Department of Applied Mathematics
Delhi Technological University,
(Formerly Delhi College of Engg.)
Bawana Road, Delhi – 42.

Scheme for Integrated B.Sc. & M.Sc. Mathematics

I YEAR: First Semester

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weights (%)				
S.No	**Subject Code**	**Course Title**	**SubjectArea**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	IMSMA 101	Calculus-I	DCC	**4**	3	1	0	3	0	25	-	25	50	-
2	IMSMA 103	Analytical Geometry	DCC	**4**	3	1	0	3	0	25	-	25	50	-
3	IMSMA 105	Abstract Algebra-1	DCC	**4**	3	1	0	3	0	25	-	25	50	-
4	IMSxx xxx	GEC-1	GEC	**4**	3	1	0	3	0	25	-	25	50	-
5	IAEC 1xx	AEC-1	AEC	**2**	x	x	x	x	x	x	x	x	x	x
6	ISEC 1xx	SEC-1	SEC	**2**	0	0	4	0	2	0	50	0	0	50
7	IVAC 1xx	VAC-1	VAC	**2**	x	x	x	x	x	x	x	x	x	x
Total				**22**										

I YEAR: Second Semester

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weights (%)				
S.No	**Subject Code**	**Course Title**	**SubjectArea**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	IMSMA 102	Calculus-II	DCC	**4**	3	1	0	3	0	25	-	25	50	-
2	IMSMA 104	Real Analysis-I	DCC	**4**	3	1	0	3	0	25	-	25	50	-
3	IMSMA 106	Ordinary Differential Equations	DCC	**4**	3	1	0	3	0	25	-	25	50	-
4	IMSxx xxx	GEC-2	GEC	**4**	3	1	0	3	0	25	-	25	50	-
5	IAEC 1xx	AEC-2	AEC	**2**	x	x	x	x	x	x	x	x	x	x
6	ISEC 1xx	SEC-2	SEC	**2**	0	0	4	0	2	0	50	0	0	50
7	IVAC 1xx	VAC-2	VAC	**2**	x	x	x	x	x	x	x	x	x	x
Total				**22**										

II YEAR: Third Semester

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weights (%)				
S. No	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	IMSMA 201	Linear Algebra	DCC	**4**	3	1	0	3	0	25	-	25	50	-
2	IMSMA 203	Probability and Statistics	DCC	**4**	3	1	0	3	0	25	-	25	50	-
3	IMSMA 205	Real Analysis-II	DCC	**4**	3	1	0	3	0	25	-	25	50	-
4	IMSxx xxx	GEC-3	GEC	**2**	2	0	0	2	0	25	-	25	50	-
5	IMSMA 207/ IMSMA 2xx	Mathematical Transforms / DEC-1	GEC4 / DEC	**4**	3/3	0/1	2/0	3/3	2/0	15/25	25/0	20/25	40/50	0
6	IAEC 2xx	AEC-3	AEC	**2**	x	x	x	x	x	x	x	x	x	x
7	ISEC 2xx	SEC-3	SEC	**2**	0	0	4	0	2	0	50	0	0	50
Total				**22**										

II YEAR: Fourth Semester

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weights (%)				
S. No	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	IMSMA 202	Numerical Analysis	DCC	**4**	3	0	2	3	0	15	25	20	40	-
2	IMSMA 204	Abstract Algebra-II	DCC	**4**	3	1	0	3	0	25	-	25	50	-
3	IMSMA 206	Sampling Distribution and Hypothesis Testing	DCC	**4**	3	0	2	3	0	15	25	20	40	
4	IMSMA 208 / IMSMA 2xx	Linear Programming Problem / DEC-2	GEC-5/ DEC	**4**	3/3	0/1	2/0	3/3	2/0	15/25	25/0	20/25	40/50	0
5	IAEC 2xx	AEC-4	AEC	**2**	x	x	x	x	x	x	x	x	x	x
6	ISEC 2xx	SEC-4	SEC	**2**	0	0	4	0	2	0	50	0	0	50
7	IVAC 2xx	VAC-3	VAC	**2**	x	x	x	x	x	x	x	x	x	x
Total				**22**										

III YEAR: Fifth Semester

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weights (%)				
S. No	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	IMSMA 301	Metric Spaces	DCC	**4**	3	1	0	3	0	25	-	25	50	-
2	IMSMA 303	Stochastic Processes	DCC	**4**	3	1	0	3	0	25	-	25	50	-
3	IMSMA 305	Partial Differential Equations	DCC	**4**	3	1	0	3	0	25	-	25	50	-
4	IMSMA 307/ IMSMA 3xx	Linear Regression Analysis / DEC-3	GEC-6 / DEC	**4**	3/3	0/1	2/0	3/3	2/0	15/25	25/0	20/25	40/50	0
5	IMSMA 309/ IMSMA 3xx	Programming with Python / DEC-4	GEC7 / DEC	**4**	3/3	0/1	2/0	3/3	2/0	15/25	25/0	20/25	40/50	0
6		Summer Internship	IAPC1	**2**	x	x	x	x	x	x	x	x	x	x
Total				**22**										

III YEAR: Sixth Semester

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weights (%)				
S. No	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	IMSMA 302	Topology	DCC	**4**	3	1	0	3	0	25	-	25	50	-
2	IMSMA 304	Complex Analysis	DCC	**4**	3	1	0	3	0	25	-	25	50	-
3	IMSMA 306/ IMSMA xxx	Econometrics/ DEC-5	GEC-8 / DEC	**4**	3/3	0/1	2/0	3/3	2/0	15/25	25/0	20/25	40/50	0
4	IMSMA 308/ IMSMA 3xx	Operation Research / DEC-6	GEC-9 / DEC	**4**	3/3	0/1	2/0	3/3	2/0	15/25	25/0	20/25	40/50	0
5	IMSMA 310/ IMSMA 3xx	Data Structure / DEC-7	GEC-10 / DEC	**2**	2/0	0/0	0/4	2/0	0/2	25/0	0/50	25/0	50/0	0/50
6	ISEC 3xx	SEC-5	SEC	**2**	2/0	0/0	0/4	2/0	0/2	25/0	0/50	25/0	50/0	0/50
Total				**20**										

IV YEAR: Seventh Semester

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weights (%)				
S. No	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	IMSMA 401	Functional Analysis	DCC	**4**	3	1	0	3	0	25	-	25	50	-
2	IMSMA 403	Mathematical Methods	DCC	**4**	3	1	0	3	0	25	-	25	50	-
3	IMSMA 405	Advanced Ordinary Differential Equations	DCC	**4**	3	1	0	3	0	25	-	25	50	-
4	IMSMA 407/ IMSMA 4xx	Machine Learning-I / DEC-8	GEC-11 / DEC	**2**	2/0	0/0	0/4	2/0	0/2	25/0	0/50	25/0	50/0	0/50
5		Project-1	IAPC2	**6**	x	x	x	x	x	x	x	x	x	x
Total				**20**										

IV YEAR: Eight Semester

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weights (%)				
S. No	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	IMSMA 402	Graph Theory	DCC	**4**	3	1	0	3	0	25	-	25	50	-
2	IMSMA 404	Mathematical Modelling and Simulation	DCC	**4**	3	0	2	3	0	25	-	25	50	-
3	IMSMA 406/ IMSMA 4xx	Time Series Analysis / DEC-9	GEC-12 / DEC	**4**	3/3	0/1	2/0	3/3	2/0	15/25	25/0	20/25	40/50	0
4	IMSMA 408/ IMSMA 4xx	Machine Learning-II / DEC-10	GEC-13 / DEC	**2**	2/0	0/0	0/4	2/0	0/2	25/0	0/50	25/0	50/0	0/50
5		Project-II	IAPC3	**6**	x	x	x	x	x	x	x	x	x	x
Total				**20**										

V YEAR: Ninth Semester

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weights (%)				
S. No	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	IMSMA 501	Matrix Computation	DCC	**4**	3	1	0	3	0	25	-	25	50	-
2	IMSMA 503	Advanced Partial Differential Equation	DCC	**4**	3	1	0	3	0	25	-	25	50	-
3	IMSMA 505	Tensor Calculus	DCC	**4**	3	1	0	3	0	25	-	25	50	-
4	IMSMA 5xx	DEC-11	DEC	**4**	3/3	0/1	2/0	3/3	2/0	15/25	25/0	20/25	40/50	0
5	IMSMA5xx	Project-III	IAPC	**6**	x	x	x	x	x	x	x	x	x	x
Total				**22**										

V YEAR: Tenth Semester

Teaching Scheme					Contact Hours/Week			Exam Duration		Relative Weights (%)				
S. No	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	IMSMA 502	Measure Theory	DCC	**4**	3	1	0	3	0	25	-	25	50	-
2	IMSMA 504	Number Theory	DCC	**4**	3	1	0	3	0	25	-	25	50	-
3	IMSMA 506	Differential Geometry	DCC	**4**	3	1	0	3	0	25	-	25	50	-
4	IMSMA 5xx	DEC-12	DEC	**4**	3/3	0/1	2/0	3/3	2/0	15/25	25/0	20/25	40/50	0
5	IMSMA 5xx	Project-IV	IAPC	**6**	x	x	x	x	x	x	x	x	x	x
Total				**22**										

Department of Applied Mathematics
Delhi Technological University,
(Formerly Delhi College of Engg.)

List of Department Skill Enhancement Courses (SEC)

S. No.	Subject Code	Subject	Elective No.	Semester
1.	ISEMA101	Programming Fundamentals	**SEC-1**	**Semester-I**
2.	ISEMA103	Basic IT Tools		
3.	ISEMA102	MATLAB Programming	**SEC-2**	**Semester-II**
4.	ISEMA104	Advanced Spreadsheet Tools		
5.	ISEMA201	LaTeX Typesetting for Beginners	**SEC-3**	**Semester-III**
6.	ISEMA203	Statistics with R		
7.	ISEMA202	Programming with Python	**SEC-4**	**Semester-IV**
8.	ISEMA204	Introduction to SPSS		
9.	ISEMA302	Research Methodology	**SEC-5**	**Semester-VI**
10.	ISEMA304	Cyber Security		

List of Basic Science Courses (GEC1-GEC3) offered by Department of Mathematics

S.No.	Subject Code	Basic Science Courses (GEC)	Semester	Credits
1.	IMSMA 107	Mathematics-1	**I**	4
2.	IMSMA 108	Mathematics-2	**II**	4
3.	IMSMA 223	Basic Probability and Statistics	**III**	2

Department of Applied Mathematics
Delhi Technological University,
(Formerly Delhi College of Engg.)

List of Department Specific Elective Courses (DEC)

S. No.	Subject Code	Subject	Elective No.	Semester
1.	IMSMA 209	Series Solution and Special Functions	DEC-1	Semester-III
2.	IMSMA 211	Discrete Mathematics		
3.	IMSMA 213	Theory of Equations		
4.	IMSMA 210	Data Structure	DEC-2	Semester-IV
5.	IMSMA 212	Fuzzy Set Theory		
6.	IMSMA 214	Dynamics		
7.	IMSMA 311	Field Theory	DEC-3	Semester-V
8.	IMSMA 313	Analysis and Design of Algorithms		
9.	IMSMA 315	Game Theory		
10.	IMSMA 317	Database Management System	DEC-4	
11.	IMSMA 319	Fourier Analysis: An Introduction		
12.	IMSMA 321	Operations Research		
13.	IMSMA 312	Artificial Intelligence	DEC-5	Semester-VI
14.	IMSMA 314	Perturbation Theory		
15.	IMSMA 316	Financial Mathematics		
16.	IMSMA 318	Chaos and Fractals	DEC-6	
17.	IMSMA 320	Elementary Fluid Dynamics		
18.	IMSMA 322	Computer Networks		
19.	IMSMA 324	Classical Mechanics	DEC-7	
20.	IMSMA 326	Data Warehousing and Data Mining		
21.	IMSMA 328	Cryptography and Coding Theory		
22.	IMSMA 409	Natural Language Processing	DEC-8	Semester-VII
23.	IMSMA 411	Digital Image Processing		
24.	IMSMA 413	Optimization Techniques		
25.	IMSMA 410	Statistical Quality Control and Decision Making	DEC-9	Semester-VIII
26.	IMSMA 412	Commutative Algebra		
27.	IMSMA 414	Theory of Computation		
28.	IMSMA 416	Portfolio Optimization	DEC-10	
29.	IMSMA 418	Stochastic Calculus		
30.	IMSMA 420	Big Data Analytics		
31.	IMSMA 507	Petri Net Theory	DEC-11	Semester-IX
32.	IMSMA 509	Approximation Theory		
33.	IMSMA 511	Univalent Function Theory		
34.	IMSMA 508	General Relativity and Cosmology	DEC-12	Semester-X
35.	IMSMA 510	Numerical Methods of Differential Equations		
36.	IMSMA 512	Quantum Calculus		

Department of Applied Mathematics
Delhi Technological University,
(Formerly Delhi College of Engg.)

Courses in Minor Track: Minor in Data Analytics (GEC4-GEC13)

S.No.	Semester	COURSE CODE	COURSE TITLE	CREDITS
1	**III**	IMSMA 207	Mathematical Transforms	**4**
2	**IV**	IMSMA 208	Linear Programming Problems	**4**
3	**V**	IMSMA 307	Linear Regression Analysis	**4**
4	**V**	IMSMA 309	Programming with Python	**4**
5	**VI**	IMSMA 306	Econometrics	**4**
6	**VI**	IMSMA 308	Operation Research	**4**
7	**VI**	IMSMA 310	Data Structures	**2**
8	**VII**	IMSMA 407	Machine Learning I	**2**
9	**VIII**	IMSMA 406	Time Series Analysis	**4**
10	**VIII**	IMSMA 408	Machine Learning II	**2**

Department of Applied Mathematics
Delhi Technological University,
(Formerly Delhi College of Engg.)

FIRST YEAR
FIRST SEMESTER

Details of Course

Course Title	Course Structure			Pre-Requisite
IMSMA 101: Calculus-I	**L**	**T**	**P**	NIL
	3	1	0	

Course Objective: To acquire knowledge in calculus of single variable

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Describe the properties of a single variable function that may lead to the concept of differentiation.
CO2	Describe the approximation of single variable function and discuss the extremum of the function.
CO3	Analyze the characteristics of different curves in cartesian and polar coordinate system.
CO4	Evaluate indefinite and definite integrals using various techniques and apply it to determine the area.
CO5	Apply the integral to calculate lengths of curves, and determine the surface area and volume of solids of revolution.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	0	0	1	3	0
CO2	2	0	1	2	0
CO3	1	0	1	1	0
CO4	2	0	1	2	0
CO5	1	0	1	2	0

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
1.	Functions of Single variable, Limits, Continuity and Derivative of a functio Successive differentiation, Leibnitz Rule.	08
2.	Maclaurin's and Taylor's series expansion, Point of inflexion, Maxima and Minima. Applications in estimation of error and approximation.	09
3.	Asymptotes, Curve tracing (Cartesian & polar), Derivative of an arc, curvature, radius of curvature.	10
4.	Indefinite and definite integrals, Reduction formulae, Area under the curve.	09
5.	Lengths of curves, Surface of a solid of revolutions, Volume of a solid of revolutions.	09
	Total	**45**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	"Calculus" by Howard Anton, Wiley publications	2015
2.	"Calculus and Analytic Geometry" by George B. Thomas Jr., Ross L. Finney, Pearson Education India	2010
3.	"Differential Calculus" by Gorakh Prasad, Pothishala Pv Ltd.	2017
4.	"Advanced Engineering Mathematics" by R.K.Jain and S.R.K. Iyengar, Narosa; 1st edition	2002

Details of Course

Course Title	Course Structure			Pre-Requisite
IMSMA 103 Analytical Geometry	**L**	**T**	**P**	Knowledge of two-dimensional geometry
	3	1	0	

Course Objective: To develop knowledge on the three dimensional geometry that may help the students to view and understand the three dimensional object very clearly.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Describe the co-ordinates with reference to three-dimensional space and apply it to understand the fundamental concepts.
CO2	Analyze the equation of a plane and apply it to understand the geometry of the planes.
CO3	Formulate the parametric equation of a straight line that may require in different branches of mathematics.
CO4	Describe the sphere as a ball in three-dimensional space and apply it to study the different properties of a sphere.
CO5	Define quadric surfaces and study a particular quadric surface known as cone. Describe a general equation of second degree that represents a cone.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	0	0	1	1
CO2	2	0	0	1	2
CO3	2	0	0	1	2
CO4	2	0	1	2	1
CO5	2	0	0	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
1.	Rectangular Cartesian Co-ordinates, Distance between two points, Co-ordinates of a point dividing the join of two points in a given ratio, Projections, Direction Cosines, Direction ratios, Angle between two straight lines, Lagrange's identity.	09
2.	A first degree equation represents a plane, Equation of planes in different forms, Planes passing through three given points, Angle between two planes, Distance of a point from a plane, Position of the origin, Plane through the intersection of two intersecting planes.	09
3.	Equation of a straight line, Equation of a straight line in symmetrical form, Straight line passing through two given points, Plane through a given straight line, Condition of co-planarity of two straight lines, Distance of a point from a straight line, Shortest distance between two skew lines.	09
4.	Equation of a sphere, Equation of a sphere on a diameter with given extremities, Equation of a circle, Intersection of two spheres, Spheres through a given circle, A straight line and a sphere, Equation of the tangent plane at a point, Condition of tangency.	09
5.	Quadric surfaces, Definition of the cone, Cone with its vertex at the origin, Condition for the general equation of the second degree to represent a cone, General equation of a cone containing the axes, Equation of the cone with the origin as vertex and a given curve as base.	09
	Total	**45**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	J. G. Chakravorty and P. R. Ghosh, Advanced Analytical Geometry, U. N. Dhur and Sons Pvt. Ltd., Fifth Edition	1994
2.	W. H. McCrea, Analytical Geometry of Three Dimension, Dover Publication,	2006
3.	D. M. Y. Sommerville, Analytical Geometry of Three Dimension, Cambridge University Press	2016
4.	A. Mukherjee and N K Bej, Analytical Geometry of Two and Three Dimension, Third Edition, Books and Allied Pvt. Ltd.	2009
5.	Robert J. T. Bell, An elementary treatise on coordinate geometry of three dimension, Ingram Short title.	2018

Details of Course:

Course Title	Course Structure			Pre-Requisite
IMSMA 105 Abstract Algebra-I	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To acquire knowledge of fundamentals of Groups, Rings and Matrix Theory.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Apply properties of numbers and different operations on it.
CO2	Describe the different columns of a matrix as a vector and analyse it in terms of eigenvalues and eigenvectors.
CO3	Analyze the properties of groups and apply it to study different types of groups.
CO4	Use tests to identify the subgroups and understand different properties of cyclic groups.
CO5	Describe the concepts of rings and other different algebraic structure.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	0	2	1	2
CO2	2	0	2	1	2
CO3	3	0	2	1	2
CO4	3	0	2	1	2
CO5	2	0	2	1	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact hours
1.	Properties of numbers, Modular Arithmetic, Mathematical Induction, Equivalence relations, Functions and permutations.	9
2.	Elementary row/column transformations, Rank of a matrix, Inverse of a Matrix, Solutions of system of linear equations, linear Independence and dependence, Eigenvalues and Eigenvectors	9
3.	Introduction to Groups, symmetric groups, Dihedral groups, Matrix Groups, Quaternion groups, Group of Congruence classes. Group Properties.	9
4.	Subgroups tests, Examples of subgroups, Order of group and order of an element, Cyclic groups and its properties.	9
5.	Ring, Subring Tests, Examples of Subrings, Zero Divisors, Integral domain, Field, Ideals and properties of ideals.	9
	Total	**45**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	N. S. Gopalakrishnan, University Algebra, New Age International Publishers	2017
2.	I. N. Herstein, Topics in Algebra(2nd Edition), Wiley Eastern Limited	2019
3.	Joseph A. Gallian, Contemporary Abstract Algebra (4th Ed.), Narosa Publishing House.	2017
4.	D. S. Dummit and R. M. Foote, Abstract Algebra (3rd Edition), John Wiley and Sons.	2009
5.	Khanna and Bhamri, A course in Abstract Algebra(5thEdition), Vikas Publishing House.	2017

Details of Course

Course Title	Course Structure			Pre-Requisite
IMSMA 107: GEC – I Mathematics – I	**L**	**T**	**P**	Knowledge of set theory
	3	1	0	

Course Objective: To gain knowledge in the field of calculus of function of single variable and multi-variable.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Understanding the concept of differential calculus in one dimension.
CO2	Describe the characteristic of the function in two variables.
CO3	Explain the nature of the curve in cartesian and polar coordinate.
CO4	Describe the introductory concept of integral calculus and explain the integral where either upper limit or lower limit or the integrand is not defined.
CO5	Apply double and triple integral to obtain surface area and the volume generated.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	2	3	3
CO2	3	2	2	2	3
CO3	2	2	2	2	3
CO4	3	3	1	2	3
CO5	2	3	3	2	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
1.	Limit and Continuity of functions of a single real variables, Differentiability of functions, Successive differentiation, Rolle's Theorem, Lagrange's Mean value theorem, Taylor's theorem with Lagrange's form of remainder, Taylor's series, Maclaurin's series.	09
2.	Limit and Continuity of functions of two or more variables. Taylor's theorem for two variables, Partial derivatives, total derivative and differentiability, Chain rule for one and two independent parameters, Maxima and Minima, Method of Lagrange's multiplier.	09
3.	Some important curves, their equations and shapes, Tangent and Normals, Curvature, Asymptotes, Curve Tracing.	08
4.	Basic Methods of Integration, Reduction Formulae, Definite Integral as a limit of sum, Sequence and series of functions: Power Series, Improper Integral, Gamma and Beta Function.	09
5.	Double integral, Iterated or repeated integral, change of order of integration. Triple integral. Cylindrical and spherical coordinates. Change of variables in double integrals and triple integrals. Transformation of double and triple integrals (problems only). Determination of volume and surface area by multiple integrals (problems only).	10
	Total	**45**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/
1.	James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA.	2005
2.	M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.	2007
3.	G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi.	2010
4.	E. Marsden, A. J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE).	2005
5.	G. Prasad, Textbook of Integral Calculus and Elementary Differential Equations, Pothishala Pvt. Ltd.	2017

Details of Course

Course Title	Course Structure			Pre-Requisite
ISEMA 101: SEC-1 Programming Fundamentals	**L**	**T**	**P**	NIL
	0	0	4	

Course Objective: The objective of the course is to understand the basic principles of programming languages and provide design & development basic programming skills. This course also introduces problem-solving methods and program development.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Design algorithmic solutions for use on computers and approach the programming task using procedural and Object-Oriented Programming techniques.
CO2	Write constructs for console input and output, apply basic operators, and perform sequential Processing, utilize the basic control.
CO3	Apply decision structures, loops, storage class, and functions.
CO4	Apply data in arrays, pointers, and data files.
CO5	Develop effective and efficient programs in C and C++.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	1	2	1	1
CO2	1	1	2	1	0
CO3	2	2	2	1	0
CO4	2	1	1	1	0
CO5	2	1	2	1	0

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
1.	Introduction: Concepts of algorithm, flow chart, Basics of Computer Languages, Compilers, Interpreter, Programming Environments and Debugging. Introduction to C programming - Data types, Expressions and Operators-Arithmetic, unary, logical, bitwise, relational, assignment, comma operators. Data conversions. Input/Output statements.	08
2.	Control statements: While, do-while, for statements, nested loops, if else, switch, break, Continue, and goto statements, Iterations. Concept of subprograms. Functions: Storage class -Scope and extent of variables, Argument types- actual, formal, dummy. Function definition, declaration, prototype. Recursion.	08
3.	Pre-processor directives: headers and library functions, macros. Array: Array representation, Operations on array elements, using arrays, multidimensional arrays. Strings, operations on strings. Structures & Unions: Declaration and usage of structures and Unions, typedef.	08
4.	Pointers: Pointer and address arithmetic, pointer operations and declarations, pointer and arrays, pointer to structure. Call by value, call by reference. Dynamic memory allocation.	10
5.	File Handling: Declaration of files, types of files File pointer. File input/ output and usage. Object Oriented Programming: OOPS concepts, OOP languages- C++, Python etc.	10
	Total	**44**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	C Programming Language by Brian W. Kernighan and Dennis M. Ritchie, Prentice Hall 2nd Edition. ISBN-13 - 978-0131103627	1988
2.	C Programming for Beginners - The C Guru	2016
3.	Let us C by Kanetkar, Y BPB Publications, 15th edition .	2016
4.	Programming in ANSI C by E Balagurusamy , McGraw Hill Education (India) Private Limited Sixth Edition. ISBN-13 : 978-	2013

List of Experiments	
1	WAP creates variables of numeric data types and performs arithmetic operations on them.
2	WAP to declare variables of string datatype and perform different operations on them.
3	Write a program to reverse a number.
4	Compute the sum of the first n terms of the following series. S= 1+1/2+1/3+1/4 + ….
5	Check if the given string is palindrome or not.
6	WAP to check if a number is prime or not.
7	WAP to generate Fibonacci series using recursion and iteration.
8	WAP to swap two numbers using pointers.
9	WAP to merge two sorted arrays.
10	WAP to add two complex numbers by passing structure to a function.
11	Create a class Employee that stores employees details. Include the following member functions: printName() and printSalary()

Details of Course

Course Title	Course Structure			Pre-Requisite
ISEMA 103: SEC-1 Basic IT Tools	**L**	**T**	**P**	NIL
	0	0	4	

Course Objective: The objective of the course is to enable students to develop IT skills that are a prerequisite in today's work environment and equip them with basic computing skills that will enhance their employability in general. This will help them to analyze and present information in a meaningful manner.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Apply word-processor to generate documents with appropriate formatting, layout, review and referencing.
CO2	Manage data in worksheets and workbooks and analyze it using spreadsheet functions and inbuilt formulas.
CO3	Draw analysis on data using spreadsheets to make decisions.
CO4	Make meaningful representations of data in the form of charts and pivot tables.
CO5	Manage data in database tables and use the same for generating queries, forms and reports.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	1	1	2
CO2	2	1	2	2	2
CO3	2	3	3	2	1
CO4	1	1	2	1	2
CO5	1	1	3	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
1.	Software Skills: Basics of MATLAB, Mathematica, LaTeX: General Structure of LaTeX File, Images, Tables and Equations in LaTeX, Beamer Presentations. Basics of Excel.	10
2.	Word Processing - Creating and saving your document, displaying different views, working with styles and character formatting, working with paragraph formatting techniques using indents, tabs, alignment, spacing, bullets and numbering and creating borders; Page setup and sections: Setting page margins, orientation, headers and footers, end notes and foot notes, creating section breaks and page borders; Working with tables: Creating tables, modifying table layout and design, sorting, inserting graphics in a table, table math, converting text to table and vice versa; Word Processing II - Create newspaper columns, indexes and table of contents, Spell check your document using inbuilt and custom dictionaries, checking grammar and style , using Thesaurus and finding and replacing text; Create bookmarks, captions and cross referencing, adding hyperlinks, adding sources and compiling and bibliography; Mail merge: Creating and editing your main document and data source, sorting and filtering merged documents and using merge instructions like ask, fill-in and if-then-else; Linking and embedding to keep things together.	12
3.	Spreadsheet Concepts, Creating, Saving and Editing a Workbook, Inserting, Deleting Work Sheets, entering data in a cell / formula Copying and Moving from selected cells, handling operators in Formulae, Functions: Mathematical, Logical, statistical, text, financial, Date and Time functions, Using Function Wizard. Formatting a Worksheet: Formatting Cells – changing data alignment, changing date, number, character or currency format, changing font, adding borders and colors, Printing worksheets, Charts and Graphs – Creating, Previewing, Modifying Charts.	12
4.	Presentations - Creating, Opening and Saving Presentations, Creating the Look of Your Presentation, Working in Different Views, Working with Slides, Adding and Formatting Text, Formatting Paragraphs, Creating & using Master Slide, Checking Spelling and Correcting Typing Mistakes, Making Notes Pages and Handouts, Drawing and Working with Objects, Adding Clip Art and other pictures, Designing Slide Shows, Running and Controlling a Slide Show, Printing Presentations. Working in Different Templates Inserting an animation o Inserting a sound o Inserting a movie file o Managing slide show and animation, Providing Aesthetics to Slides & Printing, Enhancing Text Presentation, Working with Color and Line Style, Adding Movie and Sound, Adding Headers, Footers and Notes,	10
	Total	**44**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	Joan Lambert, Microsoft Office 2016, 1st Edition, Microsoft Press. 2015	2016
2.	Stefan Kottwitz, LaTeX Cookbook, Packt Publishing. 2015	2015
3.	Stormy Attaway, Matlab: A Practical Introduction to Programming and Problem Solving. 2016	2016
4.	Stefan Wolfram, The Mathematica Book, Wolfram Media Inc. 2004	2004
5.	Linda Foulkes, " Learn Microsoft Office 2019: A comprehensive guide to getting started with Word, PowerPoint, Excel, Access, and Outlook",	2008

List of Experiments	
1	Perform basic arithmetic task on MATLAB
2	Prepare your resume in LATEX
3	Create a document in Word on a topic of your choice. Format the document with Various fonts (minimum 10, maximum 12) and margins (minimum 1.5, maximum 3). The document should include a bulleted or numbered list, table containing name, address, basic pay, department as column heading, a picture of lion using clip art gallery, an example of word art, header with student name & date, a footer with pagination.
4	Create a document with the text given below and save it as First Write in it a paragraph about yourself in 200 words. Do the following - Count the occurrences of the word "My" in the above document, Replace "My" with "Yours" in the entire document, Underline the text "Yours", make an auto correct entry for My and it should be replaced by Yours.
5	Use the document saved earlier and perform the page setting as follows - a. Top Margin 1.3", b. Bottom margin 1.4", c. Left margin 1.30", d. Right margin 1.30", e. Gutter margin 1.2", f. Header 0.7", g. Footer 0.7", h. Paper size executive, i. Orientation landscape
6	Below is given a letter and some addresses. This letter is to be sent to all these Addresses. User mail merge Addresses are: 1) Amit, H No 424 sector 8D, Lajpat Nagar, New Delhi, 2) Rohit, H No 444, Sector 125C, Chandigarh,3) Jyoti, H NO 550, Sector 16A, Gomti Nagar, Lucknow To <<Name>> <<Address>> Dear <<Name>> You are advised to appear for an interview on the <<Date>>at 9:00 A.M with your original documents. Yours Sincerely ABC Limited, New Delhi.

7	Set up a new presentation of three slides. 1. On the master slide: a) Apply a theme of your choice to the master slide., b) Include an automated page number in the bottom left of the footer, c) Place a clipart image of a pen or pencil as a logo in the top right corner. 2. Add the following text in slide 1 - Heading: Hothouse Design (Red, 25 point, Arial font, Left Aligned) 3. On the second slide type the following text where font="Arial" size="20" Earlier in the year we started to analyze the sales profile for the stationery business stream within Hothouse. The areas of initial investigation were selected as the management of our sales team, our customer base, website effectiveness, and an analysis of our most successful product lines. 4. On the third slide where font="Arial" size="20" Possible timings for these bonuses include: Weekly, Monthly, Quarterly and Annually.
8	Set up a new presentation consisting of 3 slides - 1. on the first slide a) Type Telephone Analysis for the title, using any word Art option. b) Insert any appropriate image below the title and apply an Animation effect to the Image. c) Insert a Sound from the Clip Organizer. 2. on the second slide: a) create a pie chart using the following data: Call type - Minutes International - 1640 Peak Rate- 7842 Cheap Rate- 1543 Internal- 16805 b) Insert the chart title “Telephone Analysis”. 3. on the third slide: Enter the following text: (font style="Times new roman", font size= "24") As you can see that our vast majority of calls are internal. These figures are the Average values per day for all departments, using a monitoring period of 2 weeks. 4. Use the same transitional effect between each slide and Play a slide show.
9	Set up a new presentation consisting of 4 slides 1. On the first slide - a) Include an automated slide number left aligned., b) Enter the heading New Website., c) Enter the sub heading Proposed Web Pages., d) Insert any appropriate image below the sub heading and apply an Animation effect to the image. e) Create the following hyperlink http://www.google.com on the image, f) Insert a Sound from the Clip Organizer. 2. On the second slide: a) create a pie chart using the following data: Type of Trip 2008 Dives Go deep 2512 Wreck Week 12680 Shark Experience 940 Cave Dives 353 3. On the third slide: Enter the following text: (font style=Times New Roman, font size= 24), During the development of this new website, we have realized that the proposed design brief may need to be amended. 4. On the fourth slide: Insert a Movie from a File on Your Computer 5. Use a picture as background in all your slides. 6. Use the same transitional effect between each slide and play a slide show.

Department of Applied Mathematics
Delhi Technological University,
(Formerly Delhi College of Engg.)

SECOND SEMESTER

Details of Course:

Course Title	Course Structure			Pre-Requisite
IMSMA 102: Calculus-II	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To acquire knowledge in calculus of several variables.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Analyze the characteristic of the function of the two or more variables.
CO2	Describe the approximation of the function of two variables and analyse the optimization properties of two and three variables.
CO3	Apply the techniques of the integral calculus to determine the surface area and volume.
CO4	Describe the concept of vector differential calculus and relate it with their physical interpretation.
CO5	Illustrate the integration with vectors in the integrand and apply it to solve some physical problems.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	1	1	3
CO2	1	1	1	1	3
CO3	2	2	1	2	3
CO4	2	2	1	2	3
CO5	2	2	1	2	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
1.	Definition of functions of two or more variables, Partial differentiation, Euler's theorem, Total derivative.	9
2.	Taylor's Expansion, Maxima-Minima, Lagrange's method of multipliers, Applications in estimation of error and approximation.	9
3.	Double integral (Cartesian and polar co-ordinates), change of order of integration, triple integrals (Cartesian, cylindrical and Spherical co-ordin Applications to area and volume.	9
4.	Scalar and vector point functions, gradient, directional derivative, divergence, curl and their interpretations.	9
5.	Line integral, surface integral and volume integral, Applications to work by the force, Green's, Stoke's and Gauss divergence theorems.	9
	Total	**45**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1.	"Calculus" by Howard Anton, Wiley publications	2015
2.	"Calculus and Analytic Geometry" by George B. Thomas Jr., Ross L. Finney, Pearson Education India	2010
3.	"Integral Calculus" by Gorakh Prasad, Pothishala Pv Ltd.	2015
4.	"Advanced Engineering Mathematics" by R.K.Jain and S.R.K. Iyengar, Narosa; 1st edition	2002

Details of Course

Course Title	Course Structure			Pre-Requisite
IMSMA 104: Real Analysis-I	**L**	**T**	**P**	NIL
	3	1	0	

Course Objective: To acquire knowledge of real-valued functions, sequences, series and derivatives

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Understanding the various properties of the real number
CO2	Define sequences and describe its properties.
CO3	Define series and discuss its convergence.
CO4	Describe the pointwise convergence and uniform convergence for sequence and series of functions.
CO5	Explain different mean value theorems that may lead to the development of calculus.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	0	2	2	1
CO2	3	0	3	3	1
CO3	2	0	3	2	1
CO4	2	0	3	3	1
CO5	3	0	3	3	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
1.	Real numbers, real-valued functions, countable sets, Cantor set, completeness axiom, Archimedean property, Dedekind cut.	8
2.	Sequences, limit, convergence, bounded and monotone sequences, operations on convergent and divergence sequences, Bolzano-Weirstrass theorem, Cauchy sequences.	10
3.	Series of real numbers, convergence and divergences, positive term series, tests of series, alternating series, conditional and absolute convergences.	9
4.	Sequence and series of functions, pointwise convergence of sequence of functions, uniform convergence, convergence and uniform convergence of series of functions	9
5.	Derivatives, Rolle's theorem, the law of means, fundamental theorem of calculus	9
	Total	**45**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	R. R. Goldberg, Methods of Real Analysis, Second Edition, John Wiley & Sons, Inc., New York.	1976
2	T. M. Apostol, *Mathematical Analysis*, Second Edition, Pearson Education. ISBN: 9780201002881.	1974
3	R. G. Bartle, D. R. Sherbert, "Introduction to Real Analysis", John Wiley & Sons.	1992
4	W. Rudin, "Principles of Mathematical Analysis", McGraw Hill International.	1980
5	S. C. Malik and Savita Arora, "Mathematical Analysis", New Age International Private Limited; 1st edition.	2017
6	K. A. Ross, "Elementary Analysis", Undergraduate Texts in Mathematics, Springer, 2013.	2013

Details of Course

Course Title	Course Structure			Pre-Requisite
IMSMA 106:	**L**	**T**	**P**	Basic knowledge of calculus
Ordinary Differential Equations	3	1	0	

Course Objective: To impart the knowledge of ordinary differential equations and to analyze and solve the physical problems.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Understand the first-order linear and non-linear differential equations of different forms and its applications.
CO2	Familiarize with linear dependence and independence solutions, linear second order differential equations using different methods and applying its use in applications.
CO3	Solve the initial and boundary value problems of second order and applying its use in applications.
CO4	Solve the linear differential equations of higher order with constant and variable coefficients and simultaneous equations.
CO5	Acquire the knowledge to reduce linear differential equations to first order matrix system of homogenous and non-homogeneous equations and find the solution by matrix method.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	1	0	1	1
CO2	2	1	0	1	1
CO3	2	2	1	1	2
CO4	2	2	1	1	2
CO5	2	2	1	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
1.	Order and degree of differential equations, Formation of differential equations, Ordinary differential equations of first order: linear differential equations(Leibnitz form), exact differential equations, Integrating factors, Non-linear differential equations: Bernoulli equation, Riccati equation, Clairaut's equations, Singular solutions, Initial value problem, Existence and Uniqueness of solutions, Applications of first order differential equations (Growth and decay problems, Newton's law of cooling, Orthogonal trajectories (in Cartesian and Polar coordinates)).	10
2.	Linear dependence and independence of solutions, The Wronskian, Linear differential equations of second order: complete integral in terms of a known integral, solution by changing independent variable, variation of parameters, Total differential equations,	9
3.	Second order linear homogeneous equations with constant coefficients, Initial value problems, Second order Sturm-Liouville boundary values problems, Application of second order differential equations (Simple Harmonic motion).	8
4.	Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Equations reducible to constant coefficients, Methods of undetermined coefficients and variation of parameters, Simultaneous linear equations.	9
5.	Review on matrix, system of linear equations, eigenvalues and eigenvectors, Reduction of linear differential equations to a first order matrix system, Solutions of linear system of homogeneous and non-homogeneous equations by matrix method.	9
	Total	**45**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	Martin Braun, Differential equations and their applications, Springer, 4th Ed.	1993
2.	S. L. Ross, Introduction to Ordinary Differential Equations, John Wiley & Sons, 4th Ed.	1989
3.	C.H. Edwards and D.E. Penny, Differential equations and boundary value problems, Pearson Education.	2004
4.	Richard Bronson, Schaum's Outlines of Differential equations, 2nd Ed. , Tata McGraw-Hill	2004
5.	Shair Ahmad and Antonio Ambrosetti, A text book on ordinary differential equations, 2nd Ed. Springer	2015
6.	Dennis G. Zill: A first course on Differential equations, 11ed. Cengage India Pvt. Ltd.	2019

Details of Course

Course Title	Course Structure			Pre-Requisite
IMSMA 108: GEC – 2 Mathematics-II	**L**	**T**	**P**	NIL
	3	1	0	

Course Objective: To provide knowledge about the fundamental concepts of different useful topics of mathematics that may help in real life application..

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Describe the concept of matrix and apply it to study the eigenvalue problem.
CO2	Formulate the differential equation and use the concept of integrating factor to solve it.
CO3	Illustrate different form of differential equation.
CO4	Define Laplace transform and apply it to solve integral and differential equations.
CO5	Define vector function and apply it to determine line integral, surface and volume integral.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	1	3	3
CO2	3	2	1	2	3
CO3	2	2	1	2	3
CO4	3	2	1	2	3
CO5	2	2	1	3	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
1.	Introduction to matrix, Rank of a matrix, Elementary transformation, Inverse of a matrix using elementary transformation, Consistency of linear system of equations, Eigenvalues and Eigenvectors of a matrix, Cayley Hamilton Theorem, Diagonalization of a matrix.	10
2.	Formation of differential equations, Solutions of a differential equation: Complete primitive, Particular and Singular Solution, Family of curves represented by ordinary differential equations, Exact equations, Necessary and sufficient condition, Integrating factor.	7
3.	Equations solvable by separation of variables, Homogeneous equations, Equations reducible to the homogeneous form, Linear equations, Equations reducible to the linear form, Bernoulli's equation.	8
4.	Introduction to infinite integrals. Linearity of Laplace transforms. Existence theorem for Laplace transforms. Laplace transforms of derivatives and integrals. Shifting theorems. Differentiation and integration of transforms. Convolution theorem. Solution of integral equations and systems of differential equations using Laplace transforms.	10
5.	Vector Function, Derivative of a vector function with respect to a scalar, Scalar and Vector Fields, Gradient of a scalar field, Directional Derivative, Divergence and Curl of a vector function, Integration of vectors, Work done, Circulation, Conservative vector field, Surface Integral, Volume Integrals, Green's Theorem, Stoke's Theorem, Gauss Divergence Theorem.	10
	Total	**45**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	Erwin kreyszig, Advanced Engineering Mathematics, Wiley-India, 10th Edition	2017
2.	R.K. Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, Narosa, 5th Edition	2016
3.	G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi.	2017
4.	G. Prasad, Textbook of Integral Calculus and Elementary Differential Equations, Pothishala Pvt. Ltd.	2017

Details of Course

Course Title	Course Structure			Pre-Requisite
ISEMA 102: SEC-2 MATLAB Programming	**L**	**T**	**P**	NIL
	0	0	4	

Course Objective: The objective of the course is to introduce fundamentals of MATLAB programmi perform mathematical operations in MATLAB.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Explain the basics and built in functions of MATLAB.
CO2	Describe mathematical operations on arrays in MATLAB.
CO3	Explain the working of relational and logical operators, conditional statements and loops in MATLAB.
CO4	Construct and analyze different types of two-dimensional plots in MATLAB.
CO5	Solve Polynomial and Algebraic Equations in MATLAB.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	1	3	1
CO2	1	2	2	2	3
CO3	2	1	2	1	2
CO4	1	2	2	2	2
CO5	2	1	1	2	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
1.	Introduction to MATLAB: Starting MATLAB, Working in the Command Window, Arithmetic Operations with Scalars, Elementary Math Built-in Functions, Defining Scalar Variables, Commands for Managing Variables.	10
2.	Arrays: One-Dimensional and Two-Dimensional Arrays, Array Addressing, Adding and Deleting Elements, Built-in Functions for Handling Arrays, Strings, Mathematical Operations with Arrays: Addition, Subtraction, Multiplication, and Division, Generation of Random Numbers.	10
3.	Relational and Logical Operators, Conditional Statements, Switch Case, Loops, Break and Continue commands. 2-D Plots: The plot command, fplot command, plotting multiple graphs in same plot, histograms.	12
4.	Polynomials and Symbolic Math: Polynomials, Curve Fitting, Solving Algebraic Equations, Differentiation, Integration.	12
	Total	**44**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/R
1.	MATLAB: A Practical Introduction to Programming and Problem Solving; D. Attaway, Butterworth-Heinemann, 6th edition.	2022
2.	Beginning MATLAB and Simulink: From Beginner to Pro; S. Eshkabilov, Apress, 2nd edition.	2022
3.	MATLAB: An Introduction with Applications; A. Gilat, John Wiley & Sons Inc., 6th edition.	2017

List of Experiments	
1	WAP for basic arithmetic operations with scalars in MATLAB.
2	WAP to demonstrate mathematical built-in functions in MATLAB.
3	WAP to create 1-D and 2-D arrays in MATLAB. Further, add and delete elements in the arrays.
4	WAP to perform mathematical operations (addition, subtraction, array multiplication, array division) on arrays in MATLAB.
5	WAP to demonstrate conditional statements and switch case in MATLAB.
6	WAP to demonstrate loops in MATLAB.
7	WAP to construct plots using the plot/fplot command in MATLAB.
8	WAP to construct histograms in MATLAB.
9	WAP to solve polynomials and algebraic equations in MATLAB.
10	WAP to demonstrate differentiation and integration in MATLAB.

Details of Course

Course Title	Course Structure			Pre-Requisite
ISEMA 104: SEC-2 Advanced Spreadsheet Tools	**L**	**T**	**P**	NIL
	0	0	4	

Course Objective: The objective of the course is to enable the students to use Excel for advanc analysis and equip them with automation skills on excel and make informed decision.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Define meaningful representations of data in the form of charts and pivot tables.
CO2	Analyze data using spreadsheets and use interpretation to make decisions.
CO3	Generate word documents with appropriate formatting, layout, proofing.
CO4	Manage data for generating queries, forms and reports in a database.
CO5	Apply statistical testing techniques for data analysis

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	3	2	1	2
CO2	3	3	2	2	2
CO3	1	2	3	0	1
CO4	3	2	3	1	2
CO5	3	1	3	1	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
1.	Introduction - Templates, customized ribbon & quick access toolbars, Linking between worksheets, use of hyperlink, Shortcut keys & worksheet protection, Integrating excel with other tools: MS word, outlook, PowerPoint, Access, Power BI, Overview Google spreadsheet & it's features, Excel print option and settings.	10
2.	Advanced Excel Techniques - Advance formulas & functions: If, If-And, Sumif(), Sumifs(), Countif(), Countifs(), Date & Time functions etc., Data validation & listing: student attendance sheet, mark sheet. Inventory management system, billing & EMI calc, V & H lookup, index & match formula, conditional formatting.	10
3.	Data Analysis & Decision Making - What-if analysis, goal seek, data tables, solver add-in. Problem-Solving using Solver (optimal product mix, workforce scheduling, transportation, capital budgeting, financial planning), Basic pivot table, advanced filter, slicer, dynamic and interactive charts, Graphical representation of data, Frequency distribution and its statistical parameters; Correlation and Regression Analysis, Dashboards.	12
4.	Excel Automation & Interactive Worksheets - Creating-recording and running Macro, assigning Macro to a command button, creation of a custom Macro button on quick, Access tool bar, basic VBA programming in excel, Making registration form, user for min excel using VBA with insert, update, search &delete operation.	12
	Total	**44**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	Excel 2016 Power Programming with VBA, Michae lAlexander, Dick Kusleika, Wiley.	2016
2.	MS Excel 2016, Data Analysis & Business Modelling, Wayne Winston, PHI.	2016
3.	Financial Analysis and Modelling Using Excel and VBA, Chandan Sengupta, Second Edition, Wiley Student Edition.	

List of Experiments	
1	Overview templates, customized ribbon & quick-access toolbar.
2	Linking excel worksheet and integrating with: Sword &Power Point.
3	Overview Google spreadsheet & its features.
4	Use of advance excel formulas-I .
5	Use of advance excel formulas–II.
6	Preparation of worksheet using data-validation and listing
7	Preparation of worksheet based on conditional formatting & advance filter.
8	Decision making in worksheet using what-if analysis tool.
9	Use of pivot table and slicer.
10	Preparation of worksheet including Dashboard-dynamic & interactive charts.

SECOND YEAR

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 201: Linear Algebra	**L**	**T**	**P**	Some knowledge of Groups and Rings.
	3	**1**	**0**	

Course Objective: To impart knowledge of vector space, linear transformation, Inner product of vectors, Bilinear forms and their applications

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Describe computational techniques and algebraic skills essential for the study of systems of linear equations, matrix algebra, vector spaces, eigenvalues and eigenvectors.
CO2	Use visualization, spatial reasoning, as well as geometric properties and strategies to model, solve problems, and view solutions, especially in and , as well as conceptually extend these results to higher dimensions.
CO3	Obtain various variants of diagonalisation of linear transformations. Prove results in linear algebra using appropriate proof-writing techniques such as linear independence of vectors; properties of subspace etc
CO4	Apply Gram-Schmidt process on inner product spaces, find orthogonal and orthonormal bases.
CO5	Relate matrices and bilinear forms, identify symmetric and skew symmetric bilinear forms.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	0	2	2	3
CO2	3	0	2	2	3
CO3	2	0	2	2	3
CO4	3	0	2	2	3
CO5	2	0	2	2	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hour
UNIT-1	Vector Spaces, Linear span, linear dependence and independence, Basis and Dimension, Subspaces, Homomorphism of vector spaces, Isomorphism of vector spaces, Quotient space, Direct sum of spaces	**9**
UNIT-2	Linear transformation, Linear operators, Algebra of linear transformation Range and Null space, Rank and Nullity, Invertible linear transformation, Singular and Non-singular transformation	**9**
UNIT-3	Matrices, Rank of a matrix, Representation of transformation by matrices, Determinant and Trace of linear transformation, Linear functionals, Dual spaces, Dual bases, Projections, Eigenvalue, Eigenvector, Cayley-Hamilton Theorem, Diagonalizable operators, Minimal polynomial, Jordan Canonical form.	**9**
UNIT-4	Inner product space, Euclidean and Unitary spaces, Norm of a vector, Schwarz's inequality, Orthogonality, Orthonormal set, Gram-Schmidt Orthogonalization process, Adjoints, Self-adjoint operator, Unitary operators, Normal Operators.	**9**
UNIT-5	Bilinear Forms, Matrix of a bilinear form, Symmetric bilinear form, Skew-symmetric bilinear forms	**9**
	Total	**45**

References:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1.	Hoffman and Kunze, Linear Algebra ,2nd Edition, Pearson.	2015
2.	I. N. Herstein, Topics in Algebra ,2nd Edition, Wiley Eastern Limited.	2008
3.	Gilbert Strang, Introduction to Linear Algebra , 5th Edition, Wellesley-Cambridge Press.	2016
4.	Elementary Linear Algebra with Supplementary Applications, H. Anton, C. Rorres, 11th Edition, Wiley.	2016
5.	N. S. Gopalakrishnan, University Algebra, New Age International Publishers.	2004

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 202: Numerical Analysis	**L**	**T**	**P**	Some knowledge of calculus and linear algebra
	3	**0**	**2**	

Course Objective: After the course, one should be able to solve various real-life problems computationally.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Identify various types of errors involved in the computation through examples
CO2	Apply the various numerical techniques to solve nonlinear algebraic equations and systems of linear equations for real life problems.
CO3	Demonstrate problem solving skills in the context of computational techniques through real life problems.
CO4	Apply numerical concepts such as numerical differentiation, integration to appreciate the applications to solve real-world problems.
CO5	Design the numerical solutions with various order of convergence to the problems related to ordinary differential equations.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	2	2	3	2
CO3	2	3	2	2	2
CO4	2	2	2	2	2
CO5	2	3	2	3	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Approximate Numbers and Significant digits; Round off error; Absolute, Relative and percentage errors; Relation between Relative Error and the Number of Significant Figures; Floating point systems.	**6**
UNIT-2	Nonlinear Equations: Fixed point iterations, Bisection method, Regula-Falsi and Secant method, Newton's methods and their Rate of convergences. Newton method for system of nonlinear equations. System of Linear Equations: Gauss elimination, LU decomposition, Gauss Jacobi and Gauss Seidel and their convergence.	**10**
UNIT-3	Introduction to Interpolation; Differences; Effect of an Error in a Tabular Value; Relation between Differences and Derivatives, Newton's Formula for forward and backward Interpolation, Divided Differences; Lagrange's Interpolation and their error Estimates, Splines.	**9**
UNIT-4	Introduction to Numerical Differentiation and Numerical Integration; A general quadrature formula for Equidistant Ordinates; Simpson's Rule; Trapezoidal Rule; Gauss's Quadrature Formula.	**10**
UNIT-5	Introduction to the Numerical solution of Initial Value Ordinary Differential Equation; Euler's Method and its Modification, Picard's Method, Use of Approximating Polynomials, The Runge-Kutta Method. Error estimates. Finite difference methods for solving Boundary Value Problem.	**10**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	M. K. Jain & S. R. K. Iyengar, Numerical Methods for Scientific and Engineering Computation, New Age International Publishers.	2005
2	R. S. Gupta, Elementary Numerical Analysis, Cambridge University Press.	2015
3	Ascher U. M., A first course in numerical methods, SIAM.	2013
4	S.S. Rao, Applied numerical methods for engineers & Scientist, PHI.	2001

PRACTICAL LIST	
S. No.	**List of Experiments**
1	Newton Raphson's method and its convergence
2	Comparison between convergence of various methods to find root of a nonlinear equation
3	Gauss Elimination and LU decomposition
4	Gauss Seidel and Gauss Jacobi
5	Interpolation using Newton method
6	Lagrange and splines methods for interpolation
7	Newton cotes methods for numerical integration
8	Gauss Quadrature
9	Euler's method for Initial Value Problem (IVP)
10	Runge Kutta method for IVP
11	Finite difference methods for solving BVP
12	Solving non-linear BVP

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 203: Probability and Statistics	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To impart knowledge on the probability theory which describe the things in a real scenario.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Classify different types of data and summarize its main features.
CO2	Describe different definitions of probability and conditional probability and apply it to analyse Baye's theorem.
CO3	Define random variable and distribution function and analyse its different characteristics.
CO4	Describe different correlation functions and use the concept of convergence in probability to define law of large numbers and central limit theorem.
CO5	Describe different discrete and continuous distributions.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	2	2
CO2	3	2	3	2	1
CO3	3	2	3	1	1
CO4	3	2	3	2	1
CO5	3	2	3	1	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Frequency distributions, Graphic representation of a frequency distribution, Measures of central tendency, Selection of an average, Dispersion, Measures of dispersion, Coefficient of dispersion, moments, skewness and kurtosis.	**8**
UNIT-2	Random Experiment, Sample Spaces, Events, Definitions of Probability (Classical, Frequency, and Axiomatic), Addition theorems of probability, Boole's inequality, Conditional Probability, Multiplication theorem of probability, Mutually Independent Events, Mutually Exclusive Events, Baye's Theorem.	**9**
UNIT-3	Random Variables, Distribution Function, Discrete random variables: Probability mass function and discrete distribution function, Continuous random variables: Probability density function and continuous distribution function, Two-dimensional Random Variables: Joint, Marginal and Conditional Distributions. Transformation of Random Variables.	**9**
UNIT-4	Mathematical expectation of discrete and continuous distribution, Moments, Moment Generating Function, Tchebycheff's Inequality, Convergence in Probability, Tchebycheff's Theorem, Bernoulli's Theorem, Law of Large numbers,Curve fitting, Linear correlation and Regression.	**10**
UNIT-5	Discrete Distribution: Bernoulli, Binomial, Negative binomial, Geometric, Poisson and Multinomial. Continuous Distributions: Uniform, Normal, Lognormal, Exponential, Beta distribution of first kind, Gamma. Central limit theorem.	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Meyer, Introductory Probability and Statistical Application, Oxford and IBH Publishing.	2002
2	Sheldon M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Academic Press.	2009
3	Probability and statistics for Engineers, Richard A. Johnson, Irwin Miller, John Freund, PHI	2010
4	Kishore S. Trivedi, Probability and Statistics with Reliability, Queuing and Computer Science Application, Wiley.	2006

Department of Applied Mathematics
Delhi Technological University,
(Formerly Delhi College of Engg.)

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 204: Abstract Algebra-II	**L**	**T**	**P**	Algebra-I (optional)
	3	**1**	**0**	

Course Objective: To impart knowledge of fundamentals Groups, Rings and their properties.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Explain the preliminary concepts of groups, including cosets, Lagrange's theorem, normal subgroups, and quotient groups. (Understanding and Applying)
CO2	Explore homomorphisms, kernels of homomorphisms, isomorphisms, and fundamental theorems of homomorphisms. Illustrate permutation groups and apply Cayley's theorem. (Understanding and Applying)
CO3	Analyze the center of a group, conjugate classes, class equation, and apply Sylow's theorems. (Analyzing)
CO4	Demonstrate preliminary concepts of rings, prime and maximal ideals, quotient rings, and ring homomorphisms and isomorphisms, including quotient fields. (Understanding and Applying)
CO5	Evaluate properties of different ring types, including unique factorization domains, principal ideal domains, and Euclidean domains, and apply the unique factorization and irreducibility concepts to analyze polynomial rings. (Evaluating and Applying)

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	0	2	1	2
CO2	2	0	2	1	2
CO3	3	0	2	1	2
CO4	3	0	2	1	2
CO5	2	0	2	1	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Preliminary concepts of groups, Cosets, Lagrange's theorem, Normal subgroups, Quotient groups.	**8**
UNIT-2	Homomorphism, kernel of homomorphism, Isomorphism, fundamental theorems of Homomorphism, Permutation groups, Cayley's theorem.	**10**
UNIT-3	Centre of a group, conjugate class, class equation, Sylow's theorems.	**9**
UNIT-4	Preliminary concepts of Rings, prime and maximal ideals, quotient rings, ring homomorphism, isomorphism, quotient fields.	**10**
UNIT-5	Unique factorization domain, Unique factorization theorem, principal ideal domain, Euclidean domain, Irreducibility of polynomials.	**8**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	N. S. GopalaKrishnan, University Algebra, New Age International Publishers	2021
2	I. N. Herstein, Topics in Algebra (2nd Edition), Wiley Eastern Limited	2008
3	Joseph A. Gallian, Contemporary Abstract Algebra (4th Ed.), Narosa Publishing House	1999
4	D. S. Dummit and R. M. Foote, Abstract Algebra(3rdEdition), John Wiley and Sons.	2011
5	Khanna and Bhamri, A course in Abstract Algebra(5^{th}Edition), Vikas Publishing House.	2017

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 205: Real Analysis-II	**L**	**T**	**P**	Real analysis-I (optional)
	3	**1**	**0**	

Course Objective: To impart knowledge of Metric spaces, complete, connected and Compactness, Riemann Integrals

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	The learning of the Taylor's theorem and it's wide use in expanding functions in polynomial and series form and also in maxima and minima of functions.
CO2	The learning of the basic concept of integration and to relate to their earlier knowledge of integration to the formal approach.
CO3	The learning of existence of Riemann Integrals.
CO4	Extending their knowledge of sequence and series convergence to the convergence of sequence of functions and series of functions.
CO5	Learning the concepts of sets of measure zero and its applications.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	0	2	2	3
CO2	3	0	2	2	3
CO3	3	0	2	2	3
CO4	3	0	2	2	3
CO5	3	0	2	2	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Taylor's theorem with Lagrange and Cauchy form of remainder, Taylor's series expansion of e^x, sinx, cosx, log(1+x), Relative extrema, criteria for convexity.	**9**
UNIT-2	Measure zero sets, concepts of almost everywhere, upper sum, lower sum, Definition of Riemann integrals, properties of Riemann integrals, existence of Riemann integrals.	**9**
UNIT-3	Riemann integrability of monotone and continuous functions, intermediate value theorem for integrals, fundamental theorem of calculus (first and second).	**9**
UNIT-4	Convergence of improper integrals of type first, second, mix type, Comparison tests, convergence of beta and gamma functions.	**9**
UNIT-5	Point wise and uniform convergence of sequence of functions, Theorems on interchange of limit and derivative and interchange of limit and integration of sequence of functions	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	R. G. Bartle, D. R. Sherbert, "Introduction to Real Analysis", John Wiley & Sons.	1992
2	Delinger, Charles, G.; Elements of Real Analysis, John and Bartlett (student Edition), 1st Indian Edition	2015
3	Ghorpade, Sudhir, R., Limaye, B.V.; A Course in Calculus and Real Analysis, Undergraduate text in Mathematics, Springer (SIE), 1st Indian Reprint	2013
4	W. Rudin, "Principles of Mathematical Analysis", McGraw Hill International.	1980
5	Richard Goldberg; Methods of Real Analysis, John Wiley & sons, Inc., New York, 2nd Edition	1976

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 206: Sampling Distribution and Hypothesis Testing	**L**	**T**	**P**	Elementary knowledge of Probability and Statistics
	3	**0**	**2**	

Course Objective: This course aims at giving the foundational knowledge of statistics covering the aspects of theory of estimation and testing of hypothesis. It will serve as a foundation course for students who are willing to learn machine learning.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Estimate the population parameter using the method of point estimation and interval estimation.
CO2	Analyzing the large sample testing and its applications.
CO3	Analyzing the small sample testing and its applications.
CO4	Describe various methodologies in small sample testing.
CO5	Comparing the variances across the means of different groups.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	2	2	2
CO3	3	3	3	2	2
CO4	3	3	2	1	1
CO5	3	3	3	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Population and Sample, Parameter and Statistics, Sample characteristic, Sampling Distribution of Mean and Variance, Unbiased and Consistent Estimator, Estimation of Parameters: Point Estimation and Interval Estimation, Application to normal population.	**9**
UNIT-2	Statistical Hypothesis, Null and Alternative hypothesis, Simple and Composite Hypothesis, Critical region, Type-I and Type-II errors, Level of Significance, One-tailed and Two-tailed tests, Best Critical Region, Neyman Hypothesis, Likelihood Ratio Testing, Procedure for testing the hypothesis, Tests of significance for large samples, Test of significance for single proportions, Test of significance for difference of proportions, Test of significance for single mean, Test of significance for difference of means, Test of significance for the difference of standard deviations.	**10**
UNIT-3	Derivation of the Chi-square distribution, M.G.F of Chi-square distribution, Application of Chi-square distribution: Inferences about a population variance, Goodness of Fit Test, Test of Independence of Attributes - Contingency Table.	**8**
UNIT-4	Student's 't' distribution: Derivation of Student's 't' distribution, Limiting form of t-distribution, t-test for single mean, t-test for difference of means. F-Distribution: Derivation of F-distribution, Mode and point of inflexion of F-distribution, F-test for equality of two population variances. Relation between t and F distributions, Relation between F and Chi-square distribution.	**10**
UNIT-5	Analysis of Variance: Introduction, Different sources of variation, Techniques in One-way, Two-way classified data.	**8**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	A. M. Goon, M. K. Gupta and B. Dasgupta: An Outline of Statistical Theory, Vol. I, 4th Edition. World Press, Kolkata	2003
2	S. C. Gupta, V. K. Kapoor, Fundamentals of Mathematical Statistics, Eleventh Edition, Sultan Chand and Sons	2012
3	A. M. Mood, F. A. Graybill and D. C. Boes: Introduction to the Theory of Statistics, 3rd Edition, Tata McGraw-Hill Pub. Co. Ltd	2007
4	R. V. Hogg and A. T. Craig: Introduction to Mathematical Statistics, Prentice Hall.	1978
5	R. E. Walpole, R. H. Myers, S. L. Myers, K. Ye, Probability and Statistics for Engineers and Scientists, Ninth Edition, Pearson Education	2013

PRACTICAL LIST	
S. No.	**List of Experiments**
1	Review of SPSS and Descriptive Statistics
2	Test for proportion (Binomial test)
3	Hypothesis Testing: One sample t test
4	Hypothesis Testing: Independent sample t test
5	Hypothesis Testing: Paired t test
6	Chi Square Test of Independence in contingency table
7	Chi Square Test for goodness of fit
8	Sign Test and Wilcoxon signed-rank test
9	ANOVA One Way
10	ANOVA Two Way

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 207: GEC – 4 Mathematical Transforms	**L**	**T**	**P**	Basic knowledge of several variable calculus
	3	**1**	**0**	

Course Objective: This course treats the foundations of different transform techniques that may require to solve problems in physics and engineering science.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Define Laplace transform and describe its application in the field of science and engineering.
CO2	Apply Fourier series to find the frequency information for the non-periodic functions.
CO3	Describe Fourier transform as a mathematical model that transforms the signal from frequency domain to time domain and vice versa.
CO4	Analyze a transform that produces a different set of n numbers, in a way that has a close relationship to the Fourier transform.
CO5	Analyze a transform that converts a discrete time signal into a complex valued frequency domain representation.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	2	1	1
CO2	3	1	2	1	1
CO3	2	1	1	1	1
CO4	3	1	2	1	1
CO5	3	1	1	1	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Definition, Existence of Laplace Transform, Basic Properties, Laplace transform of derivatives and Integrals, Inverse Laplace Transform, Differentiation and Integration of Laplace Transform, Convolution Theorem, Unit Step function, Periodic Function, Application of Laplace Transform to initial and boundary value problems	**10**
UNIT-2	Periodic Function, Fourier series, Dirichlet's Condition, Fourier series of function of period 2π and arbitrary period, Even and Odd functions, half range series, Numerical harmonic analysis.	**9**
UNIT-3	Fourier Transforms, Fourier Transform of Derivatives and Integrals, Application to boundary value problems in ordinary differential equations.	**9**
UNIT-4	Finite Fourier sine transforms, Inversion formula for sine transform, Finite Fourier cosine transform, Inversion formula for cosine transform, Examples	**9**
UNIT-5	The z transform, Basics of z transform theory, z transform and Difference Equations, Engineering Applications of z transform.	**8**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Phyl Dyke, An Introduction to Laplace Transforms and Fourier Series, 2nd Edition, Springer.	2014
2	J. W. Miles, Integral Transforms in Applied Mathematics, Cambridge University Press.	2008
3	Jain and Iyenger, Advanced Engineering Mathematics, Narosa Publication.	2003

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 208: GEC – 5 Linear Programming Problem	**L**	**T**	**P**	Basic concept of linear algebra
	3	**0**	**2**	

Course Objective: To develop a strong foundation in linear programming and its application in real-world problems.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Analyse any real life Linear programming system with limited constraints and depict it in a model form.
CO2	Solve linear programming problems using appropriate techniques and optimization solvers, interpret the results obtained.
CO3	Determine optimal strategy for Minimization of Cost of shipping of products from source to Destination/ Maximization of profits of shipping products using various methods, Finding initial basic feasible and optimal solution of the Transportation problems
CO4	Employ basic linear programing algorithms in a computational setting and apply existing software packages.
CO5	Employ the analytical and practical skills in real life acquired during the course.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	1	1
CO2	3	2	2	1	2
CO3	3	2	3	1	1
CO4	3	2	3	3	1
CO5	3	2	2	3	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Introduction of linear programming problem(LPP). Objective function, constraints and decision variables. Formulation of LPP, Matrix representation of constraints as well as objective, Two variables LPP model Graphical solution methods for maximization LPP and minimization LPP, infeasible solution, unbounded solution. More than two variable LPP: The theory of simplex method, Slack and surplus variables, detailed development, and computational aspects of the simplex method.	**9**
UNIT-2	Artificial variable Method, Big -M method, Two phase method for artificial variables, resolution of the degeneracy problem, the revised simplex method.	**9**
UNIT-3	Introduction to Duality theory, Dual linear programming problem and related duality theorems, Dual simplex algorithm, geometric interpretation, A primal dual algorithm.	**9**
UNIT-4	Integer Programming Problems: Problem formulation, mixed integer Programming Problems, Branch and Bound method, Cutting Plane algorithm.	**8**
UNIT-5	Introduction to transportation problem(TP), Mathematical formulation of TP and its solution, Bases in TP, Basic feasible solution, The stepping stone algorithm, Modi method, degeneracy in TP. Assignment Problem, Hungarian method for optimal solution of Assignment problem.	**10**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Hamdy A. Taha, Operations Research: An Introduction, Pearson Education Inc.	2007
2	Suresh Chandra, Jayadeva and Aparna Mehra, Numerical Optimization with Applications, Narosa Publication.	2008
3	Antonions amd L.W. Sheng, Practical Optimization and Engineering Application, New Age Publications.	2010
4	Frederick S. Hiller & Gerald J. Lieberman, Introduction to Operations Research, McGraw-Hill.	2009
5	G Hadley, Linear Programming, Narosa Publications.	1963

PRACTICAL LIST	
S. No.	**List of Experiments**
1	Formulate and solve a Linear Programming Problem (LPP) using the Graphical Method in TORA, analyzing all possible solution types (bounded, unbounded, and infeasible).
2	Solve an LPP using the Simplex Method in TORA, considering both maximization and minimization cases.
3	Implement and solve an LPP with artificial variables using the Big M Method and the Two-Phase Method in TORA.
4	Analyze and solve an LPP with degeneracy using the Simplex Method, and implement the Revised Simplex Method in TORA.
5	Formulate the dual of a given LPP and solve it using the Dual Simplex Method in TORA.
6	Interpret the concept of duality geometrically and validate the Duality Theorem using TORA.
7	Solve an Integer Programming Problem using the Branch and Bound Method in TORA.
8	Implement and apply the Cutting Plane Algorithm to solve an Integer Programming Problem using TORA.
9	Solve a Transportation Problem using TORA, obtaining an optimal solution.
10	Solve an Assignment Problem using TORA, determining the optimal assignment.

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 209: Series Solution and Special Functions	**L**	**T**	**P**	ODE
	3	**1**	**0**	

Course Objective: This course enables the students to understand how a variety of methods for discovering the properties of special functions, like beta and gamma function, Legendre polynomials, Bessel function and hypergeometric functions are useful in differential equations.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Use of series solution methods to solve first and second order differential equations and representing in polynomial and function forms.
CO2	Understand the Legendre differential equations and polynomials to applied in many physical problems involving spherical geometry and gravitation.
CO3	Analyse the wave propagation and static potentials using Bessel' function.
CO4	Use of Hypergeometric function gives the method how to express special functions and its numerous identities in terms of series and integrals.
CO5	Understand the concept of Beta and Gamma functions to solve many problems complex integral in mathematics and physics.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	0	1	2	3
CO2	2	0	1	2	3
CO3	3	0	1	2	3
CO4	2	0	1	2	3
CO5	2	0	1	3	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Series solutions of differential equations: Ordinary point, Singular point, regular singular point and irregular singular point, Power series method, Solution about regular singular point by Frobenius method.	**8**
UNIT-2	Legendre polynomials and functions: Solution of Legendre 's equation, Legendre functions of first and second kind, generating function, Rodrigue's formula of Legendre polynomial, Orthogonality of Legendre polynomials, Recurrence relations.	**10**
UNIT-3	Bessel Function: Solution of Bessel's equation, Bessel function, Recurrence formulae, Equations reducible to Bessel' equation, Generating function, Orthogonality of Bessel function, Trigonometric expansion involving Bessel functions, Bessel integral, Integral involving Bessel functions.	**10**
UNIT-4	Hypergeometric function: Hypergeometric series, Different form of Hypergeometric function, Derivative of hypergeometric function, Solution of hypergeometric function, Integral formula, Kummer's theorem, Gauss's theorem.	**8**
UNIT-5	Gamma and Beta Functions: Definition of Gamma Function, Elementary properties of Gamma Function, Transformation of Gamma function, Beta function, Evaluation of Beta function, Property of Beta function, Transformation of Beta function, Relation between Beta and Gamma functions, Dirichlet's integral.	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	E.D. Rainville, Special Functions, MacMillan Company, New York	1989
2	I.N. Sneddon: Special Functions, Mc-Graw Hill, New Delhi	1956
3	N.N. Lebedev, Richard A Silverman: Special Functions and their Applications, Dover Publications	1972
4	George E. Andrew, Richard Ashkay and Ranjan Roy, Special Functions, CUP	1999
5	J.N. Sharma and R.K. Gupta, Special Functions, Krishna Prakashan	1992

Department of Applied Mathematics
Delhi Technological University,
(Formerly Delhi College of Engg.)

Details of Course:

Course Title	Course Structure			Pre-Requisite
IMSMA 210: Data Structure	**L**	**T**	**P**	Basic Mathematics and Discrete structures
	3	**0**	**2**	

Course Objective: To introduce the concept of complexity of algorithms and to introduce different kinds of data structures with their respective operations.

Course Outcome (CO): After successful completion of the course, students shall able to

CO1	Define and illustrate different data structures.
CO2	Design algorithms to create, manipulate, and analyze data structures.
CO3	Analyze, estimate, and compare the performance of various operations performed on the data structures.
CO4	Explain and evaluate various sorting techniques to sort the data.
CO5	Illustrate and develop the usage of hashing functions and collision resolution techniques.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	1	0	0
CO2	3	2	2	1	2
CO3	3	2	1	1	1
CO4	3	3	3	1	2
CO5	3	1	3	1	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S.No.	Contents	Contact hours
UNIT-1	**Introduction:** Abstract data types, design, implementation and applications. Introduction to Algorithm, Time complexity and Space complexity Trade-off. Introduction to Arrays and Strings: Representation of Arrays in Memory: one-dimensional, Two-dimensional and Multidimensional, operations on array. Strings and String Operations. **Stacks:** Introduction, Operations on Stacks, Array representation of Stacks, Applications of Stacks, recursion, Polish expression and their compilation conversion of infix expression to prefix and postfix expression. **Queues:** Introduction, Operations of Queues, Representations of Queues Applications of Queues, Priority queues.	**10**

UNIT-2	**Linked Lists:** Singly linked lists, Representation of linked list, Operations of Linked list such as Traversing, Insertion and Deletion, Searching, Applications of Linked List, Concepts of Circular linked list and Doubly linked list and their Applications, Implementation of Stacks and Queues using linked list.	**9**
UNIT-3	**Trees and Graphs:** Binary trees, Binary search trees, and various operations on Binary search trees like traversing, searching, insertion, and deletion. Applications of Binary search Trees, Complete Binary trees, and Extended Binary Trees. AVL trees, Threaded trees, General trees, B trees, B+ trees. Introduction to types of graphs, graph representation and traversal, shortest path, and transitive closure, Spanning trees.	**10**
UNIT-4	**Sorting:** Insertion Sort, Quicksort, Merge sort, Heap sort, sorting on different keys, External sorting.	**8**
UNIT-5	**File Structure:** File Organization, Indexing & Hashing, Hashing Functions, Collision Resolution Techniques.	**8**
	TOTAL	**45**

References:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1	Horowitz, E., Sahni, S., & Anderson-Freed, S. *Fundamentals of Data Structures in C*. Silicon Press, 2nd Edition, ISBN: 978-0929306407.	2007
2	Tenenbaum, A. M., Langsam, Y., & Augenstein, M. J. *Data Structures Using C*. Prentice Hall, ISBN: 978-0131997462.	1989
3	Tremblay, J. P., & Sorenson, P. G. *An Introduction to Data Structures with Applications*. McGraw-Hill, 2nd Edition, ISBN: 978-0070651579.	1984
4	Kruse, R. L., Leary, B. P., & Tondo, C. L. *Data Structures and Program Design in C*. Prentice Hall, ISBN: 978-0137256495.	1991

PRACTICAL LIST	
S. No.	**List of Experiments**
1	Write a program to implement traversal, insertion, and deletion of elements in a linear array.
2	Write a program to: a. Fetch a substring from a string, find its position and length of the substring. b. Replacement of 1 string with another. c. Concatenation of 2 strings.
3	Write a program to: a. Implement stack using arrays (push & pop). b. Evaluate arithmetic expression by converting it from infix and postfix. c. Check for balanced parentheses in an expression.
4	Write a program to implement a linear queue using arrays.
5	Write a program to implement linear queues, circular queues, and priority queues.
6	Write a program to implement a singly linked list, doubly linked list, and circular linked list (Searching, Insertion, Deletion).
7	Write a program to perform linear search and binary search in an array.
8	Write a program to perform insertion, deletion, and traversal in a binary search tree and threaded binary tree.
9	Write a program to perform Insertion sort, Quicksort, and Merge sort.
10	Write a program to perform Depth First Traversal and Breadth First Traversal.

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 211: Discrete Mathematics	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To provide knowledge of combinatorial problems, logic, lattices, Boolean algebra and graph theory.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Apply concepts of sets, relations, functions, and recurrence to analyze mathematical structures and model complex relationships.
CO2	Utilize propositional and predicate logic to construct and evaluate logical statements, truth tables, and inference rules for effective problem-solving.
CO3	Analyze and implement properties of lattices and Boolean algebra to simplify and represent logical expressions in computational contexts.
CO4	Apply graph theory concepts, including algorithms for shortest paths, spanning trees, and graph coloring, to solve real-world problems involving networks and structures.
CO5	Understand the working of finite automata, grammars, Turing machines, and apply them to recognize formal languages and classify computational models.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	0	1	1	3
CO2	2	0	3	1	3
CO3	3	0	2	1	3
CO4	3	0	2	3	3
CO5	3	0	2	3	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Sets, relations, operations on relations, equivalence relation, equivalence classes, partial order relation, Hasse diagram, functions, recursive functions, Numeric function, Generating function and recurrence relation.	**9**
UNIT-2	Proposition, compound propositions, well-formed formulae, truth tables, tautology, contradiction, equivalence, algebra of proposition, normal forms, theory of inference, predicate logic: predicates, quantifiers, free and bound variables, theory of inference for predicates.	**9**
UNIT-3	Definition of Lattice, Properties of lattice, complete, bounded, complemented and distributive lattices, sub lattice, direct product of two lattices, Definition and properties of Boolean algebra, homomorphism, Boolean expression and representation.	**9**
UNIT-4	Graph terminology, Sub-graphs, Types of graphs, Graph isomorphism, Operations on graphs, Walk, Path and Cycle, Shortest path algorithm (BFS & Dijkstra's), Eulerian and Hamiltonian graphs, Tree, Spanning tree, Minimal spanning tree, Kruskal's and Prim's algorithm, Graph coloring, chromatic number and Matching.	**9**
UNIT-5	Deterministic and non-deterministic finite automata (DFA& NDFA), Acceptability of a string by FA, equivalence of DFA and NDFA, Minimization of FA.	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	K. H. Rosen, Discrete Mathematics and its Applications, Tata McGraw-Hill.	2001
2	J. P. Tremblay and R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, Tata McGraw-Hill.	1993
3	C. L. Liu, Elements of Discrete Mathematics, 4th Edition, Tata McGraw-Hill.	2017
4	E. G. Goodaire and M. M. Parmenter, Discrete Mathematics with Graph Theory 2nd Edition, Pearson Education (Singapore) Pvt. Ltd., Indian Reprint 2003.	2003
5	N. Deo, Graph theory with Applications to Engineering and Computer Science, PHI.	2004

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 212: Fuzzy Set Theory	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To impart fundamental concepts of fuzzy sets, numbers, relations, and logic for handling uncertainty in decision-making.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Classify vagueness and uncertainty in the systematic approach.
CO2	Analyse different applications based on fuzzy model, representing vague knowledge and describe the impact on popular dynamical systems.
CO3	Identify the fuzzy logic and fuzzy inference systems and make applications on Fuzzy logic membership function and fuzzy inference systems.
CO4	Design fuzzy-logic based controllers and list their unique characteristics.
CO5	Apply relevant software packages to analytical and practical skills gained during the course to real life and engineering problems.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	2	2	1
CO2	3	2	2	3	2
CO3	1	2	0	2	0
CO4	3	3	1	3	2
CO5	1	2	1	2	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Fuzzy Sets: Basic concepts, fuzzy sets versus crisp sets, operations on fuzzy sets, complements, intersections, unions and their combinations, Types of membership function. Alpha- cut and their properties.	9
UNIT-2	Fuzzy numbers: Introduction and properties of fuzzy number, triangular fuzzy numbers, trapezoidal fuzzy numbers, operations on fuzzy numbers, approximation and error, fuzzy equations and their solutions.	9
UNIT-3	Defuzzification: Mean of Maximum (MOM) method, Centre of area (COA) method, The height method, Centre of maxima method.	9
UNIT-4	Fuzzy Relation: Fuzzy function, type of fuzzy functions, extrema of fuzzy function, integration and differentiation of fuzzy functions. fuzzy relation, Crisp versus fuzzy relations, binary fuzzy relation, equivalence relation, compatibility relation, ordering relation, fuzzy morphisms.	9
UNIT-5	Fuzzy Logic: Classical logic verses fuzzy logic, fuzzy propositions, fuzzy quantifiers, linguistic hedges, conditional fuzzy propositions, fuzzy quantifiers.	9
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	G. J. Klir, Bo Yuan ,Fuzzy Logic Theory and Applications, , Fuzzy Sets and, Prentice Hall of India Pvt. Ltd.	1995
2	H. J. Zimmerman, Fuzzy Set Theory and its Applications, Fourth edition, Springer.	2012
3	S. Chandra, A. Mehra, A. Aggarwal, Fuzzy Sets and Applications, 1st Edition, Narosa Publishing House.	2024
4	T. J. Ross, Fuzzy Logic with Engineering Applications, Third edition, Wiley.	2013

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 213: Theory of Equations	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: The aim of this course is to provide the knowledge of solving the higher degree equations.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Explain the general properties of the equations.
CO2	Explain the concept of symmetric functions of the roots.
CO3	Describe the transformation of equations.
CO4	Explain Descarte's rule of sign.
CO5	Explain Cardon's and Ferrari's method of solving the cubic and biquadratic equation respectively

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	0	1	0	1
CO2	1	0	1	0	1
CO3	1	0	1	0	1
CO4	1	0	1	0	1
CO5	1	0	1	0	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Polynomial Equation, Zeros or roots of an Equation, Identity, Division Algorithm, Remainder Theorem, Factor Theorem, Method of synthetic division, Common roots, Equal roots, Fundamental theorem of Algebra, Sum of Powers of roots	**8**
UNIT-2	Relations between the roots and coefficients of a polynomial equation of the nth degree, Application to solution of an equation, Condition that the roots of an equation may satisfy a given relation among the roots, Symmetric functions of the roots, Order of a symmetric function, Weight of a symmetric function, Rule to find the number of terms in any symmetric function.	**10**
UNIT-3	Roots with signs changed, Roots multiplied by a given number, Reciprocal roots, Reciprocal Equation, To diminish the roots by a given number, Removal of terms, Equation with binomial coefficients, Nature of the roots of the given cubic.	**9**
UNIT-4	Character and position of the roots of an equation, Change of sign, Continuation of sign, Descarte's rule of sign, Complex roots from Descarte's rule of sign, Multiple roots.	**9**
UNIT-5	Cardon's method of solving the cubic equation, Nature of roots of the cubic equation, Descarte's method of solving the biquadratic equation, Ferrari's method of solving the biquadratic equation.	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1.	Hari Kishan; Theory of Equations, Atlantic Publisher	2022
2.	J. G. Chakravorty and P. R. Ghosh; Advanced Higher Algebra, 14th Edition, U. N. Dhur and Sons Private Ltd.	2023
3.	L. E. Dickson; First course in the Theory of Equations, John Wiley and Sons.	2009

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 214: Dynamics	**L**	**T**	**P**	NIL
	3	1	0	

Course Objective: This course aims to give an introduction to the study of dynamics of a particle through analytical methods.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Introduce the basic concept of dynamics.
CO2	Analyze the rectilinear motion and simple harmonic motion of a particle.
CO3	Describe the work done by a variable force and impulse of a force.
CO4	Describe the motion of a particle under central forces.
CO5	Apply the concept of central forces to describe the planetary motion.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	0	2	1	1
CO2	3	0	2	1	2
CO3	3	0	2	1	1
CO4	3	0	2	1	1
CO5	3	0	2	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Definitions: Mass, Particle, Displacement, Speed, Velocity, Uniform velocity, Acceleration, Retardation; Analytical expression for velocity and acceleration for motion in a straight line, Composition and resolution of velocities and accelerations, Relative velocity, Newton's law of motion, Polar coordinates	9
UNIT-2	Rectilinear motion with uniform acceleration, Field of forces, Equation of motion, Motion of a particle under attractive forces, Simple harmonic motion, Composition of two simple harmonic motion in the same straight line, Elastic Strings, Dynamical system, Harmonic Oscillator, Effect of a disturbing force, Damped Oscillation	9
UNIT-3	Work, Work done by a variable force, Work done in stretching an elastic string, Power, Energy, Conservative forces, Conservation of energy, Impulse of a force, Impulsive forces	9
UNIT-4	Central forces, Areal Velocity, Angular momentum and Kinetic energy, Motion of a particle under central force, Law of force for an elliptic orbit, Velocity under central forces, Orbit under radial and transverse acceleration.	9
UNIT-5	Newtonian Law, Orbit described under inverse square law, Planetary orbit in polar equation, Kepler's law of planetary motion, Deductions from Kepler's laws, More accurate form of Kepler's third law.	9
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	David Luenberger, Introduction to Dynamic Systems: Theory, Models, and Applications, 1st Edition, Wiley.	1979
2	Lawrence Perko, Differential Equations and Dynamical Systems, Second Edition, Springer.	1996
3	A. S. Ramsay, Dynamics, Cambridge University Press.	2010
4	J. G. Chakravorty and P. R. Ghosh, Advanced Analytical Dynamics, 12th Edition, U. N. Dhur & Sons Private LTD.	2016
5	A. Katok and B. Hasselblatt, Introduction to the Modern Theory of Dynamical Systems, Cambridge University Press	1995

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
ISEMA 201: SEC-3 LaTeX Typesetting for Beginner's	**L**	**T**	**P**	NIL
	0	**0**	**4**	

Course Objective: To acquire knowledge of Typing scientific papers.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Demonstrate foundational skills in LaTeX by creating structured documents, applying text formatting, and organizing content using a Table of Contents, List of Figures, and List of Tables. (Understanding and Applying)
CO2	Apply LaTeX for mathematical and structural formatting by typesetting complex expressions, multi-line equations, tables, images with captions, and using theorem and proof environments for technical documents. (Applying and Analyzing)
CO3	Manage and integrate references and citations with BibTeX, create bibliographies in different citation styles, and use advanced LaTeX packages (e.g., geometry and amsmath) to customize document layouts. (Applying and Creating)

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	3	3	2	1
CO2	1	3	3	2	2
CO3	1	3	3	1	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents
UNIT-1	Basics of LaTeX and document formatting. Structure of a LaTeX document, preamble, document classes and sectioning. Text formatting (fonts, bold, italics, lists) and creating title pages with elements like title, author, date, and abstract. Generating a Table of Contents, List of Figures, and List of Tables.
UNIT-2	Mathematical and structural formatting. Typeset algebraic expressions, multi-line equations, matrices, summations, and integrals using the align environment. Practice creating tables and inserting images with captions. Explores theorem, definition, and proof environments for technical document formatting
UNIT-3	cover references, citations, and advanced LaTeX features. Manage citations using BibTeX and create bibliographies in various citation styles. Learn to use LaTeX packages like geometry and amsmath for document customization

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	"LaTeX Beginner's Guide" (2nd Edition) by Stefan Kottwitz, published by Packt Publishing	2021
2	"More Math into LaTeX" (5th Edition) by George Grätzer, published by Springer	2016
3	"The LaTeX Companion" (2nd Edition) by Frank Mittelbach, Michel Goossens, Johannes Braams, David Carlisle, and Chris Rowley, published by Addison-Wesley Professional	2004

PRACTICAL LIST	
S. No.	**List of Experiments**
1	Create a simple "Hello, World!" document.
2	Create a formatted document with various text styles and lists.
3	Generate a document with a title page and an abstract section.
4	Produce a document with a TOC, list of figures, and list of tables.
5	Create a document with basic inline and display math expressions
6	Format complex mathematical expressions in a document.
7	Design a document containing structured tables and positioned images
8	Format a document with theorem statements, definitions, and proofs
9	Build a document with citations and a bibliography
10	Create a well-structured document, integrating all learned techniques for a final project (e.g., a short research paper or report)

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
ISEMA 202: SEC-4 Programming with Python	**L**	**T**	**P**	Basic computer knowledge
	0	**0**	**4**	

Course Objective: To introduce fundamentals of programming using Python and understand the concepts of the program.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Identify and recall the fundamental syntax, operators, and data structures in Python, such as variables, arithmetic operators, strings, lists, and dictionaries.
CO2	Explain how Python functions, expressions, and statements work together to produce desired outcomes, and describe the flow of execution in basic programs.
CO3	Apply Python programming techniques to develop simple applications using loops, conditionals, and error handling to solve practical problems.
CO4	Analyze the behavior of Python programs, including stack diagrams, recursion, and scope, to identify potential errors and optimize code for efficiency.
CO5	Design and develop complex Python programs incorporating object-oriented principles such as classes, inheritance, and custom exceptions to address real-world challenges.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	1	2
CO2	3	2	1	1	2
CO3	3	2	1	1	2
CO4	3	2	1	1	2
CO5	3	2	1	1	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S.No.	Contents
UNIT-1	Introduction to Python: Arithmetic Operators, Variables, Expressions and Statements in Python, Function Calls, Parameters and Arguments, Infinite Recursion and Stack Diagrams, Logical Operators, Conditional and Alternative Execution, Iterations in Python.
UNIT-2	Strings and Dictionaries in Python: Immutable Strings, String Methods and Comparison, Mutable Lists, List Operations and Methods, Concept of Dictionary and Looping, Reverse Lookup, Immutable Tuples, Tuples as Return Values, Concepts of Namespaces and scope.
UNIT-3	Error handling and Files in Python:. Error handling using try and except, Create your own exceptions, Filenames and Paths, Persistence, Reading and Writing, Catching Exceptions, Attributes. Object Oriented Concepts in Python: Introduction to Classes and Methods, Mutable Objects, Classes and Functions, Pure Functions, Modifiers, Inheritance

References:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1	Deitel, P., & Deitel, H. *Intro to Python for Computer Science and Data Science*. Pearson Education, ISBN: 978-9353949518.	2020
2	Barry, P. *Head First Python*. O'Reilly, 3rd Edition, ISBN: 978-1492051299.	2023
3	Matthes, E. *Python Crash Course: A Hands-on, Project-based Introduction to Programming*. No Starch Press, 3rd Edition, ISBN: 978-1718502703.	2023
4	Brown, M. C. *Python: The Complete Reference*. McGraw Hill Education, 4th Edition, ISBN: 978-9387572942.	2018

PRACTICALS LIST	
S. No.	**List of Experiments**
1	Write a program to determine whether the given three coordinates ((x1, x2), (y1, y2) and (z1, z2)) are collinear or not.
2	write a program to print the prime numbers between 1 to N.
3	Write a program to print Fibonacci series using a for loop.
4	Write a program to declare variables of string data type and perform different operations on them.
5	Write a program to create, insert and delete Lists.
6	Write a program to create, insert and delete Dictionaries.
7	Write a program to create, insert and delete Sets and Tuples.
8	Write a program which utilizes a user defined function search_list that takes a list of values as arguments and searches for a particular number in the list.
9	Write a program to implement the Rock Paper Scissors game.
10	Write a program for the division of two numbers where the denominator is 0. This will throw an exception and handle the exception using try and except.
11	Write a program that can create your own exceptions.

Department of Applied Mathematics
Delhi Technological University,
(Formerly Delhi College of Engg.)

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
	L	T	P	
ISEMA 203: SEC-3 Statistics With R	0	0	4	Basic knowledge of Statistics

Course Objective: To enhance the skills of students in R programming Language.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Apply data entry in R for Analysis.
CO2	Calculate the statistical measures of the data using R.
CO3	Apply statistical techniques for analysis of Data using R.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	2	2
CO2	3	2	3	2	2
CO3	3	2	3	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents
UNIT-1	Descriptive statistics: Variables and data, Types of data, Arranging of data set arrangement, define and determine the statistical measures: minimum & maximum value, mean, median, mode, quartiles, etc. Representation of data using Pie chart, Box plot and Bar diagram.
UNIT-2	Variance, Covariance, Correlation and coefficient of correlation.

PRACTICAL LIST	
S. No.	**List of Experiments**
1	Introduction to R: Installation
2	Understanding of underlying features of the software.
3	Import of Data Set to R script Editor
4	Generation of Data using R script
5	Exporting/ save of data and result.
6	Creating of frequency tables
7	Pictographic representation of data using Bar diagram, Box Plot and Pie chart
8	Drawing of Histogram and distribution curve
9	Descriptive Statistics
10	Correlation coefficient between two random variables.

Department of Applied Mathematics
Delhi Technological University,
(Formerly Delhi College of Engg.)

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
	L	T	P	
ISEMA 204: SEC-4 Introduction to SPSS	0	0	4	Basic knowledge of Statistics

Course Objective: To enhance the skills of students in SPSS for statistical analysis.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Apply data entry in SPSS for further Analysis
CO2	Calculate the statistical constants of the data using SPSS
CO3	Apply statistical techniques for analysis of Data using SPSS

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	2	2
CO2	3	2	3	2	2
CO3	3	2	3	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents
UNIT-1	Descriptive statistics: Variables and data, Types of data, Arranging of data set arrangement, define and determine the statistical measures: minimum & maximum value, mean, median, mode, quartiles, etc. Representation of data using Pie chart, Box plot and Bar diagram.
UNIT-2	Variance, Covariance, Correlation and coefficient of correlation.

PRACTICAL LIST	
S. No.	**List of Experiments**
1	Introduction to SPSS: Installation
2	Understanding of underlying features of the software.
3	Import of Data Set to SPSS script Editor
4	Generation of Data using SPSS script
5	Exporting/ save of data and result.
6	Creating of frequency tables
7	Pictographic representation of data using Bar diagram, Box Plot and Pie chart
8	Drawing of Histogram and distribution curve
9	Descriptive Statistics
10	Correlation coefficient between two random variables.

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 223: GEC – 3 Basic Probability and Statistics	**L**	**T**	**P**	NIL
	2	**0**	**0**	

Course Objective: To impart knowledge on the characteristic of the data and probability theory.

Course Outcomes (CO): After successful completion of the course, students shall able to

CO1	Classify different types of data and summarize its main features.
CO2	Describe measures of central locations and dispersions.
CO3	Describe special types of probability distributions like Binomial and Poisson.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	1	1
CO2	3	2	1	1	1
CO3	3	2	1	1	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Types of data: quantitative and qualitative data, discrete and continuous. Presentation of data: tabular and graphical. Frequency distributions, cumulative frequency distributions Graphical representations: Bar diagram, Pie chart, Histogram, Frequency curve, cumulative frequency curve (Ogive). Measure of Central Tendency: Mean, Median, Mode, percentile, quartile, Range, Mean deviation, Standard deviation, Coefficient of variation. Moments, skewness and kurtosis.	**10**
UNIT-2	Random Experiment, Sample Spaces, Events, Definitions of Probability (Classical, Frequency, and Axiomatic), Conditional Probability, Independent Events, Mutually Exclusive Events, Baye's Theorem, Simple Problems, Random Variables and its Distribution Function, Definition and Properties, Probability mass and Density Function, Probability density curve, Joint, Marginal and Conditional Distributions, Mathematical expectation, Binomial and Poisson Distribution.	**12**
	Total	**22**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Meyer, Introductory Probability and Statistical Application, Oxford and IBH Publishing.	2002
2	Sheldon M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Academic Press.	2009
3	Probability and statistics for Engineers, Richard A. Johnson, Irwin Miller, John Freund, PHI	2010
4	S. C. Gupta and V. K. Kapoor, Fundamentals of Mathematical Statistics, 12th Edition, S. Chand and Sons, Delhi	2020
5	A. M. Goon, M. K. Gupta and B. Dasgupta, Fundamentals of Statistics, 8th Edition, The World Press.	2016

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 301: Metric Spaces	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To provide knowledge about the concept of distance and its ramifications in analysis.

Course Outcomes (CO):

CO1	Describe abstract properties of distance (metric) and example of metric spaces.
CO2	Understand the notion of continuity and uniform continuity in the class of metric spaces.
CO3	Understand the notion of connectedness in metric spaces.
CO4	Analyze the property of closed and bounded sets and the notion of compactness in Metric spaces.
CO5	Apply the connectedness and compactness in proving the intermediate value theorem and maximum-minimum value theorem.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	0	1	1	0
CO2	2	0	1	1	0
CO3	2	0	2	1	0
CO4	2	0	1	2	0
CO5	2	0	1	1	0

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Metric spaces: definition and examples, convergent sequences, Cauchy sequences, completeness.	**9**
UNIT-2	Open spheres neighbourhood, open set, interior of a set, limit point of a set, closure, closed set, diameter of a set, Cantor's intersection theorem, subspaces, products, dense sets, separable spaces.	**9**
UNIT-3	Continuous mappings, characterizations of continuity, uniform continuity, homeomorphism, contraction mapping, Banach fixed point theorem.	**9**
UNIT-4	Connectedness, connected subsets of the real line, continuous mapping and connectedness.	**9**
UNIT-5	Compactness, compactness and boundedness, continuous mapping and compactness.	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Satish Shirali and HariKishan L. Vasudeva, Metric Spaces, Springer Verlag, London (2006)	2009
2	Micheal O Searcoid, Metric Spaces, Springer Verlag, London Limited	2007
3	G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill	1963
4	W. Rudin, Principles of Mathematical Analysis, McGraw-Hill International book company, Auckland	1985
5	A. Brown and C. Pearcy, An Introduction to Analysis (GTM), Springer Verlag, New York	1995

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 302: Topology	**L**	**T**	**P**	Basics of Real Analysis
	3	**1**	**0**	

Course Objective: To impart knowledge of Topological Spaces, Connectedness, Compact Spaces, Countability axioms, etc.

Course Outcomes (CO):

CO1	Describe topological spaces and their properties.
CO2	Analyze and prove properties of subspaces and relative topologies, including their relationships with the parent topological space and their topological properties.
CO3	Integrate different concepts of topology like continuity, connectedness, components, etc. in an effective manner to arrive at new and innovative concepts.
CO4	Explain the concepts of compactness, countability axioms and separation axioms and relate them.
CO5	Illustrate how topological properties such as compactness, connectedness, and continuity behave in product spaces, and being able to prove basic results related to these properties.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	2	1	2
CO2	3	1	2	1	2
CO3	3	1	2	1	2
CO4	3	1	2	1	2
CO5	3	1	2	1	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Topological Spaces, The order topology, Local Base at a point, Base for a Topology, Limit points, Interior, Exterior and Frontier points, Separable Spaces, Subspaces.	**9**
UNIT-2	Continuity, Homeomorphism, Separated sets, Connectedness, Components, Locally Connected Space.	**9**
UNIT-3	Compact spaces, Compactness in R, Countable Compactness, Local Compactness, One Point Compactification.	**8**
UNIT-4	Countability axioms, Separation axioms, Urysohn's Lemma, Urysohn's metrization theorem, Tietzeex tension theorem.	**10**
UNIT-5	Product Space of two Spaces, General Product Spaces (Tych on off Topology), Product Invariant Properties, Tych on off Theorem, Stone-Cech compactification.	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	G.F. Simmons Introduction to Topology and Modern analysis, G. Mc-Graw Hill International Edition	2016
2	James R. Munkres, Topology, Second edition, Prentice Hall of India	2002
3	S.T. Hu, Elements of General topology, Holden-DayInc	1964
4	J.G. Hocking and G.S. Young, Topology, Addison-Wesley	1961

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 303: Stochastic Processes	**L**	**T**	**P**	Probability and Statistics
	3	**1**	**0**	

Course Objective: This course develops the mathematical theory of random variables and random processes for Telecom Engineers. The goal is to teach theoretical concepts and techniques for solving problems that arise in practice. Beginning with the random variables, this course leads to the concept of stochastic process and linear filtering of random processes.

Course Outcomes (CO):

CO1	Identify the type of the random process associated with the physical phenomena and model the process
CO2	Apply random processes concepts to solve engineering and other related problems.
CO3	Model the physical situation for multidisciplinary problems/fields to suitable random processes and analyze that for better project management and finance.
CO4	Justify computing skills using MATLAB/SPSS to design and analyze different stochastic processes.
CO5	Critique the assumptions underlying stochastic models and their implications on the validity of results.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	1	2	1	1
CO2	0	1	2	1	3
CO3	0	1	2	2	3
CO4	0	0	2	1	2
CO5	0	3	2	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Stochastic processes: Introduction, Classification and examples of stochastic processes such as Bernoulli process, Poisson process, Gaussian process, Renewal process, Stationary process, Brownian motion.	**10**
UNIT-2	Random Walk: Introduction and examples, simple random with unrestricted, two absorbing barriers, one absorbing barrier, two reflecting barriers and one reflecting barrier.	**9**
UNIT-3	Poisson Processes: Definition and properties of Poisson processes, Arrival rate and inter-arrival times, Superposition and thinning of Poisson processes, Applications in modelling arrival phenomena.	**9**
UNIT-4	Discrete time Markov chain: Definition, n-step transition probability, States classification, Limiting probabilities, Distribution of times between states, Irreducible finite chains with aperiodic states, Reducible chains (Finite Markov chains with absorbing states).	**10**
UNIT-5	Introduction to Queues, M/M/1, M/M/c and Erlang loss models. Steady state solutions.	**7**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Kishor S. Trivedi, Probability and Statistics with Reliability, Queueing and Computer Science Applications, Wiley.	2001
2	Sheldon Ross, Stochastic Processes, Wiley.	1995
3	Frank Beichelt, Stochastic Processes in Science, Engineering and Finance, Chapman & Hall.	2006
4	Cox and Miller, Theory of Stochastic Processes, Chapman & Hall.	1977

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 304: Complex Analysis	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To impart knowledge of Harmonic Functions, Power Series expansions, Entire functions, etc.

Course Outcomes (CO):

CO1	Explain algebra of complex numbers, the geometry of the complex plane, and stereographic projection, including the Riemann Sphere. (Cognitive Level: Understand, Apply)
CO2	Analyze analytic and conformal functions. Solve problems involving Cauchy-Riemann equations, harmonic functions, Mobius transformations, and their geometric properties, including conformal mappings. (Cognitive Level: Analyze, Apply)
CO3	Evaluate Complex Integrals, Employ Cauchy's integral theorem, Cauchy integral formula, and residue calculus to evaluate complex integrals, including standard integral types. (Cognitive Level: Apply, Evaluate)
CO4	Classify singularities and zeros of complex functions, expand functions in Taylor and Laurent series, and utilize theorems such as Riemann's removable singularity theorem and Casorati-Weierstrass theorem. (Cognitive Level: Analyze, Evaluate)
CO5	Apply advanced theorems like Rouche's theorem, the Argument Principle, and the Maximum Modulus theorem to solve problems in complex analysis. Generalize these results to broader mathematical contexts, including the behaviour of mappings and lemmas like Schwarz's. (Cognitive Level: Apply, Evaluate)

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	0	1	1	0
CO2	2	0	1	2	0
CO3	3	0	1	1	0
CO4	2	0	0	1	0
CO5	3	0	0	2	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Algebra of complex numbers, the complex plane, polynomials, power series, transcendental functions.	**7**
UNIT-2	Analytic functions, Cauchy-Riemann equations, Mobius transformation, conformal mappings.	**10**
UNIT-3	Cauchy's integral theorem, Cauchy integral formula, Morera's theorem, Cauchy's inequality, entire functions, Liouville's theorem, power series expansion for an analytic function, fundamental theorem of algebra.	**9**
UNIT-4	Singularities, Laurent Series, Riemann's removable singularity theorem, Casorati-Weierstrass theorem, residue theorem and its applications, evaluation of standard types of integrals by the residue calculus method.	**10**
UNIT-5	Argument principle, Rouche's theorem, Maximum modulus theorem, open mapping theorem, zeros of analytic functions, identity theorem, Schwarz's lemma.	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1.	Churchill, R.V. and Brown, J.W.; Complex Variables and Applications, McGraw Hill International, 8th Edition.	2002
2.	Complex Analysis, Pearson.	1979
3.	J. B. Conway; Functions of One Complex Variable, Narosa, New Delhi	2009
4.	L. V. Ahlfors, Complex Analysis, McGraw Hill, 3rd Edition.	2012

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 305: Partial Differential Equations	**L**	**T**	**P**	Basic knowledge of calculus, ODE and multivariable functions
	3	**1**	**0**	

Course Objective: To impart the knowledge of partial differential equations and to analyze and solve the physical problems.

Course Outcomes (CO):

CO1	Understand the formation of PDEs and identify the type the first-order linear and non-linear PDEs and its applications.
CO2	Familiarize with linear second and higher order PDEs and classify PDEs, apply analytical methods and physically interpret the solutions.
CO3	Demonstrate capacity to model physical phenomena like heat equation and apply Duhamel principle and D'Alembert method to find the solution.
CO4	Understand the initial and boundary value problems in solving the wave equation.
CO5	Demonstrate capacity to solve physical problems of Laplace and Poisson equations.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	1	1	1	1
CO2	1	1	1	1	2
CO3	3	2	1	2	2
CO4	3	2	1	2	2
CO5	3	2	1	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
Unit -1	Partial differential equations (PDEs):Order and degree of differential equations, Formation of PDEs, Linear and Quasi-linear(Lagrange form) first-order PDEs, Cauchy's problem of first-order PDEs, Integral surfaces, Non-linear first-order PDEs: Standard forms and Charpit's method, Jacobi method.	**9**
UNIT-2	PDE of Second and Higher orders: Linear homogenous and non-homogeneous equations with constant coefficients, Homogeneous Linear PDE with variable coefficients, Classification of second order PDEs, Characteristic equations and characteristic curves, Canonical (Normal) form, Monge's method for second order PDEs, method of separation of variables, Initial and boundary value problems.	**10**
UNIT-3	Parabolic equations: One and two-dimensional heat equations, Fourier series solution of heat equations, The maximum and minimum principles, Duhamel's principle.	**8**
UNIT-4	Hyperbolic equations: One and two- dimensional wave equations, Fourier series solution of wave equation, D'Alembert solution of wave equation, solutions of finite vibrating string.	**8**
Unit -5	Elliptic equations: Boundary value problems for Laplace and Poisson equations, maximum and minimum principle, Poisson integral formula, Dirichlet's problem for upper half plane and cube, Neumann problem for a rectangle and upper half plane.	**10**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	K. S. Rao: Introduction to Partial Differential Equations, PHI	2011
2	Walter A. Strauss: Partial Differential Equations: An Introduction, 2nd Ed., John Wiley	2008
3	Peter V.O'Neil: Partial Differential Equations, 3rd Ed., Wiley publication	2014
4	I.N. Sneddon: Elements of Partial Differential equations, Dover Publications	2006
5	Dennis G. Zill: Differential equation with boundary value problem, 8th Ed., Brooks Cole	2012
6	Paul Duchateau and David W. Zachmann: Schaum's outlines Partial Differential Equations, Tata McGraw-Hill	2005
7	Stanely J. Farlow: Partial Differential Equations for Scientist and Engineers, Dover Publication	2003

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 306: GEC-8 Econometrics	**L**	**T**	**P**	Elementary knowledge of Statistics
	3	**1**	**0**	

Course Objective: This course aims to provide numerical values to the parameters of economic relationships using the concept of statistics.

Course Outcomes (CO):

CO1	Explain the concept of Econometric, Econometric models and other related concepts.
CO2	Explain theoretically the model of classical least squares.
CO3	Identify the problems occurred in regression analysis.
CO4	Analyse the situation when non-linearity is there in the regression model.
CO5	Explain panel data regression models.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	0	1	1	1
CO2	1	0	1	1	1
CO3	2	0	1	2	1
CO4	2	0	1	3	1
CO5	2	0	1	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Introduction to Econometrics, Econometric models, Aims of Econometrics, Econometrics and Statistics, Types of data, Aggregation Problem, Econometrics and Regression Analysis, Introduction to Econometric Analysis, Different steps in Econometric Analysis, Desirable properties of the estimates of the population parameters.	**9**
UNIT-2	Classical Ordinary Least Squares (OLS) – The model, Variance and Bias, The Gauss-Markov Theorem, The Frisch-Waugh-Lovell Theorem, Simple regression, Centered Observations, Precision of the OLS estimates, Normal Errors, When the assumptions fail.	**9**
UNIT-3	Problem with Regression Analysis – Heteroscedasticity, Autocorrelation, Multicollinearity, Model Misspecification versus pure autocorrelation	**9**
UNIT-4	Nonlinear and Qualitative Response Regression Models: Intrinsically linear and intrinsically nonlinear regression models, Estimating nonlinear regression models: The trial and error methods, Various approach to estimate nonlinear regression models, Illustrative Examples.	**9**
UNIT-5	Panel Data Regression Models: Why Panel Data?, Panel Data: An illustrative example, Constant coefficient model, The Fixed-Effect Least-Squares Dummy variable (LSDV) model, The Fixed-Effect Within-Group (WG) Estimator.	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Greene, William, Econometric Analysis, Prentice Hall, Sixth Edition	2008
2	Judge, G. G. Griffiths, R. C. Hill, T. Lee and H. Lutkepohl, The Theory and Practice of Econometrics, John Wiley	1985
3	G. S. Maddala, Introduction to Econometrics, Third Edition, John Wiley	2002
4	J. Johnston and J. Dinardo, Econometric Methods, Fourth Edition, McGraw Hill	1997
5	D. N. Gujarati and D. C. Porter, Basic Econometrics, Fifth Edition, McGraw Hill	2003

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 307: GEC-6 **Linear Regression Analysis**	**L**	**T**	**P**	Elementary knowledge of Probability
	3	**1**	**0**	

Course Objective: This course aims at determining the relationships between variables and using these relationships to forecast future observations.

Course Outcomes (CO):

CO1	Derive and describe a simple linear regression model.
CO2	Derive and describe a multiple linear regression model.
CO3	Describe how well model fits the data and how generalize it to a new data.
CO4	Analyze the degree of correlation between the same variable at two successive time intervals.
CO5	Discuss a problem on whenever an independent variable is highly correlated with one or more of the other independent variables in a multiple regression equation.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	1	2	2	1
CO2	2	1	2	2	1
CO3	3	1	2	2	2
CO4	2	1	1	2	2
CO5	3	1	1	3	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Simple Linear regression model, Least square estimation of the parameters, Hypothesis Testing on the Slope and Intercept, Interval Estimation in Simple Linear Regression, Prediction of New Observations, Coefficient of Determination	**9**
UNIT-2	Multiple Linear Regression Model, Estimation of the Model Parameters, Hypothesis Testing in Multiple Linear Regression, Confidence Intervals in Multiple Regression, Prediction of New Observations, A Multiple Regression Model for the Patient Satisfaction Data.	**9**
UNIT-3	Model Accuracy Checking- An Introduction, Residual Analysis, PRESS Statistic, Detection and Treatment of Outliers, Test for lack of fit of a regression model.	**8**
UNIT-4	Transformations and Weighting to Correct Model Inadequacies: An Introduction, Variance Stabilizing Transformations, Transformations to Linearize the Model, Analytical Methods for Selecting a Transformation: The Box-Cox Method, Transformations on the Regressor Variables, Generalized and Weighted Least Squares	**10**
UNIT-5	Multicollinearity: Definition, Sources of Multicollinearity, Effects of Multicollinearity, Multicollinearity Diagnostics, Methods for Dealing with Multicollinearity, Remedies for Multicollinearity.	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Douglas C. Montgomery, Elizabeth A. Peck and G. Geoffrey Vining, Introduction to Linear Regression Analysis, Wiley.	2001
2	Norman R. Draper and Harry Smith, Applied Regression Analysis, Wiley.	1998
3	C. R. Rao, H. Toutenburg, Shalabh and C. Heumann, Linear Models and Generalizations – Least Squares and Alternatives, Springer.	2008
4	John F Monahan, A Primer on Linear Models, CRC Press.	2008
5	Andre I. Khuri, Linear Model Methodology, CRC Press.	2010

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 308: GEC-9 Operations Research	**L**	**T**	**P**	Basic concept of linear algebra and calculus
	3	**0**	**2**	

Course Objective: To equip students with analytical techniques in operations research, including linear and integer programming, sequencing, network scheduling, and queuing and game theory for optimal decision-making.

Course Outcomes (CO):

CO1	Solve linear programming problems using appropriate techniques and optimization solvers, interpret the results obtained.
CO2	Analyze any real life system with limited constraints and depict it in a model form.
CO3	Determine optimal strategy for Minimization of Cost of shipping of products from source to Destination/ Maximization of profits of shipping products using various methods, Finding initial basic feasible and optimal solution of the Transportation problems
CO4	Analyze different queuing situations, network scheduling problems and find its optimal solutions using various operational research techniques.
CO5	Employ the analytical and practical skills in real life acquired during the course.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	0	2	1
CO2	3	3	2	3	2
CO3	3	3	2	3	2
CO4	2	2	3	3	2
CO5	2	2	0	2	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Introduction to Operations Research, Linear Programming Problems, Solution of Linear Programming Problems. Duality of Linear Programming Problems, Duality theorems, Complementary slackness condition, Dual simplex method, Sensitivity analysis.	**9**
UNIT-2	Integer programming Problems: Problem formulation, mixed integer programming Problems, Branch and bound method, Cutting plane algorithm.	**9**
UNIT-3	Sequencing: n Job 2 machine, n Job m Machine when processing order is same for each job. n job m machine when processing order is not the same. Optimal sequence, Total expected time	**9**
UNIT-4	Network Scheduling: Network and basic components, Network construction, Critical path method (CPM), Program evaluation and review techniques (PERT), Cost of completing project	**9**
UNIT-5	Queueing Theory: kendall notation, FCFS, LCFS, random selection, single service channel, multiple service channel.	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Hamdy A. Taha, Operations Research: An Introduction, Pearson Education Inc.	2007
2	Suresh Chandra, Jayadeva and Aparna Mehra, Numerical Optimization with Applications, Narosa Publication.	2008
3	Antonions, L.W. Sheng, Practical Optimization and Engineering Application, , New Age Publications.	2010
4	Frederick S. Hiller & Gerald J. Lieberman, Introduction to Operations Research, McGraw-Hill.	2009
5	G Hadley, Linear Programming, Narosa Publications.	1963

PRACTICAL LIST	
S. No.	**List of Experiments**
1	Implement the **Simplex Method** in MATLAB and TORA for solving Linear Programming Problems (LPP).
2	Implement the **Big-M Method** in MATLAB and TORA to solve LPPs with artificial variables.
3	Perform **Sensitivity Analysis (Post-Optimality Analysis)** using TORA to analyze the impact of changes in LPP parameters.
4	Implement the **Two-Phase Method** in TORA for solving LPPs with artificial variables.
5	Solve a **Dual Linear Programming Problem** using the **Dual Simplex Method** in TORA.
6	Solve an **Integer Programming Problem** using the **Branch and Bound Algorithm** and **Cutting Plane Algorithm** in TORA.
7	Solve a **Sequencing Problem** involving **n jobs and 2 or more machines**, considering both fixed and variable processing orders using TORA.
8	Implement the **Critical Path Method (CPM)** in TORA for project scheduling and determining the minimum project completion time.
9	Apply **Program Evaluation and Review Technique (PERT)** to analyze project scheduling with uncertain activity durations using TORA.
10	Analyze **Queuing Problems** using TORA, implement different queueing models.

Department of Applied Mathematics
Delhi Technological University,
(Formerly Delhi College of Engg.)

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 309: GEC-7 Programming with Python	**L**	**T**	**P**	Basic computer knowledge
	3	**0**	**2**	

Course Objective: To introduce fundamentals of programming using Python and understand the concepts of the program.

Course Outcomes (CO):

CO1	Identify and recall the fundamental syntax, operators, and data structures in Python, such as variables, arithmetic operators, strings, lists, and dictionaries.
CO2	Explain how Python functions, expressions, and statements work together to produce desired outcomes, and describe the flow of execution in basic programs.
CO3	Compare and contrast different data structures for efficient data manipulation.
CO4	Design error-handling and file operations for scalable applications.
CO5	Design and develop complex Python programs incorporating object-oriented principles.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	1	2
CO2	3	2	1	1	2
CO3	3	2	1	1	2
CO4	3	2	1	1	2
CO5	3	2	1	1	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S.No.	Contents	Contact hours
UNIT-1	Python Fundamentals: Installation, IDEs, Variables and Data Types, Assignments, dynamic typing, type conversion, Operators, Expressions and statements, operator precedence and evaluation, Functions and Modular Programming, Recursive functions.	**8**
UNIT-2	Control Flow & Iteration: conditional statements, Iteration statements, iterating over sequences, Loop Control Statements, List Comprehensions and Generators	**9**
UNIT-3	Strings, Lists, & Dictionaries: Strings, Strings Methods and Comparisons, Lists, Dictionaries and Key-Value Pairs, Reverse Lookup & Nested Data Structures: Handling complex data, Tuples, Namespaces and Scope.	**10**
UNIT-4	Error Handling & File Handling: Introduction to Exceptions, Try & Except Blocks, File Handling, Pickle, JSON, Logging module for debugging.	**8**
UNIT-5	Object-Oriented Programming: Introduction to OOPs, Classes and Objects, Encapsulation and Mutable Objects, class methods, static methods, Pure Functions, Modifiers, Inheritance & Polymorphism, Magic Methods (like __init__, __str__, __len__, etc.)	**10**
	TOTAL	**45**

References:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1	Deitel, P., & Deitel, H. *Intro to Python for Computer Science and Data Science*. Pearson Education, ISBN: 978-9353949518.	2020
2	Barry, P. *Head First Python*. O'Reilly, 3rd Edition, ISBN: 978-1492051299.	2023
3	Matthes, E. *Python Crash Course: A Hands-on, Project-based Introduction to Programming*. No Starch Press, 3rd Edition, ISBN: 978-1718502703.	2023
4	Brown, M. C. *Python: The Complete Reference*. McGraw Hill Education, 4th Edition, ISBN: 978-9387572942.	2018

PRACTICALS LIST	
S. No.	**List of Experiments**
1	Write a program to determine whether the given three coordinates ((x1, x2), (y1, y2) and (z1, z2)) are collinear or not.
2	write a program to print the prime numbers between 1 to N.
3	Write a program to print Fibonacci series using a for loop.
4	Write a program to declare variables of string data type and perform different operations on them.
5	Write a program to create, insert and delete Lists.
6	Write a program to create, insert and delete Dictionaries.
7	Write a program to create, insert and delete Sets and Tuples.
8	Write a program which utilizes a user defined function search_list that takes a list of values as arguments and searches for a particular number in the list.
9	Write a program to implement the Rock Paper Scissors game.
10	Write a program for the division of two numbers where the denominator is 0. This will throw an exception and handle the exception using try and except.
11	Write a program that can create your own exceptions.

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 310: GEC-10 Data Structure	**L**	**T**	**P**	NIL
	2	**0**	**0**	

Course Objective: To explain the concept of algorithm complexity and introduce various types of data structures along with their corresponding operations.

Course Outcomes (CO):

CO1	Define and illustrate different data structures.
CO2	Design algorithms to create, manipulate, and analyze data structures.
CO3	Analyze, estimate, and compare the performance of various operations performed on the data structures.
CO4	Explain and evaluate various sorting techniques to sort the data.
CO5	Illustrate and develop the usage of hashing functions and collision resolution techniques.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	0	1	0	0
CO2	3	2	2	1	2
CO3	3	2	1	1	1
CO4	3	1	3	1	2
CO5	3	1	3	1	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Introduction to Algorithm, Time complexity and Space complexity. Arrays and Strings: Representation of Arrays in Memory, one-dimensional, Two-dimensional operations on array. Strings and String Operations. Stacks: Operations on Stacks, Array representation of Stacks, Applications of Stacks. Queues: Operations of Queues, Representations of Queues, Applications of Queues. Linked Lists: Singly linked lists, Representation of linked list, Operations of Linked list, Applications of Linked List. Types of linked lists. Stacks and Queues as linked list.	**9**
UNIT-2	Trees: Spanning trees, Binary search trees and its various operations. Applications of Binary search Trees, Complete Binary trees, AVL trees, B trees. Graphs: Introduction to types of graphs, representation and transversal.	**7**
UNIT-3	Sorting: Bubble sort, Insertion Sort, Quicksort, Merge sort, Selection sort, Heap sort, sorting on different keys.	**6**
	TOTAL	**22**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Horowitz, E., Sahni, S., & Anderson-Freed, S. *Fundamentals of Data Structures in C*, Universities Press, 2nd Edition, ISBN: 978-8173716058.	2017
2	Tanenbaum, A. M., Langsam, Y., & Augenstein, M. J. *Data Structures Using C*, Pearson, ISBN: 978-8131706253.	2019
3	Tremblay, J. P., & Sorenson, P. G. *An Introduction to Data Structures with Applications*, McGraw Hill, 2nd Edition, ISBN: 978-0070651579.	2017
4	Kruse, R. L., Leary, B. P., & Tondo, C. L. *Data Structure and Program Design in C*, PHI, 2nd Edition, ISBN: 978-8120309968.	2009

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 311: Field Theory	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To introduce students to the concepts of the Theory of Fields and Galois Theory.

Course Outcomes (CO):

CO1	Use diverse properties of field extensions in various areas.
CO2	Establish the connection between the concept of field extensions and Galois Theory.
CO3	Describe the concept of auto morphism, monomorphism and their linear independence in field theory.
CO4	Compute the Galois group for several classical situations.
CO5	Solve polynomial equations by radicals.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	0	2	2	3
CO2	3	0	2	2	3
CO3	3	0	2	2	3
CO4	3	0	2	2	3
CO5	3	0	2	2	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Fields: Extension fields, finite extensions, degree of extension, algebraic and transcendental elements, Fundamental Theorem of Field Theory, algebraic extensions, splitting fields – existence and uniqueness.	**9**
UNIT-2	Polynomials: Reducible and irreducible polynomials. Irreducibility tests. Simple and multiple roots of polynomials, criterion for simple roots, separable and inseparable polynomials; perfect fields.	**9**
UNIT-3	Finite fields: Finite fields, Classification of finite fields, Construction of finite fields, Structure of finite fields, Subfields of a finite field.	**9**
UNIT-4	Galois Theory: Algebraically closed fields and algebraic closures, normal Extensions, Group of auto morphism of a field , fixed field, Galois extensions, Fundamental Theorem of Galois Theory.	**9**
UNIT-5	Solvabilty by Radicals: Normal and subnormal series, composition series, Jordan-Holder theorem (statement only), solvable groups, Sovability by radicals.	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	I. N. Herstein; Topics in Algebra(2ndEdition), Wiley Eastern Limited	2006
2	Joseph A. Gallian; Contemporary Abstract Algebra (9th Ed.), Narosa Publishing House.	2016
3	D. S. Dummit and R. M. Foote; Abstract Algebra(3rdEdition), John Wiley and Sons.	2011
4.	Khanna and Bhamri; A course in Abstract Algebra (5th Edition), Vikas Publishing House.	2017
5.	N. S. GopalaKrishnan; University Algebra, New Age International Publishers	2021

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 312: Artificial Intelligence	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To introduce basic knowledge representation, problem solving, and learning methods of Artificial Intelligence and understand the role of knowledge representation, problem solving and learning in intelligent system engineering.

Course Outcomes (CO):

CO1	Identify and describe Artificial Intelligence techniques such as search heuristics, knowledge representation and automated planning.
CO2	Compare Artificial Intelligence with paradigms such as Machine Learning, Deep Learning, Natural Language Processing, Expert Systems, etc.
CO3	Apply Artificial Intelligence techniques to a wide range of problems, including complex problem solving via search, knowledge-based systems, machine learning, probabilistic models, agent decision making, etc.
CO4	Analyze the computational trade-offs involved in applying different AI techniques and models.
CO5	Design and develop programs in programming languages such as Prolog.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	1	2
CO2	3	2	1	1	2
CO3	3	2	1	1	2
CO4	3	2	1	1	2
CO5	3	2	1	1	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Introduction: AI Problems, Task Domains of AI, AI Techniques: search knowledge, abstraction. Introduction to Intelligent program and Intelligent agents. Problem Solving: Basic Problem solving Method: state space search, problem characteristics, issues in design of Intelligent search algorithm.	**9**
UNIT-2	Heuristic search Techniques: Hill climbing techniques, Best First search, Variable Neighbourhood Descent, Beam and Tabu Search, Simulated Annealing, Genetic Algorithms, A* Search, IDA*Recursive Best First Search. Problem Reduction: AO* Search, Constraint Satisfaction.	**9**
UNIT-3	Planning: Forward State Space Planning, Backward State Space Planning, Goal Stack Planning, Plan Space Planning. Game Playing: Game Tree, Searching procedure Minimax, alpha beta pruning	**9**
UNIT-4	Knowledge Representation: Knowledge Representation issues, Knowledge Representation using Predicate Logic: Unification, resolution, Rule based Systems: Forward versus backward reasoning, conflict resolution. Structured Knowledge Representation: Semantic Nets, Frames, conceptual dependency, scripts.	**9**
UNIT-5	Programming Languages: Fundamental and concepts of Programming languages like Prolog. Relationship of languages with knowledge representation and inferences. Applications and Case Studies: Expert Systems, Machine Learning, Natural Language Processing, Robotics etc.	**9**
	TOTAL	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Khemani, D. *A First Course in Artificial Intelligence*, McGraw Hill Education, 6th Edition, ISBN: 978-1259029981.	2013
2	Rich, E., Knight, K., & Nair, S. B. *Artificial Intelligence*, McGraw Hill Education, 3rd Edition, ISBN: 978-0070087705.	2009
3	Russell, S., & Norvig, P. *Artificial Intelligence: A Modern Approach*, Pearson, 4th Edition, ISBN: 978-0134610993.	2022

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 313: Analysis and Design of Algorithms	**L**	**T**	**P**	Programming and Data Structures
	3	**0**	**2**	

Course Objective: To familiarize students with algorithmic design paradigms and methods of analysis

Course Outcomes (CO):

CO1	Design efficient algorithms for real-life problems, using the techniques learned as building blocks and identify the limitations in algorithm design for solving it.
CO2	Argue and justify the correctness of algorithm design and analyze the running time of algorithms using asymptotic analysis.
CO3	Describe different paradigms of algorithm design, such as Divide & Conquer, Greedy, Dynamic Programming, etc., and predict which algorithmic design situation calls for it.
CO4	Compare the notion of tractable and intractable problems and develop algorithms for computationally intractable problems.
CO5	Solve the interdisciplinary real-world problems including sorting problems, trees and graphs problems, and recurrence relations.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	1	2
CO2	1	1	1	2	2
CO3	2	0	2	1	2
CO4	2	2	2	1	1
CO5	3	1	3	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Review of basics of Data Structures, Searching, Sorting, Heap Sort. Program Performance: Time and Space Complexity, Asymptotic Notation, Solution of Recurrence Relations.	**6**
UNIT-2	Divide and Conquer: Quicksort, Randomized Quicksort, Strassen's Matrix Multiplication. Greedy Method: Minimum Cost Spanning Trees-Kruskal's Method.	**10**
UNIT-3	Dynamic Programming: Matrix Chain Multiplication Problem, Longest Common Subsequence Problem. Backtracking: Graph Coloring Problem, Hamiltonian Cycles Problem, Subset Sum Problem, N-Queens Problem. Branch and Bound: 0/1 Knapsack Problem, Traveling Salesman Problem.	**12**
UNIT-4	Graph Algorithms: Depth First Search, Breadth First Search, Shortest Path Algorithms, Topological Sorting.	**10**
UNIT-5	NP-Completeness: P and NP-Classes, NP-Hard Problems, Reduction.	**7**
	TOTAL	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. *Introduction to Algorithms*, The MIT Press, 3rd Edition, ISBN: 978-0262033848.	2009
2	Sahni, S. *Data Structures, Algorithms, and Applications in C++*, Silicon Press, 2nd Edition, ISBN: 978-0929306322.	2001
3	Horowitz, E., Sahni, S., & Rajasekaran, S. *Fundamentals of Computer Algorithms*, Universities Press, 2nd Edition.	2008

PRACTICALS LIST	
S. No.	**List of Experiments**
1	Write a Program to implement the following sorting algorithms: a. Heap Sort b. Merge Sort c. Insertion sort
2	Write a Program to implement quicksort and randomized quicksort.
3	Write a Program to implement Strassen's matrix multiplication algorithm.
4	Write a Program to implement the Kruskal's minimum cost spanning tree algorithm.
5	Write a Program to implement the following: a. Matrix Chain Multiplication b. Longest Common Subsequence
6	Write a program for the following problems: a. N-Queens problem b. Subset Sum problem
7	Write a Program to implement 0/1 knapsack using the branch and bound approach.
8	Write a Program to implement the DFS and BFS graph algorithms.
9	Write a Program to implement shortest path algorithms in a given graph.
10	Write a Program to implement Topological sorting of a given graph

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 314: Perturbation Theory	**L**	**T**	**P**	Basics of Linear Algebra and Differential Equations
	3	1	0	

Course Objective: To develop analytic techniques to solve problems with small parameters that modify known solvable systems.

Course Outcome (CO):

CO1	Understand the principles and applications of perturbation theory in solving complex systems.
CO2	Apply perturbation methods to non-degenerate and degenerate systems.
CO3	Solve classical and quantum mechanical problems using perturbative approaches.
CO4	Analyze the accuracy and limitations of perturbation approximations.
CO5	Use asymptotic methods to understand perturbative expansions and corrections.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	0
CO2	3	3	2	2	1
CO3	2	3	2	2	1
CO4	2	3	2	2	1
CO5	2	3	2	1	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Introduction to Perturbation Theory: Overview of perturbative methods and applications, Concept of small parameters and their role in approximations, Historical background and motivation for perturbation methods, Non-Degenerate Perturbation Theory: First-order and second-order perturbations, Application to simple quantum systems (e.g., harmonic oscillator), Energy corrections and wave function corrections, Convergence and limitations of perturbation series	**9**
UNIT-2	Degenerate Perturbation Theory: Handling degeneracies in perturbed systems, Lifting degeneracies and application to quantum mechanical systems, Examples in atomic and molecular systems (e.g., hydrogen atom), Time-Dependent Perturbation Theory: Basic principles of time-dependent perturbation theory, Transition probabilities and Fermi's Golden Rule, Applications to electromagnetic transitions and particle interactions	**9**
UNIT-3	WKB (Wentzel-Kramers-Brillouin) Approximation: Semi-classical approximation methods, Derivation and application of the WKB approximation, Connection to classical mechanics and tunneling effects, Variational Methods, Rayleigh-Ritz Approximation: Introduction to variational principles, Rayleigh-Ritz method for approximating ground-state energies, Applications to bound-state problems in quantum mechanics	**9**
UNIT-4	Asymptotic Expansions and Series Solutions: Introduction to asymptotic series and expansions, Perturbative expansions and approximations, Techniques for evaluating and interpreting asymptotic series, Regular and Singular Perturbation Theory, Distinction between regular and singular perturbations, Boundary layer theory and matched asymptotic expansions, Applications to differential equations in classical mechanics	**9**
UNIT-5	Applications to Classical Mechanics and Engineering: Perturbative methods in classical mechanics, Applications in celestial mechanics, oscillatory systems, and fluid dynamics, Perturbative solutions to engineering and applied mathematics problems, Advanced Topics in Perturbation Theory: Renormalization in perturbative expansions, Divergence of perturbation series and Borel summation Modern, developments and applications in field theory	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Perturbation Theory for Linear Operators, T. Kato, Springer	1980
2	Advanced mathematical methods for scientists and engineers I: Asymptotic methods and perturbation theory, C.M. Bender and S.A. Orszag, Springer	2013
3	Introduction to Perturbation Methods, Mark H. Holmes, Springer	2013

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 315: Game Theory	**L**	**T**	**P**	Basic concept of linear algebra, calculus and probability
	3	1	0	

Course Objective: This course will make student capable of making optimal decision making using concepts of game theory in various disciplines.

Course Outcomes (CO):

CO1	Identify the terminologies of game theory and solution concepts employed to predict the outcome of the game.
CO2	Analyze economic situations using game theoretic techniques.
CO3	Structure strategic problems as sequential and/or simultaneous games.
CO4	Identify the strategies to implement.
CO5	Apply the computing skill to formulate, solve interdisciplinary real world and engineering problems and apply the knowledge to real life /engineering problems.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	0	2	1
CO2	2	2	2	3	2
CO3	2	2	2	3	2
CO4	3	2	2	2	1
CO5	2	2	2	3	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Matrix 2 person games: Games in Strategic Form, Strategic-Form Games, Dominated Strategies, Dominance Principle, Mixed strategies, Nash Equilibrium, Existence and Properties of Nash Equilibria, Symmetric games.	9
UNIT-2	Matrix games and linear programming: Invertible matrix games, Graphical solution of 2 × m games, Transformation of Mixed game in LPP, Primal-Dual Theory of 2-Person Game	9
UNIT-3	2-person Nonzero sum games: 2x2 bi-matrix games, Interior Mixed Nash points by calculus. Quadratic Programming method for nonzero sum games.	9
UNIT-4	Cooperative Games: The Nucleolus, Shapley value, Bargaining- Nash model with security point, Threats.	9
UNIT-5	Dynamic Game Theory: Dynamic Games of Complete Information, Multi-Stage Game, Backward Induction, Extensive Form Games, Subgame Perfection.	9
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	E.N. Barron, Game Theory: An Introduction, John Wiley & Sons.	2008
2	Osborne M.J., An Introduction to Game Theory, Oxford University Press.	2004
3	A. Mas-Colell, M.D. Whinston and J.R. Green, Microeconomic Theory, Oxford University Press.	1995
5	T. Parthasarathy, T.E.S. Raghavan, Some Topics in Two-Person Games, American Elsevier Publishing Company.	1971
6	R.A. Gibbons, Primer in Game Theory, Pearson Education.	1992

Details of Course

Course Title	Course Structure			Pre-Requisite
IMSMA 316: Financial Mathematics	**L**	**T**	**P**	Knowledge of random variable and its various properties and normal distribution.
	3	**1**	**0**	

Course Objective: Knowledge of financial market, risk attached, and derivative on underlying asset and its pricing

Course Outcome (CO):

CO1	Describe the various terminologies used in financial market and pricing of bonds.
CO2	List the assumptions for mathematical modelling of financial markets. Categorize the types of instruments traded in the financial markets. Compute the risk and return attached with risky instruments. Compute the Forward price and apply to real problem.
CO3	Explain and define the portfolio. Pricing options using hedging method. Describe the factor influencing the pricing of the European options .
CO4	Describe the various models for option pricing. Effectively compute the volatility and its impact on derivative pricing.
CO5	Derive and use Black-Scholes formula to price the options. Calculate and use of Greeks.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	0	1	0	1
CO2	3	0	1	1	1
CO3	3	0	1	0	1
CO4	3	0	1	0	1
CO5	3	0	1	0	0

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S.No.	Contents	Contact Hours
UNIT-1	Some basic definitions and terminology: Basic Notions. Types of asset (Definition of risky and risk free assets). Rate of return, Future value: of a single cash flow, of an annuity. Bond, zero coupon Bond and coupon bond, Pricing of bond.	**9**
UNIT-2	Assumptions of financial market modelling. No-Arbitrage Principle. Risky assets, rate of return and expected return, Risk of rate of returns (variance & standard deviation). Derivatives and Hedging, One-Step Binomial Model, Forward contract: Definition, pricing and pay-off and its value.	**9**
UNIT-3	Share of stock, Portfolio, Risk and Return, Options, Call and Put Options, pay-off of options, Pricing of European option using replicating portfolio. Put call parity formula. Bounds on options price. Variables influencing the options pricing.	**9**
UNIT-4	Risk Neutral Probability Measure (RNPM). Dynamics of options pricing, Basic Theory of Option Pricing: Single and Multi-Period Binomial Pricing Models, Cox Ross-Rubinstein (CRR) Model. Matching of CRR model with a multi period Binomial model.	**9**
UNIT-5	Black-Scholes Formula for Option Pricing as a Limit of CRR Model. The Greeks: Delta, Theta, Gamma, Vega, and Rho.	**9**
	Total	**45**

References:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1.	M. Capińsky and T. Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, 2nd Edition, Springer.	2011
2.	Financial Management, I M Pandey, Vikas Publishing House Pvt Ltd. 10th Edition.	2013
3.	S. Chandra, S. Dharamraja, A. Mehra, R. Khemchandani ,Financial Mathematics: An Introduction, 1st Edition, Narosa.	2013
4.	J. C. Hull, S. Basu, Options, Futures and other derivatives, 11th Edition, Pearson.	2022

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 317: Database Management System	**L**	**T**	**P**	NIL
	3	**0**	**2**	

Course Objective: To provide knowledge about the principles, concepts and applications of Database Management System.

Course Outcomes (CO):

CO1	Define and explain fundamental RDBMS principles and design, data models, relational design, and SQL.
CO2	Design ER models to represent various applications, convert them into relational schemas, and apply relational algebra and SQL for queries.
CO3	Apply normalization techniques to optimize database design and ensure data integrity.
CO4	Compare and contrast various file structures, indexing, and hashing techniques for efficient data retrieval and storage.
CO5	Apply transaction processing and concurrency control techniques to maintain data consistency and recovery.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	1	2	2
CO2	2	3	1	1	2
CO3	2	2	2	2	1
CO4	1	2	2	2	2
CO5	2	1	1	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Introduction: Database system concepts and architecture, Data models, Schema and instances, Data independence, Database language and interface, Data definition languages, and Data manipulation languages. Data modelling using Entity Relationship Model: ER model concept, Notation for ER diagrams, Mapping constraints, Keys, Super key, Candidate key, Primary key, Generalizations, Aggregation, Transforming ER diagrams to tables, Extended ER model.	**9**

UNIT-2	Relational Data Model and Language: Relational data model concepts, Integrity constraints, Keys domain constraints, Referential integrity, Assertions, Triggers, Database language, Relational algebra, Relational calculus, Domain and Tuple calculus, Data definition, queries, and updates in SQL, NoSQL databases.	**9**
UNIT-3	Database Design: Functional dependencies, Normal forms, 1NF, 2NF, 3NF, and BCNF, Multivalued dependencies, Lossless join decompositions, Normalization using FD, MVD and JDs.	**9**
UNIT-4	File Organization, Indexing and Hashing: Basic concepts, Static hashing, Dynamic hashing, Ordered indices, Multi-level indexes, B-Tree index files, B+-Tree index files, Buffer management.	**9**
UNIT-5	Transaction processing and Concurrency Control concepts: Transaction processing system, Schedule and recoverability, Testing of serializability, Serializability of schedules, Conflict and view serializable schedule, Recovery from transaction failures, Deadlock handling, Locking Techniques, Time stamping protocols.	**9**
	TOTAL	**45**

References:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1	Elmasri, R., & Navathe, S. B., *Fundamentals of database systems*.. Addison-Wesley, 6th Edition, ISBN: 978-0-13-608620-8.	2010
2	Silberschatz, A., Korth, H. F., & Sudarshan, S., *Database system concepts*. McGraw-Hill, 7th Edition, ISBN: 978-0-07-802215-9.	2019
3	Ramakrishnan, R., & Gehrke, J., *Database management systems*. McGraw-Hill, 3rd Edition, ISBN: 978-0-07-246563-1.	2003
4	Harrison, G. *Next generation databases: NoSQL and big data.* Apress, 1st edition, ISBN: *9781484200823.*	2015

PRACTICALS LIST	
S. No.	**List of Experiments**
1	Develop an ER Diagram for a chosen/given application/project.
2	Write SQL queries to create tables using various constraints.
3	Write SQL queries to insert data in the tables.
4	Write SQL queries to perform update operations with and without WHERE clause.
5	Write SQL queries to perform delete operations with and without WHERE clause.
6	Write SQL queries to add new columns and constraints, drop columns and constraints, modify column type etc. using ALTER statement.
7	Write SQL queries to perform the function of Select statement with and without WHERE clause, using Boolean operators, logical operators, IN, BETWEEN, LIKE etc.
8	Write SQL queries to perf orm aggregate functions like SUM, MAX, MIN, AVG, DATE, TRIM etc.
9	Write SQL queries to perform the function of GROUP BY clause and HAVING clause.
10	Write SQL queries to perform various JOIN operations using - a. INNER JOIN b. EQUI JOIN c. NATURAL JOIN d. LEFT OUTER JOIN e. RIGHT OUTER JOIN f. FULL OUTER JOIN
11	Write SQL queries to create and modify the Indexes.

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 318: Chaos and Fractals	**L**	**T**	**P**	Basics of Calculus Linear Algebra and Differential Equations
	3	**1**	**0**	

Course Objective: To introduce chaos theory and fractal geometry, emphasizing their mathematical foundations and real-world applications.

Course Outcomes (CO):

CO1	Understand the mathematical foundations of chaos theory and fractal geometry.
CO2	Analyze chaotic behaviour in dynamical systems and interpret sensitivity to initial conditions.
CO3	Explore and apply mathematical models to describe fractals and self-similar structures.
CO4	Use computational methods to simulate chaotic systems and generate fractals.
CO5	Apply chaos and fractal concepts to model complex phenomena in science and engineering.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	2	2	2
CO2	3	3	2	3	2
CO3	3	3	2	2	2
CO4	2	2	2	2	2
CO5	3	3	2	3	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
Unit-1	Introduction to Chaos and Fractals: Overview of chaos theory and fractals, Historical development and significance, Examples of chaos and fractal patterns in nature and science, Nonlinear Dynamical Systems and Chaos: Fundamentals of dynamical systems, Fixed points, periodic orbits, and stability analysis, Introduction to nonlinear systems and bifurcation theory, Logistic map and routes to chaos (e.g., period-doubling)	**9**
Unit-2	Sensitivity to Initial Conditions and Lyapunov Exponents: Definition and significance of sensitivity to initial conditions, Calculation and interpretation of Lyapunov exponents, Practical examples demonstrating exponential divergence, Strange Attractors and Chaotic Dynamics: Concept of attractors in dynamical systems, Strange attractors and their properties (e.g., Lorenz attractor), Poincaré sections and phase space representation, Applications to physical and biological systems	**9**
Unit-3	Fractals and Fractal Geometry: Definition and characteristics of fractals Self-similarity and recursive construction, Fractal dimension: Hausdorff dimension, box-counting dimension, Examples: Cantor set, Sierpinski triangle, Koch curve, Generation and Analysis of Fractals: Iterated function systems (IFS), Mandelbrot and Julia sets, Escape-time algorithms for complex fractals, Random fractals and Brownian motion	**9**
Unit-4	Numerical and Computational Techniques: Numerical simulation of chaotic systems, Use of computational tools to analyze fractals Introduction to software and programming languages for chaos and fractal analysis (e.g., Python, MATLAB), Advanced Topics in Chaos and Fractals: Multifractals and their properties, Applications of chaos theory to cryptography, Complex systems and the emergence of chaotic behaviour, Current trends and research directions in chaos and fractals	**9**
Unit-5	Applications of Chaos and Fractals in Science and Engineering: Chaos in mechanical and electrical systems, Fractal structures in nature (e.g., coastlines, trees, clouds), Applications in biology, finance, meteorology, and image processing	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Chaos: An Introduction to Dynamical Systems, K.T. Alligood, T.D. Sauer, and J.A. Yorke, SIAM Review	1998
2	Chaos and Fractals: New Frontiers of Science, Heinz-Otto Peitgen, Hartmut Jürgens, and Dietmar Saupe, Springer	2004
3	Nonlinear Dynamics and Chaos, Steven H. Strogatz, CRC press	2018

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 319:	**L**	**T**	**P**	Knowledge of real analysis, complex analysis and Functional analysis
Fourier Analysis: An Introduction	**3**	**1**	**0**	

Course Objective: It gives the idea how knowledge of Fourier series helps to define Fourier transform and to study its convergence and summability.

Course Outcomes (CO):

CO1	Know about the Fourier series, uniqueness of Fourier series, Dirichlet's integral and convergence theorem.
CO2	Understand the distinction between pointwise and uniform convergence and be able to decide whether a given sequence of functions is uniformly convergent.
CO3	Be familiar with the rules for Fourier transformation and know how to apply them.
CO4	Be able to formulate important results and theorems covered by the course and to describe the main features of the proofs of important theorems;
CO5	Be able to use the theory, methods and techniques of the course to solve mathematical problems

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	1	2	3
CO2	2	2	1	2	3
CO3	3	2	1	2	3
CO4	2	3	1	2	3
CO5	2	3	1	2	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Fourier Series: Trigonometric series, Fourier series, Fourier sine and cosine series, Half range series, Uniqueness of Fourier series, The Riemann-Lebesgue lemma, Dirichlet Integral, Criterion and tests for pointwise convergence of Fourier series, Dirichlet's pointwise convergence theorem.	**9**
UNIT-2	Convergence of Fourier series: Uniform convergence, The Gibb's phenomenon, Term wise integration and differentiation, Summability of Fourier series, Cesarosummability, Abel summability, Fejer'stheoremWeierstrass's approximation theorem.	**9**
UNIT-3	Fourier Transform: Finite Fourier transform, Applications to some partial differential equation, The Poisson summation formula, Heisenberg Uncertainty principle, Paley-Wiener Theorem.	**9**
UNIT-4	Functions of the class L2: Bessel's inequality, Parseval's theorem for continous functions, The Riesz-Fischer theorem, Uniqueeness of trigonometric series, Cantor's lemma, Riemann 's first and second theorems.	**9**
UNIT-5	The Fejer-Lebesgue inversion theorem, Integrability of Fourier transform, Transforms of derivative and integrals, The plancheral theorem, Discrete Fourier transform (DFT), Inversion theorem for the DFT.	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	E.M. Stein and R. Shakarchi: Fourier analysis: An introduction, Princeton University Press.	2003
2	Körner, T. W.: Fourier Analysis. Cambridge University Press.	1998
3	Rudin, W.: Functional Analysis, Tata Mc. Graw Hill.	1974
4	LokenathDebnath and Dambaru Bhatt: Integral transform and their Applications, CRC	2007
5	I.N. Sneddon: Fourier series, Dover Publications.	1969

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 320: Elementary Fluid Dynamics	**L**	**T**	**P**	Knowledge of Partial Differential Equation
	3	1	0	

Course Objective: The aim of this course is to investigate the rotational, irrotational motion and motion of an ideal fluid.

Course Outcomes (CO):

CO1	Describe the fluid and its properties.
CO2	Explain the types of fluid flow and its continuity equation.
CO3	Describe the flow of ideal fluid using various equations.
CO4	Apply complex function for the discussion of fluid flow.
CO5	Calculate Buckingham p numbers for different types of fluid flow.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	0	1	2	1
CO2	2	0	1	2	1
CO3	2	0	1	2	1
CO4	3	0	1	2	1
CO5	3	0	1	2	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Definition of a fluid, Fluids and the Continuum, Concept of pressure and stress in a fluid, Fluid properties, Classification of fluid and flow, Steady flow, Uniform flow.	**5**
UNIT-2	Lagrangian and Eulerian approach, Scalar and vector fields, flow field and description of fluid motion, Stream lines, Streak lines and Path lines, Equation of continuity (Cartesian, Polar, Cylindrical), Rotational and Irrotational flow, Circulation and vorticity, vortex lines, stream function, velocity potential function.	**10**
UNIT-3	Reynold's transport theorem, Euler's equation, Bernoulli's equation, momentum equation, Navier-Stokes equation, Navier-stokes equation applied to simple flow problem.	**10**
UNIT-4	Complex velocity potential for standard two-dimensional flow, Sources, sinks, doublets and their images, Conformal mapping, Milne-Thompson circle theorem.	**10**
UNIT-5	Concept of similarity, Buckingham p-theorem, Reynold's number, Prandt's boundary layer, Boundary layer equations in two dimensions, Laminar and turbulent, Von-Karman integral momentum equation, Blasius solution.	**10**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	S. K. Som, G. Biswas and S. Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, McGraw Hill Education, Third Edition.	2017
2	G. Visconti, P. Ruggieri, Fluid Dynamics: Fundamentals and Applications, Springer, First Edition.	2020
3	F. Chorlton, Textbook of Fluid Dynamics, CBS Publishers & Distributors.	1985
4	R. E. Meyer, Introduction to Mathematical fluid dynamics, Dover Publications Inc.	2003
5	S. Swarup, Fluid Dynamics, Krishna Prakashan.	2023

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 321: Operations Research	**L**	**T**	**P**	Basic concept of linear algebra and calculus
	3	**0**	**2**	

Course Objective: To equip students with analytical techniques in operations research, including linear and integer programming, sequencing, network scheduling, and queuing and game theory for optimal decision-making.

Course Outcomes (CO):

CO1	Solve linear programming problems using appropriate techniques and optimization solvers, interpret the results obtained.
CO2	Analyze any real life system with limited constraints and depict it in a model form.
CO3	Determine optimal strategy for Minimization of Cost of shipping of products from source to Destination/ Maximization of profits of shipping products using various methods, Finding initial basic feasible and optimal solution of the Transportation problems
CO4	Analyze different queuing situations, network scheduling problems and find its optimal solutions using various operational research techniques.
CO5	Employ the analytical and practical skills in real life acquired during the course.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	0	2	1
CO2	3	3	2	3	2
CO3	3	3	2	3	2
CO4	2	2	3	3	2
CO5	2	2	0	2	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Introduction to Operations Research, Linear Programming Problems, Solution of Linear Programming Problems. Duality of Linear Programming Problems, Duality theorems, Complementary slackness, Dual simplex method, Sensitivity analysis (Post Optimality Analysis).	**9**
UNIT-2	Integer Programming Problems: Problem Formulation, Mixed Integer Programming Problems, Branch and Bound Algorithm, Cutting Plane Algorithm.	**9**
UNIT-3	Sequencing: *n* Jobs *2* Machines, *n* Jobs *m* Machines when processing order is same and not same for each job. Optimal sequence, Total expected time.	**9**
UNIT-4	Network Scheduling: Network and Basic Components, Network Construction, Critical Path Method (CPM), Program Evaluation and Review Techniques (PERT), Cost of completing project.	**9**
UNIT-5	Queueing Theory: Kendall notation, FCFS, LCFS, random selection, single service channel, multiple service channel.	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Hamdy A. Taha, Operations Research: An Introduction, Pearson Education Inc.	2007
2	Suresh Chandra, Jayadeva and Aparna Mehra, Numerical Optimization with Applications, Narosa Publication.	2008
3	Antonions and L.W. Sheng ,Practical Optimization and Engineering Application, , New Age Publications.	2010
4	Frederick S. Hiller & Gerald J. Lieberman, Introduction to Operations Research, McGraw-Hill.	2009
5	G Hadley, Linear Programming, Narosa Publications.	1963

PRACTICAL LIST	
S. No.	**List of Experiments**
1	Implement the **Simplex Method** in MATLAB and TORA for solving Linear Programming Problems (LPP).
2	Implement the **Big-M Method** in MATLAB and TORA to solve LPPs with artificial variables.
3	Perform **Sensitivity Analysis (Post-Optimality Analysis)** using TORA to analyze the impact of changes in LPP parameters.
4	Implement the **Two-Phase Method** in TORA for solving LPPs with artificial variables.
5	Solve a **Dual Linear Programming Problem** using the **Dual Simplex Method** in TORA.
6	Solve an **Integer Programming Problem** using the **Branch and Bound Algorithm** and **Cutting Plane Algorithm** in TORA.
7	Solve a **Sequencing Problem** involving **n jobs and 2 or more machines**, considering both fixed and variable processing orders using TORA.
8	Implement the **Critical Path Method (CPM)** in TORA for project scheduling and determining the minimum project completion time.
9	Apply **Program Evaluation and Review Technique (PERT)** to analyze project scheduling with uncertain activity durations using TORA.
10	Analyze **Queuing Problems** using TORA, implement different queueing models.

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 322: Computer Networks	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To impart knowledge about the principles, concepts, and applications of computer networks, and their communication protocols.

Course Outcomes (CO):

CO1	Describe fundamental computer network terms and outline the Data Communication System along with its components.
CO2	Illustrate the layers of the OSI model and TCP/IP reference model and also describe the functions of each layer.
CO3	Apply and evaluate the current use of Internet protocols and assess the essential requirements for designing effective network protocols.
CO4	Categorize various types of physical layer transmissions and transmission media, and demonstrate the application of techniques to manage and correct transmission errors.
CO5	Explain different routing protocols, analyze the process of IP address assignment within a network, and elaborate and demonstrate the functionality of both connection-oriented and connectionless protocols.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	0	1	0	0
CO2	3	1	1	0	1
CO3	3	2	1	1	1
CO4	2	1	3	0	2
CO5	3	2	3	1	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Introduction: Fundamentals and applications of Networks, data communications, network architecture, network classification, Reference models - OSI and TCP/IP, interfaces and services, network topology design, Physical Layer Transmission Media, Switching methods, ISDN.	**9**
UNIT-2	Data Link Layer: Framing, Error Handling, Elementary Data Link Protocols, Sliding Window protocols. Medium Access sublayer: Channel Allocations, LAN protocols, multiple access protocols, IEEE 802.X standards, FDDI.	**9**
UNIT-3	Network Layer: Point-to-point networks, logical addressing, routing, routing algorithms, Congestion control algorithms, Internetworking, IP addressing and subnet masking, IPv6.	**10**
UNIT-4	Transport Layer: Transport Layer Design issues, Transport layer protocols, connection management, congestion control. Session Layer: Design issues, remote procedure call.	**9**
UNIT-5	Presentation Layer: Data compression techniques, Encryption and Decryption. Application Layer: Application layer protocols, File Transfer, Access and Management, DNS, Electronic mail, Virtual Terminals, Internet and Public Networks.	**8**
	TOTAL	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Tanenbaum, A. S., & Wetherall, D. J. *Computer Networks*, Pearson Education, 5th Edition, ISBN: 978-0132126953.	2010
2	Forouzan, B. A. *Data Communications and Networking*, McGraw Hill, 5th Edition, ISBN: 978-0073376226.	2012
3	Stallings, W. *Data and Computer Communications*, Pearson Education, 10th Edition, ISBN: 978-0133506488.	2013

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 324: Classical Mechanics	**L**	**T**	**P**	Elementary knowledge of dynamics
	2	**0**	**0**	

Course Objective: This course aims to provide deeper understanding of fundamental concepts of classical mechanics.

Course Outcomes (CO):

CO1	Understanding concept of kinematics and describe circular motion.
CO2	Describe moment and product of inertia. Explain the basic concepts and underlying principle of the dynamics of rigid bodies.
CO3	Describe the differential equations and other advanced mathematics in the solution of the problems of dynamical systems.
CO4	Deduce Lagrange's and Hamilton's equation and describe the motion of a mechanical system using Lagrange-Hamilton formalism.
CO5	Explain generating function and canonical transformation. Describe Hamilton-Jacobi equation of motion.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	0	2	1	1
CO2	3	0	3	1	1
CO3	2	0	2	1	1
CO4	2	0	2	1	1
CO5	3	0	3	1	1

Program Outcome (PO)

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Dynamics of Rigid Bodies: Moments of Inertia and Product of Inertia, D'Alembert's Principle, The general equation of motion, Motion about an axis (finite and impulsive forces), Shortest distance between two points, Brachistochrone problem.	**6**
UNIT-2	Lagrangian Mechanics: Degrees of freedom, Constraints, Generalized coordinate, Holonomic and Non-holonomic systems, Lagrange's equations for finite forces, Derivation of Lagrange's equation from D'Alembert's principle, Theorem on Total energy, Application of Lagrange's equation.	**8**
UNIT-3	Hamiltonian Mechanics: Configuration space, Phase space, Variational method, Hamilton's principle, Principle of least action, Lagrange's equation from Hamilton's principle, Hamilton's equation of motion.	**9**
	Total	**23**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	H. Goldstein, Classical Mechanics, 3rd Edition, Addison Wesley Publications, Massachusetts.	2002
2	N.C. Rana and P.S. Joag, Classical Mechanics, Tata Mc-Graw Hill Education.	2001
3	B. Nand, B.S. Tyagi and B.D. Sharma, Dynamics of Rigid Bodies, Kedar Nath Ram Nath Publisher.	1992
4	Classical Mechanics: MIT 8.01 Course Notes by Peter Dourmashkin.	2016

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 326: Data Warehousing and Data Mining	**L**	**T**	**P**	Basics of Linear Algebra and Probability
	2	**0**	**0**	

Course Objective: To introduce the concept of Data Warehousing and Data Mining, respective techniques and applications in real world scenario.

Course Outcomes (CO):

CO1	Recall the basic concepts of data warehousing and the key elements of data mining.
CO2	Explain the process of designing and implementing a data warehouse. Describe the role of data mining primitives and query languages in data mining systems.
CO3	Apply data mining techniques to analyze large datasets and extract meaningful insights.
CO4	Analyze different data mining techniques and evaluate their application to various types of data.
CO5	Evaluate the effectiveness of classification and clustering algorithms by assessing their accuracy, scalability, and performance in real-world applications. Critique clustering results and classify the effectiveness of various approaches in data mining.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	1	2	0	2
CO2	2	2	3	1	1
CO3	3	1	3	1	2
CO4	3	2	2	1	2
CO5	2	1	3	1	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Data Warehousing: Basic concepts in data warehousing, Collecting the requirements of data warehouse, Data Warehouse Architecture, Design, Implementation & Maintenance, OLAP in data warehouse, Data warehousing and the web, Data Cube Technology, From Data Warehousing to Data Mining.	**6**
UNIT-2	Data Mining Concepts: Data mining primitives, Basics of data mining, Query language, Architectures of data mining systems Mining Association Rules in Large Databases: Association Rule Mining, Mining Single Dimensional Boolean Association Rules from Transactional Databases	**8**
UNIT-3	Classification and Prediction: Decision Tree Induction, Bayesian Classification, Back propagation, Classifier Accuracy. Cluster Analysis in Data Mining: Types of Data in Cluster Analysis. A Categorization of Major Clustering Methods, Partitioning Methods, Density Based Methods, Outlier Analysis, Evaluation of clustering result.	**8**
	TOTAL	**22**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Ponniah, P. *Data Warehousing Fundamentals for IT Professionals*, Wiley, 2nd Edition, ISBN: 978-0-470-46207-2.	2001
2	Dunham, M. H. *Data Mining: Introductory and Advanced Topics*, Pearson Education, ISBN: 978-0-13-088892-1.	2002
3	Han, J., & Kamber, M. *Data Mining: Concepts and Techniques*, Morgan Kaufmann, 2nd Edition, ISBN: 978-1-55860-901-3.	2006
4	Berry, M. J. A., & Linoff, G. S. *Data Mining Techniques: For Marketing, Sales, and Customer Relationship Management*, Wiley, 2nd Edition, ISBN: 978-0-471-47064-9.	2004

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 328: Cryptography and Coding Theory	**L**	**T**	**P**	NIL
	2	**0**	**0**	

Course Objective: To provide foundational knowledge of cryptographic principles and coding theory for secure communication and data protection.

Course Outcomes (CO):

CO1	Explain the fundamental concepts of cryptography and coding theory.
CO2	Demonstrate the ability to implement basic cryptographic algorithms such as Caesar cipher and simple error-correcting codes.
CO3	Analyze the security of basic cryptographic systems and the effectiveness of simple error-correcting codes.
CO4	Apply cryptographic and coding techniques in straightforward scenarios, such as securing a message or correcting errors in data transmission.
CO5	Assess the practical applications of cryptography and coding theory in everyday situations.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	1	1	1	1
CO2	2	1	1	1	1
CO3	2	1	1	1	1
CO4	2	1	1	1	1
CO5	2	1	1	1	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	**Introduction to Cryptography:** Historical overview, basic principles (confidentiality, integrity, authentication), classical cryptosystems (substitution and transposition ciphers), modern cryptography (symmetric key cryptography: DES, AES)	**7**
UNIT-2	**Public Key Cryptography:** Principles of public key cryptography, RSA algorithm, key exchange algorithms (Diffie-Hellman), digital signatures, hash functions and message digests.	**7**
UNIT-3	**Coding Theory:** Introduction to coding theory, error detection and correction, linear codes (Hamming code, cyclic codes), applications of cryptography and coding theory in data security and network security	**8**
	TOTAL	**22**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Stallings, W. *Cryptography and Network Security: Principles and Practice*, Pearson Education, 8th Edition, ISBN: 978-1292437484.	2022
2	Forouzan, B. A. *Cryptography and Network Security*, McGraw Hill Education, 3rd Edition, ISBN: 978-9339220945.	2015
3	Jones, G. A., & Jones, J. M. *Information and Coding Theory*, Springer, ISBN: 978-1852336229.	2000
4	Hill, R. *A First Course in Coding Theory*, Oxford University Press, ISBN: 978-0198538035.	1986

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
ISEMA 302: SEC-5 Research Methodology	**L**	**T**	**P**	NIL
	2	**0**	**0**	

Course Objective: To understand the basic techniques and develop basic skills to conduct a systematic research

Course Outcomes (CO):

CO1	Introduce research methods and processes.
CO2	Formulate research problem statement using various quantitative techniques and prepare the plan for investigations.
CO3	Communicate and present research findings following ethics in research.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	1	1	1	2
CO2	2	3	1	2	2
CO3	1	1	3	1	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Research: Meaning, Objectives, Motivation, Types. Research Approaches, Significance of Research, Research Methods vs Methodology, Criteria of Good Research, Defining the Research Problems, Meaning of Research Design, Need for Research Design, Features of a Good Design	**11**
UNIT-2	Methods of Data Collection, Processing and Analysis of data: Processing Operations, Problems in Processing, Types of Analysis, Statistics in Research, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry, Measures of Relationship, Simple Regression Analysis, Publication Ethics: Definition, Introduction and Importance	**11**
	Total	**22**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	C. R. Kothari, Research Methodology: Methods and Techniques, Second Edition, New Age International Publisher	2004
2	C. George Thomas, Research Methodology and Scientific Writing, Second Edition, Springer	2023
3	J. W. Creswell, J. D. Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, Sixth Edition,	2022
4	Upendra Pratap Singh, Sakshi Ahlawat, Sushma Sharma, Research and Publication Ethics, Sultan Chand and Sons	2023

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
ISEMA 304: SEC-5 Cyber Security	**L**	**T**	**P**	NIL
	2	**0**	**0**	

Course Objective: To equip students with the technical knowledge and skills needed to protect and defend against cyber threats.

Course Outcomes (CO):

CO1	Identify and compare various types of cyberattacks, cybercrimes, vulnerabilities and remedies thereto.
CO2	Explain and infer the cyber security risks.
CO3	Analyse and evaluate the security aspects of social media platforms and ethical aspects associated with use of social media.
CO4	Design and develop measures for self-cyber-protection as well as societal cyber-protection.
CO5	Describe the concept of digital devices and their security mechanisms.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	1	1
CO2	3	2	1	1	1
CO3	3	2	1	1	1
CO4	3	2	1	1	1
CO5	3	2	1	1	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Introduction: Concept of cyber security, Issues and challenges of cyber security, Defining Cyberspace and Overview of Computer and Web-technology, Architecture of cyberspace, Communication and web technology, Internet, World wide web.	**7**
UNIT-2	Cyber Crimes: Classification of cybercrimes, Common cyber crimes-cybercrime targeting computers and mobiles, financial frauds, social engineering attacks, malware and ransomware attacks, zero day and zero click attacks, Social media privacy, Challenges, opportunities and pitfalls in online social network, Security issues related to social media.	**7**
UNIT-3	Digital Device Security: End Point device and Mobile phone security, Password policy, Security patch management, Data backup, Downloading and management of third party software, Device security policy, Cyber Security best practices, Significance of host firewall and Ant-virus, Management of host firewall and Antivirus, Wi-Fi security, Configuration of basic security policy and permissions, Advanced attacks like SQL injection, Zero-day exploits, DDoS attacks, Cross-Site Scripting, etc.	**8**
	TOTAL	**22**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Belapure, S., & Godbole, N. *Cyber Security: Understanding Cyber Crimes, Computer Forensics, and Legal Perspectives*, Wiley India Pvt. Ltd, 1st Edition, ISBN: 978-8126521791.	2011
2	Maiwald, E. *Fundamentals of Network Security*, McGraw Hill, 1st Edition, ISBN: 978-0072226973.	2017
3	Singh, A. *Introduction to Cyber Security*, Universities Press, 1st Edition, ISBN: 978-9389211804.	2024
4	Glisson, L. *Cyber Security for Beginners*, Notion Press, 1st Edition, ISBN: 978-1946390938.	2022
5	Monte, M. *Network Attacks & Exploitation: A Framework*, Wiley, 1st Edition, ISBN: 978-1118987124.	2015

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 401: Functional Analysis	**L**	**T**	**P**	**NIL**
	3	**1**	**0**	

Course Objective: To acquire knowledge of linear mappings defined on Banach spaces and Hilbert spaces

Course Outcomes (CO):

CO1	Explain the fundamental properties of normed linear spaces, Banach and Hilbert spaces, and apply concepts like orthogonality, orthogonal projection, and complete orthonormal sets. (Understanding)
CO2	Apply the Hahn-Banach theorem and represent linear functionals in Hilbert spaces, analyzing the behavior of dual spaces and understanding strong and weak convergence of sequences of functionals. (Applying)
CO3	Examine various types of linear operators (bounded, adjoint, self-adjoint, compact) and their convergence properties, and demonstrate the implications of the Banach-Steinhaus theorem, closed graph theorem, and bounded inverse theorem. (Analyzing)
CO4	Evaluate the applications of key functional analysis theorems, including the open mapping theorem, uniform boundedness principle, and Banach fixed point theorem, in problem-solving contexts. (Evaluating)
CO5	Formulate and interpret spectral properties of operators, including eigen spectrum, spectral representation, and singular value decomposition, for self-adjoint, normal, and unitary operators in compact and non-compact cases. (Creating and Evaluating)

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	0	2	2	1
CO2	2	0	3	2	1
CO3	2	0	3	2	1
CO4	3	0	3	3	1
CO5	3	0	3	3	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Linear spaces: Normed linear spaces with examples, Banach spaces, Hilbert spaces, orthogonality in Hilbert spaces, orthogonal projection theorem, best approximation theorem, complete orthonormal set, Bessel's inequality, Parseval's theorem.	**10**
UNIT-2	Linear functionals: Dual & reflexive spaces, dual basis, Hahn-Banach extension theorem, representation of linear functionals on Hilbert spaces, strong and weak convergences of a sequence of functional.	**8**
UNIT-3	Linear operators: Bounded linear operators in a normed space, bounded linear functionals in a normed space, uniform and point wise convergence of operators, compact operator, Banach-Steinhaus theorem, bounded inverse theorem, closed linear operators, adjoint operator, self-adjoint, normal and unitary operators; Hilbert-Schmidt theorem.	**9**
UNIT-4	Open mapping theorem, closed graph theorem, uniform boundedness principle, consequences of these theorems.	**8**
UNIT-5	Spectral Analysis: Eigen spectrum and approximate Eigen spectrum; spectral results for self-adjoint, normal and unitary operators; spectral representation for compact self-adjoint operators; singular value representation of compact operators.	**10**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley & Sons, New York.	2001
2	M. Reed and B. Simon, Functional Analysis, Academic Press, Inc., London.	1980
3	A. E. Taylor, Introduction to functional Analysis, John Wiley & Sons	1958
4	G. F. Simmons, Introduction to Topology and Modern Analysis, Krieger.	2003

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 402: Graph Theory	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To introduce fundamental concepts in graph theory, and to develop and define new graph models that effectively represent and solve problems in various domains.

Course Outcomes (CO):

CO1	Understand the fundamental concepts of graphs and analyze relationships using incidence and adjacency matrices.
CO2	Analyze and solve problems related to paths, cycles, connectedness, and graph traversal.
CO3	Comprehend the properties and structures of trees, and apply algorithms to find minimum spanning trees in weighted graphs.
CO4	Explore connectivity in graphs, and apply the concepts to understand graph planarity and properties of n-connected graphs.
CO5	Develop an understanding of Coloring and matching and apply these concepts in graph theory problems.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	3	0	3	3
CO2	3	2	1	3	3
CO3	3	3	1	3	3
CO4	3	3	0	0	3
CO5	3	3	0	3	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Graphs and Simple Graphs, Vertex Degrees, Degree Sequences, Subgraphs, Incidence and Adjacency Matrices, Graph Isomorphism	**6**
UNIT-2	Walks, Paths, Cycles, Circuits, Connectedness, The Shortest Path Problem, Non separable Graphs, Eulerian Graphs, Hamiltonian Graphs, The Chinese Postman Problem, The Travelling Salesman Problem	**10**
UNIT-3	Trees, Characterization of Trees, Rooted and Binary trees, Spanning Trees and their properties, Spanning trees in weighted graphs, Minimum spanning trees, algorithms for minimum spanning trees.	**9**
UNIT-4	Cut-vertex, Bridge, Blocks, Vertex-Connectivity, Edge-Connectivity, Menger's Theorem, Properties of n-connected graphs with respect to vertices and edges, Planar graphs, Euler Identity, Non-Planar graphs, Kuratowski's Theorem	**11**
UNIT-5	Vertex coloring, n-coloring, Chromatic number of a graph, Chromatic number of standard graphs, Bichromatic graphs, Bounds for chromatic number, Perfect graphs, Chromatic polynomial, Matching, Perfect Matching, Maximum Matching	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Narishgh Deo, Graph theory with applications to engineering and computer science, Dover Publications Inc. , 1st Edition	2016
2	G. Chatrand, and O.R. Ollermann, Applied and Algorithmic Graph Theory, McGraw Hill	1993
3	Douglas B. West, Introduction to Graph Theory, Pearson Education India	2015
4	J.A. Bondy, and U.S.R. Murty, Graduate Texts in Mathematics, Springer	2010
5	F. Harary, Graph Theory, Narosa Publishing House	2001

Department of Applied Mathematics
Delhi Technological University,
(Formerly Delhi College of Engg.)

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
	L	T	P	
IMSMA 403: Mathematical Methods	3	1	0	Elementary knowledge of ODE and PDE

Course Objective: The objective of the course is to provide basics of integral equations and calculus of variations. These tools help in studying differential equations and other application based problems.

Course Outcomes (CO):

CO1	Classify the integral equations in various forms and converting IVP and BVP to integral equations and vice-versa.
CO2	Categorise and solve the Fredholm integral equations using various methods and describe the important of Hilbert-Schmidt and Green's function for solving the BVP.
CO3	Categorize and solve the Volterra integral equations using various method for solving IVP problems.
CO4	Conceptual learning of solving various mathematical and physical problems using variational techniques.
CO5	Apply the Euler-Lagrange equation to higher dimensions and higher order derivatives to solve not only one and multi-dimensional problems.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	1	2	1	2
CO2	2	2	2	2	2
CO3	2	2	2	2	2
CO4	3	2	2	2	2
CO5	2	3	2	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
Unit -1	Classification of Integral Equations: Fredholm, Volterra, Integro-Differential Equations, Singular equations, Conversion of IVP to the Volterra integral equation, Reduction of Volterra integral equation to IVP, Reduction of BVP to the Fredholm integral equation.	**9**
Unit -2	Fredholm Intergral Equations: Various types, Solutions of Fredholm integral equation of the first and second kind, Degenerate (separable) kernel, Direct computation, Successive approximation (Nuemann's series), Homogeneous Fredholm Integral, Resolvent kernel, Eigenvalues and Eigenfunctions, Fredholm equation with symmetric kernel, orthogonality, Hilbert-Schmidt Theorem and related problems, Green's function.	**9**
Unit -3	Volterra Integral Equation: Volterra integral equation of second kind, Series solution method, Successive approximation, Laplace transform method, Resolvent kernel, Solution of Volterra equation of first kind by Laplace transform method, Conversion to Volterra integral equations of second kind.	**9**
UNIT-4	Calculus of Variation: Functional and its variation, shortest distance problem, Euler- Lagrange equation, Extremal, Necessary and Sufficient conditions for the extremum of a functional, Moving boundary problem: Brachistochrone problems, One sided variations, Geodesic problems, Isoperimetric problems, problems of minimum surface of revolution.	**9**
Unit -5	Multi-dimensional problems: Two independent variables, Several independent variables, Several dependent variables but one independent variable, Second order derivative, higher order derivatives, Applications of multi-dimensional Euler- Lagrange equation.	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	I. M. Gelfand, S. V. Fomin, Calculus of variations, Prentice-Hall.	1963
2	A.J. Jerri, Introduction to Integral equations with Applications,2nd Ed.Wiley Publications	1999
3	W.V. Lovitt, Linear Integral equations, Dover Publications,	2005
4	A.M. Wazwaz, A first course in integral equations, World Scientific	1997
5	LokenathDebnath: Integral Transform and their applications, CRC Press	2006
6	D.C. Goyal and M.C. Sharma: Integral equations, PHL	2017
7	Krasnov: problems and exercise in Calculus of variations	1985
8	A. S. Gupta, Calculus of Variations with applications, PHI Learning Pvt. Ltd.	1996

Details of Course:

Course Title	Course Structure			Pre-Requisite
IMSMA 404: Mathematical Modelling and Simulation	**L**	**T**	**P**	Knowledge of differential equations and numerical methods
	3	**0**	**2**	

Course Objective: The objective of the course is to understand and develop the mathematical model to answer real life problem.

Course Outcomes (CO):

CO1	Develop an understanding of concepts of modelling and simulation, by extracting the necessary and relevant information regarding the problem.
CO2	Apply various techniques to analyse stability and long term behaviour
CO3	Development of mathematical models of some real world problems and their solution
CO4	Develop an understanding of various population models.
CO5	Develop an understanding about nonlinear dynamics, bifurcation and chaos.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	3	2
CO2	2	3	2	2	2
CO3	3	3	2	3	2
CO4	3	3	2	3	2
CO5	3	3	2	3	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Concept of Mathematical modelling; some modelling approaches: empirical, simulation, deterministic, statistical; Classification of mathematical models: black and white box, SQM space; Qualitative and quantitative approaches, Conceptual and physical model, Stationary and in-stationary models, distributed and lumped models, Compartment models.	**8**
UNIT-2	Steady State solution, Long term behaviour, Phase plane analysis, Linearization, Stability Analysis; Routh Hurwitz Criteria, Lyapunov functions.	**9**
UNIT-3	Models of single populations, Interacting Species models and extended population models, Prey – predator model, Growth models, Decay models, Lotka-Volterra model, Allee effect.	**9**
UNIT-4	Epidemic Models: Susceptible Infected (SI), Susceptible Infected Susceptible (SIS), Susceptible Infected Recovered (SIR), Lanchester combat model, Case Studies.	**9**
UNIT-5	Introduction to Bifurcation, Saddle node bifurcation, Trans-critical bifurcation, Pitchfork bifurcation, Hopf bifurcation: Forward and backward, Introduction to Chaos theory and non-linear dynamics, Case Studies.	**10**
	TOTAL	**45**

References:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	Belinda Barnes , Mathematical Modelling with case studies, CRC Press,2nd Ed.	**2011**
2	Fred Brauer and Carlos C. Chavez, Mathematical Models in population biology and Epidemiology, Springer, 2ndEd.	**2012**
3	Steven H. Strogatz , Nonlinear Dynamics and Chaos, CRC, 3rd Ed.	**2024**
4	William E. Boyce and Richard C. Diprima, Elementary Differential Equations and Boundary Value Problems, Wiley, 9th Ed.	**2009**

PRACTICALS LIST	
S. No.	**List of Experiments**
1	Write a program to draw direction fields for the system of differential equations with constant coefficients.
2	Write a program to find the steady-state solution, draw its phase plane plot for the system of ODEs and plot the solution of the system.
3	Write a program to find critical points, Jacobian matrix, eigen values and eigen vectors of system of differential equations with constant coefficients.
4	Develop a MATLAB function to check the stability of a linear system using the Routh-Hurwitz criterion.
5	Write a program to check the stability of a linear system using the Lyapunov function.
6	Simulate the Lotka-Volterra prey-predator model and analyze the population dynamics over time.
7	Implement the SIR model for an epidemic and analyze how varying parameters (infection rate, recovery rate) affect the spread of disease.
8	Simulate and analyze the saddle-node bifurcation in a simple dynamical system.
9	Simulate a transcritical bifurcation in a simple system.
10	Simulate the chaotic behavior of the Lorenz system.

Department of Applied Mathematics
Delhi Technological University,
(Formerly Delhi College of Engg.)

Details of Course:

Course Title	Course Structure			Pre-requisite
IMSMA 405 Advanced Ordinary Differential Equations	**L**	**T**	**P**	Calculus and Linear Algebra.
	3	**1**	**0**	

Course Objective: To introduce theoretical aspects of ordinary differential equations.

Course Outcomes(CO):

CO1	Classify ordinary differential equations, determine their order and degree and distinguish between initial and boundary value problems.
CO2	Determine existence and uniqueness of solutions for initial value problems of first-order, articulate interval of existence and non-existence of solutions.
CO3	Write higher-order linear differential equations into first-order system, solve linear differential equations of n^{th}-order and systems of first-order linear differential equations using matrix method
CO4	Apply Sturm theory, identify oscillatory and non-oscillatory differential equations, analyze the existence and asymptotic behaviour of the eigenvalues, and the corresponding qualitative theory of the eigenfunctions for Sturm–Liouville boundary value problems.
CO5	Sketch trajectories associated with, calculate critical points of, and demonstrate understanding of concepts related to phase plane analysis for simple autonomous linear and non-linear systems of equations.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	1	0	0	1
CO2	1	1	1	1	2
CO3	2	1	1	1	2
CO4	2	1	1	2	3
CO5	3	2	1	2	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Ordinary differential equations: Classification of ordinary differential equations – their origin and applications, initial and boundary value problems, algebraic properties of their solutions. s	**02**
UINT -2	Existence and uniqueness of solutions: First-order initial value problems, Lipschitz condition, Gronwall's inequality, ε-approximate solutions, equi-continuous set of functions, Ascoli lemma, Cauchy-Peano existence theorem, method of successive approximation, Picard-Lindelöf theorem, dependence of solutions on initial conditions and given functions, continuation of solutions, maximal and minimal interval of existence.	**11**
UNIT -3	Existence and uniqueness of solutions for system of first order equations and higher order equations: Representation of n^{th}-order equation as a system of first-order equations, existence and uniqueness theorems for systems and higher-order equations. Linear differential equations of n^{th}-order: Wronskian and its properties, reduction of order, method of variation of parameters, Abel's formula for Wronskian, homogeneous and nonhomogeneous linear differential equations. Linear systems of first-order equations: Homogeneous linear system – Wronskian of vector functions, fundamental set of solutions, Abel-Liouville formula, Non-homogenous linear systems, the matrix method for linear systems with constant coefficients, linear systems with periodic coefficients, Floquet theory.	**12**
UNIT-4	Sturm Theory: Self-adjoint equations of second order, Abel's formula, the separation and comparison theorems, Riccati equation, Sturm-Liouville boundary value problems, characteristic values and characteristic functions, orthogonality of characteristic functions.	**10**
UNIT-5	Nonlinear Differential Equations: Phase plane, paths and critical points, Autonomous Systems: Critical points and path of linear and non-linear systems, stability of linear systems with constant coefficients, method of Lyapunov for nonlinear systems, limit Cycles and periodic solutions, Benedixson's non-existence criterion, Poincaré-Benedixson theorem and its application.	**10**
	Total	**45**

References:

S. No.	Name of Books/Authors/Publishes	Year of Publication
1	S. L. Ross, Differential Equations, 3rd edition, John Wiley & Sons.	2007
2	T. Myint-U, Ordinary Differential Equations, Elsevier, North-Holland.	1978
3	S.G. Deo, V. Raghavendra, RasmitaKar, V. Lakshmikantham, Textbook of Ordinary Differential Equations, Tata McGraw-Hill.	2006
4	Earl A. Coddington and Norman Levinson, Theory of Ordinary Differential Equations, McGraw Hill Education.	2017
5	David A Sánchez, Ordinary differential equations and stability theory: An introduction, Dover Publication.	2014

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 406: GEC-12	**L**	**T**	**P**	Basics of probability and statistics as well as calculus and matrix algebra
Time Series Analysis	**3**	**1**	**0**	

Course Objective: Time-series analysis is a foundational course and is of utmost interest to data analysts.

Course Outcomes (CO):

CO1	Analyze time series data in order to extract meaningful statistics and other characteristic of the data.
CO2	Describe moving average models that can be used to calculate future values using time series data.
CO3	Analyze and measure the linear dependence between two points at different times.
CO4	Describe a typical specification strategy for linear time series models.
CO5	Analyse the measurement performed for checking the correlation and partial correlation in the time series data.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	1	2
CO2	2	2	2	2	2
CO3	2	1	1	1	2
CO4	1	1	1	3	2
CO5	2	1	1	1	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Meaning and necessity of time series analysis, Component of Time series, Adjustments to time series data, secular trend, Measurement of trend, Monthly trend of annual data, Seasonal variation, Measurement of seasonal variation, Cyclic fluctuation, Business Forecasting.	**9**
UNIT-2	Expectation, Stationarity and Ergodicity, White Noise, Moving Average Processes, Autoregressive Processes, Mixed Autoregressive Moving Average Processes, The Auto Covariance-Generating Function, Invertibility.	**9**
UNIT-3	Principles of Forecasting, Forecasts Based on an Infinite Number of Observations, Forecasts Based on a Finite Number of Observations, The Triangular Factorization of a Positive Definite Symmetric Matrix, Optimal Forecasts for Gaussian Processes, Sums of ARMA Processes.	**9**
UNIT-4	The Likelihood Function for a Gaussian AR(1) Process, The Likelihood Function for a Gaussian AR(p) Process, The Likelihood Function for a Gaussian MA(1) Process, The Likelihood Function for a Gaussian MA(q) Process, The Likelihood Function for a Gaussian ARMA(p,q) Process, Statistical Inference with Maximum Likelihood Estimation.	**9**
UNIT-5	The Population Spectrum, The Sample Periodogram, Estimating the Population Spectrum, Uses of Spectral Analysis.	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	J. D. Hamilton, Time Series Analysis, Princeton University Press..	1994
2	C. Chatfield, The Analysis of Time Series: An Introduction, Chapman & Hall/CRC, Sixth Edition.	2003
3	A. Pal, P.K.S. Prakash, Practical Time Series Analysis, Packt Publication, First Edition.	2017
4	Time Series Analysis and Its Application: With R Examples, Springer, Fourth Edition.	2017

Department of Applied Mathematics
Delhi Technological University,
(Formerly Delhi College of Engg.)

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 407: GEC-11 Machine Learning I	**L**	**T**	**P**	Basic concepts of Linear Algebra. Probability and Statistics
	2	**0**	**0**	

Course Objective: This course provides a comprehensive introduction to machine learning, covering fundamental concepts, techniques, and applications. Students will learn about supervised learning along with model evaluation.

Course Outcomes (CO):

CO1	Explain Machine Learning concepts, tasks, and system components.
CO2	Implement ML models and apply suitable techniques to problems.
CO3	Explain the role of hyperparameter tuning in improving model performance.
CO4	Interpret the results of different machine learning models and justify their selection for specific applications.
CO5	Develop machine learning models.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	0	3	3	3
CO2	0	2	3	2	3
CO3	0	1	2	0	1
CO4	0	0	2	1	2
CO5	0	1	2	2	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Introduction: Introduction to Machine Learning (ML), Fundamental Problems in ML, Examples of Automatic ML System. Overview of Different ML Tasks: Supervised Learning, Unsupervised Learning, Reinforcement Learning. Components of ML.	**6**
UNIT-2	Supervised Learning: K-Nearest Neighbors, Bayesian Classification, Linear Discriminant Analysis, Linear Regression, Logistic Regression, Decision Trees, Support Vector Machine (SVM)	**8**
UNIT-3	Introduction to Artificial Neural Network: Perceptron model, Multilayer Perceptron, Error Backpropagation. Estimating and Comparing Classifiers: Cross Validation, Maximum Likelihood Model Comparison, Bayesian Model Comparison.	**8**
	TOTAL	**22**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Mitchell, T. *Machine Learning*. McGraw Hill, ISBN: 978-0070428079.	1997
2	Bishop, C. *Pattern Recognition and Machine Learning*. Springer, ISBN: 978-0387310732.	2006
3	Murphy, K. *Machine Learning: A Probabilistic Perspective*. MIT Press, ISBN: 978-0262018029.	2012
4	Hastie, T., Tibshirani, R., & Friedman, J. *The Elements of Statistical Learning*. Springer, ISBN: 978-0387848570.	2011
5	Sutton, R. S., & Barto, A. G. *Reinforcement Learning: An Introduction*. MIT Press, ISBN: 978-0262039246.	2018

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 408: GEC-13 Machine Learning II	**L**	**T**	**P**	Basic concepts of Linear Algebra. Probability and Distribution
	2	**0**	**0**	

Course Objective: This course provides a comprehensive introduction to machine learning, covering fundamental concepts, techniques, and applications. Students will learn about unsupervised learning along with a reinforcement learning model.

Course Outcomes (CO):

CO1	Explain and compare different unsupervised learning techniques
CO2	Apply Reinforcement Learning methods for decision-making.
CO3	Review and contrast Deep Learning and Machine learning models and their applications.
CO4	Evaluate model performance using Bias-Variance trade-off and Overfitting techniques.
CO5	Apply machine learning models to real-world problems using ensemble methods.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	3	2	1
CO2	1	2	3	1	2
CO3	1	2	3	2	3
CO4	1	1	2	2	1
CO5	1	1	3	2	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Unsupervised Learning: Hierarchical Clustering, K-Means Clustering, Mixture Densities And Identifiability, Expectation Maximization, Graph Theoretic Models for Clustering, Principal Component Analysis, Low Dimensional Representation and Multidimensional Scaling.	**8**
UNIT-2	Reinforcement Learning: Markov Decision Processes (MDP), Bellman's Equations, Value Iteration and Policy Iteration, Value Function Approximation, Q Learning. Review on Deep Learning Models.	**8**
UNIT-3	Algorithm Independent Machine Learning: No Free Lunch Theorem, Minimum Description Length Principle, Overfitting Avoidance and Occam's Razor, Bias and Variance. Ensemble Methods: Ada Boost, Random Forest Classifier.	**6**
	TOTAL	**22**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Mitchell, T. *Machine Learning*. McGraw Hill, ISBN: 978-0070428079.	1997
2	Bishop, C. *Pattern Recognition and Machine Learning*. Springer, ISBN: 978-0387310732.	2006
3	Murphy, K. *Machine Learning: A Probabilistic Perspective*. MIT Press, ISBN: 978-0262018029.	2012
4	Hastie, T., Tibshirani, R., & Friedman, J. *The Elements of Statistical Learning*. Springer, ISBN: 978-0387848570.	2011
5	Sutton, R. S., & Barto, A. G. *Reinforcement Learning: An Introduction*. MIT Press, ISBN: 978-0262039246.	2018

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 409: Natural Language Processing	**L**	**T**	**P**	Basic programming fundamentals
	2	**0**	**0**	

Course Objective: Natural Language Processing aims to design computer programs to read, understand, and comprehend the text written in natural language.

Course Outcomes (CO):

CO1	Describe the basic principles, techniques, and applications of Natural Language Processing tasks.
CO2	Model a natural language in a format that is understandable by the computer program
CO3	Describe approaches for syntax and semantic analysis of text.
CO4	Determine relevant information from the text.
CO5	Apply and analyze NLP techniques.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	1	3	2	2
CO2	2	2	3	1	2
CO3	2	1	3	1	2
CO4	2	1	3	2	1
CO5	3	1	3	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Introduction: Introduction to NLP, Origins and History of NLP, Language Analysis, Phases in Language Analysis, Major Challenges of NLP, NLP and Machine Learning, Natural Language and Grammar, Applications of NLP, Simple NLP Implementation Using Python. Tasks in NLP: Word Sense Disambiguation, Machine Translation, Keyphrase Extraction, Advancements in NLP	**7**
UNIT-2	Language Modeling: Statistical Language Models, N-gram models, Smoothing Techniques, Maximum Likelihood Estimation, Markov Models, Hidden Markov Models, Continuous Space Models, Dimensionality Reduction using Latent Semantic Analysis, Word Embeddings, Grammar Based Language Models.	**7**
UNIT-3	Lexical Analysis: Tokenization, Stop Word Removal, Stemming, Lemmatization, Part-of-speech tagging, Hidden Markov Model (HMM) based POS tagging, Maximum Entropy (MaxEnt) Model, Spelling Error Detection and Correction. Syntactic Analysis: Context-free Grammar, Probabilistic Context-Free Grammar, Treebanks, Top-down Parsing, Bottom-up Parsing, Probabilistic Parsing, Structural Ambiguity. Semantic Analysis: Meaning Representation, Formal Representations of Meaning - Propositional Logic, First-Order Predicate Logic, Semantic Ambiguity, Semantic relatedness, Similarity measures.	**8**
	TOTAL	**22**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Jurafsky, D., & Martin, J. H. *Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition with Language Models*, 3rd Edition.	2025
2	Manning, C. D., & Schütze, H. *Foundations of Statistical Natural Language Processing*, MIT Press, ISBN: 978-0262133609.	1999
3	Tiwari, U. S., & Siddiqui, T. *Natural Language Processing and Information Retrieval*, Oxford University Press, ISBN: 978-0195692327.	2008
4	Allen, J. *Natural Language Understanding*, Pearson Education, 2nd Edition, ISBN: 978-0805303346.	2003
5	Bird, S., Klein, E., & Loper, E. *Natural Language Processing with Python: Analyzing Text with the Natural Language Toolkit*, O'Reilly Media, ISBN: 978-0596516499.	2009

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 410: Statistical Quality Control and Decision Making	**L**	**T**	**P**	Knowledge of probability & statistics
	3	**1**	**0**	

Course Objective: This course introduces basic quality management using Statistical Process Control (SPC) based quality improvement techniques to assist in process improvement, production control, production planning and decision-making

Course Outcomes (CO):

CO1	Describe the control variables for quality control.
CO2	Decide the sampling plan for the quality control process.
CO3	Analyse and decide the forecasting model for time series.
CO4	Create optimized monetary table for pay-off. And calculate other financial status indicating factors.
CO5	Analyse and suggest the measure of improvement

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	1	1	2
CO2	3	1	2	1	2
CO3	3	1	2	2	2
CO4	3	1	2	2	3
CO5	3	1	2	2	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Introduction to Statistical Quality Control, Process control and product control. Tools for SQC. Control charts for variables. Control Charts for attributes. Natural tolerance limits and specification limits.	**9**
UNIT-2	Acceptance sampling inspection plans. Single Sampling plan. Double sampling plan and their comparison. Sequential sampling plan.	**10**
UNIT-3	Components and analysis of time series. Measurement of trend, seasonal variations and cyclic variation. Auto-regression series.	**9**
UNIT-4	Auto-correlation and correlogram. Choosing an appropriate forecasting model. Time series forecasting of seasonal data.	**9**
UNIT-5	Decision making. Pay off tables. Decision trees. Maximax payoff, Max-min payoff. Expected monetary value. Expected opportunity loss. Return-to-risk ratio. Decision making with sample information. Utility.	**8**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	David M. Levine, David F. Stephan, and Kathryn A. Szabat., Statistics for Managers, 7th Edition, PHI Learning Delhi.	2013
2	Walpole, Myers, Myers, and Ye, Probability and Statistics for Engineers & Scientists, Prentice Hall, NJ.	2011
3	Montgomery, D. C. John Introduction to Statistical Quality Control, Wiley and Sons.	2008

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 411: Digital Image Processing	**L**	**T**	**P**	Basics of Linear Algebra and Probability
	2	**0**	**0**	

Course Objective: To introduce the concept of Image Processing techniques and applications in real world scenarios.

Course Outcomes (CO):

CO1	Recall the fundamental concepts of image processing, including different types of images, image sensing, acquisition, quantization, and sampling techniques.
CO2	Explain the mathematical concepts behind image transformations, such as image negatives, log transformations, histogram processing, and the principles of color image processing.
CO3	Apply spatial filtering techniques (smoothing and sharpening) and perform image smoothing and sharpening in the Fourier domain using discrete Fourier Transforms (DFT) and other unitary transforms.
CO4	Analyze and compare different image transforms and evaluate their properties and effectiveness in image processing tasks.
CO5	Evaluate edge detection and image segmentation techniques and assess their application in segmenting and enhancing images.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	0	2	2	1	2
CO2	0	2	2	2	2
CO3	0	2	2	2	2
CO4	0	2	2	2	3
CO5	0	2	2	2	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Introduction: Different types of images, Visual perception, Image sensing and Acquisition, Quantization, Sampling, color image processing, Revision of Mathematical concepts for image processing, Image negatives, Log transformations, Histogram processing Spatial filter: smoothing and Sharpening	**6**
UNIT-2	Image transforms: Discrete Fourier transform, properties of 2-D DFT, Image smoothing and sharpening in Fourier domain, Two-dimensional orthogonal and UNIT-ary transforms, Optimum transform, Properties of Unitary transforms, Cosine transforms, Hadamard transforms, KL transforms, Comparison of image transforms	**8**
UNIT-3	Edge detection: Gradient and Laplacian based edge detection, Diffusion based edge detection: Isotropic and anisotropic diffusion, Image segmentation: Thresholding, region-based Morphological Watersheds, Bayesian based image segmentation.	**8**
	TOTAL	**22**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Gonzalez, R. C., & Woods, R. E. *Digital Image Processing*, Pearson Education, 4th Edition, ISBN: 978-0133356724.	2018
2	Jain, A. K. *Fundamentals of Digital Image Processing*, Prentice Hall, ISBN: 978-0133361650.	1989
3	Bovik, A. C. *The Essential Guide to Image Processing*, Academic Press, ISBN: 978-0123744579.	2009

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 412: Commutative Algebra	**L**	**T**	**P**	Knowledge of Abstract Algebra
	3	**1**	**0**	

Course Objective: To introduce students to the concepts of the Commutative Algebra

Course Outcomes (CO):

CO1	Apply Nil and Jacobson Radical.
CO2	Explain different types of modules.
CO3	Identify rings of fractions and localise rings at prime ideals.
CO4	Explain the concept of chain conditions.
CO5	Compare Noetherian rings and Artinian rings.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	0	1	1	1
CO2	2	0	1	1	1
CO3	2	0	1	1	1
CO4	2	0	1	1	1
CO5	2	0	1	1	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Zero divisors, nilpotent elements, units, prime ideals, maximal ideals, nil radical and Jacobson radical.	**9**
UNIT-2	Modules, module homomorphisms, submodules, quotient modules, operations on submodules, Direct sum and product, finitely generated modules, Free Modules.	**9**
UNIT-3	Chain Conditions. Integral extensions.	**9**
UNIT-4	Localisation and local rings, Ring of fractions, Primary Decomposition Theorem.	**9**
UNIT-5	Noetherian rings, Hilbert Basis theorem, Artinian rings	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	M.F. Atiyah & I.G MacDonald, Introduction to Commutative Algebra, CRC	1994
2	T.W. Hungerford, Algebra, Springer	2003
3	H. Matsumura, Commutative Ring Theory, Cambridge University Press.	1989
4	Balwant Singh, Basic Commutative Algebra, World Scientific	2022
5	N.S. Gopalakrishnan, Commutative Algebra (2nd Ed.), Orient Blackswan Private Limited - New Delhi	2015

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 413: Optimization Techniques	**L**	**T**	**P**	Basics of Real Analysis and Linear Algebra
	2	**0**	**0**	

Course Objective: To equip students with the knowledge and techniques for solving convex, quadratic, fractional, and nonlinear optimization problems using optimality conditions and duality principles.

Course Outcomes (CO):

CO1	Build a sound foundation of various optimization techniques.
CO2	Develop, apply and analyze optimization models for real world problems.
CO3	Identify unconstrained and constrained optimization problems.
CO4	Understand various direct and indirect search methods.
CO5	Understanding of the duality concepts for the non-linear programming problem.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	1	2	1
CO2	3	3	0	3	2
CO3	1	1	1	2	1
CO4	3	2	2	2	2
CO5	2	2	1	2	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Convex Optimization and Quadratic Programming: Convex functions and their properties, Characterization of convex function, Convex optimization problems, Solution of Convex optimization problems and theorems.	**6**
UNIT-2	Quadratic and fractional Programming: Quadratic programming problems, wolf method for quadratic programming. Linear fractional programming problems, Charns and cooper method.	**8**
UNIT-3	Optimality Conditions and Duality in Nonlinear Programming: Introduction, feasible directions and linearizing cone, Basic constraint qualification, Lagrangian and Lagrange Multipliers, Karush Kuhn Tucker necessary/sufficient optimality conditions, duality in nonlinear programming, wolf dual, mixed dual and Lagrange dual.	**8**
	Total	**22**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	C.R. Bector, S. Chandra, J. Dutta, Principles of Optimization Theory, Narosa Publications.	2016
2	M.S. Bazaraa, H.D.Sherali, & C.M. Shetty, Nonlinear Programming Theory & Algorithms, John Willey & Sons.	2006
3	S. Chandra, Jayadeva, A. Mehra, Numerical optimization with Applications, Narosa Publications.	2009
4	S. S. Rao, Engineering Optimization: Theory and Practice, John Wiley & Sons.	2009
5	N.S. Kambo, Mathematical Programming Techniques, East-West Press Pvt. Ltd.	2008
6	H.A. Taha, Operations Research: An Introduction, Pearson Education Inc.	2007

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 414 **Theory of Computation**	**L**	**T**	**P**	
	3	**1**	**0**	

Course Objective: To equip students with a deep understanding of the mathematical foundations of computation, including automata theory and formal language theory, essential for advanced studies and practical applications in computer science.

Course Outcomes (CO):

CO1	Demonstrate a deep understanding of fundamental models of computation, and describe their significance in theoretical computer science.
CO2	Classify programming languages using Chomsky's hierarchy and evaluate their characteristics and limitations.
CO3	Demonstrate the concepts, representations, and limitations of regular languages.
CO4	Construct, and simplify Context free grammars, analyze and apply theoretical principles to evaluate their characteristics and behaviours.
CO5	Demonstrate a deep understanding of pushdown automata and Turing machines, and apply these models to solve computational problems.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	0	1	0	1
CO2	2	0	1	0	1
CO3	2	0	1	0	1
CO4	3	0	1	0	1
CO5	3	0	1	2	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Automata: Definition of an Automaton, Description of a Finite Automaton, Transition system & its properties, Acceptability of a string by a finite Automaton, Nondeterministic Finite Automaton (NDFA), Equivalence of DFA and NDFA, Minimization of finite automaton, Moore & Mealy machines.	**9**
UNIT-2	Formal Languages: Definition of a Grammar, Derivations, Language generated by a grammar, Chomsky classification of languages & their relation, operations on languages.	**8**
UNIT-3	Regular Sets: Regular expressions, Ardens theorem, Transition system containing -moves, Kleene's theorem, Algebraic method using Arden's theorem, construction of finite automata equivalent to a regular expression, Equivalence of two finite automata, Pumping lemma for regular sets, closure Properties of regular sets.	**9**
UNIT-4	Context Free Languages: Definition of CFL, Derivation trees, Ambiguity in CFG, Simplification of CFG, Normal forms (CNF & GNF), Pumping lemma for CFL, Decision algorithms for CFL.	**9**
UNIT-5	Pushdown Automata: Definition & Description of pda, Instantaneous description, Move relation, Acceptance by pda, Turing Machines: Basic model, Definition & representation, Instantaneous description, Representation by transition table & transition diagram Language accepted by Turing Machine, Design of Turing Machine.	**10**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	K.L.P. Mishra and N. Chandrasekaran, "Theory of Computer Science Automata, Languages and Computation", PHI, 3rd Edition	2006
2	Martin J.C., "Introduction to Languages and Theory of Computations", Tata McGraw Hill, 4th edition	2007
3	J.E. Hopcroft, R. Motwani, and J.D. Ullman, Introduction to Automata Theory, Languages, and Computation, Pearson Education India, 3rd Edition	2008
4	Peter Linz, An Introduction to Formal Languages and Automata, Jones and Bartlett Publishers, Inc, 6th Edition	2016
5	Michael Sipser, Introduction to the Theory of Computation, Cengage India Private Limited, 3rd Edition	2014

Details of Course:

Course Title	Course Structure			Pre-Requisite
IMSMA 416: Portfolio Optimization	**L**	**T**	**P**	knowledge of random variable, expectation and variance
	2	**0**	**0**	

Course Objective: Knowledge of risk and return attached to a Portfolio and its optimization.

Course Outcome (CO):

CO1	Explain the concept of risk and return in the Portfolio.
CO2	Evaluate the weights of multi-asset Portfolio by minimizing the risk and maximizing the return.
CO3	Explain the Capital market line and market Portfolio.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	0	3	2	1
CO2	3	0	3	2	2
CO3	2	0	3	2	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S.No.	Contents	Contact Hours
UNIT-1	Review of concepts of expectation, variance and covariance. Type of assets, risk and return of assets. Definition of Portfolio and its representation, weights of the assets in Portfolio, return and risk of the Portfolio, Formulation of Two-asset Portfolio Optimization problem.	6
UNIT-2	Multi-asset Portfolio optimization. Markowitz Model for Portfolio Optimization, Markowitz curve and Markowitz bullet. Markowitz Efficient Frontier, Weights for Portfolio with a given expected return and minimum risk.	10
UNIT-3	Capital Asset Pricing Model (CAPM), Capital market line, Market Portfolio, Beta of the asset and Beta of the Portfolio, Security Market line.	6
	Total	**22**

References:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1.	D. G. Luenberger, Investment Science, Oxford University Press.	2006
2.	M. Capińsky and T. Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, 2nd Edition, Springer.	2011
3.	E. J. Elton, M. J. Gruber, S. J. Brown, W. N. Goetzmann, Modern Portfolio Theory and Investment Analysis, 8th Edition, Wiley India .	2010
4.	S. Chandra, S. Dharamaraja, A. Mehra, R. Khemchandani, Financial Mathematics: An Introduction, Narosa.	2013
5.	P.Gupta, M.K. Mehlawat, M.Inulguchi, S. Chandra, Fuzzy Portfolio Optimization: Advances in Hybrid Multi-criteria Methodologies, Springer.	

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 418: Stochastic Calculus	**L**	**T**	**P**	Knowledge of random variable and its various properties and normal distribution.
	2	**0**	**0**	

Course Objective: To develop the understanding of stochastic phenomenon and its calculus

Course Outcomes (CO):

CO1	Define the Stochastic Process and its properties.
CO2	Solve the stochastic integral.
CO3	Create and solve the stochastic differential equation.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	0	1	1	1
CO2	3	0	0	1	1
CO3	2	0	1	1	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Review of Conditional Probability. Sigma Field and simple example, Stochastic process, Strong sense and Weak sense stationary process. Brownian motion and Geometric Brownian motion(GBM), Modelling of stock price using GBM. Filtration and Martingales.	**11**
UNIT-2	Stochastic Calculus: Quadratic variation and related results. Stochastic Integral (Ito integral), Ito - Doeblin Formula for Brownian Motion (BM) First & Second Version. Introduction to Stochastic Differential Equation (SDE). Existence Theorem. SDE of GBM.	**11**
	Total	**22**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Thomas Mikosch, Elementary Stochastic Calculus with Finance in view, World Scientific.	2006
2	J. Michael Steele, Stochastic Calculus and Financial Applications, Springer	2012
3	S. Chandra, S. Dharamraja, A. Mehra, R. Khemchandani ,Financial Mathematics: An Introduction, 1st Edition, Narosa.	2012
4	Bernt Oksendal, Stochastic Differential Equation An Introduction with application, Springer	2004

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 420: Big Data Analytics	**L**	**T**	**P**	NIL
	2	0	0	

Course Objective: To understand the fundamentals of various big data analysis techniques, Hadoop structure, environment and framework.

Course Outcomes (CO):

CO1	Define and explain Big Data Concepts.
CO2	Analyze the components of the Hadoop ecosystem
CO3	Develop and execute MapReduce programs for processing large-scale datasets in a distributed computing environment.
CO4	Evaluate the suitability of NoSQL databases for handling unstructured and semi-structured Big Data.
CO5	Design scalable Big Data solutions using cloud service and apply Machine Learning techniques for Big Data analytics.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	0	1	1
CO2	2	1	1	2	2
CO3	2	1	1	1	3
CO4	1	2	2	3	2
CO5	2	1	1	2	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	**Introduction to Big Data:** Definition and Characteristics (3Vs, 5Vs of Big Data), Evolution of Data and Data Growth Trends, Traditional Data Processing vs. Big Data Processing, Applications of Big Data in Various Industries, Challenges in Big Data Management.	5
UNIT-2	**Hadoop Environment:** Overview of the Hadoop Ecosystem, Hadoop Architecture, Components and examples (like MapReduce Framework, Yet Another Resource Negotiator), Hadoop Distributed File System, File Operations in HDFS.	7
UNIT-3	**Data Processing with MapReduce:** Introduction to MapReduce, Map and Reduce Phases, Writing MapReduce Programs. **NoSQL Databases for Big Data**: Introduction to NoSQL, MongoDB (Document-based NoSQL), CRUD Operations, Indexing, Aggregation, Replication, Cassandra (Column-family NoSQL).	6
UNIT-4	**Advances in Big Data:** Machine Learning for Big Data, Scalable ML Frameworks, Case Studies & Industry Applications, Cloud service for Big data (AWS, Google Cloud, Azure)	4
	Total	**22**

References:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	White, T. *Hadoop: The definitive guide*. O'Reilly Media, 4th Edition, ISBN: 978-1491901632.	2015
2	Marz, N., & Warren, J. *Big data: Principles and best practices of scalable real-time data systems*. Manning Publications, 1st Edition, ISBN: 978-1617290343.	2015
3	Kulkarni, P. (2016). *Machine learning with big data*. Springer, 1st Edition, ISBN: 978-3319431608.	2016
4	Bahga, S., & Madisetti, V. (2014). *Cloud computing for big data: Principles and best practices*. CreateSpace Independent Publishing, 1st Edition, ISBN: 978-1494435141.	2014

Department of Applied Mathematics
Delhi Technological University,
(Formerly Delhi College of Engg.)

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 501: Matrix Computation	**L**	**T**	**P**	Some knowledge of linear algebra.
	3	**1**	**0**	

Course Objective: After the course, one should be able to solve various real-life problems.

Course Outcomes (CO):

CO1	Apply computational techniques and algebraic skills essential for the study of systems of linear equations, matrix algebra, vector spaces, eigenvalues and eigenvectors, orthogonality and diagonalization.
CO2	Choose an appropriate numerical method to solve systems of linear equations, least squares problems, and the eigenvalue problem.
CO3	Evaluate and compare the efficiency and numerical stability of different algorithms for solving linear systems, least squares problems, and the eigenvalue problem using matrix norms
CO4	Design algorithms that exploit matrix structures such as triangularity, sparsity, banded structure, and symmetric positive definiteness
CO5	Quantify the sensitivity of a linear system or least squares problem to perturbations in the data

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	0	2	1	3
CO2	2	0	3	1	3
CO3	3	0	2	2	3
CO4	3	0	2	1	3
CO5	3	0	2	1	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Inner product spaces, Vector and Matrix Norms. Orthogonalization using Gram- Schmidt process and its applications. Orthogonal and unitary matrices, Symmetric and Hermitian Matrices, Hessenberg Matrices.	**10**
Unit -2	Ill-conditioned system of linear equations, Condition number of a matrix and applications, Singular values of a matrix, Singular value decomposition (SVD) and its applications.	**9**
Unit -3	Pseudo inverse of a matrix, Moore-Penrose inverse, Least square solutions to linear System using pseudo inverse, Sensitivity of the least square problem	**9**
UNIT-4	Householder's matrices and QR factorization and its applications, Positive definite matrices and diagonally dominant system and applications.	**9**
UNIT-5	Best Approximation: Orthogonal basis functions, Weighted least square, Generalized Eigen vectors, Jordan Canonical form.	**8**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	B.N. Datta, Numerical Linear Algebra and Applications, PHI, Second edition	2013
2	Lloyd N. Trefethen, Numerical Linear Algebra, SIAM	2022
3	Ascher U.M., A first course in numerical methods	2013
4	R. S. Gupta, Elementary Numerical Analysis, Cambridge University Press	2015

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 502: Measure Theory	**L**	**T**	**P**	Real Analysis(optional)
	3	**1**	**0**	

Course Objective: To impart knowledge of Measurable set and integration of functions in Lebesgue sense.

Course Outcomes (CO):

CO1	Classify sets based on countability, measurability, and related properties; apply the concepts of inner and outer Lebesgue measures to determine measurability; distinguish between measurable, non-measurable, and Borel sets. (Understanding and Applying)
CO2	Analyze the properties and convergence behaviours of measurable functions, including pointwise and almost everywhere convergence, and apply Egoroff's Theorem to assess types of convergence. (Analyzing and Applying)
CO3	Examine the structure of measurable functions, and use Lusin's and Frechet's Theorems to describe convergence properties; apply F. Riesz's Theorem and the bounded convergence theorem to evaluate Lebesgue integrability. (Analyzing and Evaluating)
CO4	Apply theorems on integration for non-negative and general measurable functions, including Fatou's Lemma, Monotone Convergence, and Dominated Convergence, to solve problems involving the Lebesgue integral and improper integrals. (Applying and Evaluating)
CO5	Explain Lp-spaces, proving inequalities such as Hölder's, Minkowski's, and Schwarz's; apply the Riesz-Fischer Theorem to characterize convergence within Lp-spaces. (Understanding, Applying, and Creating)

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	0	3	3	1
CO2	2	0	3	3	1
CO3	3	0	3	3	1
CO4	3	0	2	3	1
CO5	2	0	3	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Countability and uncountability of sets, outer and inner Lebesgue measures, Lebesgue measurable sets and their properties, non-measurable sets, Borel sets, Cantor's ternary sets.	**8**
UNIT-2	Measurable functions, continuous function, sets of measure zero, Borel measurable function, pointwise convergence, almost everywhere convergence, almost everywhere uniform convergence, Egoroff's Theorem.	**9**
UNIT-3	The structure of measurable functions: Lusin Theorem, Frechet Theorem, convergence in measure, F. Riesz's theorem on convergence almost everywhere, Lebesgue integral of bounded measurable function, bounded convergence theorem.	**10**
UNIT-4	Integral of non-negative measurable functions, Fatou's lemma, monotone convergence theorem, general Lebesgue integral, Lebesgue dominated convergence theorem, improper integral.	**10**
UNIT-5	Lp –space and its properties, Holder's inequality, Minkowski's inequality and Schwartz's inequality, Riesz-Fischer theorem.	**8**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	H.L. Royden and P.M. Fitzpatrick, Real analysis, 4th edition, Pearson Education	2015
2	G. D. Barra, Measure theory and integration, John Willy and sons	1981
3	P.K. Jain, V.P. Gupta, Pankaj Jain, Lebesgue Measure and integration, 2nd edition, New Age International Publishers	2010
4	Inder K. Rana, An Introduction to Measure and Integration, 1st edition, Narosa Publishing House.	1997

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 503: Advanced Partial Differential Equations	**L**	**T**	**P**	Functional Analysis and a basic course on ODE and PDE.
	3	**1**	**0**	

Course Objective: To introduce Theory of Partial Differential Equations in higher dimensions.

Course Outcomes (CO):

CO1	Determine the principal theoretical issues concerning the solving of partial differential equations in higher dimensions, classify well posed problems and classical solutions
CO2	Differentiate between four important linear partial differential equations in R^n- transport equation, Laplace equation, Heat equation and Wave equation, construct representation formula for transport equation, deduce fundamental solution for Laplace equation and representation formula using Green's functions, apply properties of harmonic functions
CO3	Define physical significance of heat equation, deduce fundamental solution for heat equation, solve homogeneous and non-homogeneous heat equation in higher dimensions, apply mean-value formula and maximum principle, estimate the solutions of the heat equation
CO4	Interpret physical significance of wave equation, identify the solution of wave equation in one and higher dimensions, distinguish between d'Alembert's solution ($n = 1$) and solution through spherical means ($n \geq 2$), solve non-homogeneous problem using Duhamel's principle, identify the domain of dependence
CO5	Analyse general non-linear partial differential equation in higher dimensions, construct representation formulae for nonlinear equations, devise new solutions from envelopes, apply method of characteristics to solve nonlinear equations

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	1	1	1	0
CO2	2	2	1	2	2
CO3	2	2	1	2	2
CO4	2	2	1	2	2
CO5	2	2	1	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Partial Differential Equations: Well-posed problems, classical solutions, weak solutions and regularity. Representation formula for solutions: Transport equation – initial value problem, nonhomogeneous problem.	**02**
UNIT -2	Laplace equation: Physical significance, fundamental solution, Poisson's equation, mean-value formula. Properties of harmonic functions: Strong maximum principle, uniqueness, mollifiers, regularity, local estimates for harmonic functions, Liouville's theorem, analyticity, Harnack's inequality. Green's function: Representation formula using Green's function, Green's function for a half-space and ball. Energy methods: Uniqueness and Dirichlet's principle.	**12**
UNIT-3	Heat equation: Physical interpretation, fundamental solution, solution of homogeneous problems, Duhamel's principle, nonhomogeneous problems, mean value formula, parabolic cylinder and heat ball. Properties of solutions: Strong maximum principle, uniqueness, regularity, local estimates for the solution of the heat equation. Energy methods: Uniqueness and backward uniqueness.	**11**
UNIT-4	Wave equation: Physical interpretation, solution by spherical means – d'Alembert's formula, spherical means, Euler-Poisson-Darboux equation, Kirchhoff's and Poisson's formula, solution in even and odd dimensions, non-homogeneous problem. Energy methods: Uniqueness and domain of dependence.	**10**
UNIT-5	Nonlinear First-order PDE in n-dimensions : Complete integrals, envelopes, characteristics. Conservation Laws: Shocks, entropy condition – Rankine-Hugoniot condition, Lax-Oleinik formula, weak solutions and uniqueness, Riemann problem, long time behavior, decay to N-wave.	**10**
	Total	**45**

References:

S. No.	Name of Books/Authors/Publishes	Year of Publication
1.	Lawrence C. Evans, Partial Differential equations, Graduate Studies in Mathematics Vol. 19, 2nd edition, American Mathematical Society.	2010
2.	Fritz John, Partial Differential Equations, Applied Mathematical Sciences Vol. 01, 4th edition, Springer-Verlag.	1982
3.	EmmanueleDiBenedetto, Partial Differential Equations, 2nd edition, Birkhäuser Boston.	2009
4.	Michael Renardy and Robert C. Rogers, An Introduction to Partial Differential Equations, Texts in Applied Mathematics Vol. 13, Springer-Verlag.	2004
5.	Walter A. Strauss, Partial Differential Equations: An Introduction, 2nd Edition, Wiley.	2007

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 504: Number Theory	**L**	**T**	**P**	**NIL**
	3	**1**	**0**	

Course Objective: To introduce students to the concepts of the Theory of Numbers by using analytic concepts.

Course Outcomes (CO):

CO1	Apply Euclid's algorithm in divisibility/daily life problems.
CO2	Solve linear congruence equations. Apply the congruence properties in finding divisibly of a number by 2,3,4 etc. and other daily life problems.
CO3	Describe various arithmetical functions like Euler phi function and apply these in simplifying various arithmetical problems.
CO4	Identify the order of an integer modulo n and primitive roots of composite numbers. Describe discrete logarithms.
CO5	Analyse relation between Quadratic residue and Legendre's symbols and solve quadratic congruences.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	0	2	1	2
CO2	2	0	2	1	2
CO3	3	0	2	1	2
CO4	3	0	2	1	2
CO5	2	0	2	1	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Divisibility in integers, Division algorithm, G.C.D., L.C.M., Euclid's Lemma, Fundamental theorem of Arithmetic. Diophantine equation, Goldbach Conjecture.	**9**
UNIT-2	Congruences, Residue classes and their properties, Fermat's little Theorem, Wilson's Theorem. System of linear congruences, Chinese remainder Theorem.	**9**
UNIT-3	Some elementary number theoretic functions, Greatest integer function, Mobius inversion formula, Euler's function and its properties, Euler's Theorem.	**9**
UNIT-4	Order of an integer mod n, Primitive roots, composite numbers having primitive roots, Theory of indices.	**9**
UNIT-5	Quadratic residue, Legendre's symbol and its properties, Quadratic reciprocity law.	**9**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	David M Burton, Elementary Number Theory (6th Edition), Tata McGraw Hill Education Pvt. Ltd.	2011
2	T. M. Apostol, Introduction to Analytic Number Theory, Springer International	2013
3	G. E. Andrews, Number Theory, Dover Publications, New York	2012
4	Kenneth H. Rosen, Elementary Number Theory, Pearson Education Ltd.	2013

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 505: Tensor Calculus	**L**	**T**	**P**	Basic knowledge of calculus, differential equations, vector calculus
	3	**1**	**0**	

Course Objective: This course provides an introduction to tensor calculus which is an essential tool for Applied Mathematician, Scientists and Engineers.

Course Outcomes (CO):

CO1	Understand the basic concept of tensor algebra like transformation, summation convention, different type of tensors.
CO2	Familiarize with Riemannian metric, fundamental tensor, hypersurfaces.
CO3	Understand the Christoffel symbols, covariant derivatives, geodesics.
CO4	Have knowledge of Riemannian geometry, Riemannian -Christoffel tensor, Ricci tensor, Einstein tensor and Bianchi identities.
CO5	Acquire knowledge of some advanced topics in general relativity and cosmology.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	0	1	1	1
CO2	2	0	2	2	2
CO3	3	0	2	2	1
CO4	3	0	2	1	1
CO5	3	0	3	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Tensor Algebra: Generalized N- dimensional space, Transformation of coordinates, Summation convention, Invariants, Contravariant and Covariant tensors, Mixed tensor, Kronecker delta, Addition and Subtraction of tenors, Contraction, product (Inner and Outer) tensors, Symmetric and skew-symmetric tensors, Quotient's law, Conjugate tensor.	**10**
UNIT-2	Riemannian metric: Riemannian metric, metric tensor, Length of a curve and null curve, Associated tensors, raising and lowering of indices, magnitude of vector, Levi-Civita tensor, Relative and absolute tensor, hypersurfaces, congruence of curves, Curvilinear Co-ordinates.	**10**
UNIT-3	Tensor Calculus: Christoffel symbols, properties and transformation laws of Christoffel symbols, Covariant differentiation of tensors, Gradient, divergence and curl, Geodesics, Null geodesics.	**9**
UNIT-4	Riemannian Geometry: Riemann-Christoffel tensor, Riemannian curvature tensor and properties, Riemannian symbols of second kind, Covariant form, Ricci tensor, Scalar curvature, Einstein tensor, Weyl tensor, Bianchi	**9**
UNIT-5	Some advanced topics in tensor: Lie derivative, killing vectors and equations, Applications to General Relativity and Cosmology.	**7**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	A.J. Mc Connel, Application of Tensor analysis, Dover Publications	2011
2	J.L. Singe and A. Schild, Tensor Calculus, Dover Publications	1978
3	D. C. Aggarwal, Tensor Calculus and Riemannian Geometry, Krishna Prakashan.	1989
4	C.E. Weatherburn, Introduction of Riemannian Geometry and Tensor Calculus, Cambridge	2008
5	M. Dalarsson and N. Dalarsson, Tensor Calculus, Relativity and Cosmology, Elsevier	2005
6	S. Weinberg, Gravitation and Cosmology, Wiley Publication	1972

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 506: Differential Geometry	**L**	**T**	**P**	Basic knowledge of calculus, differential equations, vector calculus, Linear Algebra
	3	**1**	**0**	

Course Objective: This course provides an introduction to differential geometry which describe the concept of curves and surfaces in space.

Course Outcomes (CO):

CO1	Understand the basic concept of geometry of space curves, osculating plane, binormal and torsion.
CO2	Be familiar with the concept of geometry of surfaces, geodesic curvature, first and second fundamental forms, edge of regression, developable surfaces.
CO3	Understand the curves on surface including Gauss curvature, Gauss-Weingarten formula, fundamental existence theorem on surfaces.
CO4	Have knowledge of geodesic and its properties, surface of revolution, geodesic polarco-ordinate, Bonnet theorem and formula.
CO5	Identify the global results about the surfaces

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	1	1	1
CO2	2	1	1	1	2
CO3	2	2	1	2	2
CO4	2	2	1	2	2
CO5	3	2	2	1	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Geometry of space curves: Parametric representation of space curves, Arc length, Tangent vectors and vector fields in space, Tangent line, Osculating plane, Inflexion point, Normal plane, Principle normal, Binormal, Curvature and torsion, Fundamental theorem for space curves, Frenet-Serret formulae, Osculating circle, Osculating sphere, Spherical indicatrix, Frenet approximation.	**11**
UNIT -2	Geometry of surfaces: Parametrization, Arc length, Tangent plane, Differentials, First and Second fundamental forms, Curves in surfaces, Normal and geodesic curvature, Ruled surface, Developable surface, Edge of regression.	**11**
UNIT-3	Curves on surface: Gauss curvature, Gauss characteristic equation, Gauss and Weingarten formula, Mainardi-Codazzi equations, Fundamental existence theorem for surfaces, Parallel surfaces.	**11**
UNIT-4	Geometry of Geodesic: Geodesic, Geodesic property, Differential equation of geodesic, Surface of revolution, Torsion of geodesic, Geodesic polar co-ordinates, Normal property of geodesics, Bonnet's theorem, Bonnet's formula.	**12**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	T.J. Willmore: An Introduction to Differential Geometry, Oxford University press, London	1972
2	Erwin Kreyszig: Differential Geometry, Dover Publication.	1991
3	Nirmala Prakash, Differential Geometry, Tata McGraw Hill.	1981
4	D. Somasundaram, Differential Geometry, Narosa Publishing House	2005
5	B. O'Neil: Elementary Differential Geometry, Academic Press	1968

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 507:	**L**	**T**	**P**	**NIL**
Petri Net Theory	**3**	**1**	**0**	

Course Objective: In this course the students will learn basic concepts of Petri nets, typical analysis problems, analysis methods, Petri net languages, restrictions and extensions of basic class of Petri nets and their applications.

Course Outcomes (CO):

CO1	Explain the basic concepts and methods of systems description using Petri nets.
CO2	Utilize Petri nets as an extra suited tool for system modelling.
CO3	Use Petri net to analyze variety of systems, at different levels of abstraction.
CO4	Identify the most suitable class of Petri nets to model a given system.
CO5	Apply and develop advanced information technologies based on suitable formal models, and use them and related theory for automating the design, implementation, and verification of computer-based systems.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	1	1	0	0
CO2	2	2	1	2	2
CO3	1	2	1	2	2
CO4	1	1	1	2	1
CO5	3	2	1	3	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Basics of Petri nets: Petri nets, Petri net structure, dual of a Petri net, inverse Petri net, markings, dynamics, state space, alternate formulations of Petri nets.	**9**
UNIT-2	Modelling with Petri nets: Events and conditions, concurrency, conflicts, finite state machine using Petri net, modelling of producer/ consumer problem, modelling of dining philosophers problem, modelling of readers/writers problem and modelling of chemical process.	**9**
UNIT-3	Analysis of Petri nets: Safeness, boundedness, conservation, liveness, coverability, firing sequences and reachability.	**9**
UNIT-4	Classes of Petri nets: S-graphs, S-systems, T-graphs, T-systems, free choice systems, deadlocks and traps.	**8**
UNIT-5	Matrix Approach: Incidence matrix of a Petri net, state equations, adjacency matrix, transitive matrix, place transitive matrix, transition transitive matrix, characteristic equation, characteristic polynomial and characterization of sub-classes of Petri nets by matrices.	**10**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Petri net theory and modelling of systems by J. L. Peterson, Englewood cliffs, NJ: Prentice-Hall Inc.	1981
2	Petri nets by W. Reisig, Springer-Verlag	1985
3	Free choice Petri nets by J. Desel and J. Esparza, Cambridge University Press, 1995, Online ISBN-9780511526558	1995

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 508: General Relativity and Cosmology	**L**	**T**	**P**	Basic knowledge of ODE, PDE & differential geometry
	3	**1**	**0**	

Course Objective: To provide deeper understanding about the structure, formation and fate of the universe**.**

Course Outcomes (CO):

CO1	Understand the basic concept of tensor algebra like transformation, summation convention, different type of tensors.
CO2	Understand the covariant derivatives, geodesics and special theory of relativity and spacetime.
CO3	Have knowledge of general theory of relativity, Einstein field equations to describe the structure of the universe
CO4	Categorise the Scwarz child solutions for interior and exterior.
CO5	Acquire knowledge of some topics in cosmology to describe the cosmological models to describe the past, present and future of the universe.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	0	1	1
CO2	2	2	1	2	2
CO3	3	2	2	2	2
CO4	3	3	1	2	2
CO5	3	3	1	2	2

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Tensor Algebra: Transformation, Summation convention, contravariant and covariant tensors, mixed tensors, Inner product, Outer product, contraction, symmetric and antisymmetric tensors, Riemannian space, Metric tensor, Levi-Civita tensor, Christoffel's 3 index symbols, Transformation law of Christoffel symbols.	**8**
UNIT-2	Tensor Calculus and Special Relativity: Equation of geodesics, covariant differentiation, Gradient, Divergence and Curl of vector and tensor fields, Null geodesics, Riemann curvature tensor and properties, Ricci tensor, Einstein tensor, Bianchi identities, Inertial and non-inertial frames, Galilean and Lorentz transformation, Postulates of Special Theory of Relativity, concepts of space and time, Minkowski space-time, Equivalence of mass energy.	**10**
Unit -3	General Relativity I: Principle of equivalence and general covariance, energy-momentum tensor, Motion of a free particle in a gravitational field, Einstein's law of gravitation, acceleration of a particle in a weak gravitational field, Einstein's field equations.	**9**
UNIT-4	General Relativity II: Metrics with spherical symmetry, Schwarzschild's exterior solution, Schwarzschild solution in isotropic form, Birkhoff solution, Crucial tests in relativity.	**8**
UNIT-5	Cosmology: Einstein and de Sitter models and properties, Cosmological Principle, Robertson-Walker metric, Hubble's law, Hubble's constant and deceleration parameter, Red shift of galaxies, Luminosity distance, Friedmann universe, Static and Non-static cosmological model, particle and event horizons, geometry of universe.	**10**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	R.C. Tolman: Relativity thermodynamics and Cosmology, Dover Publications	2016
2	Steven Weinberg: Gravitation and Cosmology, Wiley Publications	2014
3	D.F. Lawden: Introduction to Tensor calculus, Relativity and Cosmology, Dover Publications	1982
4	Satya Prakash: Relativistic Mechanics, 7th Ed., Pragati Prakashan	2015
5	James B. Hartle: Gravity: An introduction to Einstein's General Relativity, Pearso	2007

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 509: Approximation Theory	**L**	**T**	**P**	**Knowledge of Real and Functional Analysis**
	3	**1**	**0**	

Course Objective: A better understanding of approximation, the concept of Linear positive operators, Trigonometric polynomials, Exponential and Semi-Exponential operators.

Course Outcomes (CO):

CO1	To comprehend various approximation tools for a better understanding of approximation.
CO2	To get knowledge of some special functions that have various applications
CO3	To understand the concept of Linear positive operators, Trigonometric polynomials, Exponential and Semi-Exponential operators.
CO4	To be aware of some trigonometric inequalities that can be used to support several core conclusions of Approximation Theory.
CO5	To estimate moments using moment generating and convergence estimates via characteristic function.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	0	2	2	1
CO2	3	0	3	3	1
CO3	2	0	3	2	1
CO4	2	0	3	3	1
CO5	3	0	3	2	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Approximation Tools: Big-O and Little-o notations: meaning, difference with some examples, Modulus of Continuity of first and higher order along with important properties, Lipschitz class of order $\boldsymbol{\alpha}$ (Definition and properties), Function of Bounded Variation: Definition, examples and properties, Stirling numbers of First and Second kind.	**7**
UNIT-2	Some Special functions: Some important functions and their properties viz, Convex function, Hypergeometric function, Dirichlet's function, Weierstrass function, Dirac Delta function, Mittag-Leffler function and values at some points, Gauss Error function, Lambert W- function and it's properties.	**9**
UNIT-3	Certain Operators: Linear positive operators (Definition and Monotonicity as a property), Exponential type operators (Definition, Recurrence formula and some examples of discrete/integral operators), Semi-Exponential type operators (Definition, Recurrence relation with examples), Trigonometric polynomial and some properties, Kantorovich and Durrmeyer variants of discrete operators.	**9**
UNIT-4	Some trigonometric inequalities and convergence theorems: Korovkin Theorem (with proof), Weierstrass First Approximation Theorem (proofs due to Landau (1908) and Bernstein (1912)), Some Trigonometric Identities and Inequalities, Jackson Theorem (with proof using the Trigonometric identities).	**10**
UNIT-5	Moment generating functions (M.G.F.): moments and convergence via characteristic function: M.G.F. of some Exponential type operators (Gauss Weierstrass, Bernstein, Baskakov, Szász-Mirakyan, Post-Widder, Ismail-May associated with $1+x^2, x^3, x(1+x)^2 and\ 2x^{\frac{3}{2}}$ M.G.F. of Non-Exponential type operators (Lupaş operator, Jain and Pethe operators and Modified Baskakov operator), M.G.F. of Semi-Exponential type operators (generalisation of Exponential-type operators), M.G.F. of Kantorovich type operators, Convergence estimates based on Characteristic functions. Use of Mathematica software to calculate moments from mgf of various operators.	**10**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	P. Korovkin, Linear Operators and Approximation Theory, Hindustan Publ. Corporation.	1955
2	G. G. Lorentz, Bernstein Polynomials, University of Toronto Press	1953
3	E. W. Cheney, Introduction to Approximation theory, New York, McGraw-Hill Book Co	1966
4	V Gupta and R. P Agarwal, Convergence Estimates in Approximation Theory, Springer	2014
5	R Paltanea, Approximation theory using positive linear operators, Springer Science & Business Media	2004
6	V. Gupta and M. T. Rassias, Moments of Linear Positive Operators and Approximation, Series: SpringerBriefs in Mathematics, Springer Nature Switzerland AG	2019

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 510: Numerical Methods of Differential Equations	**L**	**T**	**P**	Ordinary and Partial Differential Equations, Numerical Analysis and MATLAB
	3	**1**	**0**	

Course Objective: To learn computational solution of PDEs

Course Outcomes (CO):

CO1	classify well posed and ill posed problems, identify mathematical models in engineering, and solve first order initial value problems usingsingle step methods
CO2	solve first order initial value problems using multistep methods, analyze numerical methods for consistency, stability and convergence
CO3	apply numerical methods to solve engineering problems involving elliptic PDEs
CO4	analyze the stability, consistency, and convergence of numerical methods for PDEs
CO5	explain, interpret and illustrate the numerical solution of ordinary differential equations and partial differential equations

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	0	1	2
CO2	3	2	1	1	2
CO3	3	2	1	2	3
CO4	2	2	1	2	3
CO5	3	2	1	2	3

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Ordinary Differential Equations: Review of initial value problems (IVPs), existence anduniqueness theorems, stability and asymptotic stability. Single step methods for first order IVPs: Piccard's method, Taylor series method,Euler and modified Euler method, Runge-Kutta methods and stability of single step methods.	**11**
UNIT-2	Multi step methods for first order IVPs: Predictor-Corrector (PC) method, Euler PC method, Milne and Adams Moulton PC method, stability of multi-step methods and root condition. Linear Boundary Value Problems (BVPs):Finite difference methods, shooting methods, stability, error and convergence analysis. Nonlinear BVPs and higher order BVPs.	**11**
UNIT-3	Finite Difference Methods for Elliptic PDEs - Finite difference approximations. Solution of Laplace and Poisson Equations: Five-point and nine-point formulae. Consistency, stability and Convergence of different schemes.	**11**
UNIT-4	Finite Difference Methods for Parabolic PDEs - Explicit and Implicit Schemes: Euler, Crank-Nicolson schemes for parabolic equations. Consistency, Stability and convergence: CFL condition, Von Neumann stability analysis, Finite Difference Methods for Hyperbolic PDEs: Lax-Friedrichs, Lax-Wendroff methods, Leapfrog method. Consistency , Stability and convergence of different schemes	**12**
	Total	**45**

References:

S.No.	Name of Books/Authors/Publishes	Year of Publication
1	R. J. LeVeque, Finite Difference Methods for Ordinary and Partial Differential Equations: Steady-State and Time-Dependent Problems, SIAM, 2007.	2007
2	G. D. Smith, Numerical Solution of Partial Differential Equations: Finite Difference Methods, Oxford University Press, 1985.	1985
3	K. W. Morton and D. F. Mayers, Numerical Solution of Partial Differential Equations: An Introduction, Cambridge University Press, 2005.	2005
4	J. C. Strikwerda, Finite Difference Schemes and Partial Differential Equations, SIAM, 2004.	2004
5	Kendall E. Atkinson, Weimin Han, David Stewart,Numerical Solution of Ordinary Differential Equations, John Wiley & Sons, 2009.	2009

Details of Course:

Course Title	Course Structure			Pre-requisite
IMSMA 511: Univalent Function Theory	**L**	**T**	**P**	Complex Analysis
	3	**1**	**0**	

Course Objective: To impart the knowledge of univalent functions, its elementary properties, geometrical aspects and Applications.

Course Outcomes(CO):

CO1	**Identify** and explain the fundamental concepts of univalent functions, including the Riemann mapping theorem, area theorem, and related examples, with emphasis on their elementary properties and implications. (Remembering and Understanding)
CO2	**Apply** core theorems such as Koebe's one-quarter theorem, distortion theorem, growth theorem, and Hayman's regularity theorem to analyze bounded univalent functions and evaluate their coefficient constraints. (Applying and Analyzing)
CO3	**Examine**Caratheodory functions and associated results, utilizing the Lindelof principle, Noshiro-Warschawski theorem, and Herglotz representation formula to derive properties of convex, starlike, and subordination functions. (Understanding and Analyzing)
CO4	**Assess** the properties of alpha convex, alpha spiral, and typically real functions, drawing on Rogosinski's findings and studying functions with a positive real part to derive results related to real coefficients. (Analyzing and Evaluating)
CO5	**Integrate** knowledge of close-to-convex functions, spirallike functions, and odd univalent functions by demonstrating their properties, applying Grunsky inequalities, and interpreting results from Carathéodory's convergence theorem. (Creating and Applying)

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	0	1	1	0
CO2	3	0	1	1	0
CO3	2	0	0	1	0
CO4	2	0	0	2	0
CO5	3	0	0	2	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Riemann mapping theorem, introduction to univalent functions definitions, examples, elementary properties, area theorem and its consequences.	**8**
UNIT-2	Bieberbach's conjecture, bounded univalent functions, implications of the bound on the second coefficient – Koebe one-quarter theorem, distortion theorem, growth theorem, Hayman's regularity theorem; Robertson's conjecture.	**10**
UNIT-3	Caratheodory functions, elementary properties, subordination and the Lindelof principle, the Noshiro-Warschawski theorem, the Herglotz representation formula; Convex and starlike functions, Ford's theorem, Alexander's theorem, Nevanlinna's coefficient inequality, sharp bounds for the coefficients.	**10**
UNIT-4	Convex and starlike functions of order alpha, alpha convex functions, alpha spiral functions, typically real functions, related results by Rogosinski, functions with positive real part and real coefficients.	**9**
UNIT-5	Close-to-Convex functions, spirallike functions, odd univalent functions, Caratheodory convergence theorem, Grunsky inequalities	**8**
	Total	**45**

References:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1.	P. L. Duren, Univalent Functions, Springer, New York	1983
2.	Derek K. Thomas, Nikola Tuneski, Allu Vasudevarao, Univalent Functions: A Primer, De Gruyter; 1st edition	2018
3.	A. W. Goodman, Univalent Functions, Vol-I & II, Mariner, Florida	1983
4.	M. Rosenblum & J. Rovnyak, Topics in Hardy Classes and Univalent Functions,Birkhauser Verlag	1994
5.	I. Graham & G. Kohr, Geometric Function Theory in One and Higher Dimensions,Marcel Dekker, New York	2003

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 512: Quantum Calculus	**L**	**T**	**P**	**Knowledge of real analysis**
	3	**1**	**0**	

Course Objective: A better understanding of quantum calculus and study of Ramanujan's work

Course Outcomes (CO):

CO1	To comprehend definitions in q-calculus for a better understanding of quantum calculus.
CO2	To get knowledge of some q-special functions that have various applications.
CO3	To understand the concept of q-form of positive linear operators and its variants
CO4	To be aware of some q-inequalities that can be used to support several core conclusions of results of positive linear operators.
CO5	To estimate moments using moment generating and convergence estimates via characteristic function.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	0	1	1	1
CO2	2	0	1	1	1
CO3	2	0	2	1	1
CO4	2	0	1	1	1
CO5	3	0	2	1	1

Program Outcome (PO):

PO1	To develop a thoughtful and analytical mindset towards learning by acquiring deep subject knowledge and expressing well-reasoned opinions supported by logical analysis and effective problem-solving abilities.
PO2	To design and conduct experiments, analyze data using appropriate software tools and interpretation of result to contribute to research and innovation.
PO3	Ability to build strong communication skills for working effectively within groups and organizations, demonstrating proficiency in interpersonal interactions to deliver impactful professional presentations.
PO4	An ability to model the social and environmental problem and develop soft computing skills to provide solution.
PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hours
UNIT-1	Notations and Definitions in q-Calculus: q-Derivative and h-Derivative, q-Taylor's Formula for Polynomials, generalised Taylor's Formula for Polynomials, q-Analogue of and q-Derivatives of Binomials, Gauss's Binomial Formula and a Noncommutative Binomial Formula, q-binomial coefficients, q-Pascal Rules	**8**
UNIT-2	Some q-identities: Some concepts of Linear Algebra over Finite Fields involving binomial q-coefficients, q-Taylor's Formula for Formal Power Series and Heine's Binomial Formula, Euler's Identities, q-exponential Functions, and q-trigonometric Functions	**9**
UNIT-3	q-form of some special functions: Jacobi's Triple Product Identity, Classical Partition Function, Pentagonal numbers and Euler's Product Formula, Heine's q-Hypergeometric series, and the General Binomial, Ramanujan Product Formula	**9**
UNIT-4	q-Integration: q-Antiderivative, Jackson Integral, Definite and improper integral, Fundamental Theorem of q-Calculus and Integration by part, q-Gamma and q-Beta Functions, Abel's Transform, h-Derivative and h-Integral, Bernoulli Polynomials and Bernoulli Numbers, Euler-Maclaurin Formula, Symmetricity of q and h-Differentials	**9**
UNIT-5	q-Variant of certain linear positive operators: q-Bernstein operators, q-Szasz operators, q-Baskakov operators, integral operators (Kantorovich and Durrmeyer form)	**10**
	Total	**45**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Victor Kac and Pokman Cheung, Quantum Calculus	2000
2	Ali Aral, Vijay Gupta, Ravi P. Agarwal, Applications of q-Calculus in Operator Theory	2013