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

SCHEME OF TEACHING AND EVALUATION
DEPARTMENT OF APPLIED MATHEMATICS
M.SC - MATHEMATICS

I YEAR: First Semester

Teaching Scheme					Contact Hours/Week			Relative Weights (%)				
S. No	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P/ST**	**CWS**	**PRS/ STS/ CMS**	**MTE**	**ETE/ EME**	**PRE/ STE**
1	MSMA-101	Abstract Algebra	DCC	4	3	1	0	25	-	25	50	-
2	MSMA-103	Real Analysis	DCC	4	3	1	0	25	-	25	50	-
3	MSMA-105	Ordinary Differential Equations	DCC	4	3	1	0	25	-	25	50	-
4	MSMA-107	Discrete Mathematics	DCC	4	3	1	0	25	-	25	50	-
5	MSMA-109	Mathematical Statistics	DCC	4	3	0	2	15	25	20	40	-
6	MSMA-111	Programming Lab- I	DCC	2	0	0	4	-	50	-	-	50
Total				**22**	**15**	**4**	**6**					
7.	MSHU-113	Communicative English*	AEC	4	3	1	0	25	-	25	50	-

I YEAR: Second Semester

Teaching Scheme					Contact Hours/Week			Relative Weights (%)				
S. No	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P/ST**	**CWS**	**PRS/ STS/ CMS**	**MTE**	**ETE/ EME**	**PRE/ STE**
1	MSMA-102	Complex Analysis	DCC	4	3	1	0	25	-	25	50	-
2	MSMA-104	Partial Differential Equations	DCC	4	3	1	0	25	-	25	50	-
3	MSMA-106	Topology	DCC	4	3	1	0	25	-	25	50	-
4	MSMA-108	Linear Algebra	DCC	4	3	1	0	25	-	25	50	-
5	MSMA-110	Numerical Analysis	DCC	4	3	0	2	15	25	20	40	-
6	MSMA-112	Programming Lab- II	DCC	2	0	0	4	-	50	-	-	50
Total				**22**	**15**	**4**	**6**					
7.	MSMA-114	Fundamentals of Computer*	SEC	4	3	0	2	15	25	20	40	-

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II YEAR: Third Semester

Teaching Scheme					Contact Hours/Week			Relative Weights (%)				
S. No	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P/ST**	**CWS**	**PRS/ STS/ CMS**	**MTE**	**ETE/ EME**	**PRE/ STE**
1	MSMA-201	Functional Analysis	DCC	4	3	1	0	25	-	25	50	-
2	MSMA-203	Operation Research	DCC	4	3	1	0	25	-	25	50	-
3	MSMA-205	Dissertation-1	DCC	2				-	40	-	-	60
4	MSMA XXX	DSE-1/ Track-I	DSE	4	3	1/0	0/2	25/15	0/25	25/20	50/40	-
5	MSMA XXX	DSE-2	DSE	4	3	1/0	0/2	25/15	0/25	25/20	50/40	-
6	XXXX XXX	GEC-1	GEC	4	3	1/0	0/2	25/15	0/25	25/20	50/40	
Total				**22**	**17**	**5/2**	**0/6**					

II Year: Fourth Semester

Teaching Scheme					Contact Hours/Week			Relative Weights (%)				
S. No	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P/ST**	**CWS**	**PRS/ STS/ CMS**	**MTE**	**ETE/ EME**	**PRE/ STE**
1	MSMA-202	Measure and Integration	DCC	4	3	1	0	25	-	25	50	-
2	MSMA-204	Dissertation-II	DCC	8				-	40	-	-	60
3	MSMA XXX	DSE 3/Track-I	DSE	4	3	1/0	0/2	25/15	0/25	25/20	50/40	-
4	MSMA XXX	DSE 4	DSE	4	3	1/0	0/2	25/15	0/25	25/20	50/40	-
5	XXXX XXX	GEC2	GEC	4	3	1/0	0/2	25/15	0/25	25/20	50/40	-
Total				**24**	**20**	**4/1**	**0/6**					

1. The Generic Elective (GE) courses will have a nomenclature as Generic Elective Courses (GEC) where student can choose any elective course running in the University or they may opt for a MOOC course (2 to 6 credits)
2. DSE is “Discipline Specific Elective” for clarification.
3. SEC is Skill Enhancement Course where student may opt for any course related to Fundamental of IT offered by any department of the university.

In addition to the above scheme

Elective Courses / Activities: *These are part of Co and Extra-Curricular Activities and must opt for a minimum of 2 to 6 Credits in entire duration of the program.*

The Identified MOOC’s subjects or any other On-line Courses offered by the Recognized Accredited University enlisted by the University.

OR

The Approved Co and Extra-Curricular Activities as defined by the University.

Publication in category 1 or category 2 journal publication is mandatory outcome of the Track 1. In second year (i.e., III and IV Semesters) ***Track 1 option*** *is by research work. Candidate will be finally evaluated at the end of the semester IV on the basis of his/her publication (accepted or published in category 1 or 2 journals).*

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List of Electives

S. No.	Course Code	Course Title	DSE Details
1.	MSMA – 207	Stochastic process	DSE 1
2.	MSMA – 209	Analysis and Design of Algorithms	
3.	MSMA – 211	Number Theory	
4.	MSMA – 213	Mathematical Modelling and Simulation	
5.	MSMA – 215	Calculus of Variation	
6.	MSMA – 217	Graph Theory	DSE 2
7.	MSMA – 219	Database Management System	
8.	MSMA – 221	Integral Transforms & Equations	
9.	MSMA – 223	Cryptography and Coding Theory	
10.	MSMA – 225	Classical Mechanics	
11.	MSMA – 206	Financial Mathematics	DSE 3
12.	MSMA – 208	Data Mining	
13.	MSMA – 210	Optimization Techniques	
14.	MSMA – 212	Approximation Theory	
15.	MSMA – 214	General Relativity and Cosmology	
16.	MSMA – 216	Finite Element Method	DSE 4
17.	MSMA – 218	Machine Learning	
18.	MSMA – 220	Advanced Partial Differential Equations	
19.	MSMA – 222	Univalent Function Theory	
20.	MSMA – 224	Fuzzy Sets and Applications	

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FIRST YEAR
FIRST SEMESTER

Details of Course

Course Title	Course Structure			Pre-Requisite
MSMA 101: Abstract Algebra	**L**	**T**	**P**	Basic knowledge of set theory
	3	1	0	

Course Objective: To impart the knowledge of algebraic structure of Groups, Rings and Fields.

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

CO1	*Explain* the fundamental concepts of groups, subgroups, cyclic groups, cosets, and normal subgroups, and *apply* Lagrange's theorem to solve related problems.
CO2:	*Demonstrate* the properties of group homomorphisms and isomorphisms, and *analyze* group structures using fundamental theorems, Cayley's theorem, and permutation groups.
CO3:	*Examine* the internal structure of groups using concepts like the center, conjugacy classes, and *evaluate* group properties via the class equation and Sylow's theorems.
CO4:	*Define* and *compare* structures such as rings, integral domains, and fields; *construct* quotient rings and *analyze* ring homomorphisms and ideal properties.
CO5:	*Interpret* the structure of Euclidean domains, principal ideal domains, and unique factorization domains; *apply* the unique factorization theorem to solve algebraic problems.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	1	0	0
CO2	2	3	1	0	0
CO3	3	3	1	0	0
CO4	2	3	1	0	0
CO5	3	3	1	0	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.	Groups, subgroups, cyclic groups, cosets, Lagrange's theorem and applications, normal subgroups, quotient groups.	06
2.	Homomorphism of groups, kernel of homomorphism, isomorphism, fundamental theorems of homomorphism. permutation groups, Cayley's theorem.	08
3.	Centre of a group, conjugate class, class equation, Sylow's theorems.	08
4.	Ring, subring, integral domain, field, quotient fields, embedding theorem, ideal, quotient rings, ring homomorphism, isomorphism, prime and maximal ideals.	11
5.	Euclidean domain, principal ideal domain. unique factorization domain, unique factorization theorem.	09
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	N. S. Gopalakrishnan, University Algebra, New Age International Publishers	2004
2.	Joseph A. Gallian, Contemporary Abstract Algebra (9th Ed.), Narosa Publishing House.	2016
3.	I. N. Herstein, Topics in Algebra(2^{nd} Edition), Wiley Eastern Limited	2006
4.	Khanna and Bhamri, A course in Abstract Algebra(5^{th}Edition), Vikas Publishing House.	2017
5.	D. S. Dummit and R. M. Foote, Abstract Algebra(3^{rd}Edition), John Wiley and Sons.	2011

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Details of Course

Course Title	Course Structure			Pre-Requisite
MSMA 103 Real Analysis	**L**	**T**	**P**	Some knowledge of calculus
	3	1	0	

Course Objective: To impart knowledge of real valued functions, Metric Spaces and Riemann Integration

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

CO1	Describe the concepts and properties of sets and categorize sequences and series as convergent, divergent or oscillatory.
CO2	Construct metric spaces and acknowledge their convergence, completeness, compactness and connectedness properties.
CO3	Analyze continuity and uniform continuity and apply their properties to create and establish many real-life continuous functions.
CO4	Differentiate between convergence and uniform convergence of sequences and series of functions.
CO5	Solve Riemann integrals and compute the integrals of numerical data derived from real life situations.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	3	0	0
CO2	3	3	2	0	1
CO3	2	3	2	0	1
CO4	3	3	3	0	1
CO5	3	3	3	0	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.	Review of basic concepts of real numbers, Cantor set, Archimedean property, completeness axiom, sequences and series, convergence, Heine-Borel theorem.	10
2.	Metric spaces, convergence and completeness, compactness and connectedness (With emphasis on Rn).	14
3.	Continuity and uniform continuity, differentiability, mean value theorems.	08
4.	Riemann integral and its properties, characterization of Riemann integrable functions, improper integrals, sequences and series of functions, uniform convergence, Weierstrass approximation theorem.	10
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	W. Rudin, Principles of Mathematical Analysis, 3rd Edition, Mc Graw-Hill.	1983
2.	Richard R. Goldberg, Methods of Real Analysis, Oxford & IBH publishing Co. Pvt. Ltd.	1970
3.	M. Apostal, Mathematical Analysis (Second Edition), Narosa Pub. House	2002
4.	K. Ross, Elementary Analysis: The theory of calculus, Springer Int. Edition	2004
5.	S. C. Malik & S. Arora, Mathematical Analysis, New Age International Publisher	2017

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Details of Course:

Course Title	Course Structure			Pre-Requisite
MSMA 105 Ordinary Differential Equations	**L**	**T**	**P**	Basic knowledge of calculus and linear algebra
	3	**1**	**0**	

Course Objective: After the course, the students should be able to analyse and solve the ODE.

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

CO1	Classify ordinary differential equations, determine their order and degree, solve constant coefficient equations using various methods, identify existence and uniqueness of initial value problems of first and higher order.
CO2	Identify ordinary and singular points, obtain power series solutions near ordinary point and regular singular point for important classes of ordinary differential equations including Legendre equation and Bessel's equations.
CO3	Reduce higher-order linear differential equations to first-order systems in normal form, solve systems of homogeneous first-order linear differential equations using matrix methods, solve systems of nonhomogeneous linear first-order differential equations
CO4	Apply Sturm theory, identify oscillatory and non-oscillatory differential equations, estimate 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	2	2	1	1	3
CO2	2	3	1	1	2
CO3	1	3	1	1	2
CO4	2	2	2	3	3
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
1.	**Introduction:** Review of Algebraic properties of solutions, General solution of linear equations with constant coefficients using methods of undetermined coefficients and operator method, the method of variation of parameters, Green's function for initial value problems. Existence and Uniqueness of solutions of initial value problems of first and higher order, Singular solutions, Successive Approximation and Picard's theorem.	11
2.	**Series Solution:** Ordinary and Singular points, Euler equations, Analytic functions, Power series solution, Frobenius method, Fuch's Theorem, Lagrange and Bessel functions and their properties.	8
3.	**Systems of Differential Equations:** Algebraic properties of solutions of linear systems, solutions of simultaneous linear equations, the eigenvalues – eigenvector method of finding solution, fundamental matrix solutions.	7
4.	**Two Point BVP:** Strum Liouville theory, Green functions for boundary value problems, Riccati's equation.	8
5.	**Non-linear Differential Equation:** Phase plane, Paths and Critical Points, Stability of the critical points of non-linear system and their equivalence with the corresponding linearized system.	8
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	Martin Braun, Differential equations and their applications, Springer 4th edition	1993
2.	S. L. Ross, Introduction to Ordinary Differential Equations, John Wiley & Sons, 4th edition	1989
3.	William E. Boyce, Richard C. Diprima, Elementary Differential Equations and Boundary Value Problems, 9th edition	2009
4.	John Polking, Albert Boggess, David Arnold, Differential Equations, Prentice Hall, 2nd Ed.	2017
5.	Earl A. Coddington, Robert Carlson , Linear ordinary differential equations, SIAM.	1997
6.	D. A. Sanchez; Ordinary Differential Equations and Stability Theory: An Introduction (Reprint), Dover Publ. Inc.	2012

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Details of Course

Course Title	Course Structure			Pre-Requisite
MSMA 107: Discrete Mathematics	**L**	**T**	**P**	NIL
	3	1	0	

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

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

CO1	Apply the concepts of sets, relations, and functions to model and solve discrete mathematical problems.
CO2	Analyse and evaluate logical statements using propositional logic and predicate logic, and apply inference rules to derive valid conclusions.
CO3	Demonstrate understanding of the structure of lattices and Boolean algebras and apply their properties in problem-solving and algebraic representations.
CO4	Utilize fundamental concepts of graph theory, including graph algorithms, spanning trees, coloring, and matching, to solve computational and real-world problems.
CO5	Understand the working of finite automata, grammars, and 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	2	1	0	3
CO2	3	2	1	0	3
CO3	3	2	1	2	3
CO4	3	3	1	3	3
CO5	3	2	1	0	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.	Sets, relations, operations on relations equivalence relation, equivalence classes, partial order relation, Hasse diagram, functions, recursive functions, recurrence relation and generating function.	8
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.	8
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.	7
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 chromatic polynomial, Matching.	10
5.	Deterministic and non-deterministic finite automata (DFA & NDFA), Acceptability of a string by FA, equivalence of DFA and NDFA, Minimization of FA, Grammar, Chomsky classification of grammar, Turing Machine.	9
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	Kenneth 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, 2nd Edition, Tata McGraw-Hill	2000
4.	Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory 2nd Edition, Pearson Education (Singapore) Pte. Ltd., Indian Reprint 2003.	2003
5.	Narsingh Deo, Graph theory with Applications to Engineering and Computer Science, PHI	2004

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Details of Course

Course Title	Course Structure			Pre-Requisite
MSMA 109: Mathematical Statistics	**L**	**T**	**P**	NIL
	3	0	2	

Course Objective: To acquire knowledge of descriptive statistics, random variables, specific probability distributions and their real life applications specifically in science and engineering. Acquaintance with the tools for the large and small sample testing. Estimation of parameters.

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

CO1	Formulize probability model using various approaches to probability for a given random experiment and skill in R/SPSS for presenting and analyzing the given problem.
CO2	Analyze a given random situation using concepts of expectation, statistical inequalities, law of large numbers and regression analysis.
CO3	Implement standard discrete and continuous probability distributions and their applications.
CO4	Perform large and small sample testing and their applications in real-world problems.
CO5	Draw inferences about a population from analyzing a sample drawn from that population using estimation and hypothesis testing.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	3	2
CO2	3	2	2	1	1
CO3	3	2	3	1	1
CO4	3	3	2	2	2
CO5	3	3	3	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
1.	Descriptive statistics, Classical and statistical definitions of probability. Axiomatic approach, Conditional probability, Addition and multiplication theorems, Baye's Theorem. Discrete and continuous random variables, distribution functions. Joint, marginal and conditional distributions	7
2.	Mathematical expectation. Addition and multiplication theorems of expectation. Properties of variance and covariance. Moment generating and characteristic functions. Chebyshev's inequality and the weak law of large numbers, Central limit theorem, Correlation and regression	8
3.	Binomial, Poisson, Negative binomial, geometric, hyper geometric and multinomial distributions. Normal, exponential, Weibul, gamma and beta distributions.	10
4.	Large sample theory. Tests of significance. Sampling of attributes and of variables. Exact sampling distributions: χ^2, t, F and z. ANOVA for one and two-way classification	9
5.	Characteristics of estimators, Methods of estimation: maximum likelihood, minimum variance and least squares, Bayes estimation Statistical hypothesis. MP Test and UMP Test. N-P Lemma, sequential probability ratio test (SPRT).	8
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/
1.	Sheldon M. Ross: Introduction to Probability and Statistics for Engineers and Scientists, Academic Press.	2009
2.	Meyer: Introductory Probability and Statistical Application, Oxford and IBH Publishing.	
3.	Kishor S. Trivedi: Probability and Statistics with Reliability, Queuing and Computer Science Application, Wiley.	2002
4.	S.C. Gupta and V.K. Kapoor : Fundamental of Mathematical Statistics, Sultan Chand & Sons	2006

List of Experiments	
1	Handling of data, Transportation of data to SPSS/R, Splitting and merging of files, Missing values.
2	Pictorial representation of data.
3	Descriptive statistics and Probability Laws.
4	Random variable, Expectation, Correlation and Regression.
5	Distribution curves (Discrete and Continuous).
6	Large sample testing.
7	Chi square test.
8	t, F and z tests.
9	ANOVA.
10	Estimation of parameters

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Details of Course

Course Title	Course Structure			Pre-Requisite
MSMA 111: Programming Lab - I	**L**	**T**	**P**	Basic computer knowledge
	0	0	4	

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

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

CO1	Apply programming principles to the design and implementation of C programs.
CO2	Construct programs that use decision-making and repetition mechanisms to solve well-defined computational problems.
CO3	Develop programs using functions, recursion, and various storage classes for code optimization and reusability.
CO4	Implement pointer-based operations to manage memory and data efficiently.
CO5	Design structured programs using structures, unions, and I/O operations, and illustrate basic object-oriented principles using simple C++ constructs.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	1	2
CO2	3	3	2	2	2
CO3	3	3	2	2	2
CO4	2	0	3	0	1
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 to C programming:** Variables and arithmetic expressions, Data types, constants, relational and logical operators, bitwise operators, increment and decrement operators	3
2.	**Control Flow:** if-else, switch, break, continue, loop statements.	4
3.	**Functions and Recursions:** Call by value arguments, return, extern variables, static variables, register variables, recursion.	4
4.	**Pointers and Arrays:** Pointers and function arguments, pointer arrays, character pointers and functions, multi-dimensional arrays, pointers to functions.	5
5.	**Structures and I/O:** basics of structures, structures and functions, array of structures, pointers to structures. Union, typedef. Standard input and output.	3
6.	**Introduction to OOPS:** Classes and objects. OOPS concepts – inheritance, encapsulation, abstraction, polymorphism.	2
	Total	**21**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	The C Programming Language, 2nd Edition, Brian W. Kernighan, Dennis M. Ritchie, PHI, (ISBN-978 8120305960)	1988
2.	Let Us C, 13th Edition, Yashavant Kanetkar, BPB Publications, (ISBN: 978-8183331630)	2013
3.	Mastering C, Venugopal K R, Sudeep R Prasad, Edition 1, McGraw Hill Education (ISBN- 9780070616677)	2006
4.	Programming in ANSI C, Sixth Edition, McGraw Hill Education (India) Private Limited E Balagurusamy (ISBN: 978-1259004612)	2012
5.	Object Oriented Programming with C++, Sixth edition, E. Balagurusamy, McGraw Hill Education (India) Private Limited (ISBN:978-1259029936)	2013

List of Experiments	
1	WAP that creates variables of numeric data types and perform 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 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().

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Details of Course:

Course Title	Course Structure			Pre-Requisite
MSHU 113:	**L**	**T**	**P**	NIL
Communicative English	**3**	**1**	**0**	

Course Objective: To enable students to develop communicative skills in English

S. No.	Contents	Contact Hours
1.	**Oral Communication-1:** Group Discussion; Concept, Principles, Turn-taking strategy, Dos and don'ts; Debate: Concept, characteristics, Nature of topics, Difference between Debate and Group Discussion, Dos and Don'ts.	6
2.	**Oral Communication-2:** Dialogue: Concept, Nature of topics, Difference between Dialogue and Debate; Interview: Concept; Merits of a good interview, Essentials for interviewee, Essentials for interviewers; Presentation: Concept; Characteristics of effective presentation; Target audience; Subsidiary props, Dos and don'ts.	12
3.	**Basics of Phonetics:** Phonetics; Concept, Significance and relevance of phonetic proficiency, Speech Sounds and Phonetic Symbols; Organs of Speech; Active Organs, Passive Organs, Speech Mechanism; Air Stream Mechanism; Classification of Speech Sounds: Vowel Sounds, Consonant Sounds, Stress, Syllable; Description of Speech Sounds; Place of articulation, Manner of articulation, State of glottis; Phonetic Transcription of commonly used words and small sentences.	12
4.	**Writing Skills:** Types of writing: Descriptive, Expository, Analytical and Argumentative; Letter Writing: Sales Letters and Business Letters; Concept, structure and characteristics; Official Correspondence: Official Correspondence; Memo and Notice; Notice, Memo, Order and Circular; Format, structure and Characteristics; Report Writing: Concept, Types, Structure and Principles of Report Writing; Professional Communication: Writing of CV and Resume; Difference between CV and Resume, Importance of Cover Letter, Statement of Purpose, Newsletters; Good and Bad Newsletters, Minutes of Meeting.	12
	Total	**45**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1.	Communication Skills in English- Indira Gandhi National Open University. Young Printing Press, Delhi.	2008
2.	Sethi, J. and P.V. Dhamija. A Course in Phonetics and Spoken English. PHI Learning Private Limited, New Delhi.	2009
3.	Sharma Sangeeta and Binod Mishra. Communication Skills for Engineers and Scientists. PHI Learning Private Limited, New Delhi.	2009
4.	Sinha, K.K. Business Communication. Galgotia Publishing Company, New Delhi.	2002
5.	Tyagi, Kavita and Padma Misra. Basic Technical Communication. PHI Learning Private Limited, New Delhi.	2011
6.	Connor, J.D. O'. Better English Pronunciation. Cambridge University Press, U.K.	2013
7.	Jones, Daniel. English Pronouncing Dictionary. Cambridge University Press, U.K.	2016

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SECOND SEMESTER

Details of Course

Course Title	Course Structure			Pre-Requisite
MSMA 102: Complex Analysis	**L**	**T**	**P**	Knowledge of functions and calculus
	3	1	0	

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

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

CO1	Recall and apply the algebra of complex numbers, visualize complex functions on the Riemann Sphere using stereographic projection, and analyze the convergence of power series and properties of transcendental functions.
CO2	Interpret the concept of analyticity using Cauchy-Riemann equations and construct analytic and harmonic functions; demonstrate the properties of Möbius transformations, cross-ratio, and conformal mappings.
CO3	Explain and apply Cauchy's integral theorem and formula, evaluate integrals using Morera's theorem, and examine properties of entire functions through Liouville's theorem and the Fundamental Theorem of Algebra.
CO4	Develop Taylor and Laurent series expansions of analytic functions; classify singularities and use the residue theorem to compute complex integrals, including standard types.
CO5	Apply advanced theorems such as the Argument Principle, Rouche's theorem, and Maximum Modulus Theorem to assess the behavior of analytic functions; interpret the implications of Schwarz's lemma and the Identity Theorem.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	1	0	0
CO2	2	3	1	0	0
CO3	3	3	0	0	0
CO4	3	3	0	0	0
CO5	3	3	0	0	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.	Algebra of complex numbers, the complex plane, polynomials, power series, radius of convergence, transcendental functions, Riemann Sphere, Stereographic Projection.	6
2.	Analytic functions, Cauchy-Riemann equations, Harmonic functions, Construction of analytic functions, Mobius transformation, Cross ratio, Conformal transformation.	8
3.	Cauchy's integral theorem, Winding number, Cauchy integral formula, Morera's theorem, Cauchy's estimate, entire functions, Liouville's theorem, Fundamental theorem of Algebra.	9
4.	Power series expansion of analytic function, Taylor's series, Laurent Series, Singularities, Poles and zeros, Riemann's removable singularity theorem, Casorati-Weierstrass theorem, residue theorem, evaluation of standard types of integrals by the residue calculus method.	11
5.	Argument principle, Rouche's theorem, Maximum modulus theorem, open mapping theorem, identity theorem, Schwarz's lemma.	8
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/Reprint
1.	J. B. Conway, Functions of One Complex Variable, Narosa, New Delhi	2002
2	L. V. Ahlfors, Complex Analysis, Third Edition, McGraw Hill.	1979
3	Churchill, R.V. and Brown, J.W., Complex Variables and Applications, Eighth edition; McGraw Hill International Edition	2009

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Details of Course

Course Title	Course Structure			Pre-Requisite
MSMA 104: Partial Differential Equations	**L**	**T**	**P**	Knowledge of calculus and ODE.
	3	1	0	

Course Objective: To provide deeper understanding of Partial Differential Equations to apply in applications

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

CO1	Identify the techniques to form the partial differential equations (PDEs) and solutions of standard linear and non-linear PDEs.
CO2	Solve non-linear PDEs by method of Characteristics, and demonstrate capacity to solve linear PDFs of higher order and categorize second order PDFs into elliptic, parabolic and hyperbolic.
CO3	Generate capacity to model physical phenomena of heat equations using separation of variable and Fourier series
CO4	Interpret the physical phenomena related to Laplace equation using separation of variable and Fourier Series.
CO5	Lead to understanding to form wave equation using Fourier analysis techniques and their applications in real life problems.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	1	0	1	1
CO2	2	2	2	1	2
CO3	2	1	0	0	1
CO4	2	1	2	2	1
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
1.	**Partial Differential Equations (PDEs):** Formation of PDEs, Linear and Quasi-linear first order PDEs, Cauchy's problem for first order PDEs, Non-linear first order PDEs: Standard forms and Charpit's method, Method of Characteristics for Quasilinear, Semi linear PDEs and non-linear equations.	9
2.	**Second and higher order PDEs:** Linear Homogeneous and Non-homogeneous PDEs with constant coefficients, Classification of second order PDEs, Characteristics equations and Characteristic curves, Canonical forms, Method of separation of variables.	9
3.	**Parabolic equations:** Derivation of one and two dimensional heat equation, Solution of initial and boundary value problems, Fourier series solutions, Homogeneous Dirichlet's boundary conditions, Steady state solutions, The maximum- minimum principle, Duhamel's principle.	8
4.	**Elliptic equations:** Laplace and Poisson's equations, Boundary value problem in rectangular and polar coordinates, The maximum and minimum principle, Neumann problems, Dirichlet's problem for rectangle, annuli and Disk, Green's function.	8
5.	**Hyperbolic equations**: Derivation of one dimensional wave equation, D'Alembert solution of wave equation, Solution of initial / boundary value problems, The finite vibrating string problems.	8
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	Introduction to Partial Differential Equations: K.S. Rao, PHI	2011
2.	Partial Differential Equations : An Introduction: Walter A. Strauss, John Wiley & Sons, 2nd Edition	2008
3.	Partial Differential equations: Peter V. O' Neil, Wiley Publication 3rd Edition	2014
4.	Elements of Partial differential Equations: I.N. Sneddon, Dover Publications	2006
5.	Advanced Engineering Mathematics: E. Kreyszig, Wiley Publications	2011
6.	Partial Differential Equations: F. John, Spinger-Verlag, New York	1982

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Details of Course

Course Title	Course Structure			Pre-Requisite
MSMA 106: Topology	**L**	**T**	**P**	Basics of Real Analysis
	3	1	0	

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

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

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	0	0	3
CO2	3	0	0	0	3
CO3	3	0	0	0	2
CO4	3	2	0	0	3
CO5	3	2	0	0	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.	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
2.	Continuity, Homeomorphism, Separated sets, Connectedness, Components, Locally Connected Space.	8
3.	Compact spaces, Compactness in R, Countable Compactness, Local Compactness, One Point Compactification.	7
4.	Countability axioms, Separation axioms, Urysohn's Lemma, Urysohn's metrization theorem, Tietze extension theorem.	10
5.	Product Space of two Spaces, General Product Spaces (Tychonoff Topology), Product Invariant Properties, Tychonoff Theorem, Stone-Cech compactification.	8
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	G.F. Simmons Introduction to Topology and Modern analysis, G. McGraw Hill International Edition	1963
2.	James R. Munkres, Topology, Second edition, Prentice Hall of India	2000
3.	S.T. Hu, Elements of General topology, Holden-Day Inc	1964
4.	J.G. Hocking and G.S. Young, Topology, Addison-Wesley	1961

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Details of Course

Course Title	Course Structure			Pre-Requisite
MSMA 108: 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 v 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, orthogonality and diagonalization. (Computational and Algebraic Skills).
CO2	Use visualization, spatial reasoning, as well as geometric properties and strategies to model, solve problems, and view solutions, especially in R^2 and R^3, as well as conceptually extend these results to higher dimensions (Geometric Skills).
CO3	Interpret and analyse numerical data, mathematical concepts, and identify patterns to formulate and validate reasoning (Proof and Reasoning).
CO4	Explain mathematical statements, ideas and results, both verbally and in writing, with the correct use of mathematical definitions, terminology and symbolism (Communication Skills).
CO5	Work collaboratively with peers and instructors to acquire mathematical understanding in interdisciplinary areas and to formulate and solve problems and present solutions (Collaborative Skills)

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	0	2	3
CO2	3	2	0	2	3
CO3	2	2	0	2	3
CO4	2	1	0	1	1
CO5	1	1	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.	Vector Space, linear dependence and independence, Basis and Dimension, Direct sum, Linear Transformation, Sylvester's Law of Nullity. Matrix of Linear Transformation, Change of Basis, Equivalent and Similar Matrices.	7
2.	Invertible linear Transformation, Algebra of Linear Transformations, Hom(U,V), Dimension of Hom(U,V), Dual Space, Bidual.	9
3.	Eigenvalues, Eigenvectors, Cayley-Hamilton Theorem, Minimal Polynomials, Diagonalization, Canonical forms: Triangular forms, Jordan canonical form.	10
4.	Inner Product Space, Orthogonality, Orthonormal basis, Gram-Schmidt orthonormalization process, Unitary, Adjoint, Hermitian, Skew Hermitian, Normal Linear Operators.	10
5.	Bilinear form, Matrix of a bilinear form, Symmetric bilinear form, Quadratic form, Positive definite bilinear form.	6
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	Hoffman and Kunze, Linear Algebra ,2nd Edition, Pearson.	2015
2.	Gilbert Strang, Introduction to Linear Algebra , 5th Edition, Wellesley-Cambridge Press.	2016
3.	Serge Lang, Linear Algebra , 3rd Edition, Springer.	2004
4.	I. N. Herstein, Topics in Algebra ,2nd Edition, Wiley Eastern Limited	2008
5.	Khanna and Bhamri, A course in Abstract Algebra, 5th Edition, Vikas Publishing House.	2017
6.	N. S. Gopalakrishnan, University Algebra, New Age International Publishers	2004
7.	Linear Algebra , 4th Edition, Schaum's Series	2015

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Details of Course

Course Title	Course Structure			Pre-Requisite
MSMA 110: 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	Explain the fundamental numerical methods for solving nonlinear equations, systems of linear equations, and initial value problems, including their convergence criteria.
CO2	Implement numerical algorithms such as Newton-Raphson, LU decomposition, and Runge-Kutta methods using MATLAB or other computational tools to solve real-world problems.
CO3	Analyse the stability and accuracy of interpolation and numerical integration techniques like Lagrange interpolation, Simpson's rule, and Gauss quadrature.
CO4	Evaluate and compare the performance of different iterative methods (e.g., Jacobi, Gauss-Seidel) in terms of convergence speed and computational efficiency for large systems.
CO5	Develop a computational solution using advanced methods (e.g., finite difference methods for boundary value problems) for mathematical models derived from scientific and engineering contexts.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	1	0	1
CO2	2	3	1	1	2
CO3	2	3	1	1	1
CO4	2	3	1	2	2
CO5	2	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
1.	Fixed point iteration, Bisection method, Newton Raphson method, secant & Regula Falsi method, Convergence analysis, determination of Multiple roots, Newton Raphson for simultaneous nonlinear equations.	10
2.	Vector and Matrix norms, ill conditioned equations, Gauss elimination method, LU decomposition, Jacobi & Gauss Seidel iterative methods and their convergence, relaxation methods.	10
3.	Jacobi method, Given's method, Householder's method, Eigenvalues and Eigenvectors of tridiagonal matrix, power method.	12
4.	Interpolation, Lagrange interpolation formula, Newton's divided difference, Splines, Least Square method.	
5.	Taylor's series method, Difference operator, differentiation using interpolating polynomials, Finite difference methods, Newton Cotes formulas, Simpson's rule, Gauss Quadrature, Richardson's extrapolation.	12
6.	Euler's method, Modified Euler method, Runge Kutta method, multistep methods. Finite difference method, solution of nonlinear BVP.	
	Total	**44**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
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	2013
4.	S.S. Rao, Applied numerical methods for engineers & Scientist, PHI	2001

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	Finding eigen values using power method, Jacobi method
6	Lagrange and splines methods for interpolation
7	Newton cotes methods for numerical integration
8	Gauss Quadrature, Richardson's extrapolation.
9	Euler's method for IVP.
10	Runge Kutta method for IVP
11	Finite difference methods for solving BVP
12	Solving non-linear BVP

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 112: Programming Lab - II	**L**	**T**	**P**	Basic computer knowledge
	0	**0**	**4**	

Course Objective: To introduce fundamentals of programming using Python and understand the concepts of 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	2	2	1	2	2
CO2	1	1	1	2	2
CO3	1	2	1	2	2
CO4	2	3	2	2	1
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.
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PO5	Ability to contribute effectively in a multidisciplinary team.

S. No.	Contents	Contact Hour
1.	**Introduction to Python:** Installing and Running Python, Introducing Different IDEs for Python like Spyder and PyCharm, Arithmetic Operators, Variables, Expressions and Statements in Python.	3
2.	**Functions and Recursion:** Function Calls, Parameters and Arguments, Logical Operators, Conditional and Alternative Execution, Infinite Recursion and Stack Diagrams, Iterations in Python.	4
3.	**Strings and Lists**: Immutable Strings, String Methods and Comparison, Mutable Lists, List Operations and Methods,	2
4.	**Dictionaries and Tuples:** Concept of Dictionary and Looping, Reverse Lookup, Immutable Tuples, Tuples as Return Values, Variable Length Tuples.	3
5.	**Program scope and error handling:** Concepts of Namespaces and scope. Error handling using try and except. Create your own exceptions.	3
6.	**Files:** Filenames and Paths, Persistence, Reading and Writing, Catching Exceptions, Databases, Pipes	3
7.	**Classes and Objects:** Attributes, Mutable Objects, Classes and Functions, Pure Functions, Modifiers, Classes and Methods, Inheritance	3
	Total	**21**

References:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	Think Python, Allen B. Downey, O'Reilly, ISBN – 978-9352134755	2016
2.	Introduction to Computation and Programming Using Python with Application to Understanding Data, Guttag John V., PHI, ISBN – 978-8120352926.	2016
3.	Introducing Python, Bill Lubanovic, O'Reilly. ISBN – 978-93-5110-878-8	2015

List of Experiments	
1	WAP that creates variables of numeric data types and perform arithmetic operations on them.
2	WAP to declare variables of string datatype and perform different operations on them.
3	WAP to create, insert and delete Lists in Python.
4	WAP to create, insert and delete Dictionaries in Python.
5	WAP to create, insert and delete Sets and Tuples in Python.
6	Write a menu driven program that performs as demonstrated below: "Enter the numbers on which you want to perform the operation: 12 34 Select the operation from the following menu: 1. Addition 2. Subtraction 3. Multiplication 4. Division What is your choice for operation: 1 Output = 46"
7	WAP to print Fibonacci series using for loop.
8	WAP to print all prime numbers less than 10,000 using while loop.
9	Create a function search_list which takes a list of values as arguments and search a particular number in the list.
10	WAP for division of two numbers where denominator is 0. This will throw an exception. Now handle the exception using try and except.
11	Python based small project. E.g. text based adventure games, video games, simple web applications etc.

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 114: Fundamentals of Computer	**L**	**T**	**P**	NIL
	0	**0**	**4**	

Course Objective: To enable students to learn basic computer, programming and software applications.

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

CO1	Know different operating systems and basic commands
CO2	Possess the knowledge of programming in C language
CO3	Write computer programs in MATLAB, Mathematica and SPSS to solve problems
CO4	Solve basic computational problems with C language, MATLAB, Mathematica and SPSS.
CO5	Create good documentation using MS Office tools and Latex.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	0	2	1	0	0
CO2	0	0	1	1	2
CO3	0	1	1	2	2
CO4	0	3	2	2	2
CO5	3	1	0	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.
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S. No.	Contents	Contact Hour
1.	**Introduction to Python:** Installing and Running Python, Introducing Different IDEs for Python like Spyder and PyCharm, Arithmetic Operators, Variables, Expressions and Statements in Python.	3
2.	**Functions and Recursion:** Function Calls, Parameters and Arguments, Logical Operators, Conditional and Alternative Execution, Infinite Recursion and Stack Diagrams, Iterations in Python.	4
3.	**Strings and Lists**: Immutable Strings, String Methods and Comparison, Mutable Lists, List Operations and Methods,	2
4.	**Dictionaries and Tuples:** Concept of Dictionary and Looping, Reverse Lookup, Immutable Tuples, Tuples as Return Values, Variable Length Tuples.	3
5.	**Program scope and error handling:** Concepts of Namespaces and scope. Error handling using try and except. Create your own exceptions.	3
6.	**Files:** Filenames and Paths, Persistence, Reading and Writing, Catching Exceptions, Databases, Pipes	3
7.	**Classes and Objects:** Attributes, Mutable Objects, Classes and Functions, Pure Functions, Modifiers, Classes and Methods, Inheritance	3
	Total	**21**

References:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
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2.	Introduction to Computation and Programming Using Python with Application to Understanding Data, Guttag John V., PHI, ISBN – 978-8120352926.	2016
3.	Introducing Python, Bill Lubanovic, O'Reilly. ISBN – 978-93-5110-878-8	2015

List of Experiments	
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4	WAP to create, insert and delete Dictionaries in Python.
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THIRD SEMESTER

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 201: 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): After successful completion of the course, students shall able to

CO1	Describe how functional analysis uses and unifies the concept of vector spaces and the theory of metric spaces.
CO2	Explain the normed linear space which is not an inner product space.
CO3	Describe and apply fundamental theorems for normed linear space and Banach spaces such as Hahn-Banach theorem, the open mapping theorem, the closed graph theorems.
CO4	Differentiate between Banach space and Hilbert space and recognize the basic properties of Hilbert spaces.
CO5	Describe the fundamentals of spectral theory, and recognize its power in different applications.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	3	1	2	1
CO2	1	3	1	1	2
CO3	2	3	2	1	1
CO4	2	3	1	1	0
CO5	2	3	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
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**
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**
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.	**8**
4.	Open mapping theorem, closed graph theorem, uniform boundedness principle, consequences of these theorems.	**6**
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	**42**

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

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 203: Operations Research	**L**	**T**	**P**	Linear Algrbra
	3	**1**	**0**	

Course Objective: To study the quantitative decision making the constrained money, material, machine and man power assignment in the formatted linear, integer or transportation network models.

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

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
1.	**Linear Programming:** Convex set and convex functions, Convex feasible region extreme points and basic feasible solutions, Optimal solution by Simplex method, Two phase method, Big M method. Sensitivity analysis. Dual simplex method. Duality in LPP: Dual problem, Duality theorems, Complementary slackness. Transportation problem and its solution method, assignment problem and its solution methods, degeneracy.	**12**
2.	**Integer programming Problems:** Problem formulation, Branch and bound method, Cutting plane algorithm.	**5**
3.	**Some Sequencing and scheduling Problems:** Optimal job sequencing Problem, solution of sequencing problem, Sequential activities scheduling and project network.	**7**
4.	**Network Scheduling:** Network and basic components, Network construction, Critical path method (CPM), Program evaluation and review techniques (PERT), Cost of completing project.Crashing.	**5**
5.	**Theory of games:** Basic theory of game, the two-person zero-sum game: pure strategy and mixed strategy game.	**7**
6.	**Queueing theory:** MM1 models- Single channel and multiple channel	**6**
	Total	**42**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Hamdy A. Taha: Operations Research: An Introduction, Pearson Education Inc, 8th Edition.	2018
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	P. Rama. Murthy: Operations Research, New age international publisher.	2007
6	Kanti Swaroop, P.K Gupta, Mohan Man: Operations Research—Introduction to Management Science, Sultan Chand and Sons.	2017

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 205: Dessertation I	**L**	**T**	**P**	
	0	**0**		

Course Objective: To apply the knowledge of courses learned to real world problems.

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

CO1	Identify a relevant research problem and formulate clear research objectives and scope.
CO2	Conduct a comprehensive literature review to establish the research context and identify gaps.
CO3	Demonstrate the ability to design a suitable methodology or theoretical framework for the problem.
CO4	Develop preliminary models, simulations, or analytical results supporting the proposed work.
CO5	Present the progress through a written report and effectively communicate ideas in a seminar.

CO-PO Articulation Matrix:

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

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 207: Stochastic Process	**L**	**T**	**P**	Mathematical Statistics
	3	**1**	**0**	

Course Objective: To acquire the knowledge of random processes which develop in time or space in accordance with probabilistic laws and getting idea of their applications in science and technology.

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

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	0	2	2	3	2
CO2	0	2	3	2	3
CO3	0	2	3	3	3
CO4	0	2	2	2	2
CO5	1	2	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.	Introduction and specification of stochastic process, The simple random walk with unrestricted, two absorbing barriers, one absorbing barrier, two reflecting barriers and one reflecting barrier. The general one-dimensional random walk in discrete time.	**10**
2.	A two-state Markov chain, General Markov chain, classification of states and limit theorems, closed sets of states, irreducible chain and equilibrium distributions. Ergodic process. Transient and recurrent system. Absorption problems.	**10**
3.	Markov processes with discrete and continuous states. The Poisson process, generalization of the Poisson process. Birth and death process. The Weiner process.	**11**
4.	Non-Markovian processes, Supplementary variables, Imbedded Markov process, Time domain stationary process.	**11**
	Total	**42**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	J Medhi: Stochastic Processes: New Age International Publishers, 3rd edition	2009
2	Sheldon M. Ross: Stochastic Processes. Wiley India.	2013
3	D.R. Cox and H.D. Miller: The Theory of Stochastic Processes. Chapman and Hall /CRC.	2001
4	S.K. Srinivasan, K.M. Mehata: Stochastic Processes, McGraw-Hill Education, 2Rev Ed edition.	1988
5	Bailey NTJ: The Elements of Stochastic Processes with Applications to the Natural Sciences. Wiley New York.	2005

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 209: Analysis and Design of Algorithm	**L**	**T**	**P**	MSMA 107 - Discrete Mathematics, MSMA 114 Fundamentals of Computer
	3	**0**	**2**	

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

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

CO1	Describe different paradigms of algorithm design, such as Divide & Conquer, Greedy, Dynamic Programming, Branch & Bound and Backtracking.
CO2	Argue the correctness of algorithms using inductive proofs and invariants.
CO3	Analyze the running time of algorithms in terms of asymptotic notations.
CO4	Explain graphs, trees, searching and sorting algorithms and their analyses.
CO5	Compare the notion of complexity classes of P and NP.

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
1.	Review of Basics of Data Structures, Searching, Sorting, Heap Sort. **Program Performance:** Time and Space Complexity, Asymptotic Notation, Solution of Recurrence Relations.	**6**
2.	**Divide and Conquer:** Quick Sort, Randomized Quick Sort, Strassen's Matrix Multiplication. **Greedy Method:** Minimum Cost Spanning Trees-Kruskal's Method.	**8**
3.	**Dynamic Programming:** Matrix Chain Multiplication Problem, Longest Common Subsequence Problem. **Backtracking:** Graph Coloring Problem, Hamiltonian Cycles Problem, Subset Sum Problem, N-Queen's Problem. **Branch and Bound:** 0/1 Knapsack Problem, Traveling Salesman Problem.	**12**
4.	**Graph Algorithms:** DFS, BFS, Shortest Path Algorithms, Topological Sorting.	**10**
5.	**Infeasibility:** P and NP-Classes, NP-Hard Problems, Reduction.	**6**
	Total	**42**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Introduction to Algorithms. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. 3rd Edition. 2009. The MIT Press.	2009
2	Data Structures, Algorithms, and Applications in C++. Sartaj Sahni. 2nd Edition. 2001. McGraw-Hill Pub. Co.	2001
3	Fundamentals of Computer Algorithms. Ellis Horowitz and Sartaj Sahni, Sanguthevar Rajasekaran. 2nd Edition. 2008. Universities Press.	2008
4	Algorithm Design. Jon Kleinberg and Eva Tardos, 1st Edition. 2013. Pearson.	2013

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 quick sort and randomized quick sort.
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	Using dynamic programming, write a Program to implement the following: a. Matrix Chain Multiplication b. Longest Common Subsequence
6	Apply the backtracking design approach to solve the following problems: a. Graph Colouring b. Hamiltonian cycles c. Subset Sum problem
7	Write a Program to implement 0/1 knapsack, traveling salesman problem 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

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 211: Number Theory	**L**	**T**	**P**	NIL
	3	**0**	**2**	

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

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

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
CO4	simplifying various arithmetical problems.
CO5	Identify the order of an integer modulo n and primitive roots of composite numbers.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	0	1	2
CO2	2	2	0	1	2
CO3	3	2	0	1	2
CO4	3	2	0	1	2
CO5	2	2	0	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.	Divisibility in integers, Division algorithm, G.C.D., L.C.M., Fundamental theorem of Arithmetic.	**6**
2.	Congruences, Residue classes and their properties, Fermat's little Theorem, Wilson's Theorem. System of linear congruences, Chinese remainder Theorem, It's Generalization (statement and applications).	**10**
3.	Some elementary number theoretic functions, Greatest integer function, Mobius inversion formula, Euler's function and its properties, Euler's Fermat Theorem.	**9**
4.	Order of an integer modulo n, Primitive roots, composite numbers having primitive roots, Theory of indices.	**9**
5.	Quadratic residue, Euler's criterion, Legendre's symbol and its properties, Gauss' Lemma, Quadratic reciprocity law.	**8**
	Total	**42**

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
5	I. Niven, H.S. Zuckerman, H.L. Montgomery, An Introduction to the Theory of Numbers, Wiley India	2010

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 213: Mathematical Modelling and Simulation	**L**	**T**	**P**	Some basic knowledge of Differential equations
	3	**0**	**2**	

Course Objective: To understand/ develop the mathematical model to answer real life problem.

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

CO1	Describe the concept of modelling and simulation, by extracting the necessary and relevant information regarding the problem.
CO2	Construct various mathematical models of real world problems.
CO3	Solve the mathematical models using mathematical techniques and with the help of various techniques.
CO4	Do qualitative analysis of the non-linear mathematical models.
CO5	Analyze and understand the numerical and statistical techniques.

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
1.	Introduction: Concepts of Mathematical modelling, some modeling approaches: empirical, stochastic, simulation, deterministic, Statistical models, Qualitative and quantitative approaches.	**7**
2.	Compatment models, Models of single populations and case study, Interacting population models and extended population models, Long term behaviour, Case Study.	**12**
3.	Phase plane analysis, Stability, Equilibirium points and Stability analysis, Routh Hurwitz Criteria, Lyapunov functions.	**11**
4.	Introduction to Choas Theory and non-linear dynamics, Hopf Bifurcation: Forward and backward, Case Study.	**12**
	Total	**42**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Belinda Barnes : Mathematical Modeling with case studies, 2th edition, , CRC Press	2011
2	Marotto, F. R., "Introduction to Mathematical Modeling using Discrete Dynamical Systems", Thomson Brooks/Cole.	2006
3	Steven H. Strogatz : Nonlinear Dynamics and Choas, , Persues Books	1994
4	William E. Boyce, Richard C. Diprima, Elementary Differential Equations and Boundary Value Problems, 9th Ed.	2009

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 215: Calculus of Variation	**L**	**T**	**P**	Basic knowledge of several variable calculus
	3	**1**	**0**	

Course Objective: This course treats the foundations of calculus of variations and gives examples on some applications within physics and engineering sciences.

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

CO1	Get introduced to the concept of functionals and its variations and the key features of Euler-Lagrange Equation and Brachistochrone problems.
CO2	Understand how to compute the variation of a functional, problem on minimal surface of revolution and difference between variational problems with fixed boundaries and those with free boundaries.
CO3	Understand the mathematical formulation of functionals dependent on several unknown functions and identify the problems on conditional extremum, variation problem of moving boundaries, Isoperimetric.
CO4	Identify the basic concept of variational methods: Rayleigh-Ritz, Galerkin Method, Method of Kantorovich, Trefftz Method.
CO5	Understand Hamilton's principle, Principle of least action, Hamiltonian's canonical equation.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	1	1	1	1
CO2	2	1	0	0	2
CO3	3	1	1	1	1
CO4	2	1	2	1	1
CO5	3	2	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
1.	Functional and its variation, Motivating problems, shortest distance problem, Euler's Lagrange's equation of functional dependent on one independent and one dependent variables and its first derivative with fixed end conditions, Brachistochrone problems	8
2.	Euler's Lagrange's equation of functional dependent on one independent and one dependent variables and its higher derivative with fixed end conditions, natural boundary conditions, transition conditions, associated problems, problem on minimal surface of revolution.	10
3.	functional dependent on functions of several independent variables and variational problems in parametric form, Invariance of Euler's equation, Geodesics, Problem on conditional extremum, variation problem of moving boundaries, Isoperimetric problem. Sturm Liouville problem.	10
4.	Variational Methods: Rayleigh-Ritz method, Galerkin Method, Method of Kantorovich, Trefftz Method.	8
5.	Hamilton's principle, Principle of least action, Hamiltonian's canonical equation.	6
	Total	**42**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	I. M. Gelfand, S. V. Fomin: Calculus of variations, Prentice-Hall.	2000
2	F. B. Hildebrand: Methods of Applied Mathematics, Dover Publication, 2nd Edition.	1992
3	A. S. Gupta: Calculus of Variations, PHI Learning Pvt. Ltd.	1996
4	I. S. Sokolnikoff: Mathematical Theory of Elasticity, McGraw Hill Book Co., 2nd Edition	1992

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 217: Graph Theory	**L**	**T**	**P**	Knowledge of Relations and Functions
	3	**1**	**0**	

Course Objective: To understand the concepts of graph theory and apply the knowledge to solve real life problems.

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

CO1	Apply fundamental concepts of graphs to model and analyse real-world problems.
CO2	Analyze graph structure using connectivity and planarity theorems to determine embeddings and critical graph properties.
CO3	Apply graph coloring and matching techniques to solve scheduling, allocation, and network problems using chromatic numbers, polynomials, and Hall's theorem.
CO4	Interpret and apply concepts of digraphs, tournaments, and network flows to model directed relationships and solve routing, ranking, and connectivity problems.
CO5	Evaluate domination parameters in graphs and apply them to network monitoring and resource allocation problems.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	0	3	3
CO2	2	2	1	3	3
CO3	3	3	1	3	3
CO4	3	3	0	3	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
1.	**Basic Concepts of Graph Theory:** Graphs and Simple Graphs, Vertex Degrees, Degree Sequences, Subgraphs, Incidence and Adjacency Matrices, Graph Isomorphism, Walks, Paths, Cycles, Circuits, Connectedness, The Shortest Path Problem, Non separable Graphs, Eulerian Graphs, Hamiltonian Graphs, The Chinese Postman Problem, The Travelling Salesman Problem, Trees, Spanning Trees	7
2.	**Connectivity and Planarity:** 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, Maximal Planar Graphs, Outer-Planar Graphs	10
3.	**Coloring and Matching:** Vertex coloring, n-coloring, Chromatic number of a graph, Chromatic number of standard graphs, Bichromatic graphs, Bounds for chromatic number, Perfect graphs, Edge Coloring, Edge chromatic number of standard graphs, Chromatic polynomial, Matching, Perfect Matching, Augmenting paths, Maximum Matching, Hall's theorem for bipartite graphs, Applications of Matching	10
4.	**Digraphs:** Digraphs, Oriented graphs, indegree and outdegree, Elementary theorems in digraphs, Types of digraph, Tournaments, Transitive Tournaments, Hamiltonian Tournament, Networks and Applications	8
5.	**Domination:** Dominating sets in graphs, Domination number of standard graphs, Bounds on Domination number, Minimal Dominating set, Independent Dominating set	7
	Total	**42**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication/ Reprint
1	G. Chartrand, L. Lesniak and P. Zhang, Graphs and Digraphs, Fifth Edition, CRC Press	2011
2	J.A.Bondy and V.S.R. Murthy, Graph Theory with Applications, Macmillan, London	2004
3	F. Harary, Graph Theory, Narosa Publishing House	2001
4	D.B.West, Introduction to Graph Theory, Second Edition , Pearson Education Asia	2002
5	G. Chartrand and P. Zhang, Introduction to Graph Theory, International Edition, McGraw Hill	2005
6	T.W.Haynes, S.T. Hedetneime and P.J. Slater, Fundamental of domination in graphs, Marcel Dekker.Inc. New York	1998

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Details of Course:

Course Title	Course Structure			Pre-Requisite
MSMA 219: Database Management System	**L**	**T**	**P**	MSMA 107-Discrete Mathematics, MSMA 114-Fundamental of Computer
	3	**0**	**2**	

Course Objective: To introduce students to the fundamental concepts necessary for designing, using and implementing database systems and applications.

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

CO1	Describe relational database design, relational algebra and SQL. Design models to represent simple database applications using different data models.
CO2	Convert ER-models to relational tables, populate relational database and formulate SQL queries on data.
CO3	Improve the database design by normalization.
CO4	Classify and describe transactions and concurrency control techniques
CO5	Explain basic database storage structures and access techniques.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	2	1
CO2	3	3	2	2	2
CO3	3	2	1	2	1
CO4	2	2	3	0	2
CO5	2	1	3	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
1.	**Basic Concepts:** Database & Database Users, Characteristics of the Database, Database Systems, Concepts and Architecture, Date Models, Schemas & Instances, DBMS Architecture & Data Independence, Database Languages & Interfaces, Data Modeling using Entity-Relationship Approach. Overview of Hierarchical, Network & Relational Database Management Systems. **Data Models:** Introduction, Data Association- (Entities, Attributes and Associations, Relationship Among Entities, Representation of Association and Relationship), Data Model Classification- (Approaches to Relational Model, Hierarchical Model & Network Model with Examples), Entity- Relationship Model.	8
2.	**Relational Model, Languages & Systems:** Relational Data Model & Relational Algebra, Relational Model Concepts, Relational Model Constraints, Relational Algebra, Relational Calculus. **SQL**: Relational Database Language, Data Definition In SQL, Views, Queries in SQL, Specifying Constraints and Indexes In SQL.	14
3.	**Relational Database Design:** Relational Schema, Relational Design, Functional Dependency, Normalization, First, Second, Third Normal Forms, BCNF Relations with more than One Candidates Key, Multi-Valued Dependency, Fourth Normal Form, Fifth Normal Form.	8
4.	**File Organization, Indexing and Hashing:** Overview of File Organization Techniques, Indexing and Hashing Basic Concepts, Static Hashing, Dynamic Hashing, Ordered Indices, Multi-Level Indexes, B-Tree Index Files, B+ Tree Index Files, Buffer Management.	6
5.	Transaction processing concepts and Concurrency Control Techniques.	6
	TOTAL	**42**

References:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1	Fundamentals of Database Systems. Ramez Elmasri and Shamkant B. Navathe. 7th Edition. 2015. Pearson.	2015
2	Database Systems Concepts. Abraham Silberschatz, Henry F. Korth, and S. Sudarshan. 4th Edition. 2001. McGraw-Hill Higher Education.	2001
3	Database Systems: The Complete Book. Hector Garcia-Molina, Jeffrey D. Ullman, and Jennifer Widom. 2nd Edition. 2008. Prentice Hall Press, Upper Saddle River, NJ, USA.	2008

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PRACTICAL LIST	
S. No.	**List of Experiments**
1	Insert data in the database accordingly.
2	Perform the following queries using SELECT command: a. WHERE b. IN/NOT IN c. GROUP BY d. HAVING e. ORDER BY f. VIEWS
3	Perform the following DDL statements: a. Constraints: NOT NULL, UNIQUE, DEFAULT, PRIMARY KEY, FOREIGN KEY. b. Table manipulation: i. ADD COLUMN ii. DROP iii. ADD/DROP CONSTRAINT iv. RENAME v. ALTER TABLE
4	Perform the following DML statements: a. INSERT b. UPDATE c. DELETE d. TRUNCATE
5	Perform aggregate function and sorting based queries.
6	Perform queries to display data from Multiple Tables using join.
7	Solve the given question using the concept of nested query.
8	Implement Triggers and procedures-based commands.
9	Perform Transaction control commands. operation
10	Perform the above queries based on a Case Study.

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 221: Integral Transforms and Equations	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To enable students to apply integral transform for solving differential equations and to solve various integral equations

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

CO1	Get introduced to the concept of Laplace transforms and Fourier transforms and its properties in solving the differential equations.
CO2	Understand the classifications and methods to reduce Initial value and boundary problems associated with linear differential equations to various integral equations, like Fredholm and Volterra form
CO3	Use of Fredholm integral equation to find eigen values and eigen functions.
CO4	Describe importance of symmetric kernel, Hilbert-Schmidt theory and Green's function method for solving boundary value problems
CO5	Use of Volterra integral equations of first and second to solve resolvent kernel and Neumann series solution.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	1	1	1	1
CO2	2	2	1	1	1
CO3	2	1	1	1	1
CO4	2	2	1	1	1
CO5	2	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
1.	**Laplace and Fourier Transform:** Properties, periodic functions, impulse functions, evaluation of integrals, convolution theorem, applications to initial value problems. Dirichlet's conditions, convolution, Parseval's identity, application to boundary value problems.	10
2.	**Classification of Linear Integral Equations:** Fredholm, Volterra, Integro-differential equations, conversion of Volterra equation to ODE, reduction of IVP to the Volterra integral equation, reduction of Volterra integral equation to IVP, reduction of BVP to the Fredholm integral equation.	8
3.	**Fredholm Integral Equations:** Fredholm integral equation of the first and second kind, degenerate (separable) kernel, successive approximation, resolvent kernel, eigenvalues and eigen functions.	8
4.	**Fredholm Integral Equations with symmetric kernel:** Eigenvalues and eigen functions, Hilbert-Schmidt theory, examples on Hilbert-Schmidt theory, applications of Green's function to differential equations.	8
5.	**Volterra Integral Equation:** Volterra integral equation of the first and second kind, Neumann series solution, resolvent kernel.	8
	Total	**42**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	I. N. Sneddon, The use of integral transform, Tata Mc-Graw Hill.	1985
2	A. M. Wazwaz, A first course in integral equation, World Scientific	1997
3	M. D. Raisinghania, H. C. Saxena, H. K. Dass, Simplified course in Integral Transform, S Chand and Company Pvt. Ltd.	2003

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 223: Cryptography and Coding Theory	**L**	**T**	**P**	Abstract Algebra
	3	**1**	**0**	

Course Objective: To study various classical and advanced encryption algorithms, some network security protocols and fundamentals of coding theory.

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

CO1	Classify the various classical encryption techniques.
CO2	Describe and analyse modern block ciphers.
CO3	Describe and analyse public key cryptosystems and key exchange algorithms.
CO4	Construct error correcting codes using various methods, theory and principles.
CO5	Describe and analyse convolution codes and their decoding.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	1	2	2
CO2	2	1	1	2	2
CO3	3	1	1	2	2
CO4	3	1	1	2	2
CO5	3	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
1.	Introduction to cryptography, Modular arithmetic, Euclidean algorithm,Classical encryption techniques, Cryptanalysis of classical cryptosystems, Stream ciphers and Block ciphers, Shannon's theory of confusion and diffusion, Fiestal ciphers, Data Encryption Standard (DES), IDEA, Key distribution algorithm.	8
2.	Fermat's and Euler's theorem, Primality testing, Chinese Remainder theorem, Discrete logarithms, Principals of public key cryptosystems, RSA algorithm, security of RSA, Key management, Diffie-Hellman key exchange algorithm, Elliptic curve cryptography, Elgamal encryption.	8
3.	**Security Protocols:** Message Authentication Code (MAC), Message Digest, Secure Hash Algorithm (SHA), Digital Signatures.	5
4.	Introduction to error control coding, Generator matrix and parity check matrix, Introduction to linear block codes, Syndrome decoding procedures, decoding by coset leaders, error detection, encoding and properties of Hamming codes, Hamming codes as perfect codes.	11
5.	Bounds on size of codes: Hamming bound, Singleton bound, Plotkin bound, Gilbert-Varshamov bound, Introduction to convolutional codes: Encoding, state diagram, trellis diagram, Classification, realization, distance properties, Decoding of convolutional codes: Viterbi algorithm, BCH codes, Performance bounds for convolutional codes.	10
	Total	**42**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	William Stallings, "Cryptography and Network Security: Principals and Practice", Prentice Hall, New Jersey	1997
2	Behrouz A. Forouzan, "Cryptography and Network Security", TMH.	2003
3	Douglas R. Stinson, "Cryptography: Theory and practice", CRC.	2018
4	Vera Pless, 'An Introduction to Error-Correcting Codes' 3rd edition, Wiley.	1998
5	W. Cary Huffman and Vera Pless, 'Fundamentals of Error-Correcting Codes" Cambridge	2003
6	Shu Lin & Daniel J. Costello Jr., "Error Control coding", 2nd edition, Prentice Hall	2010
7	Ling, S. and Xing, C.: "Coding Theory: A First Course", Cambridge University Press	2004
8	Roth, R. M.: "Introduction to Coding Theory", Cambridge University Press	2006

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 225: Classical Mechanics	**L**	**T**	**P**	Elementary knowledge of dynamics
	3	**1**	**0**	

Course Objective: To provide deeper understanding of fundamental concepts of classical mechanics.

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

CO1	Classify the central forces from other types of forces and apply it to describe the planetary 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	2	2	1	1
CO2	3	1	3	1	1
CO3	2	2	2	1	1
CO4	2	1	2	1	1
CO5	3	1	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
1.	**Newtonian Mechanics:** Central forces and Central orbit, Stability of orbit, Planetary Motion, Kepler's law.	6
2.	**Dynamics of Rigid Bodies:** Moments 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.	8
3.	**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
4.	**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.	10
5.	**Canonical Transformation:** Generating function, Properties of Canonical Transformation, Examples of Canonical Transformation, Poisson bracket, Hamilton-Jacobi equation, Liouville's theorem.	10
	Total	**42**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication/ Reprint
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

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FOURTH SEMESTER

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 202: Measure and Integration	**L**	**T**	**P**	Basic concepts of Real Analysis and Riemann Integration.
	3	1	0	

Course Objective: To impart knowledge of Measurable set ad integration of functions is Lebesgue sense.

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

CO1	Analyze the properties of Lebesgue measurable sets and construct key examples (e.g., Borel sets, Cantor ternary set) to illustrate the concepts of measure and non-measurability.
CO2	Characterize measurable functions and analyze the relationships between different modes of convergence-convergence in measure, pointwise convergence, almost everywhere convergence and almost everywhere uniform convergence-through counter examples and proofs.
CO3	Explain the core ideas behind the proofs of Lusin's theorem, Frechet theorem and F. Riesz's theorem on convergence almost everywhere, highlighting how they connect measure, continuity, and different types of convergence.
CO4	Compute Lebesgue integrals; describe and apply Lebesgue monotone and dominated convergence theorems and Fatou's Lemma
CO5	Analyze the structure of L^p spaces as complete normed vector spaces (Banach spaces); apply Hölder's inequality, Minkowski's inequality and Schwartz's inequality to proves estimates; interpret Riesz-Fischer theorem on completeness.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	3	1	0	0
CO2	2	3	2	1	1
CO3	1	3	3	1	0
CO4	2	3	2	1	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
1.	Countability and uncountability of sets. Outer and inner Lebesgue measure, Lebesgue measurable sets and their properties, Non-measurable sets, Borel sets and Cantor's ternary sets.	8
2.	Measurable functions, Continuous function, Set of measure zero, Borel measurable function, Point wise convergence, Almost everywhere convergence, almost everywhere uniform convergence, Egoroff's Theorem.	8
3.	The structure of measurable function: Lusin Theorem, Frechet Theorem, Convergence in measure, F. Reisz's theorem on convergence almost everywhere, Lebesgue integral of bounded measurable function, bounded convergence theorem.	9
4.	Integral of non-negative measurable functions, Fatou's lemma, Monotone convergence theorem, General Lebesgue integral, Lebesgue dominated convergence theorem, Improper integral.	10
5.	L p –space and its Properties, Holder's inequality, Minkowski's inequality and Schwartz's inequality, Riesz-Fischer theorem.	7
	Total	**42**

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	P.K. Jain, V.P. Gupta, Pankaj Jain, Lebesgue Measure and integration, 2nd edition, New Age International Publishers	2010
3	Inder K. Rana, An Introduction to Measure and Integration, 1st edition, Narosa Publishing House.	1997

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 204: Dessertation II	**L**	**T**	**P**	
	0	**0**		

Course Objective: To apply the knowledge of courses learned to real world problems.

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

CO1	Execute the proposed research plan with rigor and apply appropriate tools and techniques.
CO2	Analyze and interpret results to draw meaningful conclusions and validate the research hypothesis.
CO3	Demonstrate critical thinking and problem-solving ability in refining the research outcomes.
CO4	Prepare a comprehensive dissertation adhering to academic writing standards and ethical practices.
CO5	Defend the research work confidently in the viva-voce and respond to expert feedback.

CO-PO Articulation Matrix:

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

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
IMSMA 206: Financial Mathematics	**L**	**T**	**P**	A course in Statistics with sound knowledge of random variable, expectation and variance, m.g.f. and probability distribution
	0	**0**	**4**	

Course Objective: To acquire knowledge of financial market and various terminologies used. Assumptions for modelling of financial markets. The types of instruments traded in the financial markets and risk attached, and derivative on underlying asset and its pricing. A foundation of stochastic processes and calculus. Knowledge and understanding of Portfolio and its optimization.

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

CO1	Describe the financial market and various terminologies used. List the assumptions for mathematical modelling of financial markets. Categorize the types of instruments traded in the financial markets.
CO2	Compute the risk and return attached with risky and risk free instruments. Pricing of Bonds, Forward, and Future and apply to real problem.
CO3	Do the option pricing using various models. Effectively compute the volatility and its impact on derivative pricing.
CO4	Define the stochastic processes, and calculus for forming and solving stochastic differential equations. Apply the Stochastic calculus in option pricing, and other real world and engineering problem.
CO5	Explain the portfolio and to compute the risk and return attached with it. Construct a multi asset portfolio with minimum risk and maximum return. Use the skill for financial management.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	2	0	1	1
CO2	3	2	0	1	1
CO3	3	2	0	0	1
CO4	3	2	0	2	0
CO5	3	3	0	0	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**:** Some basic definitions and terminology: Basic Notions and Assumptions, No-Arbitrage Principle, One-Step Binomial Model, Risk and Return, Forward Contracts, Call and Put Options, Managing Risk with Options	10
2.	Use of Binomial model-single and multi-Period for pricing of option, Cox Ross-Rubinstein (CRR) Model, Limiting case of CRR Model and Black-Scholes Formula for Option Pricing.	10
3.	Introduction to stochastic process, Brownian and Geometric Brownian Motion. Definition of stationarity. Theory of Martingales. Stochastic Calculus, Stochastic Differential Equations, Ito's Formula to Solve SDE's. Feymann Kac Theorem. Applications of Stochastic Calculus in Option Pricing. Black-Scholes Partial Differential Equation and Black-Scholes Formula.	12
4.	Portfolio Theory: Concept of portfolio optimization, Markowitz Model of Portfolio Optimization and Capital Asset Pricing Model (CAPM). Premium of risk. Arbitrage pricing theory (APT).	10
	Total	**42**

References:

S. No.	Name of the books/Authors/Publishers	Year of Publication/ Reprint
1.	M. Capińsky and T. Zastawniak: Mathematics for Finance: An Introduction to Financial Engineering, Springer.	2004
2.	D. G. Luenberger: Investment Science, Oxford University Press.	1999
3.	Thomas Mikosch: Elementary Stochastic Calculus with Finance in view, World Scientific.	2006
4.	S. E. Shreve: Stochastic Calculus for Finance, Vol. I & Vol. II, Springer.	2004
5.	Paul Wilmott: The Mathematics of Financial Derivatives, Cambridge University Press 1st Edition.	1995
6.	John C. Hull, Sankarshan Basu: Options, Future & Other Derivatives, Pearson Education, Tenth edition.	2018
7.	S. Chandra, S. Dharmaraja, Aparna Mehra, R. Khemchandani: Financial Mathematics: An Introduction, Narosa publication; 1 edition	2013

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 208: Data Mining	**L**	**T**	**P**	MSMA 107- Discrete Mathematics, MSMA 109- Mathematical Statistics
	3	**0**	**2**	

Course Objective: To give an overview of the state-of-the-art Data Mining techniques that are used to assist managers to make intelligent use of data repositories. The course will survey applications in the areas such as credit rating, fraud detection, database marketing, customer relationship management, and stock market investments and provide an opportunity for hands-on experimentation with algorithms for data mining using easy-to- use software and cases.

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

CO1	Identify the scope and necessity of Data Mining & Warehousing for the society. Describe the designing and architecture of Data Warehousing to solve real world problems.
CO2	Apply various tools of Data Mining and their techniques on real world problems. Design various algorithms specialized for data mining tasks.
CO3	Designing new Data Mining techniques and analyze them critically.
CO4	Analyze and justify the use of a particular data mining technique for a problem.
CO5	Compare the various approaches to data warehousing and data mining implementations.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	3	3	3	3
CO2	1	2	3	3	2
CO3	0	2	3	2	2
CO4	0	2	3	3	2
CO5	0	2	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
1.	**Introduction to Data Mining:** Motivation and Significance of Data Mining, Major Issues in Data Mining, Data Pre-processing, Data Summarization, Data Cleaning, Data Integration and Transformation, Data Reduction Techniques, Data Discretization and Concept Hierarchy Generalization.	6
2.	**Classification and Prediction:** Decision Tree, Single-Layer Perceptron, Multi-Layer Perceptron, Support Vector Machines, Rule Based Classifier. D**eep Learning Models:** Autoencoders, Convolutional Neural Networks, Transfer learning, Recurrent Neural Network, Boltzmann Machine. **Time Series Forecasting and Prediction:** Linear Regression, Multiple Linear Regression, Auto Regressive Model, Moving Average Model, Stationary Data, Non-Stationary Data, ARIMA Model, Time Series Forecasting for Seasonal Data.	14
3.	**Cluster Analysis:** Basic Concepts, K-Means Clustering, Hierarchical Clustering, Density-based Clustering, Grid-based Clustering, Model-based Clustering, Clustering High Dimensional Data, Clustering Graph and Network Data, Clustering with Constraints, Evaluation of Clustering, Outliers and Outlier Analysis.	12
4.	**Frequent Pattern Mining and Association:** Apriori Algorithm, Frequent Pattern Growth Algorithm.	4
5.	**Mining on complex data**: Mining Sequence Data, Graphs and Network, Spatial Data, Multimedia Data, Text Data; Financial Data Analysis. **Data Mining Applications** - for Retail and Telecommunication Industry, Recommender Systems.	6
	Total	**42**

References:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	Data Mining - Concepts and Techniques. Jiawei Han, Micheline Kamber, and Jian Pei. 3rd Edition. 2011. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA.	2011
2.	Introduction to Data Mining. Pang-Ning Tan, Michael Steinbach, and S Vipin Kumar. 1st Edition. 2005. Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA.	2005
3.	Forecasting: principles and practice. Rob J Hyndman and George Athanasopoulos. 1st Edition. 2014. OTexts.com.	2014

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PRACTICALS LIST	
S. No.	**List of Experiments**
1	For a Given dataset apply following data pre-processing tasks: a. Data Cleaning b. Data Integration and Transformation c. Data Reduction Techniques d. Data Discretization
2	Write a program to implement Convolutional Neural Networks for a given dataset
3	Write a program to implement Apriori algorithm for association and find appropriate rules for a given dataset.
4	Write a program to implement FP-Growth algorithm for a given dataset.
5	Write a program to implement ARIMA Model for a given Time series dataset.
6	Write a program to implement C4.5 algorithm for a given dataset.
7	Write a program to implement Agglomerative clustering algorithm for a given dataset.
8	Write a program to implement DBSCAN Clustering algorithm for a given dataset.
9	Write a program to implement Statistical Information Grid Clustering algorithm for a given dataset
10	Prepare a report to analyze above implemented algorithms for given set of datasets.

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 210: Optimization Techniques	**L**	**T**	**P**	Real Analysis, Linear Algebra
	3	**1**	**0**	

Course Objective: To study the optima determination algorithms, linear and nonlinear problem along with its dual formulation concepts. Application to the real-world problems.

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

CO1	Define and use optimization concepts to model real-world applications as an optimization problem.
CO2	Apply optimization methods to engineering problems, including developing a model, defining an optimization problem, applying optimization methods, exploring the solution, and interpreting results.
CO3	Formulate continuous problems into unconstrained and constrained optimization problems on the basis of the conditions provided .
CO4	Identify computing derivatives methods for direct and adjoint cases.
CO5	Identify the optimization techniques to determine a robust design for a given real world problem and justify the technique for solving it.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	3	2
CO2	3	3	3	2	2
CO3	3	3	2	3	2
CO4	3	3	2	3	2
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.	**Linear programming problem overview:** Simplex algorithm of linear programs (LP) and its complexity issues, Karmarkar interior point method for solving LP, P and NP hard problems.	**7**
2.	**Optimality Conditions and Duality in Nonlinear Programming:** Convex functions and their properties, Convex optimization problems, Lagrangian and Lagrange multipliers, Karush Kuhn Tucker necessary/sufficient optimality conditions, Duality in nonlinear programming, Wolf dual and Lagrange dual.	**7**
3.	**Some Generalized Convex Functions and Fractional Programming:** Quasiconvex and Quasiconcave functions, Pseudoconvex and Pseudoconcave functions, Linear fractional programming problem and solution, methods.	**7**
4.	**Unconstrained optimization problems**: steepest descent method, Newton method, conjugate direction and conjugate gradient method.	7
5.	**Algorithm in Nonlinear Programming:** Quadratic programming problems, Wolf method for quadratic programming, Franck and Wolf's method, Penalty function method, barrier function method, Multistage decision problems.	7
6.	**Evolutionary Algorithms:** Genetic algorithm, Ant colony optimization, Particle swarm optimization (PSO).	7
	Total	**42**

References:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	M.S. Bazaraa, H.D.Sherali, & C.M. Shetty: Nonlinear Programming Theory & Algorithms, John Willey & Sons.	2006
2.	Suresh Chandra, Jayadeva, Aparna Mehra: Numerical optimization with applications, Narosa Publications.	2009
3.	Singiresu S. Rao, Engineering Optimization: Theory and Practice, John Wiley &Sons.	2009
4.	N.S. Kambo, Mathematical Programming Techniques: East-West Press Pvt. Ltd.	2008
5.	Chander Mohan, Kusum Deep: Optimkization Techniques, New age international publications.	2017
6.	Kalyanmoy Deb: Multi-Objective Optimization using Evolutionary Algorithms, Wiley.	2010

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 212:	**L**	**T**	**P**	NIL
Approximation Theory	**3**	**1**	**0**	

Course Objective: To impart knowledge of approximation of functions

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

CO1	Describe the concepts and properties of algebraic and trigonometric polynomials and Bernstein polynomials.
CO2	Construct various linear positive operators and analyze their approximation properties using different tools.
CO3	Analyze conditions for convergence of linear positive operators and find order of approximation of functions.
CO4	Describe error estimates with Jackson's, Dini-Lipschitz and Stone Weierstrass theorem.
CO5	Demonstrate the understanding of K-functional and its relationship with modulus of smoothness.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	3	3	2	1
CO2	3	3	3	2	1
CO3	2	3	3	2	1
CO4	3	3	2	2	2
CO5	3	2	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.N.	Contents	Contact Hours
1.	Polynomials, algebraic and trignometric polynomials, Bernstein polynomials in real domain, O-o term, monotone functions, convex functions, functions of bounded variations, L_p-spaces and their properties, generalizations of Bernstein polynomials	8
2.	Linear positive operators and functionals, Korovkin's theorem, moments of some linear positive operators eg. Bernstein, Szasz, Baskakov, Post-Widder and their variants, recurrence relations for moments, moment generating functions (mgf), approximation of functions by means of algebraic and trignometric polynomials, Weierstrass first and second approximation theorems	12
3.	Conditions for convergence of a sequence of linear positive operators, Korovkin's theorem, theorems on monotone operators, order of approximation of functions by means of polynomials, modulus of continuity and their properties, Lipschitz condition	8
4.	Jackson's theorems, Dini Lipschitz theorem, Stone-Weierstrass theorem	7
5.	The K-functional and modulus of continuity, equivalence theorem, modified K-functional	7
	Total	**42**

References:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
1.	I. P. Natanson, Constructive Function Theory, Vol. 1, Frederick Ungar Pub. Co., New York.	1964
2.	R. A. DeVore & G. G. Lorentz, Constructive Approximation, Springer, Berlin.	1993
3	V. Gupta & M. T. Rassias, Moments of Linear Positive Operators and Approximation, Series:Springer Briefs in Mathematics, Springer Nature Switzerland AG.	2019
4.	Z. Ditzian & V. Totik, Moduli of Smoothness, Springer, Berlin	1987
5.	V. Gupta & R. P. Agarwal, Convergence Estimates in Approximation Theory, Springer, New York	2014

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 214: General Relativity and Cosmology	**L**	**T**	**P**	Elementary knowledge of differential equations, Newtonian Mechanics, Special theory of relativity
	2	**0**	**0**	

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

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

CO1	Get introduced to the concept of contravariant and covariant tensors, mixed tensor, inner and outer products, transformation law and Christoffel symbols.
CO2	Use efficiently the mathematical tools of tensor calculus in study of geodesics, covariant differentiation, Eistein tensor, spacetime geometry.
CO3	Generate capacity to study special and General theory of relativity, Einstein' gravitation law and field equations.
CO4	Describe importance of Schwarzchild solution and Birkhoff solution.
CO5	Identify the concept of cosmology and study the behavior of the Universe of past, present and future.

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
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.	6
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
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
4.	**General Relativity II:** Metrics with spherical symmetry, Schwarzschild's exterior solution, Schwarzschild solution in isotropic form, Birkhoff solution, Crucial tests in relativity.	7
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, particle and event horizons, geometry of universe.	10
	Total	**42**

References:

S. No.	Name of Books/Authors/Publishers	Year of Publication/ Reprint
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, Pearson Publication	2007
6.	Schaum's outline series of Tensor Calculus – David C. Kay, McGraw Hills	2011

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 216: Finite Element Method	**L**	**T**	**P**	Basic knowledge of ODE and PDE
	3	**1**	**0**	

Course Objective: To introduce fundamental concepts, the essential theoretical background, and the technical tools required to solve partial differential equations arise in the modelling of real-life phenomena.

Course Outcomes (CO):

CO1	Apply logical/mathematical thinking: the analytic process that involves Variational Formulations
CO2	Implement numerical methods (Variational methods) to solve mechanics of solids problems.
CO3	Implement the formulation techniques to solve 2-D problems using triangle and quadrilateral elements.
CO4	Formulate and solve two point boundary value problems, initial value problems in one dimension.
CO5	Solve complex problems by applying the knowledge acquired to areas that are different to the original ones.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	2	2	3	2	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	2	3	3	3	3
CO5	3	3	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.	Elements of function spaces: spaces of continuous functions, spaces of integrable functions, Sobolev spaces. Elliptic boundary value problems: existence, uniqueness and regularity of weak solutions.	6
2.	Finite element methods: piecewise linear basis functions, the self-adjoint elliptic problem, calculation and assembly of stiffness matrix, Galerkin orthogonality and Cea's lemma, optimal error bound in the energy norm, The Aubin-Nitsche duality argument, super approximation in mesh dependent norms.	12
3.	Piecewise polynomial approximation: construction of finite element spaces, polynomial approximation in Sobolev spaces - The Bramble-Hilbert lemma, optimal error bounds in the energy norm, variational crimes. A posteriori error analysis by duality: reliability, efficiency and adaptivity.	12
4.	Finite element approximation of initial boundary value problems. Energy dissipation, conservation and stability. Analysis of finite element methods for evolution problems.	12
	Total	**42**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication/ Reprint
1	S. C. Brenner and R. L. Scott, The Mathematical Theory of Finite Element Methods, Springer-Verlag, 2ndEd.	2002
2	C. Johnson, Numerical solutions of Partial Differential Equations by Finite Element Methods, Volume 04 Issue 04, Cambridge University Press, 1987.	1987
3	P.G. Ciarlet, The Finite Element Methods for Elliptic Problems, North Holland, Volume 04, 1st ed., 1978.	1978
4	M. Ainsworth and J. T. Oden, A Posteriori Error Estimation in Finite Element Analysis, John Wiley and Sons, 2000.	2000
5	V. Thomee, Galerkin Finite Element Methods for Parabolic Problems, Springer-Verlag, 2nd ed., 2006.	2006

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 218: Machine Learning	**L**	**T**	**P**	MSMA 107 - Discrete Mathematics, MSMA 108 - Linear Algebra, MSMS 109 - Mathematical Statistics
	3	**0**	**2**	

Course Objective: To give an overview of many concepts, techniques, and algorithms in machine learning. The course will give the student the intuition behind machine learning methods along with formal understanding of how, why, and when they work. The underlying theme in the course is statistical inference as it provides the foundation for most of the methods covered.

Course Outcomes (CO):

CO1	Demonstrate an appreciation for what is involved in Learning models from data.
CO2	Describe a wide variety of learning algorithms including Supervised Learning, Unsupervised Learning, Reinforcement Learning.
CO3	Evaluate models generated from data using various quantitative and qualitative methods.
CO4	Apply different learning algorithms to a real problem
CO5	Present the expected accuracy that can be achieved by applying the models.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	1	2	3	1
CO2	3	3	3	2	2
CO3	3	2	2	3	2
CO4	3	3	1	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
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.	4
2.	**Supervised Learning:** K-Nearest Neighbors, Bayesian Classification, Naïve Bayes, Linear Discriminant Analysis, Linear Regression, Logistic Regression, Multilayer Perceptron, Support Vector Machine, Decision Trees.	16
3.	**Algorithm Independent Machine Learning:** No Free Lunch Theorem, Minimum Description Length Principle, Overfitting Avoidance and Occam's Razor, Bias and Variance. **Estimating and Comparing Classifiers:** Cross Validation, Maximum Likelihood Model Comparison, Bayesian Model Comparison. **Ensemble Methods:** Ada Boost, Random Forest Classifier.	8
4.	**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.	9
5.	**Reinforcement Learning:** Markov Decision Processes (MDP), Bellman's Equations, Value Iteration and Policy Iteration, Value Function Approximation, Q-Learning. **Deep Learning Models**.	5
	Total	**42**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	Pattern Classification. Richard Duda, Peter Hart, and David Stork. 2nd edition. 2000. Wiley-Interscience, New York, NY, USA.	2000
2	Machine Learning. Tom M. Mitchell, 1st Edition. 1997. McGraw-Hill International.	1997
3	Pattern Recognition and Machine Learning. Christopher M. Bishop. 1st Edition. 2006. Springer.	2006
4	Introduction to Machine Learning. E Alpaydin. 1st Edition. 2004. The MIT Press.	2004
5	Machine Learning: A Probabilistic Perspective. Kevin P. Murphy. 1st Edition. 2012. The MIT Press	2012
6	Deep Learning. Ian Goodfellow, Yoshua Bengio, and Aaron Courville. 1st Edition. 2016. The MIT Press.	2016

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PRACTICALS LIST	
S. No.	**List of Experiments**
1	Write a program to implement K-Nearest Neighbor classifier and find its accuracy on a given dataset.
2	Write a program to implement Naive Bayes classifier and find its accuracy on a given dataset.
3	Write a program to implement Linear Discriminant Analysis for a given dataset.
4	Write a program to implement Linear Regression and find its accuracy on a given dataset.
5	Write a program to implement Logistic Regression and find its accuracy on a given dataset.
6	Write a program to implement Multilayer Perceptron and find its accuracy on a given dataset.
7	Write a program to implement Support Vector Machine and find its accuracy on a given dataset.
8	Write a program to evaluate and compare above implemented algorithms for a set of given datasets using Cross Validation.
9	Write a program to implement K-Means Clustering and find its accuracy on a given dataset
10	Write a program to implement Expectation Maximization and find its accuracy on a given dataset.
11	Write a program to implement Principal Component Analysis and find its accuracy on a given dataset.

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 220: Advanced Partial Differential Equations	**L**	**T**	**P**	Basic knowledge of ODE and PDE.
	3	**1**	**0**	

Course Objective: To introduce PDE 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≥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
1.	Partial Differential Equations: Well-posed problems, classical solutions, weak solutions and regularity. Representation formula for solutions: Transport equation – initial value problem, nonhomogeneous problem. 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.	11
2.	Heat equation: 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
3.	Wave equation: 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
4.	Nonlinear First-order PDE: 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	**42**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1	L. C. Evans: Partial Differential equations, Graduate Studies in Mathematics Vol 19, 2nd ed , American Mathematical Society, 2010.	2010
2	F. John, Partial Differential Equations, 4th ed., Springer-Verlag, 1991.	1991
3	W. A. Strauss, Partial Differential equations. An Introduction, 2nd ed., Wiley-Interscience, 2008.	2008
4	E. DiBenedetto, Partial Differential Equations, 2nd ed, Birkhäuser, 2009.	2009
5	M. Renardy and R. Rogers, An Introduction to Partial Differential Equations, 2nd ed, Springer, 2004.	2004

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 222: Univalent Function Theory	**L**	**T**	**P**	NIL
	3	**1**	**0**	

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

Course Outcomes (CO):

CO1	Understand and explain the Riemann Mapping Theorem and fundamental concepts of univalent functions, including definitions, examples, and the Area Theorem.
CO2	Analyze and interpret the implications of Bieberbach's conjecture, especially in the context of bounded univalent functions, using key results such as the Koebe One-Quarter Theorem, Distortion Theorem, Growth Theorem, and Hayman's Regularity Theorem.
CO3	Apply and evaluate the theory of Carathéodory functions, subordination, the Lindelöf Principle, and the Herglotz Representation Formula to derive properties of convex and starlike functions.
CO4	Analyze and classify functions such as α-convex, α-spiral, typically real, and those with positive real part, using related theorems by Rogosinski and others.
CO5	Create and justify conditions for functions to be close-to-convex, spirallike, and odd univalent, utilizing tools like the Carathéodory Convergence Theorem and Grunsky Inequalities.

CO-PO Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5
CO1	3	3	1	0	0
CO2	3	3	1	0	0
CO3	3	3	0	0	0
CO4	3	3	0	0	0
CO5	3	3	0	0	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.	Riemann mapping theorem, introduction to univalent functions – definitions, examples, elementary properties, area theorem and its consequences.	6
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
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
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.	8
5.	Close-to-Convex functions, spirallike functions, odd univalent functions, Caratheodory convergence theorem, Grunsky inequalities	8
	Total	**42**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication/ Reprint
1.	P. L. Duren, Univalent Functions, Springer, New York	1983
2.	Ch. Pommerenke, Univalent Functions, Van den Hoek & Ruprecht, Gottingen	1975
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.	D. J. Hallenbeck & T. H. MacGregor, Linear Problems and Convexity Techniques in Geometric Function Theory, Pitman Adv. Publ. Program, Boston-London Melbourne	1984
6.	I. Graham & G. Kohr, Geometric Function Theory in One and Higher Dimensions, Marcel Dekker, New York	2003

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Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MSMA 224: Fuzzy Sets and Applications	**L**	**T**	**P**	Classical Set Theory and Discrete Mathematics
	3	**1**	**0**	

Course Objective: To enable mathematical quantification knowledge, expertise and intuition to model complex system, to deal with vague, imprecise and uncertain problem taking processes.

Course Outcomes (CO):

CO1	Classify "vagueness" and "uncertainty" in the systematic approach.
CO2	Analyse different applications based on a fuzzy model, representing vague knowledge and describe the impact on popular dynamical systems.
CO3	Appraise decision making in an interdisciplinary real-world problem within an uncertain environment.
CO4	Apply relevant software packages to formulate, solve and analyze problems for higher study and research.
CO5	Design fuzzy-logic based controllers and list their unique characteristics and Apply 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	3	2	2	1
CO2	3	3	2	3	2
CO3	3	2	1	3	3
CO4	2	3	2	3	2
CO5	3	3	3	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
1.	**Fuzzy Sets and Uncertainty:** Certainty versus uncertainty, fuzzy sets and membership functions, properties of fuzzy sets, Operations on fuzzy set: Union, Intersection, Algebraic Sum, Bounded Sum and bounded difference, algebraic product, convex combination, extension principle, t-norm and t-Conorm operation. Operations on intervals, Fuzzy numbers and operations. Fuzzy Equations.	8
2.	**Fuzzy Relations:** Fuzzy Relation on Crisp Set, Fuzzy relation on fuzzy set, composition of fuzzy relations: max-min, max-product, max-average. Fuzzy equivalence relations, Fuzzy Antisymmetric relation, Similarity relation, Fuzzy ordering relation and fuzzy compatibility relation, Fuzzy Morphism, Fuzzy Relation Equation.	8
3	**Fuzzy Logic and Fuzzification and Defuzzification::** Introduction of fuzzy logic, Fuzzy Propositions, Fuzzy Inference from Conditional fuzzy propositions, Fuzzy Implications, approximate reasoning, Construction of fuzzy set : Method of construction of membership functions: direct and Indirect methods with single expert, Direct and indirect methods with multiple expert , defuzzification: Mean of Maximum (MOM) method, Centre of area (COA) method, The height method, Centre of maxima method.	8
4.	**Fuzzy Rule Based Models and Fuzzy Systems**: Fuzzy rule-based inference, The Mamdani Model, The TSK Model, Standard additive model, Fuzzy expert systems and fuzzy controller.	7
5.	**Fuzzy Decision Making:** Fuzzy LPP, Fuzzy MCDM, Fuzzy clustering	6
6.	**Generalized Fuzzy Sets:** I- fuzzy sets, Linguistic fuzzy sets, Interval fuzzy sets, Hesitant fuzzy set.	5
	Total	**42**

References:

S. No.	Name of Book/Authors/Publishers	Year of Publication
1.	Ross, T. J., "Fuzzy Logic with Engineering Applications", Wiley India Pvt. Ltd., 3rd Ed.	2011
2.	Zimmerman, H. J., "Fuzzy Set theory and its application", Springer India Pvt. Ltd., 4th Ed.	2006
3.	Chander Mohan, "An Introduction to Fuzzy Set Theory and Fuzzy Logics", M V Learning	2015
4.	Klir, G. and Yuan, B., "Fuzzy Set and Fuzzy Logic: Theory and Applications", Prentice Hall of India Pvt. Ltd.	2002
5.	Klir, G. and Folger, T., "Fuzzy Sets, Uncertainty and Information", Prentice Hall of India Pvt. Ltd.	2002