5-Year Integrated M Sc – Mathematics

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 1					**SEMESTER 2**				
21ENG101	Communicative English	2 0 2	3	A	21ENG111	Professional Communication	1 0 2	2	A
	Language Paper I	1 0 2	2	B		Language Paper II	1 0 2	2	B
22PHY101/ 22COM101	Physics / Introduction to Management and Finance	3 0 0	3	D	22CHY111 / 22COM111	Chemistry / Basics of Accountancy	3 0 0	3	C
22MAT101	Calculus of single variable	3 0 2	4	G	22MAT111	Real Analysis-I	3 1 0	4	G
22MAT102	Discrete Structures	3 1 0	4	F	22MAT112	Algebra-I (Group Theory)	3 1 0	4	F
22CSA101	Computer Programming-C	3 0 0	3	C	22CSA111	Advanced Computer Programming - C	3 0 0	3	D
22CSA182	Computer Programming Lab.	0 0 2	1	L1	22CSA183	Advanced Computer Programming Lab.	0 0 2	1	L1
22PHY181/ 22CSA181	Physics lab / PC Software Lab.	0 0 2	1	L2	22CHY181 / 22COM181	Chemistry Lab. / Accounting Lab.	0 0 2	1	L2
21CUL101	Cultural Education I	2 0 0	2	E	21CUL111	Cultural Education II	2 0 0	2	E
					22AVP103	Mastery Over Mind	1 0 2	2	
	TOTAL		**23**			TOTAL		**24**	
SEMESTER 3					**SEMESTER 4**				
22MAT201	Algebra-II (Rings)	3 1 0	4	A	22MAT211	Real Analysis-III	3 1 0	4	A
22MAT202	Real Analysis -II (Metric Spaces)	3 1 0	4	B	22MAT212	Algebra-III (Linear Algebra)	3 0 2	4	B
22MAT203	Probability Theory	3 0 2	4	J	22MAT213	Numerical Methods	3 0 0	3	C
22MAT204	Differential Equations	3 0 2	4	H	22MAT214	Statistical Inference Theory	3 0 2	4	D
22MAT205	Calculus of Several Variables	3 0 2	4	E	22MAT215	Combinatorics	2 1 0	3	E
19ENV300	Environmental Science		P/ F	D		Open Elective A*	3 0 0	3	J
21SSK201	Life Skills I	1 0 2	2	G	22MAT282	Numerical Methods Lab (MAT Lab)	0 0 2	1	L1
22MAT281	Python programing Lab	1 0 2	2	H	21SSK211	Life Skills II	1 0 2	2	G
21AVP201	Amrita Values Programme I	1 0 0	1	F	21AVP211	Amrita Values Programme II	1 0 0	1	F
	TOTAL		**25**			TOTAL		**25**	
SEMESTER 5					**SEMESTER 6**				
22MAT301	Operations Research	3 0 2	4	A	22MAT311	Optimization Theory	3 0 2	4	A
22MAT302	Algebra-IV (Field Theory)	3 1 0	4	B	22MAT312	Stochastic Process	2 1 0	3	B
22MAT303	Basic Graph Theory and Coding Theory	3 1 0	4	C	22MAT313	Basic Topology	3 1 0	4	C
22MAT304	Complex Analysis	3 1 0	4	D	22MAT314	Formal Languages and Automata Theory	3 0 2	4	D
22MAT305	Number Theory	3 1 0	4	E	22MAT315	Calculus of Variations	3 1 0	4	E
22MAT390	Live-in-Lab.@ / Open Elective B*	3 0 0	3	J		TOTAL		**19**	
21SSK301	Life Skills III	1 0 2	2	G	22MAT399	Project (for Exit-option Students)		6	P
	TOTAL		**25**			TOTAL		**25**	
						TOTAL (for Exit-option students)	**147**		
SEMESTER 7					**SEMESTER 8**				
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
	TOTAL		**21**			TOTAL		**22**	

		SEMESTER 9						SEMESTER 10				
	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**	**219**			
ELECTIVES (any one Stream)												
		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 Differential Equations	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 students)	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						**DIFFERENTIAL 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							

LANGUAGES												
		Paper I						**Paper II**				
	21TAM101	Tamil I	1 0 2	2	B		21TAM111	Tamil II	1 0 2	2	B	
	21HIN101	Hindi I	1 0 2	2	B		21HIN111	Hindi II	1 0 2	2	B	
	21MAL101	Malayalam I	1 0 2	2	B		21MAL111	Malayalam II	1 0 2	2	B	
	21SAN101	Sanskrit I	1 0 2	2	B		21SAN111	Sanskrit II	1 0 2	2	B	

* **Two Open Elective** courses are to be taken by each student, one each at the **4th and the 5th** semesters, from the list of Open electives offered by the School.

@ Course code for Live in Lab

@ Students undertaking and registering for a Live-in-Lab project, can be exempted from registering for an Open Elective course in the fifth semester

Open Electives UG				
Course Code	**Course Title**	**L – T – P**	**Cr.**	**ES**
21OEL231	A Journey towards Free India	3 0 0	3	J
21OEL232	Political Leadership	3 0 0	3	J
21OEL233	Social issues in Contemporary India	3 0 0	3	J
21OEL234	The Story of Indian Business	3 0 0	3	J
21OEL235	Industrial Psychology	3 0 0	3	J
21OEL236	Advertising	3 0 0	3	J
21OEL237	Basic Statistics	3 0 0	3	J
21OEL238	Citizen Journalism	3 0 0	3	J
21OEL239	Creative Writing for Beginners	3 0 0	3	J
21OEL240	Desktop Support and Services	3 0 0	3	J
21OEL241	Development Journalism	3 0 0	3	J
21OEL242	Digital Photography	3 0 0	3	J
21OEL243	Emotional Intelligence	3 0 0	3	J
21OEL244	Essence of Spiritual Literature	3 0 0	3	J
21OEL245	Film Theory	3 0 0	3	J
21OEL246	Fundamentals of Network Administration	3 0 0	3	J
21OEL247	Gender Studies	3 0 0	3	J
21OEL248	Glimpses of Indian Economy and Polity	3 0 0	3	J
21OEL249	Graphics and Web-designing Tools	3 0 0	3	J
21OEL250	Green Marketing	3 0 0	3	J
21OEL251	Healthcare and Technology	3 0 0	3	J
21OEL252	History of English Literature	3 0 0	3	J
21OEL253	Indian Writing in English	3 0 0	3	J
21OEL254	Industrial Relations and Labour Welfare	3 0 0	3	J
21OEL255	Introduction to Ancient Indian Yogic and Vedic Wisdom	3 0 0	3	J
21OEL256	Introduction to Computer Hardware	3 0 0	3	J
21OEL257	Introduction to Event Management	3 0 0	3	J
21OEL258	Introduction to Media	3 0 0	3	J
21OEL259	Introduction to Right to Information Act	3 0 0	3	J
21OEL260	Introduction to Translation	3 0 0	3	J
21OEL261	Linguistic Abilities	3 0 0	3	J
21OEL262	Literary Criticism and Theory	3 0 0	3	J
21OEL263	Macro Economics	3 0 0	3	J
21OEL264	Managing Failure	3 0 0	3	J
21OEL265	Media Management	3 0 0	3	J
21OEL266	Micro Economics	3 0 0	3	J
21OEL267	Micro Finance, Small Group Management and Cooperatives	3 0 0	3	J
21OEL268	Negotiation and Counselling	3 0 0	3	J
21OEL269	New Literatures	3 0 0	3	J

21OEL270	Non-Profit Organization	3 0 0	3	J
21OEL271	Personal Effectiveness	3 0 0	3	J
21OEL272	Perspectives in Astrophysics and Cosmology	3 0 0	3	J
21OEL273	Principles of Marketing	3 0 0	3	J
21OEL274	Principles of Public Relations	3 0 0	3	J
21OEL275	Science, Society and Culture	3 0 0	3	J
21OEL276	Statistical Analysis	3 0 0	3	J
21OEL277	Teamwork and Collaboration	3 0 0	3	J
21OEL278	The Message of Bhagwad Gita	3 0 0	3	J
21OEL279	Understanding Travel and Tourism	3 0 0	3	J
21OEL280	Videography	3 0 0	3	J
21OEL281	Vistas of English Literature	3 0 0	3	J
21OEL282	Web-Designing Techniques	3 0 0	3	J
21OEL283	Organic Farming	3 0 0	3	J
21OEL284	Basic Legal Awareness on Protection of Women and Rights	3 0 0	3	J
21OEL285	Ritual Performances of Kerala	3 0 0	3	J
21OEL286	Documenting Social Issues	3 0 0	3	J
21OEL287	Fabrication of Advanced Solar Cell	3 0 0	3	J
21OEL288	Basic Concepts of X-ray Diffraction	3 0 0	3	J
21OEL289	Introduction to FORTRAN and GNUPLOT	3 0 0	3	J
21OEL290	Introduction to Porous Materials	3 0 0	3	J
21OEL291	Forensic Science	3 0 0	3	J
21OEL292	Introduction to solar Physics	3 0 0	3	J
21OEL293	Recycling Recovery and Treatment Methods for Wastes	3 0 0	3	J
21OEL294	Acting and Dramatic Presentation	2 0 2	3	J
21OEL295	Computerized Accounting	2 0 2	3	J
21OEL296	Kerala Mural Art and Painting	2 0 2	3	J
21OEL297	Painting	2 0 2	3	J
21OEL298	Reporting Rural Issues	3 0 0	3	J

Five Year Integrate M.Sc Mathematics

Syllabus-2022 admissions onwards

Int M Sc Mathematics Syllabus 2022

22PHY101 **Physics** **3 0 0 3**

Objective of the course

The objective of the course is to make students understand how physics is applied to the phenomena observed in the real world. The course also aims in enhancing the problem-solving skills using techniques that require mathematical skills, conceptual and mathematical models.

At the end of the course students **will be able to**:

CO1 : understand basic physics associated with kinematics in 1,2,&3 dimensions, explain the meaning of conservation(energy& Momentum) and use it to compare the changes occurring during collision of two objects

CO2 : apply Newton's law of universal gravitation to find the gravitational force between two masses ,use Kepler's law of harmonies to make calculations regarding the radius and period of orbits of planets.

CO3 : Understand rigid bodies, draw clear and appropriate free body diagrams. determine the mass moments and products of inertia for arbitrary rigid bodies, analyse the motion of rotating systems, calculate the inertia tensor for simple objects

CO4 :. understand Variance& invariance, check invariance of different laws of Physics under Galilean transformations& explain the meaning and significance of the postulate of Special Relativity.

CO5 : understand the fundamentals of the mechanics of continuous systems, solve problems based on principle of least action and write Lagrangian for mechanical system in terms of generalised coordinates

Skills Acquired : Develops logical skills in applying and analysing problems in mechanics

Unit –I: Force, Energy, Momentum & Collisions **(8 Hr)**

Learning objectives

After completing this chapter, student will be able to

LO1- solve problems based on Newtons laws of motion.

LO2- identify types of mechanical energy possessed by an object.

LO3 -predict whether an object's total mechanical energy would be conserved or not conserved based upon the types of forces which are doing work upon the object.

LO4 - apply the principles of energy conservation to a various of physical situations.

LO5- determine the momentum of total system and to state what momentum conservation is.

LO6- apply the principle of momentum conservation to solve collision problems.

One-, two- and three-dimensional motion under forces – Energy and momentum conservation- collision in one and two dimensions.

Unit-II: Gravitation & Kepler's laws **(10 Hr)**

Learning objectives

After completing this chapter, student will be able to

LO1- calculate the gravitational force experienced by two objects.

LO2- Relate Kepler's laws to Newton's universal law of gravitation

LO3- solve problems based on the concept of gravitational potential energy

LO4- apply Kepler's law to find the characteristics of orbit

Newton's laws- Gravitation- Central force motion and application to planetary motion- Kepler's laws

Unit-III: Rotational dynamics **(10 Hr)**

Learning objectives

After completing this chapter, student will be able to

LO1- construct appropriate free-body diagrams and solve problems in two-dimensional rigid-body dynamics.

LO2- Apply appropriate mathematical equations to solve problems based on torque and moment of inertia.

LO3- Understand the inertia matrix and the principal moments and principal directions at any point in a rigid body or system of particles

Rotational motion of a rigid body, Potential energy, Euler's angles-Euler's Equation-Moment of inertia tensor

Unit- IV: Special Theory of relativity **(7 Hr)**

Learning objectives

After completing this chapter, student will be able to

LO1- understand the concept of constant relative motion of different bodies in different frames of references

LO2- use Lorentz transformations to apply the concepts of length contraction and time dilation

LO3-Describe relativistic effects seen in conservation of momentum and perform calculations involving mass energy equivalence

Frames of reference, Galilean relativity, non-inertial frames, Lorentz transformation-basic special relativity- velocity addition- Relativistic momentum

Unit – V: Lagrangian formalism **(10 Hr)**

Learning objectives

After completing this chapter, student will be able to

LO1- Apply variational calculus to demonstrate principle of least action

LO2- define generalised coordinates, generalised velocities, generalised force

LO3- Identify the motion of a mechanical system using Lagrange formalism

LO4- qualitatively analyze, understand the mechanical systems

Least action principle, phase space, Langarangian Formulation- Applications

Text Book

1. Principles of Physics, Walker, Halliday & Resnick, Wiley, Tenth Edition
2. Mechanics: C. Kittel, W.D. Knight, M.A. Ruderman, C.A. Helmholz and B.J. Moyer (2008) Berkeley Physics Vol 1, Tata McGraw-Hill Ltd
3. Feynman Lectures in Physics Vol:1 : Feynman, R. P., Leighton, R. B., & Sands, M. L, Pearson (2020)

Reference Books

1. Classical Mechanics: R.D. Gregory (2008) Cambridge University Press
2. Introduction to Classical Mechanics: D. Morin (2009) Cambridge University Press
3. Classical Mechanics: J.R. Taylor (2005) University Science Books
4. Mechanics: L.D. Landau and I.M. Lifshitz (2007) 3 edition, Butterworth-Heinemann

CO-PO Mapping

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

22PHY181 Physics Lab - Mechanics and Properties of Matter 0 0 2 1

1. Young's modulus – Uniform bending
2. Torsional Pendulum
3. Compound Pendulum
4. Coefficient of viscosity- Poiseuille's method
5. Surface tension of liquid by capillary raise method
6. Thermal conductivity of bad conductor - Lee's disc
7. Kundt's tube
8. Specific heat capacity of a liquid by method of cooling.

Text Book: Laboratory manual supplied by the Department

22CHY111 CHEMISTRY 3 0 0 3

Unit 1 Chemical Bonding

Review of orbital concept and electronic configuration, electrovalency and ionic bond formation, ionic compounds and their properties, lattice energy, solvation enthalpy and solubility of ionic compounds, covalent bond, covalency, orbital theory of covalency - sigma and pi bonds - formation of covalent compounds and their properties Hybridization and geometry of covalent molecules - VSEPR theory - polar and non-polar covalent bonds, polarization of covalent bond - polarizing power, polarisability of ions and Fajan's rule, dipole moment, percentage ionic character from dipole moment, dipole moment and structure of molecules - co-ordinate covalent compounds and their characteristics, molecular orbital theory for H_2, N_2, O_2 and CO, metallic bond - free electron, valence bond and band theories, weak chemical bonds – inter and intra molecular hydrogen bond - van der Waals forces.

Unit 2 Thermodynamic Parameters

Stoichiometry - mole concept, significance of balanced chemical equation - simple calculations - Conditions for occurrence of chemical reactions - enthapy, entropy and free changes – spontaneity – Thermochemistry - heats of reactions - (formation, combustion, neutralization) - specific heats - variation of enthalpy change with temperature - Kirchhoff' relation (integrated form) - bond enthalpy and bond order - Problems based on the above.

Unit 3 Kinetics

Review of molecularity and order of a reaction, rate law expression and rate constant - first, second, third and zero order reactions, pseudo-first order reactions (pseudo-unimolecular reactions) - complex reactions - equilibrium and steady state approximations - mechanism of these reactions - effect of temperature on reaction rates - Arrhenius equation and its significance, Michaelis Menden kinetics - enzyme catalysis.

Unit 4 Electrochemistry

Electrolytes - strong and weak, dilution law, Debye-Huckel theory, faraday's laws, origin of potential, single electrode potential, electrochemical series, electrochemical cells, Nernst equation and its application, reference electrodes - SHE, Ag/AgCl, Calomel.

Unit 5 Photochemistry

Photochemistry, laws of photochemistry - Stark-Eistein law, Beer-Lamberts law, quantum efficiency-determination, photochemical processes - Jablonsky diagram, internal conversion, inter-system crossing, fluorescence, phosphorescence, chemiluminescence and photo sensitization, photopolymerization**.**

REFERENCE BOOKS:

1. Principles of Physical Chemistry, B.R. Puri, L.R. Sharma & M.S. Pathania, Vishal Publications, 46th, 2013.

2. *Principles of Inorganic Chemistry, B. R. Puri, L. R. Sharma, Vishal Publications, 2008*

22COM101 INTRODUCTION TO MANAGEMENT AND FINANCE 3 0 0 3

***Objective**: To give the students an understanding on the concept of management and on the various aspects of financial management.*

Unit I

Management, definition, nature, scope and objectives, importance of management, role of manager, levels of management, management and administration, functions of management.
Scientific Management Principles – Fayol's General Principles of Management - Management of Change, Resistance to Change

Unit II

Motivation and Leadership – Leadership Styles – Theories of Motivation – Maslow – McGregor.
Communication, meaning, definition and characteristics of communication, elements of communication, importance, process of communication, channels of communication.

Unit III

Financial Management, meaning, definition and scope, importance, Finance Function, objectives of financial management, finance manager, functions and role of a finance manager.

Unit IV

Banks and Banking, meaning and definition, types of banks, commercial banking, functions of commercial banks, central banking, Reserve Bank of India, Nationalisation of Commercial Banks, Retail Banking, Recent trends in banking – EMI – ECS – EFT – NEFT – RTGS – CTS – CORE Banking

Unit V

Introduction to various fundamental concepts and definitions of income tax, Finance Bill, Finance Act, person, assessment year, previous year, agricultural income, total income, gross total income, assessee, taxation of previous year's income in the same year, residence and tax liability, income excluded from total income, various heads of income, deductions available for individuals.

REFERENCE TEXTS:

1. *I.M. Pandey – Essentials of Financial Management, Vikas Publishing*
2. *Kootz and O'Donnel – Principles of Management, TMH*
3. *Tripathy, Principles of Management, TMH*
4. *Direct Taxes: Laws and Practice, Taxmann*
5. *Modern Banking, Muraleedharan, PHI*

22CSA181 PC SOFTWARE LAB. 0 0 2 1

Unit 1 Word Processing Application – MS Word

1. Open a new document and set page size to A4, margins to left (2 cm), right (2cm), top (2.5m), bottom (2.5cm)
   a. Type the following text:
      Through Her extra ordinary acts of love and self sacrifice, Amma has endeared Herself to millions. Tenderly caressing everyone who comes to Her, holding them close to Her heart in a loving embrace, Amma shares Her boundless love with all. Be they young or old, sick or poor everyone who comes to Her receives the same unconditional love. Amma's compassion has given rise to a vast network of charitable and spiritual

activities, which is drawing attention throughout the world. At the root of these services lies Amma's teaching that the divine exists in everything in every person, plant and animal. Perceiving this unity is the essence of spirituality and the means by which to end all suffering. It is through this simple, yet powerful message that Amma is transforming our world, one embrace at a time.

b. Make the document error free using Spelling and Grammar
c. Replace the word 'compassion' using Thesaurus utility.
d. Practice Cut, Copy and Paste.
e. Apply Page Borders, Paragraph Borders and shade the paragraphs.
f . Give appropriate heading in the Header and Page number, date in the Footer.
g. Apply paragraph settings to the document.
h. Format the text and apply bullets and numbering using menu.
i. Insert a picture in the document (use OLE feature)
j. Change one paragraph of the document into newspaper layout.
k. Practice tab settings.

2. Insert a table containing 6 rows and 7 columns: Headings – Student No, name, Mark1, Mark2, Mark3, Total, and Average.
   a. Enter the details of 5 students.
   b. Calculate Total & Average using 'Formula' option.
   c. Sort the details of students in the order of Average..

3. Generate 10 copies of interview letters to candidates from different states informing the place and time of interview. (Mail Merge)

Unit 2 Spread Sheet Application – MS Excel

1. Open a new work book and enter the details:
   Employee No Name Basic Pay DA HRA PF Net Pay
   E001 Anu 6000
   E002 Anju 8000
   E003 Pavan 4500
   E004 Jyothy 7600
   E005 Manu 6500
   Calculate DA as 7.5% of Basic Pay, HRA as 5% of Basic Pay PF as 6% of Basic Pay And Net Pay = Basic Pay + DA + HRA - PF .

2. Create a series using AutoFill handle.
3. Save the workbook & give suitable title in the Header and date in the Footer, Preview the file.
4. Create a name for a range of cells in the work sheet.
5. Practice Rows, columns, Cells and work sheet format options.
6. Clear the formats of 5 the row.
7. Delete the last sheet of the workbook
8. Make a copy of the first sheet and rename it.
9. Practice paste special options.

Unit 3 Spread Sheet Application – MS Excel

1. Find the Sum of Net Pay using function.

2. Write a function to find the count of employees in G20 cell.
3. Insert comments in different cells and practice hyperlinks.
4. Create your own style for worksheets.
5. Create a database having the headings Roll No, Name, Mark1, Mark2, Mark3 and Total. Before entering data give validation rules:
   a. For roll no – Enter numbers between 1 and 50
   b. For name – Enter names that have text length between 3 and 15.
   c. For marks – Enter marks between 0 and 99
6. Insert records and Sort the records.
7. Create a chart for the above details.
8. Create a pie chart for the student with highest mark.
9. Practice Auto Filter and advanced Filter.

Unit 4 Presentations using PowerPoint – 2000

1. Open a new Presentation and insert a new slide.
2. Apply appropriate slide transition to it.
3. Insert a number 4 more slides and set up the show for all.
4. Text and Word art into slides and apply custom animations.
5. Format the text and word art in the slides and apply design templates to slides.
6. Hyper link the slides (use text for link).
7. Use action buttons for hyperlink.
8. Create a PowerPoint presentation that contains News Headlines for a TV channel.
9. Create a presentation with minimum 5 slides regarding the programmes on Annual Day celebrations.
10. Create a presentation with minimum 5 slides regarding various products offered by a particular company.

Unit 5

Simple business case studies using the software tools.

TEXTBOOK:

Alexis Leon & Mathews Leon: Fundamentals of Information Technology, Vikas Publishing

REFERENCE BOOKS:

1. Microsoft Office 2000 Complete, BPB publications

2. Dennis P.Curtin, Kim Foley, Kunal Sen, Cathleen Morin : Information Technology The Breaking

Wave, TATA McGraw-Hill Edition

22COM111 BASICS OF ACCOUNTANCY 3 0 0 3

Objective: *To provide a basic knowledge on the important terms and basic concepts of financial*

accounting.

Unit 1

Business – Scope – Business Transactions – Book Keeping – meaning, objectives and functions – Accounting – meaning, functions and importance, distinction between book keeping and accounting – objectives of accounting – users of accounting – branches of

accounting – advantages and limitations of accounting – accounting terminologies – Accounting Concepts and Conventions – Accounting Standards in India.

Unit 2

Accounting Systems – Double Entry System and Single Entry System – Account – types of accounts – Rules for Debit and Credit – Accounting Equation – Journal – Journal entries – journalizing – compound entries – Banking transactions.

Unit 3

Sub-Divisions of Journal or Subsidiary Books: Advantages of Subsidiary Books and limitations of journal – Purchase Day Book – Purchase Returns Book – Sales Book – Sales Returns Book – Cash Book – Petty Cash Book – Imprest System

[Overview Only]

Unit 4

Ledger: Meaning and importance – preparation of ledger accounts or posting – balancing an account – account balance – Trial Balance – objectives and functions of trial balance.

Unit 5

Preparation of Final Accounts – simple adjustments like outstanding expenses, prepaid expenses, bad debts, accrued income, unearned income. Depreciation: Meaning and definition – causes of depreciation – need for depreciation – Fixed Instalment Method and Diminishing Balance Method.

TEXTBOOKS:

1. Goyal and Ruchi Goyal – Financial Accounting, Prentice Hall India
2. Jain and Narang – Advanced Accounts Volume 1, Kalyani Publishers

REFERENCE BOOKS:

1. T S Grewal and S C Gupta – Introduction to Accountancy, S. Chand
2. S N Maheshwari and S K Maheshwari – Financial Accounting, Vikas Publishing
3. Mukharjee and Hanif – Financial Accounting, Tata McGraw Hill

22COM181 ACCOUNTING LAB. 0 0 2 1

Objective: *To give an understanding on the application of Tally Software.*

Unit 1

Getting started with Tally – Company information – Features and configuration.

Unit 2

Tally accounting - Chart of accounts – Ledgers and Groups.

Unit 3

Vouchers – Financial and Trading vouchers - advanced voucher entry.

Unit 4

Display and reporting – reporting and printing.

Unit 5

Budgeting – Interest Calculations – Banking.

REFERENCE TEXTS:

1. Tally complete reference material
2. Tally for everyone – Roopa, Add to Cart Publishing
3. Nadhani – Tally ERP 9 Training Guide – BPB Publication

22CHY181 CHEMISTRY LAB 0 0 2 1

1. Acid base titration (double titration)
2. Complexometric titration (double titration)
3. Redox (permanganimetry) titration (double titration)
4. Conductometric titration
5. Potentiometric titration
6. Colourimetric titration

22CSA101 COMPUTER PROGRAMMING-C 3 0 0 3

Introduction to problem solving: algorithm development and flowchart. Introduction to Computer terminologies and computer languages. C Fundamentals: structure of C program: directives, functions, statements, printing strings, comments; compilation and execution, Programming errors and debugging. Variables and assignment, reading input; data types, constants, identifiers, keywords, operators - arithmetic, logical, relational, assignment; expressions - precedence and associativity, type cast-implicit and explicit; selection statements:- if, if else, nested if, if else ladder, switch. Case.
Iterative structures: entry controlled and exit controlled loop, exiting from a loop: break, continue, goto; nested loops. Functions: library functions, user defined functions: defining and calling functions, function declaration, passing arguments to a function, returning values from function. Storage classes - auto, extern, static, register variables, scope of a variable. Recursion. Number systems: binary, octal and hexadecimal. Bitwise operators and enumeration.
Arrays: one dimensional numeric arrays, initialization, accessing and usage, two dimensional numeric arrays, initialization, accessing and usage. Introduction to multidimensional arrays. Strings: literal, variables: initialization, reading, writing and accessing. String handling functions. Array of strings. Passing arrays and strings to functions.

TEXTBOOK:

Jeri Hanly and Elliot Koffman, "Problem solving and program design in C", Fifth Edition, Addison Wesley (Pearson), 2007.

***REFERENCE**:*

Reema Thareja, "Computer Fundamentals and programming in C", Oxford University Press, 2012.

22CSA111 ADVANCED COMPUTER PROGRAMMING-C 3 0 0 3

Unit 1
Structures: structures variables - declaration, bit fields, initialization and operation on structures, typedef, nested arrays and structures: arrays in structures, nested structures, arrays of structures.

Unit2
Pointers– Declarations, Passing arguments by call by reference, Functions returning pointer, Pointer Arithmetic. Pointer to pointer, Pointers and Arrays – pointer to array, array of pointers, Dynamic memory allocation – malloc(), calloc(), deallocation: free(), dangling pointers.

Unit 3
Pointers and structures, structures and functions: passing structure as argument and returning structure from functions, self-referential structure, unions.

Unit 4
Files - file pointers, standard streams and redirection, text files, binary files, file operations: open, mode, close; Input and output - character I/O, line I/O, formatted I/O. Random file access, Command line arguments.

Unit 5
Preprocessor – Macros. User defined libraries and headers, introduction to the graphics library.

TEXTBOOK:
Jeri Hanly and Elliot Koffman, "Problem solving and program design in C", Fifth Edition, Addison Wesley (Pearson), 2007.

***REFERENCE**:*
Reema Thareja, "Computer Fundamentals and programming in C", Oxford University Press, 2012.

22CSA182 COMPUTER PROGRAMMING LAB 0 0 2 1

Basic Linux commands, programs using input/output statements, operators, control structures and loops. Programs using functions and recursions. Programs using numeric one-dimensional array, two-dimensional array. Programs using strings, string handling functions and string arrays. Programs using passing arrays and strings to functions.

22CSA183 ADVANCED COMPUTER PROGRAMMING LAB 0 0 2 1

Programs to demonstrate functions call by reference and returning values by reference. Programs using pointer arithmetic operations and handling pointers. Programs to demonstrate dynamic memory allocation and de-allocation. Programs to show structure and union operations. Programs using files, command line arguments and macros. Programs using user defined libraries and graphics library.

19ENV300 ENVIRONMENTAL SCIENCE P/F

Course Objectives

· To study the nature and facts about environment
· To appreciate the importance of environment by assessing its impact on the human world
· To study the integrated themes and biodiversity, pollution control and waste management

Course Outcomes

CO1: Ability to understand aspects of nature and environment
CO2: Ability to analyse impact of environment on human world
CO3: Ability to comprehend pollution control and waste management

CO – PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	–	–	–	–	–	3	2	3	–	–	–	–	–	–
CO2	–	–	––	–	–	3	2	3	–	–	–	–	–	–
CO3	–	–	–	–	–	3	2	3	–	–	–	–	–	–

Syllabus

Unit 1

Over view of the global environment crisis - Biogeochemical cycles - Climate change and related international conventions and treaties and regulations - Ozone hole and related International conventions and treaties and regulations - Overpopulation - energy crisis - Water crisis - ground water hydrogeology - surface water resource development.

Unit 2

Ecology, biodiversity loss and related international conventions - treaties and regulations - Deforestation and land degradation - food crisis - water pollution and related International and local conventions - treaties and regulations - Sewage domestic and industrial and effluent treatment - air pollution and related international and local conventions - treaties and regulations - Other pollution (land, thermal, noise).

Unit 3

Solid waste management (municipal, medical, e-waste, nuclear, household hazardous wastes) - environmental management - environmental accounting - green business - eco-labelling - environmental impact assessment - Constitutional - legal and regulatory provisions - sustainable development.

Text Book(s)

R. Rajagopalan,"Environmental Studies – From Crisis to Cure", Oxford University Press, 2005, ISBN 0-19-567393-X.

Reference(s)

G.T.Miller Jr., "Environmental Science", 11th Edition, Cenage Learning Pvt. Ltd., 2008.
Benny Joseph, "Environmental Studies", Tata McGraw-Hill Publishing company Limited, 2008.

Evaluation Pattern

Assessment	Internal	External
Online Test	–	100
		P/F

SEMESTER I

22MAT101 Calculus of Single Variable 3 0 2 4

CO1: An ability to understand the basic concepts of Derivative.
CO2: An ability to understand the concept of extreme values and apply the derivative test to identify concavity and extreme values.

CO3: Understand the concept of integration and apply them to evaluate the area between curves.
CO4: Apply the different techniques of integration to evaluate the integrals. Also understand the nature of numerical and improper integrals.
CO5: Apply the concept of integration to applications in science and engineering

Unit 1

Differentiation: The Derivative as a Function – Differentiation Rules – The Derivative as a Rate of Change – Derivatives of Trigonometric Functions – The Chain Rule and Parametric Equations – Implicit Differentiation – Linearization and Differentials.
Chapter 2- Sec: 2.1 to 2.7 and Chapter 3- Sec: 3.1 to 3.6, 3.7, Self Study - Sec: 3.7.

Unit 2

Application of Derivatives: Extreme values of Functions – The Mean Value Theorem – Monotonic Functions and the First Derivative Test – Concavity and Curve Sketching – Intermediate Forms and L' Hospital's Rule – Anti Derivatives.
Chapter 4- Sec: 4.1 to 4.4, 4.6 to 4.8, Self Study - Sec: 4.5

Unit 3

The Definite Integral – The Fundamental Theorem of Calculus – Indefinite Integrals and the Substitution Rule – Substitution and Area between Curves.
Chapter 5- Sec: 5.1 to 5.6

Unit 4

Techniques of Integration: Basic Integration Formulas – Integration by Parts – Integration of Rational Functions by Partial Fractions – Trigonometric Integrals – Trigonometric Substitutions – Numerical Integration – Improper Integrals.
Chapter 8: 8.1 to 8.5, 8.7,8.8, Self Study - Sec: 8.6

Unit 5

Application of Definite Integrals: Volumes by Slicing and Rotation about an Axis – Volumes by Cylindrical Shells – Lengths of Plane Curves – Moments and Centre of Mass – Areas of Surface of Revolution and the Theorems of Pappus – Work – Fluid Pressure and Forces.
Chapter 6 – Sec: 6.1 to 6.7

TEXTBOOK:

1. Finney and Thomas, "Calculus", Pearson, Eleventh Edition, 2008.

REFERENCE BOOKS:

1. Howard Anton, IRl Bivens, Stephens Davis, "Calculus" Wiley, 10th Edition, 2016 Reprint.
2. M. J. Strauss, G. L. Bradley and K. J. Smith, "Calculus", 3rd Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 2007.
3. James Stewart, "Calculus: Early Transcendentals", Cengage (India), 8th Edition, 2016.

CO-PO Mapping:

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

22MAT102 **Discrete Structures** **3 1 0 4**

Course Outcomes:

CO-1: Understand the basic concepts of linear system of equations and their solutions.
CO-2: Understand the concepts of Eigen values and Eigen vectos and apply to quadratic and canonical forms.
CO-3: Understand the basic concepts of Mathematical reasoning, set and functions
CO-4: Understand the concepts of various types of relations, partial ordering and equivalence relations.
CO-5: Apply the concepts of Boolean logic to minimize the circuit design.

Unit-I Review: Matrices

Linear System of Equations, Gauss Elimination, Consistency of a linear system of equations, Vectors, Linear independence and dependence of vectors, Rank of a Matrix.
Text Book: 1

Unit-II

Eigen values, Eigen vectors, Properties of eiven values and eigen vectors, Cayley-Hamilton theorem, Some Applications of Eigen value Problems, Similarity of Matrices, Diagonalization of a matrix, Power of a matrix, Diagonalization by orthogonal transformation, Quadratic forms, Canonical form of a quadratic form, Nature of quadratic forms.
Text Book: 1

Unit-III

Propositional Logic, Equivalences, Predicates and Quantifiers. Nested Quantifiers. Rules of Inference.
Text Book: 2

Unit-IV

Advanced Counting Techniques: Recurrence relations, Solving Linear Recurrence relations. Generating Functions.
Text Book: 2

Unit -V

Boolean Algebra: Boolean Functions. Representing Boolean Functions. Logic Gates. Minimization of circuits.
Text Book: 2

TEXT BOOKS:

1. ‘Elementary Linear Algebra’, Howard Anton and Chris Rorres, John Wiley & Sons, 1994, Seventh Edition.
2. Kenneth H. Rosen, Discrete Mathematics and its Applications, McGraw Hill.

REFERENCES

1. R. P. Grimaldi, “Discrete and Combinatorial Mathematics”, Pearson Education, Fifth Edition, 2007.
2. Thomas Koshy, “Discrete Mathematics with Applications”, Academic Press, 2005.

CO-PO Mapping:

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

SEMESTER II

22MAT112 **Algebra –I (Group Theory)** **3 1 0 4**

CO-1: Ability to understand sets, functions, types of functions and operations on functions.
CO-2: Abiilty to understand the axioms in the definition of a group through examples; to understand Subgroups.
CO-3: To understand the concept of Cyclic Groups / Factor Groups and identify them; to understand and apply Lagrange's Theorem.
CO-4: Familiarization of normal subgroup and its properties; to understand the proofs of Cauchy's / Sylow's / Cayley's Theorems and their relevance.
CO-5: To familiarize the concepts of conjugate classes and its role in permutation group and the class equation. To understand the role of class equation in proving Cauchy's theorem general case.

Unit 1 Set and Functions

Sets-Operations on Sets and their properties, equivalence relation, Mappings-injective and surjective mapping, composition of mappings and its properties. **(Sec. 1.1 to 1.2)**

Unit 2 Groups

Definition of Groups, Basic Examples of Groups including Symmetric Groups, Subgroups **(Sec. 2.1 to 2.4)**

Unit 3 Groups (contd)

Cyclic Groups and Factor Groups, Lagrange's Theorem. Normal Subgroups. Quotient Groups **(Sec. 2.5 and 2.6)**

Unit 4 Groups (contd)

Homomorphisms, Kernal of a homomorphism, Automorphisms, Cauchy's Theorem and Sylow's Theorem for Abelian Groups, Cayley's Theorem **(Sec. 2.7 and 2.9)**

Unit 5 Groups (contd)

Permutation 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, Counting Principles, Cauchy Theorem **(Sec. 2.10 and 2.11)**

TEXTBOOK:

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

REFERENCES:

1. John B. Fraleigh, 'A First Course in Abstract Algebra', Narosa Publishing House, 2003.
2. Joseph A. Gallian, 'Contemporary Abstract Algebra', Cengage Learning, 2013.
3. M.Artin, 'Algebra', Prentice Hall inc., 1994.

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

22MAT111 Real Analysis-I 3-1-0-4

Course outcomes:

CO1: Understanding the set theoretic statements and the completeness property of R.
CO2: Understanding the concepts of sequences, series and Limits. Apply the tests for convergence, absolute convergence and analysing the convergence criteria.
CO3: Defining Limits, continuity and monotonicity of a function and understanding the theorems related to them.
CO4: Understanding the concepts of extreme values, Mean value theorem and applying Taylor's theorem for approximating functions.
CO5: Understanding Riemann Sum and apply it to approximate integrations.

Unit – 1: Sets and Functions: – Mathematical Induction – Finite and Infinite Sets – The Algebraic and Order Properties of – Absolute Value and Real Line – The Completeness Property of – Applications of the Supremum Property – Applications of the Supremum Property, Intervals.

(Text Book: Chapter 1, 2- Sec: 1.1 to 1.3 and 2.1 to 2.5)

Unit – 2:

Sequence: Sequence and Series: Sequences and their Limits – Limits Theorems – Monotone sequences – Subsequences and Balzano – Weierstrass Theorem. The Cauchy criterion – Properly divergence sequences.

(Text Book : Chapter 3- Sec: 3.1 to 3.6, Problems covered from Reference Book 1 & 2).

Unit – 3:

Series: Introduction to series – Absolute Convergence – Tests for Absolute Convergence – Limit Comparison Test, Root Test, Ratio test, Integral Test, Raabe's Test – Tests for Non absolute Convergence – Alternating Series Test, Dirichlet and Abel Test.

(Text Book : Chapter 3, 9 - Sec: 3.7 and Sec: 9.1 to 9.3, Problems covered from Reference Book 1 & 2).

Unit – 4:

Limits of Functions: – Limit Theorem – Some Extensions of the Limit Concept

(Chapter 4, 5 - Sec: 4.1 to 4.3 and Sec: 5.1 & 5.2).

Unit – 5:

Continuous Functions: – Continuous Functions - Combinations of Continuous Functions – Continuous Functions on Intervals – Uniform Continuity – Continuity and Gauges – Monotone and Inverse Functions (Text Book : Chapter 5- Sec: 5.3 to 5.6).

Text Book:

1. Robert G. Bartle and Donald R. Sherbert, "Introduction to Real Analysis", John Wiley and Sons, Third Edition, 2000.

Reference Book:

1. W J. Kaczor and M.T. Nowak, "Problems in Mathematical Analysis I - Real Numbers, Sequences and Series"; American Mathematical Society, 2000.
2. S. C. Malik and Savita Arora, "Mathematical Analysis", New Age International Publishers, Fourth Edition, 2012.
3. H.L. Royden and P. M. Fitzpatrick , "Real Analysis", Pearson Education Asia Limited, Fourth Edition, 2010.
4. S. Kumaresan and Ajit Kumar, *A Basic Course in Real Analysis*, CRC Press.

CO-PO Mapping:

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

SEMESTER III

22MAT201 Algebra –II (Rings) 3 1 0 4

CO-1: Understanding the axioms in the definition of a ring/ integral domain / division ring through examples.
CO-2: Familiarization of the concept of mapping between rings; to understand ideals and quotient rings and their relevance.
CO 3: Familiarization of the concept of Euclidean domain through standard examples, and derive results in number theory through ring of Gaussian integers.
CO-4: To study the Euclidean ring structure in general polynomial ring and its properties. To know the properties of polynomials over rational numbers/integers in particular.
CO 5: To understand the connection between the algebraic structures namely, Fields, Euclidean rings, Principal Ideal Domain and Unique Factorisation Domain

Unit 1

Definition of Rings, Examples including Polynomial Rings, Formal Power Series Rings, Matrix Rings and Group Rings. Commutative Rings, Integral Domain, Division Ring, Characteristics of an Integral domain, **(Sec. 3.1 to 3.2)**

Unit 2

Homomorphisms, kernel, Isomorphism, Ideals, Quotient Rings, Maximal Ideals, the Field of Quotients of an Integral Domain **(Sec. 3.3 to 3.5)**

Unit 3

Euclidean Rings, Principal Ideal, Unit Element, Greatest Common Divisor, Prime Elements, Unique Factorization Theorem, The ring of Gaussian integers, Fermat's Theorem **(Sec. 3.7 to 3.8)**

Unit 4

Polynomial Rings – F[x], Degree of a Polynomial, The Division Algorithm, Principal Ideal Ring, Irreducible Polynomial a principal ideal ring, Irreducible polynomial, Polynomial Rings over the Rational Field, Primitive Polynomials, The Content of a Polynomial, Integer Monic Polynomial, Gauss Lemma, Eisenstein Criterion **(Sec. 3.9 to 3.11)**

Unit 5

Polynomial Rings over Commutative Rings. Unique Factorization Domain **(Sec. 3.11).**

Euclidean Domains, Principal Ideal Domains, Unique Factorization Domains, and their proper inclusions **(Sec. 8.1 to 8.3 from Reference Book 1)**

TEXTBOOKS:

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

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 and 2.

CO-PO Mapping:

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

22MAT202 Real Analysis II (Metric Spaces) 3-1-0-4

Course Outcomes:

CO1: Understanding the basic concepts of metric spaces, distance, open and closed sets.
CO2: Understanding the concepts like convergence, complete metric spaces, separable spaces and countability..
CO3: Understand the concepts of compact spaces.
CO4: Understanding the concepts like Continuous Functions and Compact Spaces, Uniform Continuous Functions, Homeomorphism and Equivalent Metrics.
CO5: Understanding the Separated Sets and Connected Sets.

Unit – 1: Basic Concepts: Definition and Examples of Metric Spaces, Distance between Sets and Diameter of a Set, Open Sets and Interior Points, Closed Sets and Closure of Sets, Subspaces. (Text Book : Chapter 1- Sec: 1.1 to 1.5).

Unit – 2: Complete Metric Spaces and Separable Spaces: Convergent Sequences, Cauchy Sequences, Complete Metric Spaces, Completion. Separable Spaces, Countability, Dense Sets, Nowhere Dense Sets. (Text Book : Chapter 2 & 3 - Sec: 2.1 to 2.4 & 3.1 to 3.3).

Unit – 3: Compact Spaces: Definitions and Basic Concepts, Sequentially Compact Spaces, Totally Bounded Spaces. (Text Book : Chapter 4 - Sec: 4.1 to 4.3).

Unit – 4: Continuous Functions: Definition and Characterizations, Continuous Functions and Compact Spaces, Uniform Continuous Functions, Homeomorphism and Equivalent Metrics, Uniform Convergence of Sequences of Functions. (Text Book : Chapter 15- Sec: 5.1 to 5.5).

Unit – 5:

Connected Spaces: Separated Sets, Connected Sets, Continuous Functions and Connected Sets, Components. (Text Book : Chapter 6- Sec: 6.1 to 6.4).

Text Book

1. Qamrul Hasan Ansari, "Metric Spaces: Including Fixed Point Theory and Set-valued Maps" ; Alpha Science International, Ltd, 2010.

Reference Books:

1. Mícheál Ó Searcóid, "Metric Spaces"; Undergraduate Texts in Mathematics, Springer-Verlag London Limited, 2007.
2. E. T. Copson, "Metric spaces", Cambridge Tracts in Mathematics, Cambridge University Press, 1988.
3. Tom M. Apostol, "Mathematical Analysis", Narosa publishing house, New Delhi, 2nd Ed. 1989.

CO-PO Mapping:

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

22MAT205 CALCULUS OF SEVERAL VARIABLE 3 0 2 4

Course Outcomes:

CO-1: Understand the basic concepts of vector valued functions, their limits, derivatives and integrals and its geometrical and physical interpretations.
CO-2: Understand the concepts of scalar and vector fields, their limits, derivatives and their applications.
CO-3: Understand the concepts of line integrals and its path independence.
CO-4: Understand and apply the concepts of double integrals to various problems including Green's theorem for plane..
CO-5: Understand the concepts of surface integrals, divergence theorem and Stoke's theorem..

Unit-1

Calculus of vector-valued functions: Vector-valued functions of a real variable-Algebraic operations. Components- Limits, derivatives and integrals-Applications to curves. Tangency-Applications to curvilinear motion-Velocity, speed and acceleration-The unit tangent, the principal normal -The definition of arc length.

Vol.1, Chapter 14- Sec. 14.1 to 14.10.

Unit-2

Differential calculus of scalar and vector fields: Functions of R^ntoR^m.Scalar and vector fields-Open balls and open sets-Limits and continuity-The derivative of a scalar field with respect to a vector-Directional derivatives and partial derivatives-Partial derivatives of higher order-Directional derivatives and continuity-The total derivative-The gradient of a scalar field-A chain rule for derivatives of scalar fields- Applications to geometry. Level sets. Tangent planes

Vol.2, Chapter-8-Sec. 8.1 to 8.17.

Unit-3

Line Integrals: Introduction-Paths and line integrals-Other notations for line integrals-Basic properties of line integral-Open connected sets. Independence of paths-The second fundamental theorem of calculus for line integrals-The first fundamental theorem of calculus for line integrals-Necessary and sufficient conditions for a vector field to be gradient-Necessary conditions for a vector field to be gradient-Special methods for constructing potential functions.

Vol.2, Chapter-10-Sec 10.1 to 10.5, 10.10 and 10.11, 10.14 to10.18.

Unit-4

Multiple Integrals: Introduction-Green's theorem in the plane-Some applications of Green's theorem-A necessary and sufficient condition for a two-dimensional vector field to be a gradient-Change of variables in double integral-Special cases of transformation formula.

Vol.2, Chapter-11-Sec. 11.19 to 11.22, 11.26 to 11.28.

Unit-5

Surface Integrals: Parametric representation of a surface-The fundamental vector product-The fundamental vector product as a normal to the surface-Surface integrals-Other notations for surface integrals-The theorem of Stokes-The curl and divergence of a vector field- Further properties of the curl and divergence-The divergence theorem (Gauss' theorem)

Vol.2, Chapter-12-Sec. 12.1 to 12.4, 12.7,12.9 to12.15, 12.19 and 12.21.

TEXTBOOKS:

1. Howard Anton, IRl Bivens, Stephens Davis, "Calculus" Wiley, 10th Edition, 2016 Reprint.
2. Tom M. Apostol, CalculusVolume1, John Wiley & Sons, Second edition, 2007.
3. Tom M. Apostol, Calculus Volume 2, John Wiley & Sons, Second edition, 2007.

REFERENCE BOOKS:

1. Howard Anton "Calculus" John Wiley and Sons
2. Murray R Spiegel, Theory and problems of vector analysis, Schaum's outline series, McGraw-Hill Book Compnay 1974.
3. Finney and Thomas , Calculus, Pearson, Eleventh Edition, 2008.

CO-PO Mapping:

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

22MAT204 DIFFERENTIAL EQUATIONS 3 0 2 4

Course Outcomes:

CO-1: Understand the basic concepts of differential equations and solve the various forms of differential equations.
CO-2: Understand the concepts and solve the linear homogeneous/non homogeneous differential equations with constants and variable coefficients.
CO-3: Understand the concepts and solve the nth order differential equation and simultaneous linear differential equations with constant and variable coefficients.
CO-4: Understand the concepts of partial differential equations and solve the first order PDE.
CO-5: Understand the concepts and solve the linear homogeneous/non homogeneous parital differential equations with constants coefficients.

Unit 1

Review of differential equations (order, degree, linear, nonlinear, implicit and explicit form of solution, general solutions, particular solution, singular solution). Exactness, non-exact equations reduce to exact form.

Part I: 1.1-1.9, 2.12-2.22 (5 hours)

Equations solvable for $\frac{dy}{dx}$, y, x, equations in Clairaut's form, equations reducible to Clairaut's form.

Part I: 4.1-4.11 (4 hours)

Unit 2

Linear homogeneous differential equations with constant coefficients, Euler- Cauchy equation, Linear Nonhomogeneous Differential Equations: Wronskian, linear independence, Method of undetermined coefficients. Method of variation of parameters.

Part I: 5.1-5.5, 6.1-6.3, 1.12,1.13, 5.26-5.27, 7.1-7.5 (9 hours)

Unit 3

Conversion of nth order differential equation to n first order differential equations, homogeneous linear system with constant coefficients, fundamental matrices, complex eigen values, repeated eigenvalues. simultaneous linear differential equations with constant coefficients, simultaneous linear differential equations with variable coefficients,

PART I: 8.1-8.3, 2.1- 2.7(8 hours)

Review of partial differential equations (order, degree, linear, nonlinear).

Unit 4

Formation of equations by eliminating arbitrary constants and arbitrary functions.
General, particular and complete integrals.Lagrange's linear equation, Charpit's method, Methods to solve the first order partial differential equations of the forms f(p,q) = 0, f(z,p,q) = 0, $f_1(x,p) = f_2(y,q)$ and Clairut's form z = px + qy + f(p,q) where $p = \frac{\partial z}{\partial x}$ and $q = \frac{\partial z}{\partial y}$.

Part III: 1.1 – 1.5, 2.3-2.12, 3.1-3.2, 3.7-3.8, 3.10-3.18 (13 hours)

Unit 5

Homogeneous linear partial differential equations with constant coefficient of higher order. Non-homogeneous linear partial differential equations of higher order, method of separation of variables.
Part III: 4.1-4.12 (13 hours)

TEXTBOOKS:

1. M.D. Raisinghania, Ordinary and Partial Differential Equations, S.Chand, 18th edition, 2016.

References:

1. William E. Boyce and Richard C.DiPrima, Elementary differential equations and boundary value problems, Wiley india, 9th edition, 2012.
2. Nita H, Shah, Ordinary and Partial Differential Equations : Theory and Applications, PHI learning, 2nd edition, 2015.
3. Dennis Zill, A First Course in Differential Equations, Cengage Learning, 9th edition, 2009.

CO-PO Mapping:

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

22MAT203 PROBABILITY THEORY 3 0 2 4

Course Outcomes:

CO1 Understand the basic concepts of probability and probability modeling.
CO2 Gain in-depth knowledge about statistical distributions and their properties

CO3 Apply statistical distributions to the real time examples.
CO4 To study and apply statistical methods such as correlation and regression to real time problems
CO5 To understand and apply statistical inference problems based on parametric estimation.

Unit – I

Sample Space and Events, Interpretations and Axioms of Probability, Addition rules, Conditional Probability, Multiplication and Total Probability rules, Independence, Bayes theorem.

Unit – II

Discrete Random variables, Probability Distributions and Probability mass functions, Cumulative Distribution functions, mathematical expectation, moment generating function and characteristic function, Standard distributions- discrete distributions- binomial, Poisson and geometric distributions- continuous distributions- uniform, exponential, Gamma, Normal distributions - Chebyshev's theorem.

Unit – III

Joint, marginal and conditional probability distributions for discrete and continuous cases, independence, expectation of two dimensional random variables, conditional mean and variance, transformation of one and two random variables.

Unit – IV

Simple linear Regression, Properties of least square estimators, least squares method for estimation of regression coefficients, Correlation, properties of correlation coefficient, rank correlation coefficient.

Unit – V

Point Estimation, Sampling Distributions and Central limit theorem, Methods of point estimation: Method of Moments and Method of Maximum likelihood Estimation, -Confidence Interval on the mean of a Normal Distribution with Variance known and unknown, -Confidence interval on the variance and ratio of variances. Confidence interval for Population Proportion.

TEXT BOOKS:

1. Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley and Sons Inc., 2005
2. W. Feller, "An Introduction to Probability Theory and its Applications Vol. 1 and Vol. 2", John Wiley & Sons, 1968, 1971.

REFERENCES:

1. S. Ross, "A First Course in Probability", Pearson Education, 2012.
2. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, Probability and Statistics for Engineers and Scientists, 8th Edition, Pearson Education Asia, 2007.
3. Ravichandran, J. Probability and Statistics for engineers, First Reprint Edition, Wiley India, 2012.
4. D. Stirzaker, "Elementary Probability", Cambridge University Press, Cambridge, 2003.
5. K. L. Chung, F. AitSahlia, "Elementary Probability Theory", Undergraduate Texts in Mathematics. Springer-Verlag, 2003.

CO-PO Mapping:

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

22MAT281 PYTHON PROGRAMMING LAB 1 0 2 2

Course Outcomes:

CO1: Understand the basics of functions and Booleans and modules.
CO2: Understand and apply the concepts of string formatting and dictionaries.
CO3: Understand and apply Lambda functions for various problems.
CO4: Understand the basic concepts of object oriented programming with Python.
Lessons in this course include the following topics.

1: Introduction 2: gitHub, Functions, Booleans and Modules 3: Sequences, Iteration and String Formatting 4: Dictionaries, Sets, and Files. 5: Exceptions, Testing, Comprehensions. 6: Advanced Argument Passing, Lambda -- functions as objects. 7: Object Oriented Programming. 8: More OO -- Properties, Special methods. 9: Iterators, Iterables, and Generators. 10: Decorators, Context Managers, Regular Expressions, and Wrap Up

Text Books:

1. Charles Dierbach, "Introduction to Computer Science using Python", Wiley, 2015
2. Kenneth A. Lambert, The Fundamentals of Python: First Programs, 2011, Cengage Learning,

Reference Books:

1. Wesley J. Chun, "Core Python Applications Programming", 3rd Edition , Pearson Education, 2016
2. Jeeva Jose &P.SojanLal, "Introduction to Computing and Problem Solving with PYTHON", Khanna Publishers, New Delhi, 2016
3. Downey, A. et al., "How to think like a Computer Scientist: Learning with Python", John Wiley, 2015
4. Mark Lutz, "Learning Python", 5th edition, Orelly Publication, 2013, ISBN 978-1449355739

CO-PO Mapping:

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

SEMESTER IV

22MAT211 Real Analysis – III 3 1 0 4

Course Outcomes:

CO1- Understanding the concepts of derivatives.
CO2- Understanding the functional of bounded variation and rectifiable curves.
CO3- Understanding the Riemann integration.
CO4- Understanding the Riemann Stielties integration.
CO5- Understanding and apply mean value theorems for Riemann-Stieltjes integrals.

Unit – 1: Derivatives: Definition of derivative, Derivatives and continuity, Algebra of derivatives, The chain rule, One-sided derivatives and infinite derivatives, Functions with nonzero derivative, Zero derivatives and local extrema, Rolle's theorem, The Mean-Value Theorem for derivatives, Intermediate-value theorem for derivatives. (Text Book 1: Chapter 5 – Sec: 5.1 to 5.11)

Unit – 2: Functions of Bounded Variation and Rectifiable Curves : Properties of monotonic functions, Functions of bounded variation, Total variation, Additive property of total variation, Total variation on [a, x] as a function of x, Functions of bounded variation expressed as the difference of increasing functions, Continuous functions of bounded variation. (Text Book 1: Chapter 6– Sec: 6.1 to 6.8)

Unit – 3: The Riemann Integral: Riemann Integral - Riemann Integrable Functions - The Fundamental Theorem - Approximate Integration. (Text Book 2 : Chapter 7; sec – 7.1 -7.3 & 7.5)

Unit – 4: The Riemann-Stieltjes Integral: Notation, The definition of the Riemann-Stieltjes integral, Linear properties, Integration by parts, Change of variable in a Riemann-Stieltjes integral, Reduction to a Riemann integral, Step functions as integrators, Reduction of a Riemann-Stieltjes integral to a finite sum, Euler's summation formula, Monotonically increasing integrators. Upper and lower integrals, Additive and linearity properties of upper and lower integrals, Riemann's condition, Comparison theorems, Integrators of bounded variation. (Text Book 1: Chapter 7– Sec: 7.1 to 7.15)

Unit – 5: Sufficient conditions for existence of Riemann-Stieltjes integrals, Necessary conditions for existence of Riemann-Stieltjes integrals, Mean Value Theorems for Riemann-Stieltjes integrals, the integral as a function of the interval, Second fundamental theorem of integral calculus, Change of variable in a Riemann integral, Second Mean-Value Theorem for Riemann integrals, Riemann-Stieltjes integrals depending on a parameter, Differentiation under the integral sign. (Text Book 1: Chapter 7– Sec: 7.16 to 7.24)

Text Book

1. Tom M. Apostol, "Mathematical Analysis", Narosa publishing house, New Delhi, 2nd Ed. 1989.
2. Robert G. Bartle and Donald R. Sherbert, "Introduction to Real Analysis", John Wiley and Sons, Third Edition, 2000.

Reference Books:

1. Rudin. W, "Principles of Mathematical Analysis", McGraw Hill International Editions, Third Edition, 1976.
2. 2. H.L. Royden and P.M. Fitzpatrick, "Real Analysis", Pearson Education Asia Limited, Fourth Edition, 2010.

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

22MAT212 Algebra-III (Linear Algebra) 3 0 2 4

CO-1: To understand the axioms in the definition of a vector space through examples; to understand Subspaces / Quotient Space / mappings and identify them; To familiarize the concept of basis and its relevance.
CO-2: To study linear transformation defined on a vector space and the structure on this collection. To understand the link between linear transformations and matries.
CO-3: To understand the determinant function, study its properties and its relevance in linear transformation.
CO-4: To understand the construction of matrices for a linear transformation in the triangular/Jordan form and its effect on the vectorspace.
CO-5: To understand inner products, orthonormal basis and different type of operators on inner product spaces. To familiarize bilinear forms.

Unit 1. Vector spaces, subspaces, basis and dimension, coordinates, row equivalence, computations concerning subspaces (Chapter 2. Sec.2.1-2.6)
Unit 2. Algebra of linear transformations, isomorphisms, representation of linear transformations by matrices. Linear functionals and annihilators, double dual and transpose of a linear transformation. (Chapter 3. Sec.3.1-3.7)
Unit 3. Determinant functions. Permutations and the uniqueness of determinants. Modules and Multilinear Functional. Characteristic values, Annihilating polynomials, invariant subspaces. (Sec.5.2-5.6, Sec.6.1-6.4)
Unit 4. Cyclic subspaces ad Annihilators. Cyclic decompositions and Rational form. Jordan form. Computations of invariant factors. Semi-simple operators. (Chapter 7. Sec.7.1-7.5)
Unit 5. Inner products, Inner product spaces, Linear functionals and adjoints, unitary and normal operators. Bilinear Forms and Symmetric bilinear forms. (Sec. 8.1-8.5, 10.1-10.2)
Text Book:
1. K. Hoffman and R. Kunze: Linear Algebra, 2nd Edition, Prentice Hall of India, 2005.

Reference Books:
1. Peter D. Lax, Linear algebra, Wiley student edition, 1997.
3. 2. I.N. Herstein, 'Topics in Algebra', Second Edition, John Wiley and Sons, 2000.
4. 3. S. Axler: Linear Algebra Done Right, 2nd Edition, Springer UTM, 1997.
5. 4. Howard Anton and Chris Rorres,'Elementary Linear Algebra', 9th Edition, Wiley, 2005.

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

22MAT213 NUMERICAL METHODS 3 0 0 3

Course Outcomes:

CO-1: Understand the basic concepts of root finding methods, system of equations and their solutions.
CO-2: Understand the concepts of interpolation and construction of polynomials.
CO-3: Application of numerical methods to understand the concept of Calculus (Differentiation and Integration).
CO-4: Application of numerical concepts to solve ODEs and PDEs.
CO-5: Usage of software tools to solve various problems numerically.

Unit I:

Roots of Transcendental and Polynomial Equations: Bisection method, Iteration methods based on first degree equation, Rate of convergence, system of nonlinear equations.

Solution of System of Linear Algebraic Equations: Iteration methods

Eigenvalues and Eigenvectros: Jacobi Method for symmetric matrices, Power method for arbitrary matrices.

Sections : 2.2, 2.3, 2.5, 2.7, 3.4, 3.5, 3.6

Unit II:

Interpolation and Approximation: Lagrange and Newton interpolation for unequal intervals, Finite difference operators, Interpolating polynomials using finite differences.

Sections: 4.2, 4.3, 4.4.

Unit III:

Differentiation and Integration: Numerical differentiation, Methods based on interpolation, Numerical integration, Methods based on undetermined coefficients.

Sections: 5.2, 5.6, 5.7, 5.8

Unit IV:

Solutions of Ordinary Differential Equations: Initial Value problems, single step methods, Taylor series method, Second, Third and Fourth order Runge-Kutta methods.

Sections: 6.1, 6.3, 6.4

Unit V:

Solutions of Partial Differential equations: Elliptic partial Differential equations, Parabolic partial differential equations, Hyperbolic partial differential equations.

Sections: 12.1, 12.2, 12.3

TEXTBOOKS:

1. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical methods for scientific and Engineering computation, New Age International Publishers, 2007, 5th edition.
2. **C. F. Gerald and P. O. Wheatley, *Applied Numerical Analysis*, 5th Ed., Addison-Wesley, 1994**

REFERENCE BOOKS:

1. S.D. Conte and Carl de Boor, 'Elementary Numerical Analysis; An Algorithmic Approach'. International series in Pune and Applied Mathematics, McGraw Hill Book Co., 1980.

2. Philips, G. M.,Taylor, P. J. ; Theory and Applications of Numerical Analysis (2nd Ed.), Academic Press, 1996.
3. Gourdin, A. and M Boumhrat; Applied Numerical Methods. Prentice Hall India, New Delhi, (2000).
4.R.L. Burden, J. D. Faires, Numerical Analysis, Richard Stratton, 2011, 9th edition.

CO-PO Mapping:

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

22MAT214 Statistical Inference Theory 3 0 2 4

Course Outcomes:

CO1 To understand the concept and types of hypothesis testing and its applications
CO2 To apply normal and t-distribution based tests for two-mean problems

CO3 To understand the concept of ANOVA and DoE and their applications
CO4 To understand the concept of Latin Square and Factorial designs and applications
CO5. To study types of control charts, their constructions and applications

Unit – I

Hypothesis Testing, Tests on a Population Proportion- Tests on the Mean of a Normal Distribution with Variance known and unknown, Tests on the variance –Test for Goodness of fit, Contingency table tests -Nonparametric tests mean and median.

Sections: 9.1-9.9

Unit – II

Inference on the Difference in Means of Two Normal Distributions, Variance Known and Unknown , A nonparametric tests for difference in Two means, Paired t test, Inference on the variances of the Two Normal Distributions, Inference on Two Population Proportions.

Sections: 10.1-10.6

Unit – III

Introduction design of experiment of single factor , Completely Randomized Single Factor Experiment, computation of sum of squares, Random effect models, Randomized complete block design, computation of sum of squares – estimation of variance components.

Sections: 13.1-13.4

Unit – IV

Introduction to design of experiment with several factors – Latin Square Design – statistical model for LSD, computation of sum of squares – two factor factorial experiment – main and interaction effects, data and statistical model- computation of sum of squares – estimation of variance components.

Sections : 14.1-14.5

Unit –V

Quality improvement and statistics, Introduction to control limits - control charts for variables – X-bar chart, R-chart, S chart for individual observations- attribute control charts – Control charts for Proportions and for defects per unit.

Sections : 15.1-15.6

TEXT BOOK

1. Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley and Sons Inc., 2005.
2. I. Miller, M. Miller, "John E. Freund's Mathematical Statistics with Applications", Pearson, 2013.

REFERENCES:

1. Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying Ye, Probability and Statistics for Engineers and Scientists, 8th Edition, Pearson Education Asia, 2007.
2. Ravichandran, J. Probability and Statistics for engineers, First Reprint Edition, Wiley India, 2012.
3. H. J. Larson, "Introduction to Probability Theory and Statistical Inference", John Wiley & Sons, 1982.
4. George Casella and Roger L Berger: Statistical Inference, Thomsan Learning, 2002.

CO-PO Mapping:

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

22MAT215 Combinatorics 2 1 0 3

Course Outcomes:

CO-1: Understand the basic permutations and combinations.
CO-2: Understand and apply the binomial and multinomial theorems to the counting problems.
CO-3: Understand and apply the concepts of principle of inclusion and exclusions.
CO-4: Understand the concepts of partitioning the numbers.
CO-5: Understand and apply the concepts of Polya's Enumeration Formula for enumeration problems.

Unit I: Permutation and Combinations: Basic counting techniques, permutations and combinations of multisets. Pigeonhole principle. (Sec. 2.1-2.5 and 3.1-3.2)
Unit II: Generating Permuations and combinations. Genering r-subsets. Binomial coefficients: Pascal's Triangle. Binomial and multinomial theorem. (Sec. 4.1-4.4 and 5.1-5.4)
Unit III: Inclusion and Exclusion principle. Combinations with repetition, derangments, Forbidden positions and Mobius inversion. (Sec. 6.1-6.7.

Unit IV: Counting sequences: Catalan numbers, stirling numbers. Partition numbers. Lattice paths and Schroder numbers. (Sec. 8.1-8.6)

Unit V: Polya Counting: Symmetry groups, Burnside theorem, Polya's counting formula. (Sec.14.1-14.4).

Text Book:
1. Richard A Brnaldi, Introductory Combinatorics, Pearson Education, Inc. 5th edition, Pearson Education Asia Ltd, 2009.
References:
1. Miklos Bona, Introduction to Enumerative Combinatorics, Mc Graw Hill (2007).
1. Richard P. Stanley, *Enumerative combinatorics*, Volume 1, Cambridge University Press, 2000.
2. Richard P. Stanley, *Enumerative combinatorics*, Volume 2, Cambridge University Press, 2001.

CO-PO Mapping:

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

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

22MAT282 Numerical Methods Lab (MATLAB) 0 0 2 1

Unit-I :

Preliminaries of MATLAB

Matrices, operations, and basic MATLAB functions; M-files, logical-relational operators and IF statements; Functions in MATLAB; FOR and WHILE loops in MATLAB; Graphics in MATLAB; Efficiency of algorithms in MATLAB; Useful functions and commands in MATLAB.

Unit-II

Linear Algebra

Roots of the function: Bisection method, fixed point iteration method, secant method, Regula-falsi method, Newton-Raphson method;

Interpolation: Lagrange's method, divided difference, finite difference;

System of equations: Gauss elimination, Gauss Jordan elimination, Gauss Jacobi method, Gauss Seidel method, Newton's method for nonlinear systems of equations;

Least squares and eigenvalue problems.

Unit-III

Ordinary Differential Equations

Euler's method, Modified Euler's method, Runge-Kutta fourth order method, system of ordinary differential equations.

Partial Differential Equations

Classification of Partial differential Equations, Elliptic, Parabolic, Hyperbolic PDEs.

TEXT / REFERENCE BOOKS:

1. Rudra Pratap, Getting started with MATLAB 7: A Quick introduction for Scientists and Engineers, Oxford University Press, 2005.
2. Stephen J Chapman, MATLAB Programming for Engineers, Thomson Learning, 4rd Edition, 2007.
3. Sukanta Nayak and Snehashish Chakraverty, Interval Finite Element Method with MATLAB, Academic Press, 1st edition, 2018.

CO-PO Mapping:

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

SEMESTER V

22MAT302 Algebra – IV (Field Theory) 3 1 0 4

CO-1: To understand the field extensions and in particular finite extensions and construction of such extensions using irreducible polynomials
CO-2: To Familiarize the concept of algebraic extensions and their properties/applications.
CO-3: To understand the application of the concept of Field extensions in geometry.
CO-4: To familiarise the concept of splitting fields and construction of such fields
CO-5: To understand the connection between multiple roots and derivatives of polynomilas in finite and zero characteristics

Unit 1. Basic Theory of Field Extensions (Sec. 13.1)
Unit 2. Algebraic Extensions (Sec. 13.2)
Unit 3. Classical Straightedge and compass constructions (Sec. 13.3)
Unit 4. Splitting Fields and Algebraic Closures (Sec. 13.4)
Unit 5. Separable and inseparable Extensions (Sec. 13.5)

Text Books:

1. D. S. Dummit and R. M. Foote, Abstract Algebra, 2nd Ed., John Wiley, 2002.

References:

2. I. N. Herstein, 'Topics in Algebra', Second Edition, John Wiley and Sons, 2000.
1. M. Artin, Algebra, Prentice Hall of India, 1994.
2. R. Lidl and H. Niederreiter, Introduction to Finite Fields and Their Applications, Cambridge University Press, 1986.

CO-PO Mapping:

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

22MAT301 Operations Research 3 0 2 4

Course Outcomes:

CO1 Understand the basic concepts of linear programming and simplex method for solving linear programming problem.
CO2: Understand the primal and dual problems and dual simplex method.
CO3 Understand the mathematical formulation of transportation and assignment problems and solution methods.
CO4 Understand the network representation of project works and computation of PERT and CPM. CO5: Understand the basic concepts of sequencing problem, integer programing algorithms and solution methods.

Unit – I :

Introduction to Operations Research, Models in Operations Research - Introduction to Linear Programming Problems, Formulation of Linear Programming Problems -Graphical solution to Linear Programming Problems - Simplex method. (Sections from Book 1: 1.1, 2.1, 2.2, 3.1, 3.2, 3.3)

Unit- II

Penalty method, two phase method- special cases in Simplex method - Duality in Linear Programming Problem - Primal-Dual relationships, Dual simplex method.

(Sections from Book 1: 3.4, 3.5, 4.1, 4.2, 4.4.1)

Unit – III

Introduction to Transportation problem- Mathematical formulation of transportation problem, Initial basic feasible solution (IBFS), MODI method for Optimal solution – unbalanced transportation problems, degeneracy in transportation problem - Introduction to assignment problem, Mathematical formulation of assignment problem, comparison between assignment problem and transportation problem, Optimal solution based on Hungarian method.

(Sections from Book 1: 5.1, 5.3, 5.4)

Unit – IV

Network Representation, Critical Path (CPM) computations, Construction of the Time Schedule, Linear programming formulation of CPM - PERT calculations.

(Sections from Book1: 6.5)

Unit – V

Problem of sequencing, n jobs through 2 machines - two jobs through m machines - n jobs through m machines

(Sections from Book 2: 12.1 to 12.6)

Integer Programming Algorithms: Branch and Bound Algorithms and Cutting Plane Algorithm.

(Sections from Book 1: 9.2)

Text Books:

1. Hamdy A. Taha, "Operations Research - An Introduction", Eighth Edition, Prentice Hall India, 2007.
2. KantiSwarup, P.K. Gupta and Man Mohan, "Operations Research", Ninth Edition,Sultan Chand and Sons, 2001.

References:

1. Ravindran, Phillips, Solberg, Operations Research: Principles and Practice, 2nd edition, Wiley, 2007.
2. J K Sharma, Operations Research, 4th edition, Macmillan, 2009

CO-PO Mapping:

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

Course Outcomes:

CO-1: Understand the basic concepts of graphs.
CO-2: Understand the concepts of Trees and algorithms on trees.
CO-3: Understand the concepts of Euler and Hamiltonian graphs.
CO-4: Understand the basic concepts of liner codes and error correcting codes.
CO-5: Understand and apply the concepts of dual codes, hamming codes and perfect codes to some problems.

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

Text Book-1 (Sec. 1.1-1.9)

Unit II: Trees: Trees, cut-edges and cut-vertices, Cayley's formula. Spanning trees, minimum spanning trees, Connectivity: Graph connectivity, k-connected graphs and blocks.

Text Book-1 (Sec.2.1-2.5 and 3.1-3.2)

Unit III: Euler and Hamiltonian graphs: Euler tour, Hamiltonian graph, necessary and sufficient conditions for Hamiltonian graph. Chinese postman problem and travelling salesman problem.

Text Book-1 (Sec. 4.1-4.4)

Unit IV Introduction to linear codes and error correcting codes. Encoding and decoding of a linear code.

Text Book-2

Unit V Dual codes. Hamming codes and perfect codes. Cyclic codes. Codes with Latin Squares, Introduction to BCH codes.

Text Book-2

TEXTBOOKS:

1. J. A. Bondy and U. S. R. Murty, Graph Theory and Applications, Springer, 2008.
2. *Raymond Hill, A first course in Coding Theory, Clarandon Press, Oxford (1986).*

REFERENCES BOOKS

1. *D. B. West, Introduction to Graph Theory, P.H.I. 2010.*
2. *Bollobás, B.* Modern Graph Theory (Graduate Texts in Mathematics). *New York, NY: Springer-Verlag, 1998.*
3. *J.H. Van Lint, Introduction to Coding Theory, Springer (1998).*
4. *W. Cary Huffman and Versa Pless, Fundamentals of Error Correcting Codes, Cambridge University Press (2003).*

CO-PO Mapping:

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

22MAT304 COMPLEX ANALYSIS 3 1 0 4

Course Outcomes:

CO1: Understand the concepts of the complex numbers analyticity, series expansions and some elementary complex functions
CO2:Understand about complex integrations
CO3:Understand about the singularities and Residues
CO4:Understand the evaluation of different type integrals
CO5:Understand the concept of complex mappings and Linear transformations some basic mappings.

Unit 1

Review: Algebra of complex numbers, operations of absolute value and conjugate, standard inequalities for absolute value (Chapter 1)

Limits, Continuity, derivatives and analytic functions, Cauchy-Riemann equations, , Harmonic functions and harmonic conjugates, Power series, Exponential and Logarithmic functions(Chapter 2 and Sec.: 29 and 30).

Unit 2

Contour Integrals -Anti derivatives-Cauchy-Goursat theorem-Simply Connected Domains-Multiply Connected Domains, Cauchy's theorem for rectangle – Cauchy's theorem in a disk, An Extension of the Cauchy Integral Formula. (Chapter 4, Sec: 39-51, 53, 54).

Unit 3

Taylors series, Laurent series; Isolated singularities: removable singularities, poles and essential singularities; Cauchy's residue theorem, Residues at Infinity, evaluation of definite integrals using Cauchy's residue theorem. (Chapter 5, Sec: 57, 58, 60,61, Chapter 6, Sect:68-73).

Unit 4

Evaluation of Improper Integrals -Improper Integrals from Fourier Analysis - Jordan's Lemma - Indented Paths - Definite Integrals Involving Sines and Cosines - Argument Principle. Rouche's theorem.(Chapter 7, Sec: 78, 80-82, 85-87).

Unit 5

Linear Transformations-The Transformation w = 1/z - Mappings by 1/z -Linear Fractional Transformations. (Chapter 8, Sec: 90-94).

TEXT BOOK

James ward Brown, Ruel V. Churchill, Complex Variables and Applications, Eighth Edition, McGrawHill.

REFERENCES

1. S. Ponnusamy, Foundations of Complex Analysis, 2nd Edition, Narosa Publishing House, 2005.
2. Conway, John B., Functions of One Complex Variable, II, Graduate Texts in Mathematics, 159, Springer-Verlag, New York, 1995.
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	2	2	2	3	3	-	-	-	-	-	1	2
CO2	3	3	2	3	3	-	-	-	-	-	1	2
CO3	2	2	3	3	3	-	-	-	-	-	1	2
CO4	3	3	3	3	3	-	-	-	-	-	1	2
CO5	3	3	3	3	3	-	-	-	-	-	1	2

22MAT305 Number Theory 3 1 0 4

Course Outcomes:

CO1: Understand integers with divisibility properties and realize the group structure in integers using modular operaions.
CO2: Apply division algorithm and factorization techniques in Cryptography.
CO3: Study arithmetic functions and its applications in Number Theory
CO4: Understand quadratic residue, primitive roots and solve Diophantine equations. CO5: Apply these number theory techniques to simple information security problems.

Unit 1

Divisibility: Definition, properties, division algorithm, greatest integer function (Sec 1.1)

Primes: Definition, Euclid's Theorem, Prime Number Theorem (statement only), Goldbach and Twin Primes conjectures, Fermat primes, Mersenne primes. The greatest common divisor: Definition, properties, Euclid's algorithm, linear combinations and the GCD - The least common multiple: Definition and properties. The Fundamental Theorem of Arithmetic: Euclid's Lemma, canonical prime factorization, divisibility, gcd, and lcm in terms of prime factorizations. Primes in arithmetic progressions: Dirichlet's Theorem on primes in arithmetic progressions (statement only) (Sec 1.2 to 1.5)

Unit 2

Congruences

Definitions and basic properties, residue classes, complete residue systems, reduced residue systems - Linear congruences in one variable, Euclid's algorithm - Simultaneous linear

congruences, Chinese Remainder Theorem - Wilson's Theorem - Fermat's Theorem, pseudoprimes and Carmichael numbers - Euler's Theorem (Sec 2.1 to 2.6).

Unit 3

Arithmetic functions

Arithmetic function, multiplicative functions: definitions and basic examples - The Moebius function, Moebius inversion formula - The Euler phi function, Carmichael conjecture - The number-of-divisors and sum-of-divisors functions - Perfect numbers, characterization of even perfect numbers (Sec 3.1 to 3.6).

Unit 4

Quadratic residues

Quadratic residues and nonresidues - The Legendre symbol: Definition and basic properties, Euler's Criterion, Gauss' Lemma - The law of quadratic reciprocity (Sec 4.1 to 4.3).

Unit 5

Primitive roots:

The order of an integer - Primitive roots: Definition and properties - The Primitive Root Theorem: Characterization of integers for which a primitive root exists (Sec 5.1 to 5.3).

Diophantine Equations

Linear Diophantine Equations - Pythagorean triples – Representation of an integer as a Sum of squares (Sec 6.1, 6.3, 6.5).

TEXTBOOK:

James Strayer, 'Elementary Number Theory', Waveland Press, 1994/2002, ISBN 1-57766-224-5

REFERENCE BOOKS:

1. Tom M. Apostol,' Introduction to Analytic Number Theory', Springer, Under Graduate Studies in Mathematics, 1976.
2. Kenneth Rosen, Elementary Number Theory and its Applications, 5th Edition, McGraw Hill.
3. I. Niven, H. Zuckerman, H. Montgomery, An Introduction to the Theory of Numbers, 5th Edition, Wiley.
4. Burton, David M. *Elementary Number Theory*. Allyn and Bacon, 1976.

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

SEMESTER VI

22MAT311 **Optimization Theory** **3-0-2-4**

Course Outcomes:

CO1. Understand different types of Optimization Techniques in engineering problems. Learn Optimization methods such as Bracketing methods, Region elimination methods,Point estimation methods.
CO2. Learn gradient based Optimizations Techniques in single variables as well as multi-variables (non-linear).
CO3. Understand the Optimality criteria for functions in several variables and learn to apply OT methods like Unidirectional search and Direct search methods.
CO4. Learn constrained optimization techniques. Learn to verify Kuhn-Tucker conditions and Lagrangian Method.

Unit-I

Introduction, Conditions for local minimization. One dimensional Search methods: Golden search method, Fibonacci method, Newton's Method, Secant Method, Remarks on Line Search Sections 7.1 -7.5

Unit II

Gradient-based methods- introduction, the method of steepest descent, analysis of Gradient Methods, Convergence, Convergence Rate. Analysis of Newton's Method, Levenberg-Marquardt Modification, Newton's Method for Nonlinear Least-Squares.

Sections 8.1 - 8.3 and 9.1 – 9.4

Unit-III

Conjugate direction method, Introduction The Conjugate Direction Algorithm, The Conjugate Gradient Algorithm for Non-Quadratic Quasi Newton method – Approximating the inverse Hessian.

Sections 10.1 - 10.4 and 11.1, 11.2

Unit IV

Nonlinear Equality Constrained Optimization- Introduction, Problems with equality constraints Problem Formulation, Tangent and Normal Spaces, Lagrange Condition, Second-Order Conditions, Minimizing Quadratics Subject to Linear Constraints

Sections 19.1 -19.6

Unit V

Nonlinear Inequality Constrained Optimization -Introduction - Problems with inequality constraints: Kuhn-Tucker conditions, introduction to projections, Projected Gradient methods, Penalty methods.

Sections 20.1, 20.2, 22.1 – 22.4

Text Book

1. Edwin K.P. Chong, Stanislaw H. Zak, "An introduction to Optimization", 2nd edition, Wiley, 2013.

Reference Books

1. Mokhtar S. Bazarra, Hamit D sherali, C.M. Shetty, "Nonlinear programming Theory and applications", 2nd edition, Wiley , 2004.
2. Mohan C. Joshi and Kannan M. Moudgalya, Optimization: Theory and Practice, Narosa Publishing House, New Delhi, 2004 (Reference)
3. Kalyanmoy Deb, "Optimization for Engineering Design Algorithms and Examples", Prentice Hall of India, New Delhi, 2004.
4. S.S. Rao, "Optimization Theory and Applications", Second Edition, New Age International (P) Limited Publishers, 1995.

CO-PO Mapping:

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

22MAT313 Basic Topology 3 1 0 4

Course Outcomes:

CO-1: To understand the basic definitions of infinite sets, countable set, uncountable sets and axiom of choice through examples.
CO-2: To understand the definitions of order and subspace topology.
CO-3:.To understand the closed sets and limit points, continuous functions and the product topology.
CO-4: To study the basic properties of compact metric spaces. To understand the concepts of compact metric space and separable metric space through examples
CO-5: Understand and apply the concepts of completeness and compactness to prove the existence and uniqueness of solutions to certain ordinary differential equations.

Preview: Functions, Cartesian Products, Finite sets, Countable and Uncountable Sets, Infinite Sets (Text Book : Sec 1 – 7)

Unit – 1: The Axiom of Choice, Well-ordered Sets, The Maximum Principle, Topological Spaces, Basis for a Topology. (Text Book : 9 – 13)

Unit – 2: The Order Topology, The Product Topology on $X \times Y$, The Subspace Topology. (Text Book : 14 – 16)

Unit – 3:, Closed Sets and Limit Points, Continuous Functions, The Product Topology. (Text Book : 17 – 19)

Unit – 4: Connected Spaces, Connected Subspaces of the Real Line, Components and Local Connectedness. (Text Book : 23 - 25)

Unit – 5: Compact Spaces, Compact Subspaces of the Real Line, Limit point compactness, Local Compactness. (Text Book : 26 - 29)

Text Book

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

Reference Books:

1. G.F.Simmons, "Introdution to Topology and Modern Analysis" McGraw Hill Education-2004.
2. S. Kumaresan, "Topology of Metric Spaces"; Narosa Publishing House, New Delhi, 2011 Second Reprint.
3. J. Dugundji, " Topology" Allyn and Bacon, Boston-1966.

CO-PO Mapping:

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

22MAT312 **Stochastic Processes** **2 1 0 3**

Course Outcomes:

CO1 Understand the concepts of stochastic process, markov chains and classifical of states and chains.
CO2. Understand the markov process with discrete state space as poisson process and its properties with related theorems.
CO3. Understand the markov process with continuous state space as wiener process and its properties.

CO4. Understand the renewal process and related theorems.
CO5. Understand the concepts of branching process and Bellman-Harris process.

Unit – I Introduction to Probability and Stochastic Processes:

Definition of Stochastic Processes, specification of Stochastic processes, Stationary processes– Markov Chains: definition and examples, higher transition probabilities, Generalization of Independent Bernoulli trails, classification of states and chains.
(Sections: 2.1, 2.2, 2.3, 3.1, 3.2, 3.3, 3.4)

Unit – II Markov Processes with Discrete State Space:

Poisson process, Poisson process related distributions, properties of Poisson process, Generalizations of Poisson Processes, Birth and death processes, continuous time Markov Chains.
(Sections: 4.1, 4.2, 4.3, 4.4, 4.5)

Unit – III Markov processes with continuous state space:

Brownian motion – Wiener Process - Differential equations for a Wiener process – Kolmogorov equations – first passage time distribution for Wiener process – Ornstein-Uhlenbech process.
(Sections: 5.1 to 5.6)

Unit – IV Renewal processes and theory:

Renewal process – Renewal processes in continuous time – Renewal equation – stopping time – Wald's equation – Renewal theorems.
(Sections: 6.1 to 6.5)

Unit – V Branching Processes:

Introduction, properties of generating functions of Branching process, Distribution of the total number of progeny, Continuous-Time Markov Branching Process, Age dependent branching process: Bellman-Harris process.
(Sections: 9.1, 9.2, 9.4, 9.7, 9.8)

Text Book:

1. J. Medhi, "Stochastic Processes", 2nd Edition, New Age International Private limited, 2006.

Book for Reference:

1. P. G. Hoel, S. C. Port and C. J. Stone: Introduction to Stochastic Processes, Houghton Mifflin, 1972.
2. Sheldon M. Ross, "Stochastic Processes", 2ndEdition, Wiley, 1995.
3. J. Ravichandran, "Probability and Random Processes for Engineers", 1st Edition, IK International, 2015.

CO-PO Mapping:

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

22MAT315 **Calculus of Variations** **3 1 0 4**

Course Outcomes:

CO1: To understand variational problems and the necessary condition for extremal namely Euler equation. To apply these conditions in evaluations of extremal of functionals for several variables.
CO2: To apply the variational problems in solving physical problems which involves the Principle of Least Action, Conservation Laws, The Hamilton-Jacobi Equation.
CO3: To understand the concept of weak and strong extremum. To apply in the Field of a Functional, Hilbert's Invariant Integral, The Weierstrass E-Function.
CO4: To apply these techniques in solving differential equations by the Ritz Method and the Method of Finite Differences. To solve the Sturm-Liouville Problem using variational method.
CO5: To understand the idea of solving various integral equations and to apply these tools to solve Fredholm and Volterra Integro - Differential equation by the methods of the Green's function. Decomposition, direct computation, Successive approximation, series solution, successive approximation.

Calculus of Variations.

Unit 1: Elements of the theory: Functionals. Some Simple Variational Problems, Function Spaces, The Variation of a Functional- A Necessary Condition for an Extremum, The Simplest Variational Problem. Euler's Equation, The Case of Several Variables, A Simple Variable End Point Problem, The Variational Derivative, Invariance of Euler's Equation.

Further generalizations: The Fixed End Point Problem for n Unknown Functions, Variational Problems in Parametric Form, Functionals Depending on Higher-Order Derivatives, Variational Problems with Subsidiary Conditions.

The general variation of a functional Derivation of the Basic Formula, End Points Lying on Two Given Curves or Surfaces, Broken Extremals, The Weierstrass-Erdmann Conditions.

Unit 2: The canonical form of the euler equations and related topics: The Canonical Form of the Euler Equations, First Integrals of the Euler Equations, The Legendre Transformation, Canonical Transformations, Noether's Theorem, The Principle of Least Action, Conservation Laws, The Hamilton-Jacobi Equation. Jacobi's Theorem.

Unit 3: The second variation. Sufficient conditions for a weak extremum: Quadratic Functionals. The Second Variation of a Functional, The Formula for the Second Variation. Legendre's Condition, Analysis of the Quadratic Functionals $\int_a^b (Ph'^2 + Qh^2)\, dx$, Jacobi's Necessary Condition. More on Conjugate Points, Sufficient Conditions for a Weak Extremum, Generalization to n unknown functions, Connection Between Jacobi's Condition and the Theory of Quadratic Forms. Sufficient conditions for a strong extremum: Consistent Boundary Conditions. General Definition of a Field, The Field of a Functional, Hilbert's Invariant Integral, The Weierstrass E-Function. Sufficient Conditions for a Strong Extremum.

Unit 4: Direct methods in the calculus of variations: Minimizing Sequences, The Ritz Method and the Method of Finite Differences. The Sturm-Liouville Problem.

Integral Equations

Unit 5: Introduction and basic examples, Classification, Conversion of Volterra Equation to ODE, Conversion of IVP and BVP to Integral Equation, The Green's function. Decomposition, direct computation, Successive approximation, Successive substitution methods for Fredholm Integral Equations, series solution, successive approximation, successive substitution method for Volterra Integral Equations, Volterra Integral Equation of first kind, Integral Equations with separable Kernel, Fredholm's first, second and third theorem, Integral Equations with symmetric kernel, Eigen function expansion, Hilbert-Schmidt theorem, Fredholm and Volterra Integro - Differential equation, Singular and nonlinear Integral Equation.

TEXTBOOKS

1. I.M.Gelfand and S. V. Francis. Calculus of Variation, Prentice Hall, 1991. ***(All the chapters except chapter 7 are included)***

2. F. G. Tricomi, Integral equations, Dover, 1985.

REFERENCES

1. *A. S. Gupta, Calculus of Variations with Applications, PHI 2006.*
2. *Weinstock, Robert, Calculus of Variations with Applications to Physics and Engineering, Dover, 1974.*
3. *Cordumeanu, C., Integral Equations and Applications, Cambridge University Press, 1991*

CO-PO Mapping:

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

22MAT314 Formal Languages and Automata Theory 3 0 2 4

Course Outcomes:

CO-1: Understand the basic concepts of languages and finite state machine.
CO-2: Understand the concepts of regular language and regular expressions.
CO-3: Familiarse the concepts of various types of grammars.
CO-4: Understand the concepts of context free grammar and language. CO-5 Understand the concepts of Regular languages and Turing machine.

Unit 1

Fundamentals: Strings, Alphabet, Language, Operations, Finite state machine, definitions, finite automaton model, acceptance of strings, and languages, deterministic finite automaton and non deterministic finite automaton, transition diagrams and Language recognizers.
Finite Automata: NFA with Î transitions - Significance, acceptance of languages.
Conversions and Equivalence: Equivalence between NFA with and without Î transitions, NFA to DFA conversion, minimisation of FSM, equivalence between two FSM's, Finite Automata with output - Moore and Melay machines.

Unit 2

Regular Languages: Regular sets, regular expressions, identity rules, Constructing finite Automata for a given regular expressions, Conversion of Finite Automata to Regular expressions. Pumping lemma of regular sets, closure properties of regular sets (proofs not required).

Unit 3

Grammar Formalism: Regular grammars - right linear and left linear grammars, equivalence between regular linear grammar and FA, inter conversion, Context free grammar, derivation trees, sentential forms. Right most and leftmost derivation of strings.

Unit 4

Context Free Grammars: Ambiguity in context free grammars. Minimisation of Context Free Grammars. Chomsky normal form, Greiback normal form, Pumping Lemma for Context Free Languages. Enumeration of properties of CFL (proofs omitted).

Push Down Automata: Push down automata, definition, model, acceptance of CFL, Acceptance by final state and acceptance by empty state and its equivalence. Equivalence of CFL and PDA, interconversion. (Proofs not required). Introduction to DCFL and DPDA.

Unit 5

Turing Machine: Turing Machine, definition, model, design of TM, Computable functions, recursively enumerable languages. Church's hypothesis, counter machine, types of Turing machines (proofs not required).

TEXTBOOKS

1. Hopcroft, Motwani and Ullman, Introduction to Automata Theory Languages andComputation. Third Edition, 2007, Pearson Education, Addison-Wesley.
2. Peter Linz - An Introduction to Formal Languages and Automata, Fifth Edition Jones & Bartlett.

REFERENCES

1. Daniel I.A. Cohen, Introduction to Computer Theory, John Wiley.
2. John C Martin, Introduction to languages and the Theory of Computation, TMH.

3. Lewis H.P. & Papadimition Elements of Theory of Computation C.H. Pearson /PHI.
4 Mishra and Chandrashekaran, Theory of Computer Science – Automata Languages and Computation 2nd Edition, PHI.

CO-PO Mapping:

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

22MAT399 Project (for Exit Option Students) 6 credits

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

CO-PO Mapping:

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

SEMESTER VII/ SEMESTER I (M.Sc Students)

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

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 2 4

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 VIII

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, 2nd Edition, 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)

Text Book

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

Reference Books:

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, 2nd 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 - Completeness of $L^p(\mu)$.

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 IX

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 X

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 mulTipliers 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, 6th Ed., 2005.*
2. *Riley, Hobson and Bence, Mathematical Methods for Physics and Engineering, Cup, 3rd 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	