divisibility theorem. Applications to the theory of finite groups: Burnside's theorem. Induced representations and their characters (Mackey formula). Frobenius reciprocity. Representations of $GL(2; Fq)$. Representations of the symmetric group and the general linear group. Schur-Weyl duality. The fundamental theorem of invariant theory.
5. Representations of quivers. Indecomposable representations of quivers of type A1, A2, A3, D4. The triple of subspaces problem. Gabriel's theorem. Proof of Gabriel's theorem: Simply laced root systems, reflection functors.
6. **CO-PO Mapping:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	1	-	-	-	-	-	1	
CO2	3	3	2	2	2	-	-	-	-	-	1	
CO3	2	2	3	2	2	-	-	-	-	-	1	
CO4	3	3	3	2	1	-	-	-	-	-	1	

22MAT637 Linear Algebra (Only for M.Sc students) 3 0 0 3

Course Outcomes:

CO-1: To understand inner products and compute the angle/length of a vector. To apply Gram-Schmidt process to construct the orthonormal basis.
CO-2: To familiarize the concept of characteristic roots/ vectors and related properties. To apply the link between linear transformation and matrix to find characteristic roots/ vectors.
CO-3: To understand the construction of matrices for a linear transformation in the triangular/Jordan form. To apply the canonical form to find the rank of the matrix/transformation.
CO-4: To familiarize the types of matrices, understand their properties and apply them in transformation.
CO-5: To understand the process of diagonalizing and apply diagonalization to identify Conic Sections.

Unit 1 Review: Vector Spaces.
Inner Products, Angle and Orthogonality in Inner Product Spaces, Length of a Vector, Schwarz Inequality, Orthogonal Vectors, Orthogonal Complement, Orthogonal Bases: Gram-Schmidt Process. **(Sec. 4.4)**

Unit 2 The Algebra of Linear Transformations, Characteristic Roots, Invertible Linear transformations, Characteristic Roots, Characteristic Vector, Minimal Polynomial, Matrices, Matrix of a Linear Transformation. **(Sec. 6.1 to 6.3).**

Unit 3 Canonical Forms: Triangular, Nilpotent Transformations, Jordan and Rational Canonical Form, invariant subspaces, cyclic subspaces.
(Sec. 6.4 to 6.6).

Unit 4 Trace and Transpose, Determinants, Symmetric and Skew Symmetric Matrices, Adjoint and Hermitian Adjoint of a Matrix, Hermitian, Unitary and Normal Transformations, Self Adjoint and Normal Transformations. **(Sec. 6.8 to 6.10)**

Unit 5 Problems in Eigen Values and Eigen Vectors, Diagonalization, Orthogonal Diagonalization, Quadratic Forms, Diagonalizing Quadratic Forms, Conic Sections. **(Sec. 7.1 to 7.3 and 9.5 to 9.6 from Reference Book 2)**

TEXT BOOK:

1. I. N. Herstein, 'Topics in Algebra', Second Edition, John Wiley and Sons, 2000.

REFERENCES:

1. David C. Lay, Linear Algebra and its Applications, Pearson.
2. Gilbert Strang,' Linear Algebra and its Applications, Fourth Edition, Cengage Learning, 2014.
3. Howard Anton and Chris Rorres, 'Elementary Linear Algebra', 9th Edition, Wiley, 2005.
4. Nabil Nassif, Jocelyne Erhel, Bernard Philippe, Introduction to Computational Linear Algebra, CRC press, 2015.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	-	-	-	-	-	3	2
CO2	3	3	2	3	3	-	-	-	-	-	3	2
CO3	3	2	3	3	3	-	-	-	-	-	3	2
CO4	3	3	3	3	3	-	-	-	-	-	2	2
CO5	3	3	3	3	3	-	-	-	-	-	2	2

22MAT634 Finite Field 3 0 0 3

Course Outcomes:

CO1: To understand the structure of finite fields.
CO2: To understand the concepts of cyclotomic polynomilas and related topics.
CO3: To understand the polynomials over finite field.
CO4: To understand the construction of irreducible polynomials and binomials and trinomials.
CO5: To understand the linear recurring sequences.

Structure of finite fields: characterization, roots of irreducible polynomials,traces, norms and bases, roots of unity, cyclotomic polynomial, representation of elements of finite fields, Wedderburn's theorem;
Polynomials over finite field: order of polynomials, primitive polynomials, construction of irreducible polynomials, binomials and trinomials, factorization of polynomials over small and large finite fields, calculation of roots of polynomials;
Linear recurring sequences: LFSR, characteristic polynomial, minimal polynomial, characterization of linear recurring sequences, Berlekamp-Massey algorithm; Applications of finite fields: Applications in cryptography, coding theory, finite geometry, combinatorics.

Reference Books:

1. R. Lidl, H. Neiderreiter, “Finite Fields”, Cambridge university press, 2000.
2. G. L. Mullen, C. Mummert, “Finite Fields and Applications”, American Mathematical Society, 2007.
3. A. J. Menezes et. al., “Applications of Finite Fields”, Kluwer Academic Publishers, 1993.
4. Z-X. Wan, “Finite Fields and Galois Rings”, World Scientific Publishing Co., 2012.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT641 FIXED POINT THEORY 3 0 0 3

Course Outcomes:

CO-1: Understand and apply the concepts of fixed point theorems to prove the existence and uniqueness of solution to certain ordinary differential equations.
CO-2: To understand the existence and uniqueness of fixed point for non expansive and set valued mappings
CO-3: To understand the existence of best approximation point for non expansive mapping and its applications.
CO-4: To understand the existence and uniqueness of fixed point for partially ordered metric space.

Unit 1 Contraction Principle, and its variants and applications;

Unit 2 Fixed points of non-expansive maps and set valued maps, Brouwer-Schauder fixed point theorems,

Unit 3 Ky Fan Best Approximation Theorem, Principle and Applications of KKM - maps, their variants and applications.

Unit 4 Fixed Point Theorems in partially ordered spaces and other abstract spaces.

Unit 5 Application of fixed point theory to Game theory and Mathematical Economics.

TEXTBOOKS / REFERENCES BOOKS

1. M.A. Khamsi and W.A. Kirk, An Introduction to Metric Spaces and Fixed Point Theory, Wiley - Inter Sci. (2001).
2. Sankatha Singh, Bruce Watson and Pramila Srivastava, Fixed Point Theory and Best Approximation: The KKM - map Principle, Kluwer Academic Publishers, 1997.
3. Kim C. Border, Fixed Point Theorems with Applications to Economics and Game Theory, Cambridge University Press, 1985.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	

22MAT647 Operator Theory 3 0 0 3

Course Outcomes:

CO1: To understand compact operators and apply in Fredholm Theory and $C*$- algebras.
CO2: To understand and apply Gelfand-Neumark representation theorem.
CO3: To understand and apply projections, Toeplitz operators.

Compact operators on Hilbert Spaces. (a) Fredholm Theory (b) Index, $C*$- algebras - noncommutative states and representations, Gelfand-Neumark representation theorem, Von-Neumann algebras; projections, double commutant theorem, $L\infty$ functional calculus, Toeplitz operators.

Reference Books:

1. W. Arveson, “An invitation to C*-algebras”, Graduate Texts in Mathematics, No. 39. Springer-Verlag, 1976.
2. N. Dunford and J. T. Schwartz, “Linear operators. Part II: Spectral theory. Self adjoint operators in Hilbert space”, Interscience Publishers John Wiley i& Sons 1963.
3. R. V. Kadison and J. R. Ringrose, “Fundamentals of the theory of operator algebras. Vol. I. Elementary theory”, Pure and Applied Mathematics, 100, Academic Press, Inc., 1983.
4. V. S. Sunder, “An invitation to von Neumann algebras”, Universitext, Springer-Verlag, 1987.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	

22MAT642 FRACTALS 3 0 0 3

Course Outcomes:

CO1. Understand the basic concepts and structure of fractals .
CO2. Understand the space of fractals and transformation on metric spaces.
CO3. Understand the iterated function system with contraction mapping theorem.
CO4. Apply fractal concepts to compute fractal dimension of sets and construct fractal interpolation functions.

CO5. Understand the hidden variable fractal interpolation function, fractal splines and fractal surfaces.

Unit 1 Classical Fractals, Self-similarity - Metric Spaces, Equivalent Spaces.

Unit 2 The Space of Fractals, Transformation on Metric Spaces.

Unit 3 Contraction Mapping and Construction of fractals from IFS.

Unit 4 Fractal Dimension, Hausdorff measure and dimension, Fractal Interpolation Functions.

Unit 5 Hidden Variable FIF, Fractal Splines, Fractal Surfaces, Measures on Fractals.

TEXT BOOKS

1. *M.F. Barnsley, Fractals Everywhere, Academic Press, 1993.*
2. *P.R. Massopust, Interpolation and Approximation with Splines and Fractals, Oxford University Press, 2009.*
3. *K. Falconer, Fractal Geometry (Mathematical Foundations and Applications), John Wiley & Sons, 2003.*

REFERENCES

1. P.R. Massopust, Fractal Functions, Fractal Surfaces and Wavelets, Academic Press, 1994.
2. Heinz-Otto Peitgen and Peter Richter, The Beauty of Fractals, Springer, 1986.
3. Richard M. Crownover, Introduction to Chaos and Fractals, Jones and Bartlett Publishers, 1995.
4. Gerald A. Edgar, Measure, Topology and Fractal Geometry, Springer, 1990.
5. M.F. Barnsley, Superfractals, Academic Press, 2006.
6. B.B. Mandelbrot, The Fractal Geometry of Nature, Freeman, 1981.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT643 HARMONIC ANALYSIS 3 0 0 3

Course Outcomes:

CO1. Understand the basic concepts of Fourier series, Fourier transforms and their related results.
CO2. Analyze the characters of discrete and compact groups with their related results.
CO3. Understand the concepts of Fourier integrals with their convergence results.
CO4. Understand the different summability and analyze the inequlity of Hausdroff and Young.
CO5. Understand the concepts of Hardy spaces and invariant subspaces and their results.

Unit 1 Fourier series and integrals – Definitions and easy results – The Fourier transform – Convolution – Approximate identities – Fejer's theorem – Unicity theorem – Parselval relation – Fourier Stieltjes Coefficients – The classical kernels.

Unit 2 Summability – Metric theorems – Pointwise summability – Positive definite sequences – Herglotz;s theorem – The inequality of Hausdorff and Young.

Unit 3 The Fourier integral – Kernels on R. The Plancherel theorem – Another convergence theorem – Poisson summation formula – Bachner's theorem – Continuity theorem.

Unit 4 Characters of discrete groups and compact groups – Bochners' theorem – Minkowski's theorem.

Unit 5 Hardy spaces - Invariant subspaces – Factoring F and M. Rieza theorem – Theorems of Szego and Beuoling.

TEXT BOOK:
Content and Treatment as in Henry Helson, Harmonic Analysis, Hindustan Book Agency, Chapters 1.1 to 1.9, 2.1 to 3.5 and 4.1 to 4.3

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT644 NONLINEAR PARTIAL DIFFERENTIAL EQUATIONS 3 0 0 3

Course Outcomes:

CO1- Understand the general concept of weak solution and the criterion of having weak solution for hyperbolic equation.
CO2- Able to model the basic diffusion processes and understand the mathematical methods that are useful in studying the structure of their solutions.
CO3-Understand the existence and uniqueness of traveling wave solutions solutions.
CO4-Understand the concept of nonlinear eigenvalue problem the stability of equilibrium solutions for reaction-diffusion equation.
CO5-Understand the formulation of system of PDEs and their applications.

Review of first order equations and characteristics.

Unit 1 Weak solutions to hyperbolic equations - discontinuous solutions, shock formation, a formal approach to weak solutions, asymptotic behaviour of shocks.

Unit 2 Diffusion Processes - Similarity methods, Fisher's equation, Burgers' equation, asymptotic solutions to Burgers' equations.

Unit 3 Reaction diffusion equations - traveling wave solutions, existence of solutions, maximum principles and comparison theorem, asymptotic behaviour.

Unit 4 Elliptic equations - Basic results for elliptic operators, eigenvalue problems, stability and bifurcation.

Unit 5 Hyperbolic system.

TEXT BOOK

J David Logan, An Introduction to Nonlinear Partial Differential Equations, John Wiley and Sons, Inc., 1994

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT645 WAVELET ANALYSIS 3 0 0 3

Course Outcomes:

CO1	Understand and apply the concepts of DFT and its significance in Engineering problems
CO2	Understand and apply the concept of first stage wavelet basis and iterative stages of wavelet bases in finite dimensional space.
CO3	Understand and apply the concept of first stage wavelet basis and iterative stages of wavelet bases in infinite dimensional space.
CO4	Understand the concepts of Fourier transform and MRA and the construction of wavelets and its applications.

Unit 1 Basic Properties of the Discrete Fourier Transform, Translation - Invariant Linear Transformations. The Fast Fourier Transform.

Unit 2 Construction of Wavelets on Z_N, The First Stage Construction of Wavelets on Z_N, The Iteration Step"s. Examples and Applications, $l2(Z)$

Unit 3 Complete Orthonormal Sets in Hilbert Spaces, $L_2([-\pi, \pi))$ and Fourier Series, The Fourier Transform and Convolution on $l_2(Z)$, First-Stage Wavelets on Z
The Iteration Step for Wavelets on Z , Implementation and Examples.

Unit 4 $L_2(R)$ and Approximate Identities, The Fourier Transform on R, Multiresolution Analysis and Wavelets,

Unit 5 Construction of Multiresolution Analyses, Wavelets with Compact Support and Their Computation.

TEXT BOOK:
Michael W. Frazier, An Introduction to Wavelets Through Linear Algebra, Springer, 1999.

REFERENCES:

1. *Daubechis, Ten Lectures on Wavelets, SIAM, 1992.*
2. *S. Mallat, A Wavelet Tour of Signal Processing, Elsevier, 2008.*

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	

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22MAT648 Fourier transform and Distribution Theory 3 0 0 3

Unit1: Test functions and Distributions: Introduction-Test function spaces -calculus with distributions –localization-supports of distributions-Distributions as derivatives-convolutions.
Unit 2: Fourier Transforms: Basic properties-Tempered distributions-paley-wiener theorems-sobolev’s lemma
Unit3: Applications to Differential Equations-Fundamental solutions-Elliptic equations
Text Books / Reference Books:
1. Walter Rudin, Functional Analysis, McGraw-Hill Inc., New York (1973).
(Chapter 6, 7, 8, 9)
2. R.S. Pathak, A course in distribution Theory, Narosa Publishing course 2001
3. Robert S Strichartz, A guide to Distribution Theory and Fourier Transforms, World Scientific.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	3	2	-	-	-	-	-	-
CO2	2	2	3	3	3	1	-	-	-	-	-	-
CO3	2	2	3	3	3	3	-	-	-	-	-	-
CO4	2	2	3	3	3	3	-	-	-	-	2	2

22MAT655 ADVANCED NUMERICAL ANALYSIS 3 0 0 3

Course Outcomes:
CO1. To understand the Quantitative analysis of solution of
trancendental and polynomial equations.
CO2. To understand the Quantitative analysis of solution of system of linear algebraic equations, ordinary and
partial differential equations.
CO3. To understand the interpolation of polynomial approximation by means of computational methods.

UNIT I :
Transcendental and polynomial equations
Transcendental and polynomial equations: Iteration methods based on second degree equation - Rate of convergence - iterative methods – Methods for finding complex roots – iterative methods : Birge-Vieta method, Bairstow's method, Graeffe's root squaring method
UNIT II
System of Linear Algebraic Equations
System of Linear Algebraic Equations - Direct methods - Gauss Jordan Elimination Method – Triangularization method – Cholesky method – partition method. Error Analysis – Iteration methods : Jacobi iteration method – Gauss - Seidal iteration method – SOR method. Jacobi method for symmetric matrices.
UNIT III
Interpolation and Approximation
Interpolation and Approximation - Hermite Interpolations – Piecewise and Spline Interpolation – Appproximation – Least Square Approximation - Numerical Differentiation - Numerical Integration – Methods based on Interpolation.
UNIT IV
Numerical Solutions of ODE
Ordinary Differential Equations : Multi – step method – Predictor – Corrector method – Boundary value problem – Initial value methods – Shooting method – Finite Difference method (with MATLAB programs).
UNIT V
Numerical solutions of PDE
Partial Differential Equations: Initial and Boundary value problems - Parabolic Problems – one dimension problems with constant coefficients – Elliptic Problems with Dirichlet Condition - Finite difference methods (with MATLAB programs)
(Questions not to be asked from MATLAB)
TEXT BOOKS / Reference Books:
1. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering
Computation, III Edn. Wiley Eastern Ltd., 1993.
2. M.K. Jain, Numerical Solution of Differential Equations, II Edn., New Age International Pvt Ltd., 1983.
3. Kendall E. Atkinson, An Introduction to Numerical Analysis, II Edn., John Wiley & Sons, 1988.
4. Amos Gilat, MATLAB An Introduction with Applications, John wiley& sons, 2004.
5. Samuel. D. Conte, Carl. De Boor, Elementary Numerical Analysis, McGraw-Hill International Edn., 1983.
6. Gordon D Smith, Numerical Solution of Partial Differential Equations – Finite Difference Methods, Oxford University Press, 1985.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	3	2	-	-	-	-	-	-
CO2	2	2	3	3	3	1	-	-	-	-	-	-
CO3	2	2	3	3	3	3	-	-	-	-	-	-
CO4	2	2	3	3	3	3	-	-	-	-	2	2

22MAT659 Nonlinear Dynamics and Chaos 3 0 0 3

Course Outcomes:

CO1: Able to analyse the behaviour of dynamical systems (e.g. find periodic orbits and assess their stability, draw phase portraits, etc.) expressed as either a discrete-time mapping or a continuous-time flow.

CO2: Able to analyse qualitative changes (i.e. bifurcations) to dynamical systems as system parameters are varied.

CO3: Able to understand how and why a dynamical system becomes chaotic and how to quantify chaotic dynamics.

CO4: Able to apply the techniques of nonlinear dynamics to analyse various physical, biological, and engineering systems.

Unit -1. One Dimensional flows

Flows on the line-A Geometric Way of Thinking, Fixed Points and Stability, Population Growth, Linear Stability Analysis, Existence and Uniqueness, Solving Equations on the Computer. Bifurcations-Saddle-Node Bifurcation, Transcritical Bifurcation, Pitchfork Bifurcation.

Unit -2. Two-Dimensional Flows

Linear Systems-Definitions and Examples, Classification of Linear Systems. Phase Plane-Phase Portraits, Fixed Points and Linearization, Index Theory. Limit Cycles- Ruling Out Closed Orbits, Poincare-Bendixson Theorem, Lienard Systems, Relaxation Oscillators, Weakly Nonlinear Oscillators. Bifurcations Saddle-Node, Transcritical, and Pitchfork Bifurcations, Hopf-Bifurcations. Oscillating Chemical Reactions, Global Bifurcations of Cycles, Hysteresis in the Driven Pendulum and Josephson Junction, Coupled Oscillators and Quasiperiodicity, Poincare Maps.

Unit-3. Chaos

Lorenz Equations-Simple Properties of the Lorenz Equations, Chaos on a Strange Attractor, Lorenz Map, Exploring Parameter Space. One-Dimensional aps- Fixed Points and Cobwebs, Logistic Map: Logistic Map: Analysis, Periodic Windows, Liapunov Exponent, Universality and Renormalization.

Text / Reference Books:

1. Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry, and Engineering by Steven H. Strogatz (CRC Press; 2nd Edition), 2015.
2. Chaos: An Introduction to Dynamical systems by K. T. Alligood, T. D. Sauer, J. A. Yorke (Springer Verlag), 1996.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	

22MAT646 MATHEMATICAL PHYSICS 3 0 0 3

Objective*: This course intends to introduce applications of various mathematical techniques to problems of Theoretical Physics. Examples could be chosen from all 4 traditional divisions of Modern Fundamental Theoretical Physics – Classical Mechanics, Electrodynamics, Quantum Mechanics and Statistical Physics.*

Course Outcomes:

CO1 Applying Vector Calculus in Electromagnetic Theory and Fluid Mechanics
CO2 Understand and apply the concept of tensors in physics and geometry and covariance of law of physics
CO3 Understand and apply the concept of calculus of variation in classical mechanics related problems
CO4 Apply the concepts of Gamma, Beta functions etc in Problems related to quantum mechanics
CO5 General applications of Linear Algebra in various applications of Physics

Unit 1

Vector calculus and applications in electromagnetic theory and fluid mechanics.

Unit 2

Introduction to tensor calculus: review of basics, index notation, tensors in physics and geometry, Levi-Civita tensor, transformations of vectors, tensors and vector fields, covariance of laws of physics.

Unit 3

Calculus of variations and extremal problems, Lagrange muItipliers to treat constraints, Introduction to the Lagrangian and Hamiltonian formulations of classical mechanics with applications.

Unit 4
Gamma and Beta functions, Dirac delta function, Special functions, Review of Legendre, Bessel functions and spherical harmonics (with applications to Quantum mechanics), series solutions, generating functions, orthogonality and completeness,

Unit 5
Applied linear algebra: Dirac notation, dual vectors, projection operators, symmetric hermitian, orthogonal and unitary matrices in physics, diagonalization, orthogonality and completeness of eigenvectors, spectral decomposition and representation, simultaneous diagonalization, normal matrices, applications to coupled vibrations, Schrodinger equation in matrix form.

TEXT BOOKS:

1. *Arften and Weber, Mathematical Methods for Physics, Elsevier, 6^{th} Ed., 2005.*
2. *Riley, Hobson and Bence, Mathematical Methods for Physics and Engineering, Cup, 3^{rd} Edition, 2010.*

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT671 QUEUING THEORY AND INVENTORY CONTROL THEORY 3 0 0 3

Course Outcomes:

CO1 Understand the Inventory Concepts and study further the components of Inventory control
CO2 Understand the Deterministic Continuous Review model and Deterministic Periodic Review model.
CO3 Understand the classical EOQ , Non zero lead time and EOQ with shortages allowed
CO4 Understand the Deterministic Multiechelon Inventory models for supply chain management

Unit 1 Inventory concept – Components of Inventory model.

Unit 2 Deterministic Continuous Review model - Deterministic Periodic Review model.

Unit 3 The classical EOQ – Non zero lead time – EOQ with shortages allowed.

Unit 4 Deterministic Multiechelon Inventory models for supply chain management.

Unit 5

A stochastic continuous review model – A stochastic single period model for perishable products.

TEXT BOOKS

1. F S Hillier and Gerald J Lieberman, Introduction to Operations research, 8th edition, McGraw Hill.

2. Ravindran, Phillips and Solberg, Operations research Principles and Practice, 2nd Edition, John Wiley & Sons.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	

22MAT672 STATISTICAL PATTERN CLASSIFICATIONS 3 0 0 3

Course Outcomes:

CO1 To gain knowledge about pattern classification and dimensionality reduction method
CO2 To understand the use of Maximum-likelihood and Bayesian Parameter Estimation
CO 3 To understand and apply Nonparametric Techniques and Linear Discriminant Functions
CO4 To apply Nonmetric methods and Algorithm-independent Machine Learning
CO5 To implement clustering methods under unsupervised learning

Unit 1 Introduction and Bayesian Decision Theory

Introduction – Pattern recognition systems – the design cycle – learning and adaptation – Bayesian decision theory – continuous features – Minimum error rate classification – discriminant functions and decision surfaces – the normal density based discriminant functions.

Unit 2 Maximum-likelihood and Bayesian Parameter Estimation

Maximum likelihood estimation – Bayesian estimation - Bayesian parameter estimation – Gaussian case and general theory – problems of dimensionality – components analysis and discriminants – hidden Markov models.

Unit 3 Nonparametric Techniques and Linear Discriminant Functions

Nonparametric techniques – density estimation – Parzen windows – nearest neighborhood estimation – rules and metrics – linear discriminant functions and decision surfaces – generalized linear discriminant functions – two-category linearly separable case – minimizing the perception criterion function.

Unit 4 Nonmetric methods and Algorithm-independent Machine Learning

Nonmetric methods – decision trees – CART methods – algorithm-independent machine learning – lack of inherent superiority of any classifier – bias and variance for regression and classification – resampling or estimating statistics – estimating and comparing classifiers.

Unit 5 Unsupervised Learning and Clustering
Unsupervised learning and clustering – mixture densities and identifiability – maximum likelihood estimates – application to normal mixtures – unsupervised Bayesian learning – data description and clustering – criterion functions for clustering – hierarchical clustering – component analysis – low-dimensional representations and multi-dimensional scaling.

TEXT AND REFERENCE BOOKS:

1. Richard O. Duda, Peter E. Hart and David G. Stork, Pattern Classification, Second Edition, 2003, John Wily & Sons.
2. Earl Gose, Richard Johnson baugh and Steve Jost, Pattern Recognition and Image Analysis, 2002, Prentice Hall of India.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT673 STATISTICAL QUALITY CONTROL AND SIX SIGMA QUALITY ANALYSIS 3 0 0 3
Course Outcomes:

CO1 To develop basic knowledge about TQM
CO2 To understand old and new quality improvement tools
CO3 To understand the aspects of project planning and capability analysis
CO4 To understand the concept of Six Sigma and Lean methods
CO5 To apply Taguchi methods

Unit 1 Introduction to Quality Management – Japanese System of Total Quality Management.

Unit 2 Quality Circles - 7 Quality Control tools - 7 New Quality Control tools.

Unit 3 ISO 9000 Quality system Standards - Project Planning, Process and measurement system capability analysis - Area properties of Normal distribution.

Unit 4 Metrics of Six sigma, The DMAIC cycle - Design for Six Sigma - Lean Sigma – Statistical tools for Six Sigma.

Unit 5 Taguchi methods. Loss functions and orthogonal arrays and experiments.

TEXT AND REFERENCE BOOKS
1. Ravichandran. J, Probability and Statistics for Engineers, 1st Edition 2012 (Reprint), Wiley India.

2. *Montgomery Douglas C., Introduction to Statistical Quality Control, Sixth Edition. John Wiley & Sons, (2008).*
3. *Ishikawa K., Guide to Quality Control, 2nd Edition: Asian Productivity Organization, Tokyo (1983).*
4. *Taguchi G, Introduction to Quality Engineering: Designing Quality into Products and Processes Second Edition. (1991).*
5. *Harry, M and Schroeder R., Six Sigma: The Breakthrough Management Strategy. Currency Publishers, USA. (2000).*

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT674 THEORY OF SAMPLING AND DESIGNS OF EXPERIMENTS 3 0 0 3

Course Outcomes:

CO1 To study different types of basic sampling methods
CO2 To understand the types of estimators and their applications
CO3 To understand with and without replacement sampling methods
CO4 To understand the use of sampling in experimental designs
CO5 To apply factorial experiments

Unit 1

Stratified random sampling, estimation of the population mean, total and proportion, properties of estimators, various methods of allocation of a sample, comparison of the precisions of estimators under proportional allocation, optimum allocation and srs. Systematic sampling. Comparison of systematic sampling - srs and stratified random sampling for a population with a linear trend.

Unit 2

Unbiased ratio type estimators - Hartly-Ross estimator, regression method of estimation. Cluster sampling, single stage cluster sampling with equal and unequal cluster sizes, estimation of the population mean and its standard error. Two-stage cluster sampling with equal and unequal cluster sizes, estimation of the population mean and its standard error.

Unit 3

Unequal probability sampling, PPS sampling with and without replacement, cumulative total method, Lahiris method, Midzuno-Zen method, estimation of the population total and its estimated variance under PPS wr sampling, ordered and unordered estimators of the population total under PPS wor, Horwitz – Thomson estimator.

Unit 4

Elementary concepts (one and 2 way classified data) Review of elementary design (CRD, RBD, LSD) Missing plot technique in RBD and LSD with one and two missing values, Gauss-Markov theorem, BIBD: Elementary parametric relations, Analysis, PBIBD.

Unit 5
General factorial experiments, factorial effects, best estimates and testing the significance of factorial effects, study of 2^3 and 2^4 factorial experiments.

TEXT AND REFERENCE BOOKS

1. Cochran, W.C. Sampling Techniques, Third Edition, Wiley Eastern, (1977).
2. Des Raj, Sampling Theory, Tata McGraw Hill, New Delhi, (1976).
3. Murthy, M.N., Sampling Theory, Tata McGraw Hill, New Delhi, (1967).

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT675 TIME SERIES ANALYSIS 3 0 0 3
Course Outcomes:

CO1 To gain in-depth knowledge about time series and its components
CO2 To understand the smoothening concepts and the relevant tests.
CO3 To understand and apply the concepts of autocorrelation and autocovariance
CO4 To apply various types of autoregressive models
CO5 To understand the estimation procedures in time series

Unit 1 Time series, components of time series, additive and multiplicative models, determination of trend, analysis of seasonal fluctuations.

Unit 2 Test for trend and seasonality, exponential and moving average smoothing, holt-winter smoothing, forecasting based on smoothing.

Unit 3 Time series as a discrete parameter stochastic process, auto covariance and auto correlation functions and their properties, stationary processes, test for stationarity, unit root test, stationary processes in the frequency domain, spectral analysis of time series.

Unit 4 Detailed study of the stationary processes: moving average (MA), autoregressive (AR), autoregressive moving average (ARMA) and autoregressive integrated moving average (ARIMA) models.

Unit 5 Estimation of ARMA models, maximum likelihood method (the likelihood function for a Gaussian AR(1) and a Gaussian MA(1)) and Least squares, Yule-Walker estimation for AR Processes, choice of AR and MA periods, forecasting, residual analysis and diagnostic checking.

TEXT BOOKS

1. *Anderson, T.W. The Statistical Analysis of Time Series, John Wiley, New York, 1971.*
2. *Box, G.E.P. and Jenkins, G.M. Time Series Analysis- Forecasting and Control, Holden-day, San Francisco,1976.*
3. *Kendall, Sir Maurice and Ord, J.K., Time Series, Edward Arnold, London, 1990.*

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT676 STATISTICAL TECHNIQUES FOR DATA ANALYTICS 3-0-0-3

Course Outcomes:

CO1 To understand data collection methods and to apply descriptive statistics to data
CO2 To understand and apply data fitting methods and analyze the outcomes
CO3 To analyse data using dimensionality reduction methods
CO4 To understand and apply clustering methods
CO5 To understand and apply nonmetric decision making methods

Data Collection, classification and analysis - Sampling methods, classification of data and representation of data- bar and pie charts – histogram frequency polygon - Data Analysis Measures of Central tendency and dispersion - Mean, median, mode, absolute, quartile and standard deviations, skewness and kurtosis for both grouped and ungrouped data. Association of attributes.

Curve fitting and interpolation - Fitting of straight lines and curves - Correlation, regression, fitting of simple linear lines, polynomials and logarithmic functions - Interpolation and extrapolation methods - Binomial expansion, Newton and Gauss methods.

Index numbers and time series analysis - Types of index numbers, construction of index numbers such as simple aggregate, weighted aggregate index numbers, chain index numbers and consumer price indices - Time series and its components and computation of trends and variations - Seasonal variations - Trend analysis methods.

Decision analysis and Game theory - Payoffs, regrets, maximin and minimax criteria and loss and risks – Games – payoff matrix, saddle point, value of game and methods of solving – two-person-zero-sum games, dominance method, sub-game method

Text Books:

1. *Pillai R.S. N. andBagavathi. "Statistics", S. Chand, New Delhi, 2001.*
2. *Kanti Swarup, Gupta, P.K., and Man Mohan. "Operations Research" (Chapters 16 and 17), S. Chand, New Delhi, 2001.*

References Book

1. *Amir D Aczel, Jayavel Soundarapandian , Palanisamy Saravanan, Rohit Joshi, Complete Business Statistics,7edition,McGraw Hill, New Delhi*

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	2	-	-	-	-	1	1
CO2	3	3	2	2	2	2	-	-	-	-	1	1
CO3	2	2	3	2	2	2	-	-	-	-	1	1
CO4	3	3	3	2	2	2	-	-	-	-	1	1
CO5	3	3	3	1	1	2	-	-	-	-	1	1

22MAT677 Mathematical Finance 3 0 0 3

Course Outcomes:

CO1: To understand the basic concepts of financial marker models
CO2: To understand the valuation and hedging in complete markes.
CO3: Apply stochastic calculus for some financial market models.

Financial market models in finite discrete time, Absence of arbitrage and martingale measures, Valuation and hedging in complete markets, Basic facts about Brownian motion, Stochastic integration, Stochastic calculus: ItÔ's formula, Girsanov transformation, Itˆo's representation theorem, BlackScholes formula.

Reference Books:

1. J. Jacod, P. Protter, "Probability Essentials", Universitext, Springer-Verlag, 2003.
2. D. Lamberton, B. Lapeyre, "Introduction to Stochastic Calculus Applied to Finance", Chapman-Hall, 2008.
3. H. F¨ollmer, A. Schied, "Stochastic Finance: An Introduction in Discrete Time", de Gruyter, 2011.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	1	-	-	-	-	-	1	
CO2	3	3	2	2	1	-	-	-	-	-	1	
CO3	2	2	3	2	1	-	-	-	-	-	1	

22MAT658 Singular Perturbation Theory 3 0 0 3

Course Outcomes:

CO1: To understand basics of PDE and solutions
CO2: To understand the basic concepts of regular perturbation theory.
CO3: To understand the singular perturbation theory.

UNIT I: Partial Differential Equations

Theory of distributions in n dimensions, fundamental solutions to Laplace, wave and heat equations in 1D , 2D and 3D - Construction of Green's functions for Laplace, wave and heat equations using method of images, partial transforms, complete transforms, eigenfunction expansions.

UNIT II: Regular Perturbation Theory
Asymptotic approximations - regular perturbation for roots of a polynomial, differential equations, eigenvalue problems and partial differential equations; method of strained coordinates -
eigenvalues of nonlinear boundary-value problems; stationary and Hopf bifurcations.

UNIT III: Singular perturbation theory
Multiple scales analysis- singular perturbation theory for algebraic equations, boundary layer problems – singular perturbation theory for nonlinear dynamics - WKB approximation – homogenization theory.

REFERENCE BOOKS
1. Kevorkian and Cole, Multiple Scale and Singular Perturbation Methods.
2. AH Nayfeh (1993), Introduction to perturbation techniques, Jhon wiley and sons Newyork, USA.
3. Samuel. D. Conte, Carl. De Boor, Elementary Numerical Analysis, Mc Graw-Hill International E

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	1	-	-	-	-	-	1	
CO2	3	3	2	2	1	-	-	-	-	-	1	
CO3	2	2	3	2	1	-	-	-	-	-	1	

dn, 1983.
4. Gordon D Smith, Numerical Solution of Partial Differential Equations – Finite Difference Methods, Oxford University Press, 1985.
5. M. Stynes H. G Roos and L. Tobiska (2010), Numerical Methods for Singularly Petrubed Differential Equations Convection-Diffusion and Flow Problems. Springer Verlag.

22MAT651 ADVANCED BOUNDARY LAYER THEORY 3 0 0 3

Course Outcomes:
CO1: To understand the limitations of ideal fluid dynamics and to understand the significance of Prandtl’s boundary layer theory, two-dimensional boundary layer equations, Boundary layer flow over a flat plate and a wedge.

CO2: To understand the energy integral equation of 2-dimensional laminar boundary layers, boundary layers with pressure gradient and application of Von-Karman’s integral equations.

CO3: To understand the displacement, momentum and energy thickness, Von-Karman’s momentum equation for laminar boundary layer, coefficient of drag, Similar solutions & separation of boundary layer.

CO4: To understand MHD boundary layers, MHD Blasius flow, Thermal boundary layers with and without coupling of momentum and energy equations, forced convection in the laminar flow past a flat plate

CO5: To understand the thermal boundary layer in the free convection from a heated plate, the thermal energy integral equation and the boundary layer control using suction and injection.

Unit 1

Introduction – limitations of ideal fluid dynamics – Importance of Prandtl's boundary layer theory - boundary layer equations in two dimensional flows – boundary layer flow over a flat plate – Blasius solution – Boundary layer over a wedge.

Unit 2

Energy integral equation for two-dimensional laminar boundary layers in incompressible flow – application of Von Karman's integral equations to boundary layer with pressure gradient.

Unit 3

Displacement, momentum, energy thickness – axially symmetric flows – momentum equation for laminar boundary layer by von Karman – Wall shear and drag force on a flat plate due to boundary layer – coefficient of drag. Boundary layer equations for a 2D viscous incompressible fluid over a plane wall – Similar solutions – Separation of boundary layer flow.

Unit 4

Hydromagnetic Boundary layers – Hartman Layer – MHD Blasius flow. Thermal boundary layers – thermal boundary layer equation in two dimensional flow – Thermal boundary layers with and without coupling of velocity and temperature field – forced convection in a laminar boundary on a flat plate.

Unit 5

Polhausen's method of exact solution for the velocity and thermal boundary layers in free convection from a heated plate – thermal energy integral equation. Boundary layer control using suction and injection.

TEXT BOOKS / REFERENCES:

1. H.Schlichting and K.Gersten, "Boundary Layer Theory", Eighth Edition, Springer, 2000.
2. L. Rosenhead, "Laminar Boundary Layers", Dover, 1988.
3. G.K.Batchelor, "An Introduction to Fluid Dynamics", Cambridge University Press,1993.
4. P.H.Roberts , "An Introduction to MHD" , Longmans, 1967.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	3	3	3	-	-	-	-	-	-	1
CO2	2	2	3	3	3	-	-	-	-	-	-	1
CO3	2	2	3	3	3	-	-	-	-	-	-	1
CO4	2	2	3	3	3	-	-	-	-	-	-	2
CO5	2	2	3	3	3	-	-	-	-	-	-	2

22MAT652 COMPUTATIONAL FLUID DYNAMICS 3 0 0 3

Course Outcomes:

CO1: To understand the basic concepts of fluid dynamics.

CO2: To understand the different types of PDE and their solutions.

CO3: To understand the basics of finite volume method.

CO4: To understand the basics of turbulence modelling.

Unit 1 Review of Conservation equations for mass, momentum and energy; coordinate systems; Eulerian and Lagrangian approach, Conservative and non-conservative forms of the equations, rotating co-ordinates.

Unit 2 Classification of system of PDEs: parabolic elliptic and hyperbolic; Boundary and initial conditions; Overview of numerical methods; Review of Finite Difference Method, Introduction to integral method, method of weighted residuals, finite elements finite volume method & least square method.

Unit 3 Numerical Grid Generation: Basic ideas, transformation and mapping, unstructured grid generation, moving grids, unmatched meshes. Finite Volume Method: Basic methodology, finite volume discretization, approximation of surface and volume integrals, interpolation methods - central, upwind and hybrid formulations and comparison for convection-diffusion problem; Basic computational methods for compressible flows.

Unit 4 Advanced Finite Volume methods: FV discretization in two and three dimensions, SIMPLE algorithm and flow field calculations, variants of SIMPLE, Turbulence and turbulence modelling, illustrative flow computations.

Unit 5 Introduction to turbulence modelling, CFD methods for compressible flows.

TEXT BOOKS / REFERENCE BOOKS:

1. Anderson D A, Tannehill J C, and Pletcher R H, Computational Fluid Mechanics and Heat Transfer, 2nd edition, Taylor & Francis, 1997.

2. Ferziger, J. H. and Peric, M., Computational Methods for Fluid Dynamics, 3rd edition, Springer. 2003.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	

22MAT653 FINITE ELEMENT METHOD 3 0 0 3

Course Outcomes:

CO-1: Understand the basic concepts of weighted residue and energy methods.
CO-2: Understand the concepts of global and local finite element models and its derivations.
CO-3: Application of interpolation and various polynomials to model stiffness matrices.

CO-4: Application of global and local finite element models with boundary conditions in a steady state problem.
CO-5: Usage of finite element concept for one dimensional heat and wave equations.

Unit 1 Finite Element Method: Variational formulation - Rayleigh-Ritz minimization - weighted residuals - Galerkin method applied to boundary value problems.

Unit 2 Global and local finite element models in one dimension - derivation of finite element equation.

Unit 3 Finite element interpolation - polynomial elements in one dimension, two dimensional elements, natural coordinates, triangular elements, rectangular elements, Lagrangian and Hermite elements for rectangular elements - global interpolation functions.

Unit 4 Local and global forms of finite element equations - boundary conditions - methods of solution for a steady state problem - Newton-Raphson continuation.

Unit 5 One dimensional heat and wave equations.

TEXT AND REFERENCE BOOKS

1. *J.N .Reddy, An Introduction to the Finite Element Method, McGraw Hill, NY.*
2. *Chung, Finite Element Analysis in Fluid Dynamics, McGraw Hill Inc.*

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT654 MAGNETO-HYDRO DYNAMICS 3 0 0 3

Course Outcomes:

CO1: To understand Maxwell’s electromagnetic equations, MHD equations and MHD approximations, induction equation, Alfven’s theorem, Ferraro’s law of irrotation and the decomposition of magnetic stresses into a tension and pressure

CO2: To understand the magentohydrostatics, hydromagnetic equilibria, force-free magnetic fields, Chandrasekar’s Theorem on isolated bodies without a magnetic fields, General solution of force-free magnetic fields when “alpha” is constant.

CO3: To understand Hartman Flow and Hartman boundary layer and simple flow problems with tensor electrical conductivity

CO4: To understand the propagation of magnetohydrodynamic waves in incompressible and compressible fluids and analysing stability of MHD systems using normal mode analysis

CO5: To understand Bernstein’s method of small oscillations and Chandrasekar’s generalization of Jean’s criterion for gravitational stability for MHD flows

Unit 1
Electromagnetic field equations – Maxwell's equations - Electromagnetic effects and the magnetic Reynolds number – induction equation. Alfven's Theorem – Ferraro's Law of irrotation – Electromagnetic stresses.

Unit 2
Magnetohydrostatics and steady states – Hydromagnetic equilibria and Force free magnetic fields —Chandrasekhar's theorem – General solution of force free magnetic field when**Error! Objects cannot be created from editing field codes.** is constant – Some examples of force free fields.

Unit 3
Steady laminar motion – Hartmann flow. Tensor electrical conductivity, Hall current and ion slip – simple flow problems with tensor electrical conductivity.

Unit 4
Magnetohydrodynamic waves - Alfven waves – Stability of hydromagnetic systems - Normal mode analysis - Squire's theorem – Orr-Sommerfield equation – Instability of linear pinch – Flute instability – A general criterion for stability.

Unit 5 Bernstein's method of small oscillations – Jeans Criterion for Gravitational stability – Chandrasekhar's generalization for MHD and rotating fluids.

TEXT BOOKS / REFERENCES:

1. Ferraro, V.C.A and Plumpton, C., "An Introduction to Magneto-Fluid Mechanics", Clarendon Press, Oxford, 1966.
2. M.R. Crammer, and Shi-I Pai, "Magneto-Fluid Dynamics for Engineers and Applied Physicists", Scripta Publishing Company, Washington, 1973.
3. P.H. Roberts, "An Introduction to Magnetohydrodynamics", Longmans, Green and Co, London, 1967.
4.S. Chandrasekhar, "Hydrodynamic and Hydromagnetic Stability", Dover Publications, 1981.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	-	2
CO2	3	3	2	3	3	-	-	-	-	-	-	2
CO3	2	2	3	3	3	-	-	-	-	-	-	2
CO4	3	3	3	3	3	-	-	-	-	-	-	3
CO5	3	3	3	3	3	-	-	-	-	-	-	2

22MAT657 STOCHASTIC DIFFERENTIAL EQUATIONS 3 0 0 3
Course Outcomes:
CO1: To understand and the basic ideas of deterministic and random differential equations.

CO2: To understand the basics of Brownian motion and Markov property.

CO3:To understand the basic of existence and uniqueness of stochastic differential equations.

Introduction: Deterministic and random differential equations, stochastic differential, chain rule.
Probability Theory: Basic definitions, expected value, variance, independence, some probabilistic methods, law of large numbers, central limit theorem, conditional expectation, martingales.
Brownian Motion: Definition, elementary properties, construction of Brownian motion, sample path properties, Markov property.
Stochastic Integrals: Ito's Integral, Ito's chain and product rules, Ito's integral in higher dimensions.
Stochastic Differential Equations: Existence and uniqueness of solutions, properties of solutions, linear stochastic differential equations.

TEXT BOOKS / REFERENCE BOOKS:
1. Lawrence C. Evans, An Introduction to Stochastic Differential Equations, American Mathematical Society, 2013.
2. Hui-HsiungKuo, Introduction to Stochastic Integration, Springer, 2006
3. ksendal, B.: Stochastic Differential Equations,5th edition, Springer, 2002.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	3	2	-	-	-	-	2	1
CO2	2	2	3	3	3	1	-	-	-	-	2	1
CO3	2	2	3	3	3	3	-	-	-	-	2	1

22MAT656 **Hemodynamics** **3 0 0 3**

Course Objective:

CO1: To understand and the basic ideas of fluid dynamics, the significance of Lagrangean and Eulerian frames of reference, the material derivative, equation of conservation of mass and momentum, and a review of Fourier Series and Bessel's equation.

CO2: To understand the basic rheological, viscoelastic, Newtonian & non-Newtonian properties of blood, the elastic nature of wall and permeability of different layers of wall, significance of Reynolds and Womersley number .

CO3:To understand the modelling of blood flow with constant, oscillatory and pulsatile pressure garadient and to analyze pathological states using medically significant hemodynamic wall parameters

CO4) To understand the recent developments in blood flow, the challenges involved in modelling and to identify research level problems and reviewing a few articles.

Unit 1. Microscopic and macroscopic scales, Eulerian and Lagrangian motion, acceleration in flow field, laminar and turbulent flow, steady, oscillatory and pulsatile flow, governing equations –conservation of mass, conservation of momentum - physical interpretation, Fourier series and Bessel Equations.

Unit 2. Introduction to physiology of human circulatory system, rheology of blood, composition of blood, viscosity and density of blood, viscoelasticity of blood, Newtoian and non-Newtonian behaviour of blood, Mechanism of arterial wall, permeability and porosity of different wall layers, Dean number, force balance, pressure, viscosity, shear stress, inertia, and vessel elasticity. Pressure gradient – physical interpretation, Reynolds number and Womersley number.
Unit 3. Principles of blood flow in arteries, parallel plate approximation, uniform circular cross section, constant, oscillatory and pulsatile pressure gradient; no slip conditions- single phase model, quantitative and qualitative analysis of results in the normal and pathological state of cardiovascular disease - hemodynamic perspective.
Unit 4. Recent developments in blood flow modeling, strategy and challenges in biomechanics, Identifying gap in the literature of mathematical modeling, cardiovascular physiology and biomechanics. Identifying research level open problems in the field of hemodynamics.

Text Book / Reference Book/Articles

1. C G Caro and T J Pedley, R C Schroter and W A Seed, The mechanics of the circulation, Cambridge University Press, New York, 2012.
2. Wilmer W Nichols, Michael O'Rourke, McDonald's Blood Flow in Arteries, Theoretical, Experimental and Clinical Principles, Oxford University Press, New York, 2005.
3. Y C Fung, Biomechanics: Circulation, 2nd edition, Springer, New York, 1993.
4. M Zamir, The Physics of Pulsatile Flow, AIP press Springer, 2000.
5. A C Burton, Physiology and Biophysics of the Circulation, Introductory Text, Book Medical Publisher, Chicago, 1966.
6. M Texon, Hemodynamic basis of atherosclerosis, Hemisphere, Washington D C, 1980.
7. David N Ku, Blood flow in arteries, Annual Review of Fluid Mechanics, Vol.29, pp.399-434, 1997.
8. Ai L and KambizVafai, A coupling model for macromolecule transport in a stenosed arterial wall, International Journal of Heat and Mass Transfer, Vol.49, No.9-10, pp.1568-1591, 2006.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	3	3	2	-	-	-	-	-	-
CO2	2	2	3	3	3	1	-	-	-	-	-	-
CO3	2	2	3	3	3	3	-	-	-	-	-	-
CO4	2	2	3	3	3	3	-	-	-	-	2	2

22MAT662 COMPUTER AIDED DESIGN OF VLSI CIRCUITS 3 0 0 3

Course Outcomes:
CO1: To understand the basics of VLSI Physical design.
CO2: To understand the basics of graph algorithms and complexities.
CO3: Apply graph algorithms for circuit partitioning and compation
CO4: Apply graph algorithms for circuit routings.

Unit 1

Introduction of Design Methodologies and Graph Theory: The VLSI Design Problems - Design Methods – Design Cycle – Physical Design Cycle - Design Styles.

Unit 2
Algorithmic and System Design - Structural and Logic Design - Layout Design. Graph terminologies – Data structures for the representation of Graphs – Algorithms: DFS – BFS - Dijkstra's shortest path algorithm – Prim's algorithm for minimum spanning trees. Combinatorial Optimization Problems – Complexity Class – P - NP Completeness and NP Hardness problems.

Unit 3
Placement, Partitioning and Floor Planning: Types of Placement Problems – Placement Algorithms – K-L Partitioning Algorithm. Optimization Problems in Floor planning - Shape Function and Floor plan Sizing.

Unit 4
Routing and Compaction: Types of Routing Problems – Area Routing – Channel Routing – Global Routings.

Unit 5 1D and 2D Compaction. Gete level – Switch level Modeling and Simulations.

TEXT BOOK / REFERENCES:

1. *Gerez, "Algorithms for VLSI Design Automation", John Wiley & Sons, 2000.*
2. *Naveed Sherwani, "Algorithms for VLSI Physical Design Automation", Second Edition, Kluwer Academic Publishers, 1995.*
3. *Sadiq M Sait and Habib Youssef, "VLSI Physical Design Automation: Theory and Practice", IEET, 1999.*
4. *M. Sarrafzadeh and C. K. Wong, An Introduction to VLSI Physical Design, McGraw- Hill, New York, NY, 1996.*
5. *Giovanni De Micheli, Synthesis and Optimization of Digital Circuits, Tata McGraw Hill, 1994*

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT663 CRYPTOGRAPHY 3 0 0 3

Course Outcomes:

CO-1: Understand the basic concepts of classical ciphers.
CO-2: Understand the concepts of encryptions and pseudorandomness.
CO-3: Understand the concepts private-key encryption.
CO-4: Understand the concepts of EIGamal encryption.

Unit 1 **Classical ciphers:** Cryptanalysis of classical ciphers, Probability theory, Perfect security.

Block ciphers: DES, AES, Block cipher modes of operation.

Unit 2 Private-key encryption: Chosen plaintext attacks, Randomised encryption, Pseudorandomness, Chosen cyphertext attacks.

Unit 3 Message authentication codes: Private-key authentication, CBC-MAC, Pseudorandom functions, CCA-secure private-key encryption.

Unit 4 Hash function: Integrity, Pre-image resistance, 2nd pre-image resistance, Collision freeness.
Key distribution: Key distribution centres, Modular arithmetic and group theory, Diffie-Hellman key exchange.

Unit 5 Public-key Distribution: EIGamal encryption, Cramer-Shoup encryption, Discrete logarithm problem.
Digital Signatures: RSA signatures, RSA-FDH and RSA-PSS signatures, DSA signatures.

TEXT / REFERENCE BOOKS:

1. Katz and Lindell, Introduction to Modern Cryptography. Second Edition, Chapman & Hall/ CRC Press, 2014.
2. Jonathan Katz and Yehuda Lindell, Introduction to Modern Cryptography, CRC Press.
3. Hans Delfs, Helmut Knebl, "Introduction to Cryptography, Principles and Applications", Springer Verlag.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	

22MAT664 FUZZY SETS AND ITS APPLICATIONS 3 0 0 3

Course Outcomes:

CO-1: Understand the basic concepts of Fuzzy sets
CO-2: Understand the concepts of arithmetci operations on fuzzy numbers.
CO-3: Understand the concepts Fuzzy relations.
CO-4: Understand the concepts of Fuzzy logic.
CO-5: Understand the concepts of uncertainty and crisp sets.

Unit 1 Fuzzy Sets

Crisp Sets - an Overview, Fuzzy Sets - Definition and Examples, α - Cuts and its Properties, Representations of Fuzzy Sets, Extension Principles of Fuzzy Sets, Operations on Fuzzy Sets - Fuzzy Complements, Fuzzy Intersections, Fuzzy Unions, Combinations of Operations, Aggregation Operations.

Unit 2 Fuzzy Arithmetic

Fuzzy Numbers, Arithmetic Operations on Intervals, Arithmetic Operations on Fuzzy Numbers.

Unit 3 Fuzzy Relations
Binary Fuzzy relations, Fuzzy Equivalence Relations, Fuzzy Compatibility Relations.

Unit 4 Fuzzy Logic
Classical Logic, Multivalued Logic, Fuzzy Propositions, Fuzzy Quantifiers, Linguistic Hedges, Inference from Conditional Fuzzy Propositions, Conditional and Qualified Propositions and Quantified Propositions.

Unit 5 Uncertainty-based Information
Information and Uncertainty, Non Specificity of Crisp Sets – Non Specificity of Fuzzy Sets, Fuzziness of Fuzzy Sets, Uncertainty In Evidence Theory, Principles of Uncertainty.

TEXT AND REFERENCE BOOKS:

1. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic- Theory and Applications, Prentice Hall of India, 1997.
2. Timothy J. Ross, Fuzzy Logic with Engineering Applications, McGraw Hill, 1997.
3. H.J. Zimmermann, Fuzzy Sets and its Applications, Allied publishers, 1991.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT665 INTRODUCTION TO SOFT COMPUTING 3 0 0 3

Course Outcomes:

CO-1: Understand the various types of soft computing techniques
CO-2: Understand the concepts of artificial intelligence.
CO-3: Understand and apply the concepts fuzzy logic in optimization problems.
CO-4: Understand the concepts of neural networks.
CO-5: Understand the concepts of genetic algorithms.

Unit 1 Soft Computing
Introduction of soft computing, soft computing vs. hard computing, various types of soft computing techniques, applications of soft computing.

Unit 2 Artificial Intelligence
Introduction, Various types of production systems, characteristics of production systems, breadth first search, depth first search techniques, other Search Techniques like hill Climbing, Best first Search, A* algorithm, AO* Algorithms and various types of control strategies.

Unit 3 Fuzzy Logic

Crisp set and Fuzzy set, basic concepts of fuzzy sets, membership functions. Basic operations on fuzzy sets, Properties of fuzzy sets, Fuzzy relations. Propositional logic and Predicate logic, fuzzy If - Then rules, fuzzy mapping rules and fuzzy implication functions, Applications.

Unit 4 Neural Networks
Basic concepts of neural networks, Neural network architectures, Learning methods, Architecture of a back propagation network, Applications.

Unit 5 Genetic Algorithms
Basic concepts of genetic algorithms, encoding, genetic modeling.
Hybrid Systems: Integration of neural networks, fuzzy logic and genetic algorithms.

TEXT AND REFERENCE BOOKS

1. S. Rajasekaran and G. A. Vijaylakshmi Pai. Neural Networks Fuzzy Logic, and Genetic Algorithms, Prentice Hall of India.
2. K. H. Lee. First Course on Fuzzy Theory and Applications, Springer-Verlag.
3. J. Yen and R. Langari. Fuzzy Logic, Intelligence, Control and Information, Pearson Education.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	
CO5	3	3	3	3	3	-	-	-	-	-	1	

22MAT666 OBJECT- ORIENTED PROGRAMMING AND PYTHON 3 0 0 3
Course Outcomes:

CO-1: Understand the various classes in C++
CO-2: Understand the concepts of constructors and operators in C++
CO-3: Understand and apply the concepts functions for some problems.
CO-4: Understand the concepts of RTTI typeid dynamic casting.
CO-5: Understand and practice the Python programming.

Unit 1 Object-oriented programming concepts – objects – classes – methods and messages – abstraction and encapsulation – inheritance – abstract classes – polymorphism.

Introduction to C++ – classes – access specifiers – function and data members – default arguments – function overloading – friend functions – const and volatile functions - static members – Objects - pointers and objects – constant objects – nested classes – local classes.

Unit 2 Constructors – default constructor – Parameterized constructors – Constructor with dynamic allocation – copy constructor –destructors – operator overloading – overloading through friend functions – overloading the assignment operator – type conversion – explicit constructor.

Unit 3 Function and class templates - Exception handling try-catch-throw paradigm – exception specification – terminate and Unexpected functions – Uncaught exception.

Unit 4 Inheritance – public, private, and protected derivations – multiple inheritance - virtual base class – abstract class – composite objects Runtime polymorphism – virtual functions – pure virtual functions – RTTI – typeid – dynamic casting – RTTI and templates – cross casting – down casting.

Unit 5 Python Programming.

TEXT BOOK

1. B. Trivedi, "Programming with ANSI C++", Oxford University Press, 2007.

REFERENCES BOOKS

1. Ira Pohl, "Object Oriented Programming using C++", Pearson Education, Second Edition Reprint 2004.

2. S. B. Lippman, Josee Lajoie, Barbara E. Moo, "C++ Primer", Fourth Edition, Pearson Education, 2005.

3. B. Stroustrup, "The C++ Programming language", Third edition, Pearson Education, 2004.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	2	-	-	-	-	1	1
CO2	3	3	2	2	2	2	-	-	-	-	1	1
CO3	2	2	3	2	2	2	-	-	-	-	1	1
CO4	3	3	3	2	2	2	-	-	-	-	1	1
CO5	3	3	3	1	1	2	-	-	-	-	1	1

22MAT667 Graph Analytics and Applications 3 0 0 3

Unit 1

Review of Graphs: Graphs and Sub graphs, isomorphism, matrices associated with graphs, degrees, walks, connected graphs, shortest path algorithm. Eccentricity.

Unit 2

Connectivity: Graph connectivity, k-connected graphs and blocks.

Euler and Hamilton Graphs: Euler graphs, Euler's theorem. Hamilton cycles, Chinese-postman problem, approximate solutions of traveling salesman problem. Closest neighbour algorithm. Matchings, maximal matchings. Coverings and minimal coverings. Graph Dominations and Independent sets. Vertex colorings, Planar graphs. Euler theorem on planar graphs.

Unit 3

Large Scale networks: Introduction. Graph and Networks. Network topologies. Examples of large-scale networks and networked systems. Power Law distributions. Scale-free networks.

Unit 4

Random graph models for large networks: Erdos-Renyi graphs, power-law graphs, small world graphs, phase transitions. Network stabilities.

Unit 5

Graph Networks and Centralities:. Degree and distance centralities. Closeness centrality. Betweeness centrality. Eigenvector centrality and Page ranking algorithm and applications. Clustering coefficient and clustering centrality. Introduction to community detections.

Case Studies: Transport networks, Biological networks, ect.,

TEXTBOOKS

1. J.A. Bondy and U.S.R. Murty, Graph Theory and Applications, Springer, 2008.

2. Mohammed Zuhair Al-Taie, Seifedine Kadry, Python for Graph and Network Analysis, Springer, 2018.

REFERENCES BOOKS

1. Barabasi and Pasfai, Network Science, Cambride University press, 2016.

2. Meghanathan Natarajan, Centrality Metrics for Complext Networks Analysis, IGI publisher, 2018.

3. Networks: An Introduction , M. E. J. Newman , Oxford University Press , 2010.

4. Complex Graphs and Networks , F. Chung and L. Lu , American Mathematical Society , 2006

5. Graph Algorithms in Neo4j

22MAT661 ALGORITHMS FOR ADVANCED COMPUTING 3-0-0-3

Course Outcomes:

CO-1: To understand various types of classifications.
CO-2: To familiarise the concepts of decision trees and their applications.
CO-3: To understand the basis of clustering and information extraction.
CO-4: To familiarise various soft computing techniques.

CO-5: To understand the basic networks and network algorithms.

Unit I Issues regarding classification and prediction, Bayesian Classification, Classification by back propagation, Classification based on concepts from association rule mining, Other Classification Methods, Classification accuracy.

Unit II Introduction to Decision trees - Classification by decision tree induction – Various types of pruning methods – Comparison of pruning methods – Issues in decision trees – Decision Tree Inducers – Decision Tree extensions.

Unit III Introduction, Core text mining operations, Preprocessing techniques, Categorization, Clustering, Information extraction, Probabilistic models for information extraction

Unit IV Soft Computing: Rationale, motivations, needs, basics: examples of applications in diverse fields, Basic tools of soft computing: Neural Networks, Fuzzy Logic Systems, and Support Vector Machines, Statistical Approaches to Regression and Classification - Risk Minimization, Support Vector Machine Algorithms.

Unit V Single-Layer Networks: The Perceptron, The Adaptive Linear Neuron (Adaline) and the Least Mean Square Algorithm - Multilayer Perceptrons: The Error Backpropagation Algorithm – The Generalized Delta Rule, Heuristics or Practical Aspects of the Error Backpropagation Algorithm.

Text Books:

1. *Jiawei Han and Micheline Kamber, "Data Mining: Concepts and Techniques", Morgan Kaufmann Publishers, 3rd ed, 2010.*
2. *Jared Dean, "Big Data, Data Mining, and Machine Learning: Value Creation for Business Leaders and Practitioners", Wiley India Private Limited, 2014.*

References Books :

1. *LiorRokach and Oded Maimon, "Data Mining and Knowledge Discovery Handbook", Springer, 2nd edition, 2010.*
2. *Ronen Feldman and James Sanger, "The Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data", Cambridge University Press, 2006.*
3. *Vojislav Kecman, "Learning and Soft Computing", MIT Press, 2010.*

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	2	-	-	-	-	1	1
CO2	3	3	2	2	2	2	-	-	-	-	1	1
CO3	2	2	3	2	2	2	-	-	-	-	1	1
CO4	3	3	3	2	2	2	-	-	-	-	1	1
CO5	3	3	3	1	1	2	-	-	-	-	1	1

22MAT660 Machine Learning 3 0 0 3

Course Outcomes:

CO1: To understand the basics of supervised leaning.

CO2: To understand the basics of unsupervised learning.

CO3: To understand the basics of deep learning and its applications.

CO4: Carry out some case studies using ML techniques..

Supervised Learning (Regression/Classification) : Basic methods: Distance-based methods, Nearest-Neighbors, Decision Trees, Naïve Bayes. Linear models: Linear Regression, Logistic Regression, Generalized Linear Models. Support Vector Machines, Nonlinearity and Kernel Methods. Beyond Binary Classification: Multi-class/Structured Outputs, Ranking

Unsupervised Learning: Clustering: K-means/Kernel K-means. Dimensionality Reduction: PCA and kernel PCA. Matrix Factorization and Matrix Completion. Generative Models (mixture models and latent factor models)

Assorted Topics: Evaluating Machine Learning algorithms and Model Selection. Introduction to Statistical Learning Theory. Ensemble Methods (Boosting, Bagging, Random Forests). Sparse Modeling and Estimation. Modeling Sequence/Time-Series Data. Deep Learning and Feature Representation Learning. Scalable Machine Learning (Online and Distributed Learning). A selection from some other advanced topics, e.g., Semi-supervised Learning, Active Learning, Reinforcement Learning, Inference in Graphical Models, Introduction to Bayesian Learning and Inference.

Text books/ Reference books.

1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009 (freely available online)
3. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.
4. Hal Daumé III, A Course in Machine Learning, 2015 (freely available online).

5. **CO-PO Mapping:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	2	-	-	-	-	1	1
CO2	3	3	2	2	2	2	-	-	-	-	1	1
CO3	2	2	3	2	2	2	-	-	-	-	1	1
CO4	3	3	3	2	2	2	-	-	-	-	1	1

22MAT668 Social Network Analytics 3 0 0 3

Course Outcomes:

CO1: To understand the basics of social networks and its modelling.

CO2: To understand the fundamental of social data analytics.

CO3: Understand and apply the data mining concepts in social networks.

CO4: Carry out some case studies in social network analysis.

Unit 1 : Online Social Networks (OSNs)

Introduction - Types of social networks (e.g., Twitter, Facebook), Measurement and Collection of Social Network Data. Techniques to study different aspects of OSNs -- Follower-followee dynamics, link farming, spam detection, hashtag popularity and prediction, linguistic styles of tweets. Case Study: An Analysis of Demographic and Behaviour Trends using Social Media: Facebook, Twitter and Instagram

Unit 2: Fundamentals of Social Data Analytics

Introduction - Working with Social Media Data, Topic Models, Modelling social interactions on the Web – Agent Based Simulations, Random Walks and variants, Case Study: Social Network Influence on Mode Choice and Carpooling during Special Events: The Case of Purdue Game Day

Unit 3 : Applied Social Data Analytics

Application of Topic models, Information Diffusion, Opinions and Sentiments - Mining, Analysis and Summarization, Case Study: Sentiment Analysis on a set of Movie Reviews using Deep Learning techniques, Recommendation Systems, Language dynamics and influence in online communities, Community identification, link prediction and topical search in social networks, Case Study: The Interplay of Identity and Social Network: A Methodological and Empirical Study

Text and Reference Literature

1. Cioffi-Revilla, Claudio. *Introduction to Computational Social Science*, Springer, 2014.
2. Matthew A. Russell. *Mining the Social Web: Data Mining Facebook, Twitter, Linkedin, Google+, Github, and More*, 2nd Edition, O'Reilly Media, 2013.
3. Robert Hanneman and Mark Riddle. *Introduction to social network methods.* Online Text Book, 2005.
4. Jennifer Golbeck, *Analyzing the social web*, Morgan Kaufmann, 2013.
5. Claudio Castellano, Santo Fortunato, and Vittorio Loreto, *Statistical physics of social dynamics*, Rev. Mod. Phys. 81, 591, 11 May 2009.
6. S. Fortunato and C. Castellano, *Word of mouth and universal voting behaviour in proportional elections*, Phys. Rev. Lett. 99, (2007).
7. Douglas D. Heckathorn, *The Dynamics and Dilemmas of Collective Action*, American Sociological Review (1996).
8. Michael W. Macy and Robert Willer, *From factors to actors: Computational Sociology and Agent-Based Modeling*, Annual Review of Sociology Vol. 28: 143-166 (2002).
9. Nilanjan Dey Samarjeet Borah Rosalina Babo Amira Ashour, *Social Network Analytics - Computational Research Methods and Techniques, First Edition*, eBook ISBN: 9780128156414, Paperback ISBN: 9780128154588, Imprint: Academic Press, Published Date: 23rd November 2018

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	2	-	-	-	-	1	1
CO2	3	3	2	2	2	2	-	-	-	-	1	1

CO3	2	2	3	2	2	2	-	-	-	-	1	1
CO4	3	3	3	2	2	2	-	-	-	-	1	1

22MAT669 Computer Aided Drug Designing 3 0 0 3

Course Outcomes:

CO1: To understand the basics of molecular modelling.

CO2: To understand the quantitative structure and activity relationship.

CO3: Understand and apply PCA in molecular design.

CO4: To understand important drug databases, designing Lipinski's rule of five.

Introduction to Molecular Modeling: Molecular Modeling and Pharmacoinformatics in Drug Design, Phases of Drug Discovery, Target identification and validation

Protein Structure Prediction and Analysis: Protein Structure prediction methods: Secondary Structure Prediction, Tools for Structure prediction; Protein structural visualization; Structure validation tools; Ramachandran Plot.

QSAR : Quantitative Structure and Activity Relationship - Historical Development of QSAR, Tools and Techniques of QSAR, Molecular Structure Descriptors.

Multivariate Statistical methods in QSAR -Principal Component Analysis (PCA) and Hierarchical Cluster Analysis(HCR). Regression analysis tools - Pincipal Component Regression (PCR), Partial Least Squares (PLS) - Case studies.

High Throughput / Virtual screening- Introduction, Basic Steps, Important Drug Databases, Designing Lipinski's Rule of Five, ADMET screening

Docking Studies- Target Selection, Active site analysis, Ligand preparation and conformational analysis, Rigid and flexible docking .

Molecular visualization tools: RasMol and Swiss-Pdb Viewer

Molecular docking tools: AutoDock and ArgusLab.

References/ Textbooks

1. Leach Andrew R., Valerie J. Gillet, An introduction to Chemoinformatics. Publisher: Kluwer academic , 2003. ISBN: 1402013477.
2. Gasteiger Johann, Handbook of Chemoinformatics: From Data to Knowledge (4 Volumes), 2003. Publisher: Wiley-VCH. ISBN:3527306803.
3. Opera Tudor I,Ed. , Chemoinformatics in drug discovery, Wiley-VCH Verlag,2005.

4. Bunin Barry A. Siesel Brian,Morales Guillermo,Bajorath Jürgen. Chemoinformatics: Theory, Practice, & Products Publisher:New York, Springer. 2006. ISBN: 1402050003.
5. Gasteiger Johann, Engel Thomas. Chemoinformatics: A Textbook. Publisher: WileyVCH; 1st edition. 2003. ISBN: 3527306811.

Kenneth M Merz, Jr, Dagmar Ringe, Charles H. Reynolds , Drug design: Structure and ligand based approaches (2010) publisher : Cmabridge University press

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	2	-	-	-	-	1	1
CO2	3	3	2	2	2	2	-	-	-	-	1	1
CO3	2	2	3	2	2	2	-	-	-	-	1	1
CO4	3	3	3	2	2	2	-	-	-	-	1	1

21MAT670 EVOLUTIONARY GAME DYNAMICS 3 0 0 3

Course Outcomes:

CO1: To understand the basics of evolutions and its game theoretic frameworks.

CO2: To understand the basic qualitative theory of dynamical systems.

CO3: To understand the deterministic evolutionary game dynamics in infinite populations.

CO4: To understand the stochastic evolutionary game dynamics in finite populations.

Unit-1 : Basics of evolution-Examples of evolution in biology, ecology, society, and language; Darwin's theory; Fisher's fundamental theorem; Price equation; Hamilton's inclusive fitness theory.

Unit-2 : Basics of game theoretic concepts-Concepts of Nash equilibrium, Pareto efficiency, risk dominance, and evolutionary stable strategy; normal and extensive forms; repeated games and evolution of cooperation; spatial games.

Unit-3 : Basics of nonlinear dynamic-Autonomous flows and maps, fixed points, linear stability analysis, limit cycles, chaos.

Unit-4 : Games in infinite population: deterministic models, Quasispecies equation, replicator--mutator equation, imitation dynamics, monotone selection dynamics, best--
-response dynamics, adjustment dynamics, adaptive dynamics, evolutionary stable state,

connection between replicator-- mutator equation and expanded Price equation, Folk theorem, application to language evolution.

Unit-5: Games in finite population: stochastic models, Moran process, birth--death process, fixation probability, Kimura's neutral theory of evolution, one--third law and its relation with risk dominance, evolutionary stability, evolutionary graph theory.

Text Book:

1. M. A. Nowak, Evolutionary Dynamics, The Belknap Press of Harvard University Press (2006).

2. J. Hofbauer and K. Sigmund, Evolutionary Games and Population Dynamics, Cambridge University Press (1998).

3. R. Cressman, Evolutionary Dynamics and Extensive Form Games, The MIT Press (2003).

4. D. Easley and J. Kleinberg; Networks, Crowds, and Markets; Cambridge University Press (2010).

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	3	3	-	-	-	-	-	1	
CO2	3	3	2	3	3	-	-	-	-	-	1	
CO3	2	2	3	3	3	-	-	-	-	-	1	
CO4	3	3	3	3	3	-	-	-	-	-	1	