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

B.Tech Mathematics and Computing

I Year: First Semester

Teaching Scheme					Contact Hours/Week			Exam Duration (h)		Relative Weights (%)				
S. No.	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	AM101	Mathematics-I	BSC	4	3	1	0	3	0	25	-	25	50	-
2	AP101	Physics	BSC	4	3	0	2	3	0	15	25	20	40	-
3	EC101	Basic Electronics & Communication Engineering	ESC	4	3	0	2	3	0	15	25	20	40	-
4	ME105	Computer Aided Engineering Graphics-II	ESC	4	3	0	2	3	0	15	25	20	40	-
5	MC103	Python Programming	SEC	2	0	0	4	0	3	-	50	-	-	50
6	AEC/VAC	AEC/VAC	AEC/VAC	2	2/1/0	0	0/2/4	3/3/0	0/2/3	25/15/0	0/25/50	25/20/0	50/40/0	0/0/50
Total				**20**										
I Year: Second Semester														
1	AM102	Mathematics-II	BSC	4	3	1	0	3	0	25	-	25	50	-
2	CO102	Programming Fundamentals	ESC	4	3	0	2	3	0	15	25	20	40	-
3	MC102	Discrete Mathematics	ESC	4	3	1	0	3	0	25	-	25	50	-
4	MC104	Complex Analysis	DCC	4	3	1	0	3	0	25	-	25	50	-
5	MC106	MATLAB Programming	SEC	2	0	0	4	0	3	0	50	-	-	50
6	AEC/VAC	AEC/VAC	AEC/VAC	2	2/1/0	0	0/2/4	3/3/0	0/2/3	25/15/0	0/25/50	25/20/0	50/40/0	0/0/50
Total				**20**										

Additional 02 credits are to be earned from mandatory community engagement course in first year to fulfil the requirement of award of the four year B.Tech Degree.

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II Year: Third Semester

Teaching Scheme					Contact Hours/Week			Exam Duration (h)		Relative Weights (%)				
S. No.	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	MC201	Data Structure	ESC	4	3	0	2	3	0	15	25	20	40	-
2	MC203	Real Analysis	DCC	4	3	1	0	3	0	25	0	25	50	-
3	MC205	Probability and Statistics	DCC	4	3	0	2	3	0	15	25	20	40	-
4	MC207	Modern Algebra	DCC	4	3	1	0	3	0	25	0	25	50	-
5	MC209	Database Management Systems	DCC	4	3	0	2	3	0	15	25	20	40	-
6	AEC/VAC	AEC/VAC	AEC/VAC	2	2/1/0	0	0/2/4	3/3/0	0/2/3	25/15/0	0/25/50	25/20/0	50/40/0	0/0/50
7	MS299	Community Engagement Course	Mandatory	2										
Total				**24**										
II Year: Fourth Semester														
1	MC202	Operating Systems	ESC	4	3	0	2	3	0	15	25	20	40	-
2	MC204	Scientific Computing	DCC	4	3	0	2	3	0	15	25	20	40	-
3	MC206	Analysis and Design of Algorithms	DCC	4	3	1	0	3	0	25	-	25	50	-
4	MC208	Linear Algebra	DCC	4	3	1	0	3	0	25	-	25	50	-
5	MC210	Differential Equations	DCC	4	3	0	2	3	0	15	25	20	40	-
6	AEC/VAC	AEC/VAC	AEC/VAC	2	2/1/0	0	0/2/4	3/3/0	0/2/3	25/15/0	0/25/50	25/20/0	50/40/0	0/0/50
Total				**22**										

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III Year: Fifth Semester

Teaching Scheme					Contact Hours/Week			Exam Duration (h)		Relative Weights (%)				
S. No.	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	MC301	Theory of Computation	DCC	4	3	1	0	3	0	25	-	25	50	-
2	MC303	Stochastic Processes	DCC	4	3	1	0	3	0	25	-	25	50	-
3	MC305	Computer Networks	DCC	4	3	1	0	3	0	25	-	25	50	-
4	MGMT	Engineering Economics / Fundamentals of Management	SEC	3	3	1	0	3	0	25	-	25	50	-
5	MC3XX	Departmental Elective Course -1	DEC	4	3/3	0/1	2/0	3	0	15/25	25/0	20/25	40/50	-
6	GEC	General Elective Course -1	GEC	4	3/3	0/1	2/0	3	0	15/25	25/0	20/25	40/50	-
Total				**23**										
III Year: Sixth Semester														
1	MC302	Mathematical Modelling and Simulation	DCC	4	3	0	2	3	0	15	25	20	40	-
2	MC304	Financial Engineering	DCC	4	3	1	0	3	0	25	-	25	50	-
3	MGMT	Fundamentals of Management / Engineering Economics	SEC	3	3	1	0	3	0	25	-	25	50	-
4	MC3XX	Departmental Elective Course -2	DEC	4	3/3	0/1	2/0	3	0	15/25	25/0	20/25	40/50	-
5	MC3XX	Departmental Elective Course -3	DEC	4	3/3	0/1	2/0	3	0	15/25	25/0	20/25	40/50	-
6	GEC	General Elective Course -2	GEC	4	3/3	0/1	2/0	3	0	15/25	25/0	20/25	40/50	-
Total				**23**										

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IV Year: Seventh Semester

Teaching Scheme					Contact Hours/Week			Exam Duration (h)		Relative Weights (%)				
S. No.	**Subject Code**	**Course Title**	**Subject Area**	**Credit**	**L**	**T**	**P**	**Theory**	**Practical**	**CWS**	**PRS**	**MTE**	**ETE**	**PRE**
1	MC401	B. Tech Project-I	DCC	4	-	-	-	-	-	-	40	-	-	60
2	MC403	Internship	DCC	2	-	-	-	-	-	-	40	-	-	60
3	MC4XX	Departmental Elective Course -4	DEC	4	3/3	0/1	2/0	3	0	15/25	25/0	20/25	40/50	-
4	MC4XX	Departmental Elective Course -5	DEC	4	3/3	0/1	2/0	3	0	15/25	25/0	20/25	40/50	-
5	GEC	General Elective Course -3	GEC	4	3/3	0/1	2/0	3	0	15/25	25/0	20/25	40/50	-
6	AEC/VAC	Indian Knowledge System	VAC	Non Credit										
Total				**18**										

IV Year: Eight Semester

1	MC402	B. Tech Project-II	DCC	8	-	-	-	-	-	-	40	-	-	60
2	MC4XX	Departmental Elective Course -6	DEC	4	3/3	0/1	2/0	3	0	15/25	25/0	20/25	40/50	-
3	GEC	General Elective Course -4	GEC	4	3/3	0/1	2/0	3	0	15/25	25/0	20/25	40/50	-
Total				**16**										

Cumulative Total	**166**	

B. Tech. Mathematics and Computing

Departmental Elective Course

Departmental Elective Course -1 (Semester - 5)	
MC307	Artificial Intelligence
MC309	Number Theory
MC311	Numerical Linear Algebra
MC313	Operations Research
MC315	Partial Differential Equations
Departmental Elective Course -2 & 3 (Semester - 6)	
MC306	Object Oriented Programming
MC308	Computer Graphics
MC310	Machine Learning
MC312	Wireless and Mobile Computing
MC314	Quantum Information Theory
MC316	Computer Organization and Architecture
MC318	Software Engineering
MC320	Web Technology
MC322	Graph Theory
MC324	Fuzzy set and Fuzzy logic

Departmental Elective Course -4 & 5 (Semester - 7)	
MC405	Optimization Techniques
MC407	Numerical methods for ODE
MC409	Tensor Calculus
MC411	Statistical Inference
MC413	Big Data Analytics
MC415	Data Warehousing and Data Mining
MC417	Cryptography and Network Security
MC419	Differential Geometry
MC421	Topology
MC423	Functional Analysis
MC425	Compiler Design
Departmental Elective Course -6 (Semester - 8)	
MC404	Numerical Methods for PDE
MC406	Finite Element Methods
MC408	Statistical Quality Control and Decision Making
MC410	Game Theory
MC412	Information Theory and Coding
MC414	Natural Language Processing

Offered by Department of Applied Mathematics

Minor in Mathematics & Computing (For students of other Disciplines)			
S. No.	**Course Code**	**Course Title**	**Course Type**
1	MC208	Linear Algebra	Compulsory
2	MC210	Differential Equation	Compulsory
3	MC205	Probability and Statistics	Compulsory
4	MC302	Mathematical Modelling and Simulation	Elective
5	MC307	Artificial Intelligence	Elective
6	MC311	Numerical Linear Algebra	Elective
7	MC313	Operations Research	Elective
8	MC322	Graph Theory	Elective
9	MC417	Cryptography and Network Security	Elective
10	MC324	Fuzzy set and Fuzzy logic	Elective
Minor in Industrial Mathematics			
S. No.	**Course Code**	**Course Title**	**Course Type**
1	MC205	Probability and Statistics	Compulsory
2	MC303	Stochastic Processes	Compulsory
3	MC304	Financial Engineering	Compulsory
4	MC302	Mathematical Modelling and Simulation	Elective
5	MC313	Operations Research	Elective
6	MC322	Graph Theory	Elective
7	MC324	Fuzzy set and Fuzzy logic	Elective
8	MC408	Statistical Quality Control and Decision Making	Elective
9	MC410	Game Theory	Elective
10	MC411	Statistical Inference	Elective
11	MC405	Optimization Techniques	Elective
12	MC310	Machine Learning	Elective
Minor in Computational Intelligence			
S. No	**Course Code**	**Course Title**	**Course Type**
1	MC205	Probability and Statistics	Compulsory
2	MC206	Analysis and Design of Algorithms	Compulsory
3	MC303	Stochastic Processes	Compulsory
4	MC302	Mathematical Modelling and Simulation	Elective
5	MC307	Artificial Intelligence	Elective
6	MC413	Big Data Analytics	Elective
7	MC408	Statistical Quality Control and Decision Making	Elective
8	MC415	Data Warehousing and Data Mining	Elective
9	MC411	Statistical Inference	Elective
10	MC310	Machine Learning	Elective
11	MC406	Finite Element Methods	Elective

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I Year

Details of Course:

Course Title	Course Structure			Pre-Requisite
AM101: Mathematics-I	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To acquaint the students with the knowledge of series & sequence, single & multiple variable calculus, knowledge of vector calculus and their applications.

Course Outcome (CO):

CO1	Analyse an infinite series of positive terms for convergence or divergence, and distinguish between absolute and conditional convergence.
CO2	Apply differential calculus to obtain Maclaurin's and Taylor's expansions, find the radius of curvature, sketch some standard curves, and calculate arc length and surface area using definite integrals.
CO3	Explain the various concepts of calculus and the properties of functions of several variables, find the maxima-minima, and estimate the error.
CO4	Explain the concept of multiple integrals, and apply multiple integration techniques for solving problems related to area and volume.
CO5	Interpret various concepts of differential and integral calculus of vector point functions and apply them to evaluate work done by a force or in other applications, and understand the concepts underlying Green's, Stoke's, and Gauss divergence theorems.

S. No.	Contents	Contact hours
UNIT 1	Infinite series: Tests for convergence of positive term series (Comparison, Ratio, nth Root, integral, Raabe's, Logarithmic), Alternating series, Absolute convergence, Conditional convergence.	**8**
UNIT 2	Differential & Integral Calculus of single variable: Maclaurin's and Taylor's Expansions, Radius of curvature, Tracing of some standard curves, Applications of definite integral to arc length and surface area of revolution (Cartesian and polar coordinates).	**8**
UNIT 3	Calculus of several variables: Partial differentiation, Euler's theorem, Total derivative, Taylor's Expansion, Maxima-Minima, Lagrange's method of multipliers, Applications in estimation of error and approximation.	**8**
UNIT 4	Multiple Integrals: Double integral (Cartesian and polar co-ordinates), change of order of integration, triple integrals (Cartesian, cylindrical and spherical co-ordinates), Applications to area and volume.	**9**
UNIT 5	Vector Calculus: Scalar and vector point functions, gradient, directional derivative, divergence, curl and their interpretations. Line integral, surface integral and volume integral, Applications to work done by the force, Green's, Stoke's and Gauss divergence theorems.	**9**
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1.	Kreyszig; Advanced Engineering Mathematics, Wiley-India, 10th Edition ISBN-978-1-119-45592-9	2020
2.	Jain and lyenger; Advanced Engineering Mathematics, Narosa, 5th Edition ISBN-978-81-8487-560-7	2019
3.	Alan Jeffery; Advanced Engineering Mathematics, Academic Press ISBN- 978-93-80501-50-5	2010
4.	Thomas and Finney; Calculus and Analytic Geometry, Narosa, ISBN-978-81-85015-52-1	2013
5.	Dennis G. Zill; Advanced Engineering Mathematics, Jones and Bartee Publications, 6th Edition ISBN-978-12844105902.	2016

Details of Course:

Course Title	Course Structure			Pre-Requisite
AM102: Mathematics-II	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To impart knowledge of matrices, Differential equations, Laplace transform, Fourier series & their applications.

Course Outcome (CO):

CO1	Solve the system of linear equations, interpret the eigenvalues and eigenvectors of a matrix.
CO2	Explain the concept of differential equations and evaluate various methods to solve ordinary differential equations.
CO3	Find the series solutions of differential equations using Power series and Frobenius methods.
CO4	Implement the integral transformation using the concept of Laplace transformation and apply it to solve differential equations.
CO5	Find Fourier series of a periodic function and apply it in harmonic analysis.

S. No.	Contents	Contact hours
UNIT 1	Matrices: Rank of a matrix, inverse of a matrix using elementary row transformations, solutions of system of linear equations, eigen values and eigen vectors of a matrix**.**	**8**
UNIT 2	Ordinary differential equations: Second and higher order linear differential equations with constant coefficients, General solution of homogenous and non-homogenous equations, method of variation of parameters, simultaneous linear differential equations.	**9**
UNIT 3	Special Functions: Power series method, Frobenious method, Legendre equation, Legendre Polynomials, Rodrigues formula, Bessel equation, Bessel function of first kind and their Orthogonal properties.	**9**
UNIT 4	Laplace Transforms: Basic properties, Laplace transform of derivatives and integrals, Inverse Laplace transform, Differentiation and Integration of Laplace transform, Convolution theorem, Unit step function, periodic function. Applications of Laplace transform to initial and boundary value problems.	**8**
UNIT 5	Fourier series: Fourier series (2π period and of arbitrary period), Fourier series of Even and odd functions, half range Fourier series, Harmonic analysis.	**8**
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1.	Kreyszig; Advanced Engineering Mathematics, Wiley-India, 10th Edition ISBN-978-1-119-45592-9	2020
2.	Jain and Iyenger; Advanced Engineering Mathematics, Narosa, 5th Edition ISBN-978-81-8487-560-7	2019
3.	Alan Jeffery; Advanced Engineering Mathematics, Academic Press ISBN- 978-93-80501-50-5	2010
4.	Peter V. O'Neil; Advanced Engineering Mathematics, Cengage Learning. ISBN-978-81-315-0310-2	2007
5.	Dennis G. Zill; Advanced Engineering Mathematics, Jones and Bartee Publications, 6th Edition ISBN-978-12844105902.	2016

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC102:	**L**	**T**	**P**	NIL
Discrete Mathematics	**3**	**1**	**0**	

Course Objective: To provide knowledge of combinatorial problem, algebraic structure, logic and graph theory required for building mathematical foundation**.**

Course Outcome (CO):

CO1	Describe concepts of set theory, relations, functions, and discrete structures to solve various problems.
CO2	Apply logical equivalences to simplify and manipulate logical expressions, and apply rules of inference to derive conclusions from premises in both propositional and predicate logic.
CO3	Apply the concepts of counting principles and combinatorics to solve problems, identify various algebraic structures and describe their properties.
CO4	Describe lattices and explain the structure of Boolean algebra to construct and simplify Boolean expressions.
CO5	Illustrate, formulate and solve the problems based on the concepts of graphs and trees.

S. No.	Contents	Contact hours
UNIT 1	Basic concepts of set theory, operations on sets, Cartesian products, relations, equivalence relation, equivalence classes, operations on relations, partial order relation, Hasse diagram, functions, recursive functions.	**8**
UNIT 2	Proposition, compound propositions, well-formed formulae, truth tables, tautology, contradiction, equivalence, algebra of proposition, normal forms, theory of inference, predicate logic: predicates, quantifiers, free and bound variables, theory of inference for predicates.	**8**
UNIT 3	Permutations, combinations, Discrete Numeric Function, Generating Function, recurrence relations, Principles of Inclusion and Exclusion, Dearrangement, Pigeon Whole Principle. Definition and properties of semigroups, monoids and groups, homomorphism, Rings and their homomorphism.	**10**
UNIT 4	Definition of lattice, properties of lattices, bounded, complemented, distributive and complete lattice, Introduction, axioms and theorems of Boolean algebra, algebraic manipulation of Boolean expressions.	**8**
UNIT 5	Graphs, digraphs, adjacency matrix, incidence matrix, connectivity, subgraphs, trees, spanning tree, complete graphs, walk, path, cycle. Isomorphism of Graph.	**8**
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1.	J. P. Tremblay and R. Manohar, Discrete Mathematical Structures with Applications to Computer Science, Tata McGraw-Hill	1997
2.	C. L. Liu, D. P. Mohapatra, Elements of Discrete Mathematics, 4th Edition, Tata McGraw-Hill	2017
3.	Kenneth H. Rosen, Discrete Mathematics and its Applications, Tata McGraw-Hill	2001
4.	A. M. Raigorodskii, M. T. Rassias, Discrete Mathematics and Applications, 1st Edition, Springer	2020

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC 103:	**L**	**T**	**P**	Basic computer knowledge
Python Programming	**0**	**0**	**4**	

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

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.

S.No.	Contents	Contact hours
UNIT 1	**Introduction to Python:** Arithmetic Operators, Variables, Expressions and Statements in Python, Function Calls, Parameters and Arguments, Infinite Recursion and Stack Diagrams, Logical Operators, Conditional and Alternative Execution, Iterations in Python.	**6**
UNIT 2	**Strings and Dictionaries in Python**: Immutable Strings, String Methods and Comparison, Mutable Lists, List Operations and Methods, Concept of Dictionary and Looping, Reverse Lookup, Immutable Tuples, Tuples as Return Values, Concepts of Namespaces and scope.	**6**
UNIT 3	**Error handling and Files in Python:** Error handling using try and except, Create your own exceptions, Filenames and Paths, Persistence, Reading and Writing, Catching Exceptions, Attributes. **Object Oriented Concepts in Python:** Introduction to Classes and Methods, Mutable Objects, Classes and Functions, Pure Functions, Modifiers, Inheritance	**9**
	TOTAL	**21**

Suggested Books:

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

PRACTICALS LIST	
1	Write a program to determine whether the given three coordinates ((x1, x2), (y1, y2) and (z1, z2)) are collinear or not.
2	Given any number say N, write a program to print the prime numbers between 1 to N.
3	Write a program to print Fibonacci series using a for loop.
4	Write a program to declare variables of string data type and perform different operations on them.
5	Write a program to create, insert and delete Lists.
6	Write a program to create, insert and delete Dictionaries.
7	Write a program to create, insert and delete Sets and Tuples.
8	Create a function search_list that takes a list of values as arguments and searches for a particular number in the list.
9	Write a program to implement the Rock Paper Scissors game.
10	Write a program for the division of two numbers where the denominator is 0. This will throw an exception and handle the exception using try and except.
11	Write a program that can create your own exceptions.

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC104: Complex Analysis	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To acquaint the students with the knowledge of complex variables, contour integration, conformal mappings.

Course Outcome (CO):

CO1	Describe complex numbers, variables, and functions and their various representations.
CO2	Analyse analytic functions, solve problems using Cauchy-Riemann equations and construct analytic functions.
CO3	Examine and apply various types of transformation types.
CO4	Evaluate the complex integrals using various techniques.
CO5	Apply series expansion, examine various types of singularities and calculate the residues.

S. No.	Contents	Contact hours
UNIT 1	Algebra of complex numbers, the complex plane, polynomials, power series, radius of convergence, transcendental functions, Riemann Sphere, Stereographic Projection.	**8**
UNIT 2	Analytic functions, Cauchy-Riemann equations, Harmonic functions, Construction of analytic functions.	**8**
UNIT 3	Linear and bilinear Transformation, cross ratio and conformal Mappings.	**8**
UNIT 4	Line integral in the Complex Plane, Cauchy's integral theorem, Cauchy's integral formula, Derivatives of Analytic functions, Morera's theorem, Cauchy's estimate, Liouville's theorem, Fundamental theorem of Algebra.	**9**
UNIT 5	Taylor Series and Laurent Series, Singularities, types of singularities, zeros and poles, Residues, Residue theorem and its applications to evaluate improper real integrals.	**9**
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1.	J. B. Conway; Functions of One Complex Variable, Springer	2012
2.	J. Bak and D. J. Newman; Complex Analysis, Springer, 3rd Edition.	2017
3.	Churchill and Brown; Complex Analysis with applications, Mc Graw Hill, 9th Edition.	2009
4.	Complex variables, Schaum outlines.	2009
5	A. Bourchtein and L. Bourchtein, Complex Analysis, 1st Edition, Springer	2021

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC 106:	**L**	**T**	**P**	NIL
MATLAB Programming	**0**	**0**	**4**	

Course Objective: To introduce fundamentals of MATLAB programming and perform mathematical operations in MATLAB.

Course Outcome (CO):

CO1	Demonstrate basic mathematical operations, including working in the command window and contrast different data types and structures available.
CO2	Implement and apply relational and logical operations and conditional and iterative structures for decision-making and iterative processes.
CO3	Apply operations or tools to analyze and visualize data.
CO4	Judge the suitability of tools for different computational and mathematical tasks.
CO5	Design and implement projects.

S.No.	Contents	Contact hours
UNIT 1	**Introduction to MATLAB:** Starting MATLAB, Working in the Command Window, Arithmetic Operations with Scalars, Elementary Math Built-in Functions, Defining Scalar Variables, and Commands for Managing Variables.	**4**
UNIT 2	**Arrays:** One-Dimensional and Two-Dimensional Arrays, Array Addressing, Adding and Deleting Elements, Built-in Functions for Handling Arrays, Strings, Mathematical Operations with Arrays: Addition, Subtraction, Multiplication, and Division, Generation of Random Numbers.	**6**
UNIT 3	Relational and Logical Operators, Conditional Statements, Switch Case, Loops, Break and Continue commands. **Plots**: The plot command, fplot command, plotting multiple graphs in the same plot, histograms.	**6**
UNIT 4	**Polynomials and Symbolic Math**: Polynomials, Curve Fitting, Solving Algebraic Equations, Differentiation, Integration, User-defined functions.	**5**
	TOTAL	**21**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1	Attaway, D. *MATLAB: A Practical Introduction to Programming and Problem Solving*. Butterworth-Heinemann, 6th Edition, ISBN: 978-0323917506.	2022
2	Eshkabilov, S. *Beginning MATLAB and Simulink: From Beginner to Pro*. Apress, 2nd Edition, ISBN: 978-1484287477.	2022
3	Gilat, A. *MATLAB: An Introduction with Applications*. John Wiley & Sons Inc., 6th Edition, ISBN: 978-1119299257.	2017

PRACTICALS LIST	
1	Write a program for basic arithmetic operations with scalars.
2	Write a program to demonstrate mathematical built-in functions.
3	Write a program to create 1-D and 2-D arrays. Further, add and delete elements in the arrays.
4	Write a program to perform mathematical operations (addition, subtraction, array multiplication, array division) on arrays.
5	Write a program to calculate the rank of a 2-D array.
6	Write a program to demonstrate conditional statements and switch cases.
7	Write a program to demonstrate loops.
8	Write a program to construct plots using the plot/fplot command.
9	Write a program to construct histograms.
10	Write a program to solve polynomials and algebraic equations using map functions.
11	Write a program to demonstrate differentiation and integration for a given function.

II Year

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC 201: Data Structure	**L**	**T**	**P**	Basic Mathematics and Discrete structures
	3	**0**	**2**	

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

Course Outcome (CO):

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

S.No.	Contents	Contact hours
UNIT 1	**Introduction:** Abstract data types, design, implementation and applications. Introduction to Algorithm, Time complexity and Space complexity Trade-off. Introduction to Arrays and Strings: Representation of Arrays in Memory: one-dimensional, Two-dimensional and Multidimensional, operations on array. Strings and String Operations. **Stacks:** Introduction, Operations on Stacks, Array representation of Stacks, Applications of Stacks, recursion, Polish expression and their compilation conversion of infix expression to prefix and postfix expression. **Queues:** Introduction, Operations of Queues, Representations of Queues Applications of Queues, Priority queues.	**10**
UNIT 2	**Linked Lists:** Singly linked lists, Representation of linked list, Operations of Linked list such as Traversing, Insertion and Deletion, Searching, Applications of Linked List, Concepts of Circular linked list and Doubly linked list and their Applications, Implementation of Stacks and Queues using linked list.	**7**
UNIT 3	**Trees and Graphs:** Binary trees, Binary search trees, and various operations on Binary search trees like traversing, searching, insertion, and deletion. Applications of Binary search Trees, Complete Binary trees, and Extended Binary Trees. AVL trees, Threaded trees, General trees, B trees, B+ trees. Introduction to types of graphs, graph representation and traversal, shortest path, and transitive closure, Spanning trees.	**10**
UNIT 4	**Sorting:** Insertion Sort, Quicksort, Merge sort, Heap sort, sorting on different keys, External sorting.	**8**
UNIT 5	**File Structure:** File Organization, Indexing & Hashing, Hashing Functions, Collision Resolution Techniques.	**7**
	TOTAL	**42**

Suggested Books:

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

PRACTICALS LIST	
1	Write a program to implement traversal, insertion, and deletion of elements in a linear array.
2	Write a program to: a. Fetch a substring from a string, find its position and length of the substring. b. Replacement of 1 string with another. c. Concatenation of 2 strings.
3	Write a program to: a. Implement stack using arrays (push & pop). b. Evaluate arithmetic expression by converting it from infix and postfix. c. Check for balanced parentheses in an expression.
4	Write a program to implement a linear queue using arrays.
5	Write a program to implement linear queues, circular queues, and priority queues.
6	Write a program to implement a singly linked list, doubly linked list, and circular linked list (Searching, Insertion, Deletion).
7	Write a program to perform linear search and binary search in an array.
8	Write a program to perform insertion, deletion, and traversal in a binary search tree and threaded binary tree.
9	Write a program to perform Insertion sort, Quicksort, and Merge sort.
10	Write a program to perform Depth First Traversal and Breadth First Traversal.

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC 202: Operating System	**L**	**T**	**P**	NIL
	3	**0**	**2**	

Course Objective: To familiarise with the fundamental principles of the operating system, its services and functionalities, the concepts of processes, synchronization and scheduling, memory management and the need for protection in computer systems.

Course Outcome (CO):

CO1	Describe the fundamental design principles and core components of operating systems, including processes, threads, memory, files, and I/O devices.
CO2	Analyze process scheduling, synchronization, and deadlock management, and evaluate performance trade-offs in different design approaches.
CO3	Explain memory management techniques and compare space allocation strategies for main memory, virtual memory, and file systems.
CO4	Implement operating system concepts using system calls for process management, memory handling, and file operations.
CO5	Differentiate various types of operating systems and analyze their functionalities based on application requirements.

S.No.	Contents	Contact hours
UNIT 1	**Operating System:** Introduction and Evolution of Operating System (OS) - Batch, Interactive, Time-Sharing, Real-Time System, System Protection. Computer-System Organization and Architecture, OS Structure - System Components, System Structure, OS Services, User - OS Interface, System Calls.	**8**
UNIT 2	**Process Management I:** Process concept, Inter Process Communication, Process operations. Process Threads - Introduction and Multithreading Models. CPU Scheduling - Scheduling Concept, Performance Criteria, Scheduling Algorithms, Multiple-Processor Scheduling.	**8**
UNIT 3	**Process Management II:** Process Concurrency - Producer-Consumer Problem, Critical Section Problem and Solution, Mutex Locks, Semaphores, Classical problems in Concurrency. Deadlock Management - System Model, Deadlock Characterization, Prevention, Avoidance, Banker's Algorithm, Deadlock Detection, Recovery from Deadlock.	**9**
UNIT 4	**Memory Management:** Basics, Memory protection, Multiprogramming with fixed partition and variable partition, Multiple base register, Paging, Segmentation, Page Table Structure. Virtual Memory - Basic concepts, Demand paging, Copy-on-write, Performance, Page replacement algorithms, Thrashing.	**9**

UNIT 5	**Disk Management:** Disk Structure and its attachments, Disk Scheduling Algorithms. File Management - File Concept and Access Methods, File System structure and its Implementation, Directory Structure and its implementation. I/O Management - I/O devices and organisation, I/O functions, I/O Buffering. Case studies – Windows, Linux, and Unix	**8**
	TOTAL	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1.	Silberschatz, A., Galvin, P. B., & Gagne, G., Operating system concepts. Wiley, 9th Edition, ISBN: 978-1118063330.	2012
2.	Tanenbaum, A. S., & Woodhull, A. S., Operating systems: Design and implementation. Pearson Education, 3rd Edition, ISBN: 978-0-13-142938-3.	2006
3.	Stallings, W., Operating systems: Internals and design principles. Pearson, 9th Edition, ISBN: 978-0-13-467095-9.	2018

PRACTICALS LIST	
1	Write a C program to copy the contents of one file to another file using system calls like read(), write(), open() and close().
2	Write a C program to create a child process using fork(). Print the process id of child and the parent process. Also, explain the behaviour of fork in parent-child process.
3	Write a C program that creates a new child process using fork(). The child process should be assigned to find the length of your name using the execlp() system call.
4	Write a C program that creates another process. The child process should print the contents of any text on the screen using the cat command. The parent process should exit only after the child process has completed its execution.
5	Write a program to implement the FCFS and Elevator Algorithm for Disk Scheduling. Print the Seek time for each algorithm. You may consider your own input queue for the requests (cylinder no.).
6	Write a program to implement the SSTF and LOOK Disk Scheduling Algorithms. Print the Seek time for each algorithm. You may consider your own input queue for the requests (cylinder no.).
7	Write a menu-driven program to implement First Come First Serve and Shortest Time First Algorithm (Non Preemptive) scheduling algorithm. Input - Sequence of Processes with their arrival time and burst time. Output - Sequence of processes executing, Average Waiting time and Average Turnaround time
8	Write a menu-driven program to implement Round Robin Algorithm. Input - Sequence of Processes with their arrival time and burst time, and Maximum Time Quantum. Output - Sequence of processes executing, Average Waiting time and Average Turnaround time.
9	Write a menu-driven program to implement the Shortest remaining time First and Preemptive Priority-based Scheduling Algorithms. Input - Sequence of Processes with their arrival time and

	burst time. Output - Sequence of processes executing, Average Waiting time and Average Turnaround time
10	Write a program to implement Banker's Algorithm. The program should either print the safe sequence of execution of given processes (if any exists) or print "There is a deadlock in the system.
11	Write a program to implement FIFO and Least Recently Used algorithm for page replacement. Input - Reference String and Number of frames. Output - Number of page faults for each LRU and FIFO.

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC203: Real Analysis	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To impart knowledge of real numbers system, sequences, metric spaces, and Riemann integral.

Course Outcome (CO):

CO1	Describe the basic concepts of Real numbers system, sets and bounds.
CO2	Explain the convergence of real sequences.
CO3	Demonstrate the understanding of Metric spaces and its topology.
CO4	Explain continuity and uniform continuity in Metric spaces.
CO5	Identify the Riemann integrability of a given function.

S. No.	Contents	Contact hours
UNIT 1	Peano's Axiom, Real number system $\mathbb{R}$, countable and uncountable sets, concepts of bound, least upper bound & greatest lower bound, order and completeness properties of $\mathbb{R}$, Archimedean property of real numbers, Nested interval property.	**8**
UNIT 2	Definition of real sequence, sub-sequence, bounded sequence, convergence of a sequence (Limit of a sequence), monotone sequences and their convergence, operations on convergent sequences, Bolzano-Weierstrass theorem for sequences, Cauchy sequence, Cauchy's general principle for convergence.	**9**
UNIT 3	Definition and examples of Metric Spaces, Euclidean spaces, Pseudo metric space, open sphere, neighbourhood of a point, open set, limits points of a set, closure of a set, closed set, limit and continuity of functions in metric space.	**9**
UNIT 4	Cluster points, Convergent sequences in metric space, sub sequence, Cauchy sequence in a metric space.	**8**
UNIT 5	Riemann sums, Riemann integral, criterion for integrability, properties of Riemann integral, fundamental theorem of calculus.	**8**
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1.	Richard R. Goldberg; Methods of Real Analysis, Oxford & IBH publishing Co. Pvt. Ltd.	2020
2.	Bartle, R.G., and Sherbert, D.R.; Introduction to Real Analysis, John Wiley & Sons, Inc., New York, 4th Edition.	2011
3.	Mathematical Analysis, Apostol, Narosa pub. House, 2nd Edition.	2002
4.	S.C. Malik and Savita Arora; Mathematical Analysis, New Age International publishers, 5th Edition.	2017
5.	Walter Rudin; Principles of Mathematical Analysis, Mc Draw Hill, 3rd Edition.	2017

Details of Course

Course Title	Course Structure			Pre-Requisite
MC204:	**L**	**T**	**P**	NIL
Scientific Computing	**3**	**0**	**2**	

Course Objective: The course will develop numerical methods aided by technology to solve algebraic, transcendental, and differential equations, and to calculate derivatives and integrals. The course will also develop an understanding of the elements of error analysis for numerical methods and certain proofs. The course will further develop problem solving skills.

Course Outcome (CO):

CO1	Apply numerical methods to obtain the errors and the approximate solutions to the transcendental and polynomial equations.
CO2	Describe the Eigen value problems for the system of linear algebraic equations and analyze the applications.
CO3	Identify numerical methods for various mathematical operations and tasks, such as interpolation formulae like forward, backward, and divided difference formulae.
CO4	Apply the appropriate techniques for numerical differentiation and integration problems.
CO5	Design the numerical solution of initial value problems of the ordinary differential equations with implicit and explicit methods as appropriate.

S. No.	Contents	Contact hours
UNIT 1	Solution of Transcendental and polynomial equations: Types of error in numerical methods, Iterative methods: Bisection method, Secant method, Regula-Falsi method, Newton-Raphson method, Fixed point method, their convergence, Solution of system of nonlinear equations using Newton -Raphson method.	**8**
UNIT 2	Linear systems of equations: Direct Methods (Gauss Elimination, LU decomposition); iterative methods (Gauss - Jacobi, Gauss-Seidel), convergence of iterative methods; ill-conditioned system of equations, Eigen value problems using power method.	**8**
UNIT 3	Finite differences and Interpolation: Finite difference operators and their properties, Interpolation of equally spaced intervals: Newton and Gauss forward and backward formulae, Bessel's formula; Interpolation of unequally spaced intervals: Newton's divided difference, Lagrange's method, Hermite interpolation formula; Inverse interpolation, quadratics and cubic spline Interpolation.	**9**
UNIT 4	Numerical differentiation and integration: Differentiation for equal and unequal spaced using interpolating formulae; Integration: Newton's Cotes formula, Gauss Quadrature formula, Trapezoidal formula, Simpson's one-third and three-eight rules and error estimates.	**9**

UNIT 5	Numerical solution of Initial Value Problems: Picard's method, Taylor series method, Euler's and Modified Euler's method, and their Convergence, Runge-Kutta method, Predictor-corrector method.	**8**
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1	M. K. Jain and S.R.K. Iyengar , Numerical Methods for Scientific and Engineering Computation, New Age International Publishers.	2007
2	Curtis F. Gerald & Patrick O. Wheatley , Applied Numerical Analysis, Pearson Publication, 7th Ed.	2007
3	S.D. Conte, & C. Deboor , Elementary Numerical Analysis, Tata Mc- Graw Hill.	2005
4	Uri Ascher, A First Course in Numerical Methods, SIAM Publication.	2011
5	R. S. Gupta: Elements of Numerical Analysis, Cambridge, 2nd Ed.	2015
6	S.S. Sastry, Introductory methods of numerical analysis, Prentice Hall India Learning Private Limited, 5th Ed.	2012

PRACTICALS LIST	
1	Write a program to implement following methods: 1. Bisection method 2. Secant method 3. Regula Falsi method 4. Newton Raphson method.
2	Write a program to implement Gauss Elimination method with and without partial pivoting.
3	Write a program to implement Gauss Seidel and Jacobi Iterative methods.
4	Write a program to implement Power method for finding maximum eigen value and corresponding eigen vector.
5	Write a program to create Forward and Backward difference table from the given data.
6	Write a program to implement Lagrange's method of Interpolation.
7	Write a program for Spline method for Interpolation.
8	Write a program to implement Trapezoidal and Simpson's 1/3 rule for integration.
9	Write a program to implement Runge-Kutta method for solving ODE.
10	Write a program to implement Picard's method for solving ODE.

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC205:	**L**	**T**	**P**	NIL
Probability and Statistics	**3**	**0**	**2**	

Course Objective: To acquire knowledge on 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.

Course Outcome (CO):

CO1	Prepare the data set and Summarize its main features. (exploratory data analysis). Also student shall be able to calculate and infer for real problems on the basis of probabilistic theory.
CO2	Describe and identify the various probability distribution function and infer their statistical properties. The student shall be able to derive the relation between bivariate random variables.
CO3	Analyze and apply the laws of Sampling. Also, be able to perform random sampling, construct the confidence intervals for parameter estimates.
CO4	Compute and interpret the results of Bivariate Regression and Correlation Analysis, for forecasting and investigating the relationships between them. Define and perform hypothesis testing and perform ANOVA.
CO5	Demonstrate the qualitative and quantitative properties of data using appropriate diagrams, tabulations, hypotheses testing and summaries using SPSS.

S.No.	Contents	Contact Hours
UNIT 1	Descriptive statistics**,** Axioms on probability, Conditional probability, Addition and multiplication rules, Bayes' Theorem. Random variables: Discrete and Continuous, Probability mass and density functions, Joint marginal and conditional distributions.	**8**
UNIT 2	Mathematical Expectation, Variance, Covariance, Moment generating function, Markov's inequality, Chebyshev's inequality. Correlation and Regression, Rank Correlation.	**8**
UNIT 3	Binomial, Negative binomial, Poisson, Geometric, Hypergeometric, Uniform, Normal, Exponential, Gamma, Weibull, Erlang and Beta distributions	**8**
UNIT 4	Types of sampling, Parameter and statistic, Law of large numbers, Central limit theorem, Sampling distributions, Confidence intervals, Hypothesis testing, Sampling of attributes and variables, Tests of significance for large sample testing.	**9**
UNIT 5	Exact sampling distributions: Chi-square, Student's t, Snedecor's F and their applications. ANOVA: one and two-way classification.	**9**
	Total	**42**

Suggested Books:

S.No	Name of Books/Authors/Publishers	Year of Publication
1	S. M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Academic Press.	2021
2	R. E. Walpole, R. H. Myers, S.L. Myers, Probability and Statistics for Engineers and Scientists, Pearson, Ninth Edition.	2013
3	S. C. Gupta & V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand and Sons.	2017
4	P. L. Meyer, Introductory Probability and Statistical Application, Oxford and IBH Publishing.	2002
5	K. S. Trivedi, Probability and Statistics with Reliability, Queuing and Computer Science Application, Wiley, Second Edition.	2001

PRACTICALS LIST	
1	Transportation of Data Set to SPSS Editor
2	Merging of Data set & providing missing values
3	Pictographical representation of data using Bar diagram and Pie chart
4	Drawing of Histogram and distribution curve
5	Descriptive Statistics
6	Correlation between two random variables
7	Regression Analysis
8	Hypothesis Testing 't' - test
9	Chi Square test
10	ANOVA One Way

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC 206: Analysis and Design of Algorithms	**L**	**T**	**P**	Data Structures
	3	**1**	**0**	

Course Objective: To introduce the concept of algorithmic efficiency by analyzing various algorithms such as Searching, Sorting, Divide-and-Conquer algorithms and to know detail about Greedy Paradigm, Principle of Dynamic Programming, Back Tracking, Branch and Bound, and Computational Complexity.

Course Outcome (CO):

CO1	Recall the different paradigms of algorithm design and identify criteria for determining the correctness of algorithms.
CO2	Explain the concepts of asymptotic notation and its role in analyzing the running time of algorithms.
CO3	Design and implement algorithms using various algorithmic paradigms, and apply asymptotic analysis to evaluate their efficiency.
CO4	Analyze the limitations of different algorithmic paradigms and differentiate between tractable and intractable problems, developing strategies for solving computationally intractable problems.
CO5	Evaluate and solve real-world inter-disciplinary problems, including sorting, tree and graph problems, and recurrence relations, by applying appropriate algorithms and analyzing their performance.

S.No.	Contents	Contact hours
UNIT 1	**Introduction:** Concept of algorithmic efficiency, run time analysis of algorithms, Asymptotic Notations. Growth of Functions, Recurrence Relation, Master's Theorem, Correctness of Algorithm. **Divide and Conquer Approach:** Introduction, Analysis of Run time and Correctness of divide and conquer based Searching and Sorting algorithms, Heap sort, Strassen's matrix multiplication.	**8**
UNIT 2	**Greedy Method:** Overview of the greedy paradigm examples of exact optimization solutions: minimum cost spanning tree, **approximate solutions:** Knapsack problem, Kruskal's algorithm and Prim's algorithm for finding Minimum cost spanning tree, Dijkstra's algorithm for single source shortest path problem.	**9**
UNIT 3	**Dynamic programming:** Principle of dynamic programming. **Applications:** Bellman Ford Algorithm for single source shortest path problem, Floyd-Warshall algorithm for all pair shortest path problem, 0/1 Knapsack Problem, Matrix chain multiplication, Traveling salesman Problem, longest Common sequence (LCS).	**8**

UNIT 4	**Back tracking:** Overview, 8-queen problem, and 0/1 Knapsack problem, Subset Sum Problem, Traveling Salesman problem. **Branch and bound:** LC searching Bounding, FIFO branch and bound, LC branch and bound application: 0/1 Knapsack problem.	**8**
UNIT 5	**Computational Complexity:** Complexity measures, Polynomial Vs non-polynomial time complexity; NP-hard and NP-complete classes, **examples:** Circuit Satisfiability, Vertex cover, Subset Sum problem, Randomized Algorithms, String Matching, NP-Hard and NP- Completeness, Approximation Algorithms, Sorting Network, Matrix Operations, Polynomials and FFT, Number Theoretic Algorithms.	**9**
	TOTAL	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1	Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C., Introduction to algorithms, The MIT Press, 4th Edition, ISBN: 978-0-262-04630-5.	2022
2	Horowitz, E., Sahni, S., & Rajasekaran, S., Computer algorithms C++: C++ and pseudocode versions, W. H. Freeman, ISBN: 978-0716783152.	1997
3	Baase, S., & Van Gelder, A., Computer algorithms: Introduction to design and analysis, Pearson Education India, 3rd Edition, ISBN: 978-0201612448.	1999

Details of Course

Course Title	Course Structure			Pre-Requisite
MC207: Modern Algebra	**L**	**T**	**P**	Basic knowledge of set theory
	3	**1**	**0**	

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

Course Outcome (CO):

CO1	Identify different algebraic structures like groups, rings, fields etc. and to apply them in various science related problems.
CO2	Apply concepts of abstract algebra with various scientific tools to evolve new ideas to solve practical problems.
CO3	Demonstrate problem solving skills in the context of abstract algebra topics through consideration of examples, pattern exploration, conjecture, proof construction, and generalization of results.
CO4	Apply algebraic concepts such as groups and ring theory to model, analyze and solve real-world problems.
CO5	Comprehend abstract definitions and theorem statements by building examples and non-examples of definitions, and drawing conclusions using definitions and theorems given mathematical information.

S. No.	Contents	Contact hours
UNIT 1	Groups, Abelian groups, Subgroups, Centre of a group, Order of a group and an element, Cyclic groups, groups of prime order. Cayley's digraph of cyclic groups.	**8**
UNIT 2	Permutation groups, Alternating subgroup, Important examples of groups such as S3(Symmetric group of order 6), K4 (Klein's 4 –group) and Q8 (Quaternion group) groups. Cosets, Lagrange's Theorem for finite groups, Normal subgroup, Quotient group.	**9**
UNIT 3	Group Homomorphism, Isomorphism, Kernel of group homomorphism, Fundamental theorem of group homomorphism, Cayley's theorem.	**9**
UNIT 4	Ring, Subring, Integral domain, Field, Ideal of a ring, Quotient ring, Ring homomorphism, Isomorphism, and some elementary properties.	**8**
UNIT 5	Prime ideal, Maximal ideal, Ring of polynomials and their properties.	**8**
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1.	Joseph A. Gallian; Contemporary Abstract Algebra, Narosa Publishing House, 10th Edition.	2021
2.	N. S. Gopalakrishnan, University Algebra, New Age International Publishers, 4th Edition.	2021
3.	I. N. Herstein; Topics in Algebra, Wiley Eastern Limited, 2nd Edition.	2006
4.	Khanna and Bhamri; A course in Abstract Algebra, Vikas Publishing House, 5th Edition.	2017
5.	D. S. Dummit and R. M. Foote; Abstract Algebra, John Wiley and Sons, 3rd Edition.	2011

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC208: Linear Algebra	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: The objective of this paper is to impart knowledge of vector space, linear transformation, bilinear form and Inner Product spaces.

Course Outcome (CO):

CO1	Explain computational techniques and algebraic skills essential for the study of systems of linear equations and matrix algebra.
CO2	Apply geometric properties and strategies to model and solve problems of vector spaces.
CO3	Compute and recognize the properties of special matrices.
CO4	Apply eigenvectors in obtaining canonical forms of matrices.
CO5	Describe inner product spaces, bilinear forms and positive definiteness of real quadratic forms.

S. No.	Contents	Contact hours
UNIT 1	Vector spaces, Properties of vector spaces, Subspaces, Linear dependence and independence, Linear span, Bases and Dimension, Linear Sum, Direct Sum, Quotient Spaces.	**8**
UNIT 2	Linear transformations, Range and Null spaces, Rank–Nullity theorem and its application, Inverse linear transformation, Representation of linear transformations by matrices, Change of basis, Dual space, Dual bases .	**10**
UNIT3	Transpose of a linear transformation, Eigenvalues and Eigenvectors, Cayley–Hamilton Theorem, Diagonalization, Minimal polynomials, Jordan canonical form.	**8**
UNIT 4	Inner product spaces, norm of a vector, orthogonality, orthonormal set, orthonormal basis, Gram-Schmidt orthonormalization, orthogonal projections, Linear functional and adjoints, Hermitian, self-adjoint.	**8**
UNIT 5	Unitary and normal operators, Bilinear forms, Symmetric and skew-symmetric bilinear forms, Real quadratic forms and it's characterization.	**8**
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1	K. Hoffmann and R. Kunze, Linear Algebra, 2nd Edition , Pearson Education	2015
2	G. Hadley, Linear Algebra, Narosa publication	2002
3	Gilbert Strang, Linear Algebra and its applications, Cengage Learning, 4th edition	2007
4	Serge Lang, Introduction to Linear Algebra, Springer	2004

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC209: Database Management System	**L**	**T**	**P**	NIL
	3	**0**	**2**	

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

Course Outcome (CO):

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

S.No.	Contents	Contact hours
UNIT 1	**Introduction:** Database system concepts and its architecture, Data models, Schema and instances, Data independence, Database language and interface, Data definition languages, Data manipulation languages**.** **Data modelling using Entity Relationship Model:** ER model concept, Notation for ER diagrams, Mapping constraints, Keys, Super key, Candidate key, Primary key, Generalizations, Aggregation, Transforming ER diagrams to tables, Extended ER model.	**8**
UNIT 2	**Relational Data Model and Language:** Relational data model concepts, Integrity constraints, Keys domain constraints, Referential integrity, Assertions, Triggers, Database language, Relational algebra, Relational calculus, Domain and Tuple calculus, Data definition, queries, and updates in SQL, NoSQL databases.	**9**
UNIT 3	**Database Design:** Functional dependencies, Normal forms, 1NF, 2NF, 3NF, and BCNF, Multivalued dependencies, Fourth normal form, Join dependencies, Fifth normal forms, Lossless join decompositions, Normalization using FD, MVD and JDs.	**8**
UNIT 4	**File Organization, Indexing and Hashing:** Basic concepts, Static hashing, Dynamic hashing, Ordered indices, Multi-level indexes, B-Tree index files, B+ Tree index files, Buffer management.	**8**
UNIT 5	**Transaction processing concepts:** Transaction processing system, Schedule and recoverability, Testing of serializability, Serializability of schedules, Conflict and view serializable schedule, Recovery from transaction failures, Deadlock handling. **Concurrency Control Techniques:** Locking Techniques, Time stamping protocols, Multiple granularities and Multi-version schemes.	**9**
	TOTAL	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1	Elmasri, R., & Navathe, S. B., Fundamentals of database systems. Addison-Wesley, 6th Edition, ISBN: 978-0-13-608620-8.	2010
2	Silberschatz, A., Korth, H. F., & Sudarshan, S., Database system concepts. McGraw-Hill, 7th Edition, ISBN: 978-0-07-802215-9.	2019
3	Ramakrishnan, R., & Gehrke, J., Database management systems. McGraw-Hill, 3rd Edition, ISBN: 978-0-07-246563-1.	2003

PRACTICALS LIST	
1	Design an ER diagram for a chosen/given application/project.
2	Write SQL queries to implement the following DDL statements: a. Create table b. Create a table with constraints: NOT NULL, UNIQUE, DEFAULT, CHECK, PRIMARY KEY, FOREIGN KEY c. Alter table: Add and Drop a column, Add and Drop a constraint, Rename column d. Drop table
3	Write SQL queries to implement DML statements: Insert, Update, Delete, Truncate.
4	Write SQL queries to implement SELECT statements: a. with and without WHERE clause, using Boolean operators, logical operators, IN, BETWEEN, LIKE etc. b. using GROUP BY and HAVING c. using ORDER BY
5	Write SQL queries to perform aggregate functions: SUM, MAX, MIN, AVG, COUNT.
6	Write SQL queries to perform Nested queries with various JOIN operations: a. INNER JOIN b. EQUI JOIN c. NATURAL JOIN d. LEFT OUTER JOIN e. RIGHT OUTER JOIN f. FULL OUTER JOIN
7	Write SQL query to create a view.
8	Write SQL queries using in-built functions like Date, Current date, Interval, etc.
9	Write SQL queries to create and modify the Indexes.
10	Write SQL queries to implement Triggers.
11	Write SQL queries to implement the following transaction statements: a. Commit b. Savepoint c. Rollback

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC210: Differential Equations	**L**	**T**	**P**	Basic knowledge of calculus and matrix
	3	**0**	**2**	

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

Course Outcome (CO):

CO1	Evaluate linear systems of differential equations, both homogeneous and non-homogeneous by matrix method and Sturm-Liouville boundary value problems including orthogonality properties.
CO2	Analyse the stability of linear and non-linear differential equations through phase portrait diagram.
CO3	Formulate partial differential equations, evaluate linear, quasi linear and non-linear first order PDEs and address Cauchy's problem for first order PDE.
CO4	Solve homogeneous and non- homogeneous linear PDE with constant coefficients and classify second order PDE to determine characteristics.
CO5	Apply the method of separation of variables to solve initial and boundary value problem including heat equation, wave equation and Laplace equation.

S. No.	Contents	Contact hours
UNIT 1	Ordinary differential equations I: Solutions of linear system of differential equations (homogenous and non-homogenous) by matrix method, solution of Sturm-Liouville boundary values problems including characteristic functions and orthogonality.	**8**
UNIT 2	Ordinary differential equations II: Linear and non-linear autonomous systems, Phase plane, Paths, Critical Points and its types, Stability of the critical points, Phase plane analysis, Lyapunov's direct method, periodic solutions, limit cycle.	**8**
UNIT 3	Partial differential equations I (PDEs): Formation of PDEs, LinearandQuasi-linear first order PDEs (Lagrange form), Cauchy's problem for first order PDEs, Non-linear first order PDEs: Standard forms and Charpit's method.	**8**
UNIT 4	Partial differential equations II: Linear homogeneous and non-homogeneous second and higher order PDEs with constant coefficients, Classification of second order PDEs, Characteristic equations and characteristic curves, method of separation of variables.	**9**
UNIT 5	Applications of partial differential equations: Solutions of one-dimensional heat equation, one-dimensional wave equation, two-dimensional heat equation, two dimensional Laplace equation in Cartesian and polar coordinates.	**9**
	Total	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication /Reprint
1.	Martin Braun, Differential equations and their applications, Springer, 4thEd.	1993
2.	S. L. Ross, Introduction to Ordinary Differential Equations, John Wiley & Sons, 4thEd.	1989
3.	R.K Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, Narosa, 5thEd.	2017
4.	K S Rao, Introduction to Partial Differential Equations, Prentice Hall India, 3rdEd.	2011
5.	G.F. Simmons, Differential equation with Applications and Historical Notes CRC Press, 3rdEd.	2017
6.	Peter V. O'Neil, Beginning Partial Differential equations, Wiley Publication, 3rd Ed.	2014

PRACTICALS LIST	
1	Write a program in MATLAB to solve homogeneous and non-homogeneous linear system of differential equations using matrix-method.
2	Write a program in MATLAB to solve Initial Value Problems of homogeneous and non-homogeneous linear system of differential equations using matrix-method.
3	Write a program in MATLAB to solve Sturm Liouville boundary value problem to obtain characteristic values and characteristic functions.
4	Write a program in MATLAB to analyse the stability of linear and non-linear differential equations through phase portrait diagram.
5	Write a program in MATLAB to solve quasi-linear equations using Lagrange's method.
6	Write a program in MATLAB to solve non-linear PDE using Charpit's method.
7	Write a program in MATLAB to solve higher order linear homogeneous partial differential equations with constant coefficients.
8	Write a program in MATLAB to solve one-dimensional heat equation using method of separation of variables.
9	Write a program in MATLAB to solve one-dimensional wave equation using method of separation of variables.
10	Write a program in MATLAB to solve Laplace equation using method of separation of variables.

III Year

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC301:	**L**	**T**	**P**	NIL
Theory of Computation	**3**	**1**	**0**	

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

Course Outcome (CO):

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

S. No.	Contents	Contact hours
UNIT 1	Automata: Definition of an Automaton, Description of a Finite Automaton, Transition system & its properties, Acceptability of a string by a finite Automaton, Nondeterministic Finite Automaton (NDFA), Equivalence of DFA and NDFA, Minimization of finite automaton, Moore & Mealy machines.	**8**
UNIT 2	Formal Languages: Definition of a Grammar, Derivations, Language generated by a grammar, Chomsky classification of languages & their relation, operations on languages.	**6**
UNIT 3	Regular Sets: Regular expressions, Arden's theorem, Transition system containing - moves, Kleene's theorem, Algebraic method using Arden's theorem, construction of finite automata equivalent to a regular expression, Equivalence of two finite automata, Pumping lemma for regular sets, closure Properties of regular sets.	**8**
UNIT 4	Context Free Languages: Definition of CFL, Derivation trees, Ambiguity in CFG, Simplification of CFG, Normal forms (CNF & GNF), Pumping lemma for CFL, Decision algorithms for CFL.	**6**
UNIT 5	Pushdown Automata: Definition & Description of PDA, Instantaneous description, Move relation, Acceptance by PDA.	**6**
UNIT 6	Turing Machines: Basic model, Definition & representation, Instantaneous description, Representation by transition table & transition diagram Language accepted by Turing Machine, Design of Turing Machine, Decidability and Complexity.	**8**
	Total	**42**

Suggested Books:

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

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC302: Mathematical Modelling and Simulation	**L**	**T**	**P**	Knowledge of differential equations and numerical methods
	3	**0**	**2**	

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

Course Outcome (CO):

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

S. No.	Contents	Contact Hours
UNIT 1	Concept of Mathematical modelling, some modelling approaches: empirical, simulation, deterministic, statistical, Classification of mathematical models: black and white box, SQM space, Qualitative and quantitative approaches, Conceptual and physical model, Stationary and in-stationary models, distributed and lumped models, Compartment models.	**8**
UNIT 2	Steady State solution, Long term behaviour, Phase plane analysis, Linearization, Stability Analysis, Routh Hurwitz Criteria, Lyapunov functions.	**8**
UNIT 3	Models of single populations, Interacting Species models and extended population models, Prey – predator model, Growth models, Decay models, Lotka-Volterra model, Allee effect.	**8**
UNIT 4	Epidemic Models: Susceptible Infected (SI), Susceptible Infected Susceptible (SIS), Susceptible Infected Recovered (SIR), Lanchester combat model, Case Studies.	**8**
UNIT 5	Introduction to Bifurcation, Saddle node bifurcation, Trans-critical bifurcation, Pitchfork bifurcation, Hopf bifurcation: Forward and backward, Introduction to Chaos theory and non-linear dynamics, Case Studies.	**10**
	TOTAL	**42**

Suggested Books:

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

PRACTICALS LIST	
1	Write a program to draw direction fields for the system of differential equations with constant coefficients.
2	Write a program to find the steady-state solution, draw its phase plane plot for the system of ODEs and plot the solution of the system.
3	Write a program to find critical points, Jacobian matrix, eigen values and eigen vectors of system of differential equations with constant coefficients.
4	Develop a MATLAB function to check the stability of a linear system using the Routh-Hurwitz criterion.
5	Write a program to check the stability of a linear system using the Lyapunov function.
6	Simulate the Lotka-Volterra prey-predator model and analyze the population dynamics over time.
7	Implement the SIR model for an epidemic and analyze how varying parameters (infection rate, recovery rate) affect the spread of disease.
8	Simulate and analyze the saddle-node bifurcation in a simple dynamical system.
9	Simulate a transcritical bifurcation in a simple system.
10	Simulate the chaotic behavior of the Lorenz system.

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC303: Stochastic Processes	**L**	**T**	**P**	Probability and Statistics
	3	**1**	**0**	

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

Course Outcome (CO):

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

S. NO	Contents	Contact Hours
UNIT 1	Introduction, Classification and examples of stochastic processes such as Bernoulli process, Poisson process, Gaussian process, Renewal process, Stationary process, Brownian motion.	**9**
UNIT 2	Introduction and examples of Random Walk, simple random with unrestricted, two absorbing barriers, one absorbing barrier, two reflecting barriers and one reflecting barrier.	**8**
UNIT 3	Properties of Poisson processes, Arrival rate and inter-arrival times, Superposition and thinning of Poisson processes, Applications in modelling arrival phenomena.	**8**
UNIT 4	Discrete time Markov chain, n-step transition probability, States classification, Limiting probabilities, Distribution of times between states, Irreducible finite chains with aperiodic states, Reducible chains (Finite Markov chains with absorbing states).	**8**
UNIT 5	Continuous time Markov chain, Chapman- Kolmogorov equation, Birth-Death process, Special cases of Birth-Death process, Markov chains with absorbing states, Application to queueing models, M/M/1; M/M/c and Erlang loss models. Steady state solutions.	**9**
	TOTAL	**42**

Suggested Books:

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

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC304: Financial Engineering	**L**	**T**	**P**	A course in Statistics with sound knowledge of random variable, expectation and variance, m.g.f. and probability distribution.
	3	**1**	**0**	

Course Objective: The objective of the course is to Knowledge of financial market, risk attached, and derivative on underlying asset. Knowledge and Optimization of portfolio.

Course Outcome (CO):

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.

S. NO	Contents	Contact Hours
UNIT 1	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**
UNIT 2	Basic Theory of Option Pricing: Single and Multi-Period Binomial Pricing Models, Cox Ross-Rubinstein (CRR) Model, Black-Scholes Formula for Option Pricing as a Limit of CRR Model.	**10**
UNIT 3	Introduction to Brownian and Geometric Brownian Motion, 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**
UNIT 4	Mean-Variance Portfolio Theory: Markowitz Model of Portfolio Optimization and Capital Asset Pricing Model (CAPM). Limitations of Markowitz Model and New Measures of Risk.	**10**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	M. Capińsky and T. Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, Springer.	2004
2	Investment Science, D. G. Luenberger, Oxford University Press.	1999
3	Elementary Stochastic Calculus with Finance in view, Thomas Mikosch, World Scientific.	2006
4	Stochastic Calculus for Finance, Vol. I & Vol. II, S. E. Shreve, Springer.	2004
5	Financial Mathematics: An Introduction, S. Chandra, S. Dharmaraja, Narosa.	2014

Details of Course:

Course code: Course Title	Course Structure			Pre-Requisite
MC305: Computer Networks	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To provide knowledge about the principles, concepts and applications of computer networks, its application and communication protocols.

Course Outcome (CO):

CO1	Define basic computer network terminology and describe the Data Communications System and its components.
CO2	Illustrate the layers of the OSI model and TCP/IP reference model and also describe the functions of each layer.
CO3	Analyze the way protocols are currently used on the Internet and the requirements for designing network protocols.
CO4	Explain different types of physical layer transmissions and transmission media, and determine techniques for handling transmission errors.
CO5	Explain the routing protocols and discuss the process of assigning IP addresses within a given network, also demonstrate the connection-oriented and connection-less protocols.

S.No.	Contents	Contact Hours
UNIT 1	**Introduction:** Fundamentals and applications of Networks, data communications, network architecture, network classification, Reference models - OSI and TCP/IP, interfaces and services, network topology design, Physical Layer Transmission Media, Switching methods, ISDN.	**8**
UNIT 2	**Data Link Layer:** Framing, Error Handling, Elementary Data Link Protocols, Sliding Window protocols. **Medium Access sublayer:** Channel Allocations, LAN protocols, multiple access protocols, IEEE 802.X standards, FDDI.	**9**
UNIT 3	**Network Layer:** Point-to-point networks, logical addressing, routing, routing algorithms, Congestion control algorithms, Internetworking, IP addressing and subnet masking, IPv6.	**9**
UNIT 4	**Transport Layer:** Transport Layer Design issues, Transport layer protocols, connection management, congestion control. **Session Layer:** Design issues, remote procedure call.	**8**
UNIT 5	**Presentation Layer:** Data compression techniques, Encryption and Decryption. **Application Layer:** Application layer protocols, File Transfer, Access and Management, DNS, Electronic mail, Virtual Terminals, Internet and Public Networks.	**8**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	Tanenbaum, A. S., Feamster, N., & Wetherall, D., Computer networks, Pearson Education, 6th Edition, ISBN: 978-0-13-752321-4.	2021
2	Forouzan, B. A., Data communications and networking, McGraw-Hill, 5th Edition, ISBN: 978-0-07-337622-6.	2012
3	Stallings, W., Data and computer communications, Pearson Education, 10th Edition, ISBN: 978-0-13-350648-8.	2013

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC306:	**L**	**T**	**P**	Programming
Object Oriented Programming	**3**	**0**	**2**	Fundamentals

Course Objective: To introduce object-oriented paradigm using C++ and Java, including composition, inheritance, polymorphism, templates, exception handling and file operations.

Course Outcome (CO):

CO1	Define the object-oriented features of C++ and Java.
CO2	Identify classes, objects, members of a class and relationships among them needed for a specific problem.
CO3	Explain how to apply the major object-oriented concepts such as encapsulation, inheritance, polymorphism, exception handling, etc to implement object-oriented programs in C++ and Java.
CO4	Develop, analyze and test programming solutions of real life problems in C++ and Java.
CO5	Design and develop Java application programs using GUI, Swings, network programming etc.

S.No.	Contents	Contact Hours
UNIT 1	**Introduction to Object-Oriented paradigm using C++**: Evolution of programming paradigm, structured versus object-oriented development, elements of object-oriented programming, Objects, classes, methods, software reuse. **Classes and objects:** Introduction, Class revisited, constant objects, constructor, constructor overloading, static data members with constructors and destructors, composition, objects as arguments, returning objects, friend functions and friend classes, constant parameters and member functions, static data and member functions, this pointer.	**9**
UNIT 2	**Operator Overloading**: Basic concept of overloading, overloading of unary and binary operators, conversion between objects and basic types, conversion between objects of different classes, overloading with friend functions and member functions. **Inheritance and Polymorphism:** Public vs Private vs Protected inheritance, inheritance with composition, abstract classes, virtual base classes, virtual functions, pointer to derived class objects, and base class objects, pure virtual functions, virtual destructors.	**8**
UNIT 3	**Generic programming with templates:** Introduction, function templates, overloaded function templates, class templates, inheritance of class template, class template with overloaded operators. **Exception Handling:** Exception types, nested try-catch, throw, throws and finally statements, Multi Thread Programming: thread creation, synchronization and priorities.	**7**

UNIT 4	**Introduction to Java:** Main method, objects and classes, objects on garbage collectible heap, reference variables, arrays and arraylist in Java, encapsulation, method arguments and return types, using the library and packages, inheritance, polymorphism, overriding methods, abstract classes and abstract methods, polymorphic references, deadly diamond of death problem, interfaces, constructor chaining, exception handling.	**10**
UNIT 5	**Advanced Topics:** GUI in Java, Swings, Input Output streams, Object Serialization, File operations. Networking concepts: connecting, sending and receiving, network sockets.	**8**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	Deitel, P., & Deitel, H. C++ How to Program: Introducing the New C++14 Standard. Pearson, 10th Edition, ISBN: 978-0134448237.	2016
2	Stroustrup, B. The C++ Programming Language. Pearson, 4th Edition, ISBN: 978-0321563842.	2013
3	Sierra, K., Bates, B., & Gee, T. Head First Java: A Brain-Friendly Guide. O'Reilly, 3rd Edition, ISBN: 978-1491910771.	2022
4	Balagurusamy, E. Programming with Java. McGraw Hill, 7th Edition, ISBN: 978-9355322575.	2023

PRACTICALS LIST	
1	Create a class named "Time" in C++ with three data members namely hour, minute and seconds. Create two member functions of the class namely "setTime" that sets the hour, minute and seconds for any object; and "print" function that prints the hour, minute, and seconds value for the object. Test the class by creating its two objects in main.
2	Write a program in C++ demonstrating the use of constructor (with no arguments), constructor (with parameterized arguments) and destructor. Create objects of that class in main and test those objects with these constructors and destructor function.
3	Write a C++ program illustrating the operator overloading of binary operators (addition and subtraction), and unary operators (prefix and postfix increment).
4	Implement inheritance in C++ program. Create a base class named Person (with data members first_name, and last_name). Derive a class named Employee from base class Person. The Employee class should include a data member named employee_id. Further a class named Manager should be derived from the class Employee and the Manager class should include two data members named employee_designation and employee_salary. Create at least three objects of class Manager, specify the values of all their attributes, and determine which manager has the highest salary.
5	Write a program in C++ demonstrating class templates.
6	Write a program in C++ demonstrating rethrowing an exception.

7	Create an inheritance hierarchy (any inheritance example of your choice) in JAVA. Create one super class and three sub classes should inherit from that super class. Also highlight the concept of function overriding and function overloading in your program. Create objects of sub classes and test you program.
8	Write a JAVA program explaining the working of constructors along with the super keyword.
9	Write a Java program consisting of abstract classes and abstract method(s). The first concrete sub class in the inheritance hierarchy must implement the abstract method(s). Create the objects of the concrete class and test your program.
10	Write a Java program explaining the working of static methods in a class.
11	Write a Java program implementing Swing Applet.

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC307: Artificial Intelligence	**L**	**T**	**P**	NIL
	3	**0**	**2**	

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

Course Outcome (CO):

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

S.No.	Contents	Contact Hours
UNIT 1	**Introduction:** AI Problems, Task Domains of AI, AI Techniques: search knowledge, abstraction. Introduction to Intelligent program and Intelligent agents. **Problem Solving:** Basic Problem solving Method: state space search, problem characteristics, issues in design of Intelligent search algorithm.	**8**
UNIT 2	**Heuristic search Techniques:** Hill climbing techniques, Best First search, Variable Neighbourhood Descent, Beam and Tabu Search, Simulated Annealing, Genetic Algorithms, A* Search, IDA*Recursive Best First Search. **Problem Reduction:** AO* Search, Constraint Satisfaction.	**9**
UNIT 3	**Planning:** Forward State Space Planning, Backward State Space Planning, Goal Stack Planning, Plan Space Planning. **Game Playing:** Game Tree, Searching procedure Minimax, alpha beta pruning	**8**
UNIT 4	**Knowledge Representation:** Knowledge Representation issues, Knowledge Representation using Predicate Logic: Unification, resolution, Rule based Systems: Forward versus backward reasoning, conflict resolution. Structured Knowledge Representation: Semantic Nets, Frames, conceptual dependency, scripts.	**9**
UNIT 5	**Programming Languages:** Fundamental and concepts of Programming languages like Prolog. Relationship of languages with knowledge representation and inferences. **Applications and Case Studies:** Expert Systems, Machine Learning, Natural Language Processing, Robotics, Generative AI etc.	**8**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	Khemani, D. A First Course in Artificial Intelligence. McGraw Hill Education, 6th Edition, ISBN: 978-9352606371.	2018
2	Rich, E., Knight, K., & Nair, S. Artificial Intelligence. McGraw Hill Education, 3rd Edition, ISBN: 978-1259029981.	2017
3	Russell, S., & Norvig, P. Artificial Intelligence: A Modern Approach. Pearson, 4th Edition, ISBN: 978-0134610993.	2022

PRACTICALS LIST	
1	Write a program to solve the 8-Puzzle problem using Generate and Test Strategy.
2	Write a program to solve the 8-Puzzle problem using DFID (Depth First Iterative Deepening) Strategy.
3	Write a program to solve the 3- SAT Problem using Variable Neighbourhood Descent Algorithm.
4	Write a program to solve the 3- SAT Problem using Stochastic Hill Climbing Algorithm.
5	Write a program to solve the 8- Puzzle using A* Algorithm.
6	Write a program to implement AO* search algorithm on any AND OR graph.
7	Write a program in Prolog to find a maximum of two/three numbers.
8	Write a program in Prolog to find the factorial of a number.
9	Write a program in Prolog to find the sum of first N numbers.
10	Write a program in Prolog to find Fibonacci sequence upto Nth term.
11	Consider the following statements of a knowledge database: • Prakash likes food if the food is edible and it tastes sweet. • Chocolates taste sweet. • Toffees taste sweet. • Gourd tastes bitter. • Chocolates are edible. • Toffees are edible. • Gourds are edible. Write a program to represent the above statements in Prolog. Further ask a question/query in Prolog such that the output of the question should be Chocolates Toffees No

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC308: Computer Graphics	**L**	**T**	**P**	NIL
	3	**0**	**2**	

Course Objective: To learn how various objects and backgrounds are rendered and transformed on the screen.

Course Outcome (CO):

CO1	Define and explain fundamental concepts and analyze the performance trade-offs of various scan conversion and filling algorithms.
CO2	Apply and evaluate geometric transformations on 2D/3D objects and their composite applications.
CO3	Compare and contrast the trade-offs of various clipping methods.
CO4	Analyze projections and visible surface detection techniques for 3D scene display on 2D screen.
CO5	Draw realistic scenes using illumination models and shading techniques to enhance its visualization.

S.No.	Contents	Contact Hours
UNIT 1	**Overview of Computer Graphics:** Usage of Graphics and their applications, Overview of Graphics Systems, Refreshing display devices, Random and raster scan display devices, Colour Models- RGB, HSV etc., Tablets, Joysticks, Trackballs, Mouse and light pens, plotters, printers, digitizers.	**6**
UNIT 2	**Output primitives:** DDA Line drawing algorithm, Bresenham's Line Drawing Algorithm, Midpoint circle algorithm, Mid-point Ellipse algorithms, Filling algorithms, Boundary fill and flood fill algorithms, Scan-line filling, Character generation, Line attributes, Fill styles, Anti- aliasing.	**7**
UNIT 3	**Transformations:** Basic 2D Transformations, Matrix representations & Homogeneous Coordinates, Matrix Representations for basic 2D and 3D transformations, Composite Transformations, Reflection and Shear transformations, Affine transformation, Transformations between coordinate systems.	**7**
UNIT 4	**Two dimensional viewing:** The viewing Pipeline, Viewing Coordinate Reference Frame, Window-to-Viewport Coordinate Transformation, Two Dimensional Viewing Functions, Barky line clipping algorithm, Algorithm for polygon clipping, Sutherland-Hodgeman polygon clipping, Cyrus Beck Algorithm, Wailer-Atherton polygon clipping, curve clipping, Text clipping.	**8**
UNIT 5	**Curves and Surfaces:** Representation of surfaces, Polygon meshes, Plane equations, Parametric cubic curves, Hermite Curves, Bezier Curves, 4-point and 5-point Bezier curves using Bernstein Polynomials, Conditions for smoothly joining curve segments, Bezier bi-cubic surface patch, B-Spline Curves, Cubic B-Spline curves using uniform knot vectors, Testing for first and second order continuities.	**7**

UNIT 6	**Projection:** Parallel Projection, Oblique Projection on XY plane, Isometric Projection, Perspective Projection, One Vanishing Point (V.P.) projection, Generation of 2 V.P. Projection, planar geometric projections. **Shading and Hidden Surface Removal:** Shading, Illumination Model for diffused Reflection, Effect of ambient lighting, distances, Specular Reflection Model, Computing Reflection Vector, Curved Surfaces, Polygonal Approximations, Guard Shading, Phong Model, Hidden Surface Removal, Back Face Detection, Depth Buffer (Z-Buffer, A-Buffer) Method, Scan Line Method, Depth Sorting Method, Area Subdivision Method.	**7**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication / Reprint
1	Hearn, D., & Baker, M. P. Computer graphics. Prentice Hall, 2nd Edition, ISBN: 978-0-13-161530-4.	1994
2	Plastock, R., & Kalley, G. Theory and Problems of Computer Graphics. Schaum's Series, McGraw Hill, 1st Edition, ISBN: 978-0070502571.	1986
3	Foley, J., van Dam, A., Feiner, S., & Hughes, J. Computer Graphics: Principles & Practice. Addison Wesley, 2nd Edition, ISBN: 978-0201848403.	1999

PRACTICALS LIST	
1	Write a program on a platform of your choice that displays any scene or any object like car, house trees, flowers, cartoon, etc.
2	Write a program to draw a hut using DDA algorithm.
3	Write a program to draw a car (without tyres) using Mid-Point algorithm
4	Write a program to draw sun using the Midpoint Circle drawing algorithm.
5	Write a program to draw a teddy bear using the Midpoint algorithm for drawing an Ellipse.
6	Write a program to clip lines using Cohen Sutherland Algorithm.
7	Write a program to clip lines using Cyrus Beck Algorithm.
8	Write a menu-driven program to fill the Concave polygon using a) Boundary Fill method b) Flood Fill method and c) Scan Fill method.
9	Write a menu-driven program to perform various 2D transformations on an object.
10	Write a program to perform concave polygon clipping using a) Sutherland-Hodgeman polygon clipping and b) Wailer-Atherton polygon clipping algorithms.
11	Write a program to implement the Z-buffer algorithm. Perform the algorithm on a set of at least 5 objects in a viewing coordinate system.

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC309: Number Theory	**L**	**T**	**P**	Elementary School Level number theory
	3	**1**	**0**	

Course Objective: Even though number theory is one of the oldest disciplines in mathematics, it has recently contributed to many practical problems such as coding theory, cryptography or other tools in modern information technology. The aim is to impart knowledge of numbers theory and its applications.

Course Outcome (CO):

CO1	Apply Euclid's algorithm in divisibility/daily life problems
CO2	Solve linear congruence equations. Apply the congruence properties in finding divisibly of a number by 2,3,4 etc. and other daily life problems
CO3	Describe various arithmetical functions like Euler phi function and apply these in simplifying various arithmetical problems.
CO4	Analyse relation between Quadratic residue and Legendre's symbols and solve quadratic congruences.
CO5	Generate encrypted information and decrypt it.

S.No.	Contents	Contact Hours
UNIT 1	**Divisibility and factorization:** Division algorithm, greatest common divisor, Euclid's algorithm, linear equations and its theorem, fundamental theorem of arithmetic.	**7**
UNIT 2	**Congruences:** Linear congruence theorem, solution of linear congruence, simultaneous linear congruences, Chinese Remainder Theorem, Wilson's theorem, Fermat's theorem, Euler's theorem.	**8**
UNIT 3	**Arithmetic functions:** Arithmetic function, multiplicative functions Moebius function, Moebius inversion formula, Euler phi function, Euler's formula, τ - function, σ - function, perfect numbers, characterization of even perfect numbers.	**9**
UNIT 4	**Prime numbers and Quadratic reciprocity:** Prime number, Euclid's theorem, Fermat primes, Mersenne primes, Dirichlet's theorem on primes, Legendre and Jacobi symbols, Euler's criterion, Gauss's lemma, law of quadratic reciprocity.	**9**
UNIT 5	**Cryptology:** Character cipher, public key encryption, some algorithm for encryption and decryption, RSA crypto system.	**9**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1.	David M. Burton; Elementary Number Theory, McGraw Hill Education, 7th Edition.	2012
2.	Joseph H. Silverman; A friendly Introductory Number Theory, Pearson, 3rd Edition.	2009
3.	K.H. Rosen; Elementary Number Theory and its Application, McGraw Hill,5th Edition ISBN 0-21-87073-8	2015
4.	G.A. Jones and J.M. Jones; Elementary Number Theory, Springer	1998
5.	I Niven, H. Zuckerman, and H. Montgomery; An Introduction to the Number Theory, Wiley, 5th Edition ESBN: 0-471625469.	1991

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC310: Machine Learning	**L**	**T**	**P**	Probability and Statistics, Linear Algebra
	3	**0**	**2**	

Course Objective: This course provides a comprehensive introduction to machine learning, covering fundamental concepts, techniques, and applications. Students will learn about supervised and unsupervised learning, model evaluation, and practical implementation using popular programming tools.

Course Outcome (CO):

CO1	Recall the fundamental problems in Machine Learning (ML) and key ML tasks. Identify different types of learning techniques.
CO2	Explain the components of ML and describe the working principles of various ML algorithms.
CO3	Implement and apply supervised and unsupervised learning algorithms to solve real-world classification problems.
CO4	Analyze and identify their strengths and weaknesses in solving specific types of problems. Critique on supervised and unsupervised learning algorithms
CO5	Design and develop the ML algorithms related to real-world case studies.

S.No.	Contents	Contact Hours
UNIT 1	**Introduction:** Introduction to Machine Learning (ML), Fundamental Problems in ML, Examples of Automatic ML System. Overview of Different ML Tasks: Supervised Learning, Unsupervised Learning, Reinforcement Learning. Components of ML.	**7**
UNIT 2	**Supervised Learning:** K-Nearest Neighbors, Bayesian Classification, Naïve Bayes, Linear Discriminant Analysis, Linear Regression, Logistic Regression, Multilayer Perceptron, Support Vector Machine, Decision Trees.	**12**
UNIT 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.	**7**
UNIT 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.	**8**

UNIT 5	**Reinforcement Learning:** Markov Decision Processes (MDP), Bellman's Equations, Value Iteration and Policy Iteration, Value Function Approximation, Q Learning. Review on Deep Learning Models.	**8**
	TOTAL	**42**

Suggested Books:

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

PRACTICALS LIST	
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.

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC311: Numerical Linear Algebra	**L**	**T**	**P**	Linear Algebra, Scientific Computing
	3	**1**	**0**	

Course Objective: The objective of this course is to develop a comprehensive understanding of numerical methods in linear algebra, students will gain proficiency in algorithm implementation and sensitivity analysis for efficient, stable solutions.

Course Outcome (CO):

CO1	Compute the condition number and analyze the numerical stability, demonstrating an understanding of error propagation.
CO2	Perform sensitivity analysis on linear systems and least squares problems by evaluating the impact of perturbations in data and model parameters, including sensitivity of eigenvalues, eigenvectors, singular values and singular vectors.
CO3	Implement and apply various matrix factorization techniques such as LU decomposition, Cholesky decomposition, and QR factorization to solve linear systems and least squares problems.
CO4	Evaluate and compare the efficiency and numerical stability of different algorithms for solving linear systems, least squares problems, and the eigenvalue problem using matrix norms.
CO5	Implement iterative methods such as Gauss-Seidel, Successive Over Relaxation (SOR), Conjugate Gradient, and Krylov Subspace Methods for large-scale linear systems and eigenvalue problems.

S.No.	Contents	Contact Hours
UNIT 1	Floating point computations, IEEE floating point arithmetic, analysis of round off errors, Sensitivity analysis and condition numbers, Linear systems, Gaussian elimination with partial pivoting, Gauss-Jacobi, LU decompositions, Gauss-Seidel and successive over relaxation methods.	**10**
UNIT 2	Banded systems, positive definite systems, Cholesky decomposition - sensitivity analysis, Gram-Schmidt orthonormal process, Householder transformation. Solution of linear least squares problems.	**8**
UNIT 3	Normal equations, singular value decomposition (SVD), Moore-Penrose inverse, Rank deficient least squares problems, Sensitivity analysis of least squares problems, Sensitivity of eigenvalues and eigenvectors.	**9**
UNIT 4	Reduction to Hessenberg and tridiagonal forms; Power, inverse power and Rayleigh quotient iterations, Explicit and implicit QR algorithms for symmetric and non-symmetric matrices.	**8**
UNIT 5	Reduction to bi-diagonal form, Sensitivity analysis of singular values and singular vectors, Krylov subspace methods, conjugate gradient method.	**7**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	B.N. Datta, Numerical Linear Algebra and Applications, 2nd Edition, SIAM.	2010
2	G. H. Golub and C. F. Van Loan, Matrix Computations, 4th edition, John Hopkins University Press.	2013
3	Lloyd N. Trefethen and D. Bau, Numerical Linear Algebra, SIAM.	1997
4	M. K. Jain, S. R. K. Iyengar, R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publishers.	2022

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC312: Wireless and Mobile Computing	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To understand the concept of wireless communication, mobile computing paradigm, its novel applications and limitations.

Course Outcome (CO):

CO1	Explain the wireless and cellular telephone concepts.
CO2	Analyze security, energy efficiency, mobility, scalability, and their unique characteristics in wireless networks.
CO3	Compare various security and routing protocols for wireless networks.
CO4	Describe wireless networking protocols and their architecture.
CO5	Develop various mobile computing applications along with their computation methods and algorithms.

S.No.	Contents	Contact Hours
UNIT 1	**Introduction**: Issues in mobile computing, overview of wireless telephony: cellular concept, GSM: air-interface, channel structure, location management: HLR, VLR, hierarchical, handoffs, channel allocation in cellular systems, Cellular telephone, Digital Cellular Standards, Call Routing in GSM , Satellite Technology, FDMA, TDMA, CDMA and GPRS.	**8**
UNIT 2	**Wireless Networking:** Wireless LAN Overview: MAC issues, PCF, DCF, Frame types, addressing, IEEE 802.11 standards, Bluetooth: Architecture , Layers and protocols, Wireless multiple access protocols, TCP over wireless, Wireless applications, data broadcasting, Mobile IP, WAP: Architecture, protocol stack, application environment, applications, WAP application environment(WAE), WML, WSP, WTP and WTLS, Software Defined Networks.	**9**
UNIT 3	**Data management**: Issues, data replication for mobile computers, Replication through data allocation, User profile replication scheme, optimistic replication and active replication, adaptive clustering for mobile wireless networks. **Mobile Agents computing:** Introduction, Advantages, Application Domains; security and fault tolerance: Protecting server, code signalling, Firewall approach; security techniques and algorithms: DES, 3DES, AES, Diffie Hellman, RSA and Elliptic curve.	**9**
UNIT 4	**Ad Hoc networks:** Localization, Routing protocols: Global state routing (GSR), Destination sequenced distance vector routing (DSDV), Fisheye state routing(FSR), Dynamic source routing (DSR), ABR, Route Discovery, Route Repair/Reconstruction, Establishment, Maintenance; Ad Hoc on demand distance vector routing (AODV).	**9**

UNIT 5	**Transaction processing in mobile computing environment:** Structure, properties, Data consistency, Transaction relation, Recovery and wireless data Dissemination. Temporary ordered routing algorithm (TORA), Quality of Service in Ad Hoc Networks and applications, Advancements in Mobile Computing.	**7**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	Kamal, R. Mobile Computing. Oxford Press, 3rd Edition, ISBN: 978-0199455416.	2018
2	Kute, V. Adhoc and Wireless Networks. Notion Press, 1st Edition	2023
3	Athawale, S. V. Ad-Hoc and Wireless Sensor Network. Pearson, 1st Edition	2022
4	Olin, B. Handbook of Wireless and Mobile Communications. Willford Press, 1st Edition	2016

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC313: Operations Research	**L**	**T**	**P**	NIL
	3	**0**	**2**	

Course Objective: The objective of the course is to identify and develop operational research models from the verbal description of the real system. Understand the mathematical tools that are needed to solve optimization problems. Use mathematical software to solve the proposed models.

Course Outcome (CO):

CO1	Solve linear programming problems using appropriate techniques and optimization solvers, interpret the results obtained.
CO2	Analyze any real-life system with limited constraints and depict it in a model form.
CO3	Determine optimal strategy for Minimization of Cost of shipping of products from source to Destination/Maximization of profits of shipping products using various methods, Finding initial basic feasible and optimal solution of the Transportation problems.
CO4	Analyze 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.

S.No.	Contents	Contact Hours
UNIT 1	Introduction to Operations Research, Linear Programming Problems: basic concepts, general and standard forms of LPP, Mathematical formulation, Feasible region, extreme points and basic feasible solutions, Optimal solution determination by using Graphical method and Simplex method, Two phase method, Big M method.	**10**
UNIT 2	Duality in LPP: Dual problem, Duality theorems, Strong and Weak Duality Complementary slackness, Economic interpretation of duality, Dual simplex method, Sensitivity analysis (Post Optimality Analysis).	**10**
UNIT 3	Integer programming Problems: Problem formulation, Branch and bound method, Cutting plane algorithm, Applications of LPP and ILPP.	**8**
UNIT 4	Transportation and Assignment models: Transportation Problem, Duality of Transportation problem, Degeneracy in transportation problem, Solution of Transportation problem (by stepping stone and modified distribution methods), assignment problem, Hungarian method, Travelling salesman Problem.	**7**
UNIT 5	Network Scheduling: Network and basic components, Network construction, Critical path method (CPM), Program evaluation and review techniques (PERT), Cost of completing project.	**7**
	TOTAL	**42**

Suggested Books:

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

PRACTICALS LIST	
1	Solving Linear Programming Problem using Simplex Method in Tora.
2	Solving Linear Programming Problem using Two Phase Method in Tora.
3	Solving Linear Programming Problem using Big M Method in Tora.
4	Solving Linear Programming Problem using Dual Simplex Method in Tora.
5	Solving LPP problem and apply sensitivity analysis on Tora software.
6	Solving IPP (Integer Programming Problem) problem on Tora software.
7	To solve transportation problem in Tora. Finding Initial basic feasible solution using: 1) N-W corner method 2) Least cost method 3) Vogel's Approximation method
8	To solve Assignment problem in Tora.
9	To implement Critical path method using Tora.
10	To implement project evaluation & review technique using Tora.

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC314:	**L**	**T**	**P**	Linear Algebra
Quantum Information Theory	**3**	**1**	**0**	

Course Objective: The Objective of the course is to provide elementary or introductory knowledge of quantum information theory.

Course Outcome (CO):

CO1	Apply the knowledge of abstract Hilbert space in the field of quantum information theory.
CO2	Demonstrate an understanding of the basic concept of quantum computing.
CO3	Describe the physical properties of a quantum states that allow them to encode information in it.
CO4	Identify the effect of quantum noise.
CO5	Demonstrate an understanding of the theory of entanglement that has no classical analogue.

S.No.	Contents	Contact Hours
UNIT 1	Formalism of quantum information: Hilbert space and Dirac notation, Operators on Hilbert space, Postulates of quantum mechanics, Composite systems.	**8**
UNIT 2	Quantum Computation: Qubits, Quantum gates, Universal gate sets, The quantum Fourier transform, Some quantum algorithms.	**8**
UNIT 3	Density operator: Ensembles of quantum states, General properties, Bloch sphere representation, Reduced density operator, Schmidt decomposition and purification.	**9**
UNIT 4	Quantum Noise and Quantum Operations: Environments, Operator sum representation, Kraus representation theorem, Freedom in the operator sum representation, Examples of single qubit quantum noise.	**9**
UNIT 5	Theory of Entanglement: EPR paradox, Bell's inequality, Maximally and non-maximally entangled state, Non-locality, Separability problem, Entanglement measures, Entanglement as a resource in quantum communication.	**8**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication / Reprint
1	Quantum Computation and Quuantum Information – M. A.Nielsen And I. L. Chuang, Cambridge University Press.	2002
2	Quantum Information Theory- Mark. M. Wilde, Cambridge University Press.	2017
3	Quantum information: An introduction to basic theoretical concepts and experiments - G. Alber, T. Beth, M. Horodecki, P. Horodecki, R. Horodecki, M. Rotteler, H. Weinfurter, R. Werner, and A. Zeilinger, Springer.	2003
4	Introduction to quantum computation and information - H. K. Lo, T. Spiller, & S. Popescu, World Scientific.	1998
5	Elements of information theory –Thomas M. Cover, Joy.A. Thomas, New York: Wiley Interscience.	2006
6	Quantum Computing- A Gentle Introduction, E. Rieffel, W. Polak, MIT Press.	2011

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC315: Partial Differential Equations	**L**	**T**	**P**	Ordinary differential equations, multivariable calculus, Fourier series and Fourier transforms.
	3	**1**	**0**	

Course Objective: The Objective of the course is to introduce Partial Differential Equations, apply analytical methods, and interpret solutions in a physical context.

Course Outcome (CO):

CO1	Classify and form partial differential equations (PDEs), apply a range of techniques to find solutions of first order partial differential equations.
CO2	Identify the initial and boundary values problems for second and higher-order PDEs, transform second-order PDEs to canonical or normal form, distinguish qualitative differences between elliptic, parabolic and hyperbolic equations, solve second-order equations using various methods.
CO3	Demonstrate capacity to model physical phenomena using classical PDEs such as the wave equation, the Laplace equation and the heat (diffusion) equation.
CO4	Determine accurate and efficient use of Fourier analysis techniques and their applications in the theory of PDEs for some standard second-order PDEs.
CO5	Apply problem-solving using concepts and techniques from PDEs like Duhamel principle, maximum and minimum principles etc. and Fourier analysis applied to diverse situations in physics, engineering and in other mathematical contexts.

S. No.	Contents	Contact Hours
UNIT 1	First order partial differential equation (PDEs): Origin of PDEs, classification of first order PDEs, Lagrange method, integral surface passing through a given curve, surfaces orthogonal to a given system of surfaces, Cauchy's method of characteristics, Charpit's method and Jacobi's method.	**9**
UNIT 2	Second order PDEs: Classification of second order PDEs, reduction to canonical or normal forms, characteristics curves of second order equations, initial and boundary value problems, method of separation of variables, Monge's method.	**9**
UNIT 3	Wave equation: Derivation and Physical interpretation, infinite and semi-infinite string problems, d'Alembert solution of the wave equation, Fourier series solution of the wave equation, inhomogeneous wave equation.	**8**
UNIT 4	Heat equation: Physical interpretation, maximum and minimum principles, Fourier series solution of the heat equation, heat conduction in finite and infinite media, solution by Fourier transforms, inhomogeneous heat equation.	**8**
UNIT 5	Laplace equation: Physical interpretation, boundary value problems for Laplace, maximum and minimum principles, Green's identity and fundamental solution, Dirichlet's problem for upper half plane and rectangle, Neumann problem for a rectangle and upper half plane.	**8**
	TOTAL	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1	David Bleecker and George Csordas, Basic Partial Differential Equations, International Press.	2003
2	I. N. Sneddon, Elements of Partial Differential Equations, Dover Publications.	2006
3	E. Kreyszig, Advanced Engineering Mathematics, Wiley.	2020
4	Peter V. O' Neil, Advanced Engineering Mathematics, Cengage Learning.	2023
5	Phoolan Prasad and R. Ravindran, Partial Differential equations, New Age International.	2011

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC316: Computer Organization and Architecture	**L**	**T**	**P**	**NIL**
	3	**1**	**0**	

Course Objective: To provide knowledge about the principles, concepts and applications of Computer Organization and Architecture.

Course Outcome (CO):

CO1	Describe the basic structure of the computer and control unit, and also evaluate, and perform various micro-operations.
CO2	Explain and analyze memory organization and design principles for the evaluation of instruction set architecture.
CO3	Design pipeline and demonstrate and conceptualize instruction-level parallelism.
CO4	Classify and examine the concept of memory and cache mapping techniques.
CO5	Analyze and elaborate the concept of I/O organization.

S.No.	Contents	Contact Hours
UNIT 1	**Introduction:** Fundamentals of Gates and Flip Flops, Karnaugh's Map simplification, Digital computer generation, computer types and classifications, functional units and their interconnections, Bus architecture, types of buses and bus arbitration. Register, bus and memory transfer. **Register Transfer Language:** Data movement around registers, Data movement from/to memory. Arithmetic, and logic micro-operations. Concept of bus and timing in register transfer.	**9**
UNIT 2	**Central Processing Unit:** Addition and subtraction of signed numbers look ahead carry adders. Multiplication: Signed operand multiplication, Booth's algorithm, and array multiplier. Division and logic operations. Floating point arithmetic operation, Processor organization, general register organization, stack organization and addressing modes.	**8**
UNIT 3	**Control Unit:** Instruction types, formats, instruction cycles and subcycles (fetch and execute, etc.), micro-operations, execution of a complete instruction, Interrupts: interrupt hardware, types of interrupts and exceptions. RISC and CISC. **Pipelining:** instruction pipeline, performance evaluation, types of pipelines, dependencies in pipeline. **Hardwired and microprogrammed control:** Microprogrammed sequencing, wide branch addressing, and microinstruction with next address field, concept of horizontal and vertical programming.	**9**
UNIT 4	**Memory:** Basic concept and hierarchy, Main memory, Auxiliary memory, Associative memory, Cache memories: concept and design issues, associative mapping, direct mapping, set-associative mapping, cache writing and initialization.	**8**

UNIT 5	**Input/Output Organization:** Peripheral devices, I/O interface, I/O ports, Priority Interrupt, Asynchronous Data transfer, Modes of Data Transfer: Programmed I/O, interrupt initiated I/O and Direct Memory Access. I/O channels and processors. Serial Communication: Synchronous & asynchronous communication, standard communication interfaces.	**8**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	Mano, M. M. Computer System Architecture. Pearson Education, 3rd edition, ISBN: 978-9332585607.	2016
2	Patterson, D. A., & Hennessy, J. L. Computer Organization and Design. MK Publications, Elsevier, ISBN: 978-0124077263.	2013
3	Stallings, W. Computer Organization and Architecture: Designing for Performance. Pearson Education, 9th edition, ISBN: 978-0132936330.	2013

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC318:	**L**	**T**	**P**	**NIL**
Software Engineering	**3**	**1**	**0**	

Course Objective: To introduce the fundamentals of software engineering, including requirements specifications, software design, testing and maintenance.

Course Outcome (CO):

CO1	Describe software characteristics, its components and applications, and demonstrate the ability to apply software development life cycle models in software projects.
CO2	Summarize and organize software requirements from clients, analyze, document and verify them.
CO3	Apply software design concepts to meet the specific requirements of customers with consideration of factors such as cost, reusability, maintenance, flexibility, reliability and ethics.
CO4	Demonstrate the ability to apply software project management concepts to deliver a high-quality product on time and within budget. Apply the knowledge of modelling, measurement and improvement of software reliability.
CO5	Evaluate an attribute of a program or a system by applying various testing techniques.

S.No.	Contents	Contact Hours
UNIT 1	**Introduction:** Software characteristics, software components, software applications, software engineering principles, software engineering challenges. Software process models - waterfall model, V model, incremental model, iterative enhancement model, rapid application development model, evolutionary process models, prototyping, spiral model, concurrent models, agile.	**8**
UNIT 2	**Software Requirements:** Requirement engineering process, types of requirements, requirements elicitation techniques, requirements analysis, requirements documentation, and requirements validation, models for requirements analysis: data flow diagrams, entity relationship diagrams, and data dictionaries.	**6**
UNIT 3	**Software Design:** Conceptual and technical designs, objectives of design, design principles: problem partitioning, abstraction, modularity, top-down and bottom-up design strategies; coupling and cohesion. Function oriented design, Object oriented design. **Software metrics:** categories of metrics, token count, data structure metrics, information flow metrics, size estimation: Lines of code, function count.	**8**
UNIT 4	**Software Project Management:** project management concepts, cost estimation, project planning, project scheduling, COCOMO model, Putnam resource allocation model, software risk management. **Reliability and Quality Assurance:** Software reliability concepts, software quality models, software reliability models, capability maturity model.	**10**

UNIT 5	**Software Testing:** Terminologies, testing process, verification and validation, alpha and beta testing, acceptance testing, functional testing, structural testing, validation testing, debugging. Levels of testing: unit testing, integration testing, and system testing. **Software Maintenance:** Maintenance process, structured and unstructured maintenance, maintenance models, maintenance cost estimation, reverse engineering, software re-engineering, configuration management. Use case for product development.	**10**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	Pressman, R. S. Software Engineering: A Practitioner's Approach. McGraw Hill, 9th Edition, ISBN: 978-1259872976.	2020
2	Sommerville, I. Software Engineering. Pearson, 9th Edition, ISBN: 978-0137035151.	2016
3	Jalote, P. An Integrated Approach to Software Engineering. Narosa, 3rd Edition, ISBN: 978-8173197024.	2005
4	Aggarwal, K. K., & Singh, Y. Software Engineering. New Age International, 2nd Edition, ISBN: 978-8122416381.	2005
5	Peter, J., & Pedrycz, W. Software Engineering: An Engineering Approach. Wiley, ISBN: 978-0471713456.	2007

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC320: Web Technology	**L**	**T**	**P**	NIL
	3	**0**	**2**	

Course Objective: Understand the Internet and the Web, including their evolution, development, and ongoing research in the field.

Course Outcome (CO):

CO1	Identify fundamental networking principles and describe their role in web communication.
CO2	Explain the concepts of email, Telnet, and Usenet, and examine the evolution of the web from Web 1.0 to Web 3.0 by comparing key advancements.
CO3	Design responsive web pages and develop dynamic websites using modern web development technologies.
CO4	Implement database connectivity with web applications for dynamic content management.
CO5	Utilize web search strategies, analyze web mining techniques, and construct efficient workflows for extracting and processing web data.

S.No.	Contents	Contact Hours
UNIT 1	**Inter-Networking:** Internet, Growth of Internet, Owners of the Internet, Anatomy of Internet, APRANET and Internet history of the World Web, Basic Internet Terminology, Net etiquette. Working of Internet: Packet switching technology. **Internet Protocols:** TCP/IP, Router. Internet Addressing Scheme: Machine Addressing (IP address), E-mail Address, Resource Addresses.	**6**
UNIT 2	**Internet Applications:** E-mail, file transfer (FTP), telnet, usenet, Internet chat, Web. Evolution of Web: Web 1.0, Web 2.0: From 1.0 to 2.0, Web 3.0: From 2.0 to 3.0; Semantic Web: What, How, Why; From Web 3.0 to Web 4.0.	**6**
UNIT 3	**Web Development:** Phases; Web Page, Website, and Web Application: Example, Technology Framework for development. **Client-side technology:** HTML (HTML 5). Client-side scripting: JavaScript.	**9**
UNIT 4	**Server-side technologies:** PHP, Node.js, React, and Angular. Introduction to Microservices and Web Services.	**12**
UNIT 5	**Database Connectivity:** JDBC, ODBC; Database-to web connectivity. **Recent trends on web:** Web search and mining, search engine optimization, web mining taxonomy, web mining frameworks, and social web mining.	**9**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	Kumar, A. Web Technology: Theory and Practice. Chapman & Hall/CRC, 1st Edition, ISBN: 978-1138550438.	2018
2	Gopalan, N. P., & Akilandeswari, J. Web Technology: A Developer's Perspective. PHI Publication, 2nd Edition, ISBN: 978-8120350069.	2014
3	Levene, M. An Introduction to Search Engines and Web Navigation. Pearson Education, ISBN: 978-0470526842.	2010
4	Sarukkai, R. R. Foundations of Web Technology. Kluwer Academic Publishers, ISBN: 978-0792376445.	2002
5	Willard, W. HTML: A Beginner's Guide. Tata McGraw-Hill, ISBN: 978-0071496299.	2009

PRACTICALS LIST	
1	Getting files from server via HTTP using request, response, general and entity headers.
2	Post messages to the server via electronic mail using PHP or Node.js.
3	Post messages to server via SMTP
4	Design a webpage with HTML, document features and tag attributes having facilities for inserting table, form and text boxes.
5	Design a multimedia-rich webpage with images, audio, and video.
6	Design a webpage for enrollment of students which accepts complete details of students.
7	Create a web page with all types of Cascading style sheets.
8	Write a java script function to display current date and time dynamically.
9	Design a simple Calculator by using HTML, CSS, and JavaScript.
10	Develop a User Registration and Login System using server-side technologies and database.

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC322: Graph Theory	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: The objective of this course is to introduce and elucidate fundamental concepts in graph theory, and to develop and define new graph models that effectively represent and solve standard problems in various domains.

Course Outcome (CO):

CO1	Define fundamental graph terminology.
CO2	Develop and critically analyze graph traversal algorithms, shortest path algorithms, and the Max-Flow algorithm, evaluating their efficiency and application in real-world scenarios.
CO3	Define and characterize the fundamental properties of trees, including terminology, and implement minimum spanning tree algorithms.
CO4	Illustrate the concepts of cut vertices, bridges, and edge connectivity, explaining their importance in determining and analyzing the robustness and resilience of networks.
CO5	Describe the principles of graph coloring, including chromatic number and its variants, and apply these concepts to solve practical problems.

S.No.	Contents	Contact Hours
UNIT 1	Introduction: Graphs, Sub graphs, Some basic properties of graphs and sub graphs, Isomorphism, Various types of graphs and their sub graphs , trails, walks, paths, circuits and cycles, connected graphs, disconnected graphs and components, various operations on graphs, Eulerian graphs, Hamiltonian paths and cycles, Adjacency and incidence matrices of a graph, shortest path, algorithms to find shortest path.	**10**
UNIT 2	Hamiltonian and Eulerian Graphs: Necessary conditions for Hamiltonian graphs, sufficient conditions for Hamiltonian graphs, traveling salesman problem, characterization of Eulerian graphs, construction of Eulerian tour, The Chinese postman problem.	**8**
UNIT 3	Trees: Characterization of trees, rooted and binary trees, spanning trees and their properties, spanning trees in weighted graphs, minimum spanning tree, algorithms for minimum spanning tree.	**8**
UNIT 4	Cut Vertices and Edge Connectivity: Cut vertices, cut sets and their properties, the max-flow min-cut theorem, max-flow algorithm, connectivity and Edge connectivity.	**8**
UNIT 5	Coloring of Graphs: Coloring, proper coloring, chromatic number, chromatic partitioning, a maximal independent set, matching, maximum matching in bipartite graphs and in general graphs.	**8**
	TOTAL	**42**

Suggested Books:

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

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC324:	**L**	**T**	**P**	NIL
Fuzzy Sets and Fuzzy Logic	**3**	**1**	**0**	

Course Objective: Humans have a remarkable capability to reason and make decisions in an environment of uncertainty, imprecision, incompleteness of information, and partiality of knowledge, truth and class membership. The principal objective of fuzzy logic is formalization/mechanization of this capability by providing an understanding of the basic mathematical elements of the theory of fuzzy sets, fuzzy logic inference with emphasis on their use in the design of intelligent or humanistic systems. Provide an insight into fuzzy inference applications.

Course Outcome (CO):

CO1	Classify vagueness and uncertainty in knowledge formally using the systematic approach.
CO2	Analyze different applications based on fuzzy model, represent "vague" knowledge formally and describe the impact on popular dynamical systems.
CO3	Identify the fuzzy logic and fuzzy inference systems and make applications on Fuzzy logic membership function and fuzzy inference systems.
CO4	Identify the basic fuzzy theory with some of the traditional design approaches.
CO5	Create fuzzy logic based controllers and list their unique characteristics.

S.No.	Contents	Contact Hours
UNIT 1	Fuzzy sets versus crisp sets, membership functions, operations on fuzzy sets, complements, intersections, unions and their combinations, alpha-cut, fuzzy numbers, fuzzy equations.	**9**
UNIT 2	Crisp versus fuzzy relations, binary fuzzy relations, equivalence relations, compatibility relations, ordering relations, fuzzy relational equation, fuzzy morphisms.	**8**
UNIT 3	Classical logic versus fuzzy logic, multivalued logics, fuzzy propositions, fuzzy quantifiers, Linguistic Hedges, influence from conditional fuzzy propositions, conditional and qualified propositions, quantified propositions.	**8**
UNIT 4	Fuzzy Modus Ponens and Generalized Fuzzy Modus Ponens. Single Rule with single antecedent, Single Rule with multiple antecedents, multiple rule with multiple antecedent, Mamdani's General Model.	**9**
UNIT 5	Defuzzification methods, Takagi-Sugeno-Kang Inference Method, Fuzzy controllers.	**9**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	George J. Klir, Bo Yuan, Fuzzy Sets and Fuzzy Logic Theory and Applications, Prentice Hall of India Pvt. Ltd.	1995
2	H. J. Zimmerman, Fuzzy Set Theory and its Applications, Fourth edition, Springer.	2012
3	Timothy J. Ross, Fuzzy Logic with Engineering Applications, Third edition, Wiley.	2013
4	Suresh Chandra, Aparna Mehra, Abha Aggarwal, Fuzzy Sets and Applications: Modelling Logic and Decision making, First edition, Narosa publication.	2024

IV Year

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC404: Numerical Methods for PDE	**L**	**T**	**P**	Some knowledge of numerical methods, PDEs and MATLAB
	3	**1**	**0**	

Course Objective: The objective of this course is to learn computational solution of PDEs.

Course Outcome (CO):

CO1	Classify partial differential equations (PDEs), identify mathematical models in engineering, and adapt basic concepts like accuracy, consistency, and stability associated with the numerical methods.
CO2	Solve elliptic PDEs using numerical methods, analyze numerical methods for consistency, stability and convergence
CO3	Apply numerical methods such as Jacobi, Gauss-Seidel, Crank-Nicolson, and Lax-Wendroff to solve engineering problems involving parabolic and hyperbolic PDEs.
CO4	Analyze the stability, consistency, and convergence of finite difference methods used for solving PDEs, using techniques like the CFL condition and Von Neumann stability analysis.
CO5	Explain the existence, uniqueness, and regularity of weak solutions, calculate and assemble the stiffness matrix, and apply finite element method to solve 1D and 2D problems

S. No.	Contents	Contact Hours
UNIT 1	Introduction to Partial Differential Equations(PDEs) - Classification of PDEs, Examples of PDEs in engineering: Heat equation, Wave equation, Laplace equation. Analytical methods: separation of variables, Fourier series solution. Introduction to Numerical Methods: Basic concepts, accuracy, consistency, and stability.	**10**
UNIT 2	Finite Difference Methods for Elliptic PDEs - Finite difference approximations. Solution of Laplace and Poisson Equations: Five-point and nine-point formulae. Consistency, stability and Convergence of different schemes.	**10**
UNIT 3	Finite Difference Methods for Parabolic PDEs - Explicit and Implicit Schemes: Euler, Crank-Nicolson schemes for parabolic equations. Consistency, Stability and convergence: CFL condition, Von Neumann stability analysis.	**8**
UNIT 4	Finite Difference Methods for Hyperbolic PDEs: Lax-Friedrichs, Lax-Wendroff methods, Leapfrog method, Consistency, Stability and convergence of different schemes	**5**

UNIT 5	Finite Element Methods for PDEs - Introduction to Finite Element Method in 1D and 2D problem in (FEM): Variational formulation, weak solutions. Linear and quadratic elements, assembly of the stiffness matrix, Error analysis, Application to elliptic and parabolic equations: Galerkin method.	**9**
	TOTAL	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1	R. J. LeVeque, Finite Difference Methods for Ordinary and Partial Differential Equations: Steady-State and Time-Dependent Problems, SIAM.	2007
2	G. D. Smith, Numerical Solution of Partial Differential Equations: Finite Difference Methods, Oxford University Press.	1985
3	K. W. Morton and D. F. Mayers, Numerical Solution of Partial Differential Equations: An Introduction, Cambridge University Press.	2005
4	J. C. Strikwerda, Finite Difference Schemes and Partial Differential Equations, SIAM.	2004
5	S. C. Brenner and L. R. Scott, The Mathematical Theory of Finite Element Methods, Springer.	2008
6	O. C. Zienkiewicz, R. L. Taylor, and J. Z. Zhu: The Finite Element Method: Its Basis and Fundamentals, Butterworth-Heinemann.	2005

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC404:	**L**	**T**	**P**	Real Analysis,
Optimization Techniques	**3**	**0**	**2**	Linear Algebra

Course Objective: The general objectives of the course is to introduce the fundamental concepts of Optimization Techniques that make the learners aware of the importance of optimizations in real scenarios and provide the concepts of various classical and modern methods of for constrained and unconstrained problems in both single and multivariable.

Course Outcome (CO):

CO1	Define and use optimization concepts to model the 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 the optimization techniques to determine a robust design for a given real world problem and justify the technique for solving it.
CO5	Employ basic optimization algorithms in a computational setting and apply existing optimization software packages to solve and analyze the interdisciplinary real-world problems and for higher study and research.

S.No.	Contents	Contact Hours
UNIT 1	Convex functions and their properties, Convex optimization problems, Convex programming problems, Quadratic programming problems, wolf method for quadratic programming.	**9**
UNIT 2	Unconstrained Optimization- Line search Algorithm, Steepest Descent Method and Conjugate Gradient Method.	**8**
UNIT 3	Introduction, feasible directions and linearizing cone, Basic constraint qualification, Lagrange multipliers, Karush Kuhn Tucker necessary/sufficient optimality conditions.	**8**
UNIT 4	Duality in nonlinear programming, wolf dual, mixed dual and Lagrange dual.	**8**
UNIT 5	Franck and wolf's method, Gradient projection method, Penalty function method, barrier function method.	**9**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	C.R.Bector, S.Chandra, J. Dutta, Principles of Optimization Theory, Narosa Publications.	2016
2	M.S. Bazaraa, H.D.Sherali, & C.M. Shetty, Nonlinear Programming Theory & Algorithms, John Willey & Sons.	2006
3	Suresh Chandra, Jayadeva, Aparna Mehra, Numerical optimization with applications, Narosa Publications.	2009
4	Singiresu S. Rao, Engineering Optimization: Theory and Practice, John Wiley &Sons.	2009
5	N.S. Kambo, Mathematical Programming Techniques, East-West Press Pvt. Ltd.	2008

PRACTICALS LIST	
1	Program to check whether a given function is convex or not
2	Program to check whether a given function is convex or not by using Hessian Matrix
3	Program to check whether the given optimization function is convex or not
4	Program to derive the KKT conditions for a given optimization problem
5	Program to solve a given optimization problem using Lagrange Method
6	Program to solve the quadratic programming problem by Wolfe Method
7	Program to solve a non-linear programming problem using Frank-Wolfe Algorithm
8	Program to solve linear fractional programming problem using Charnes and Cooper Method
9	Program to solve a given NLPP using Penalty Method
10	Program to solve a given NLPP using Barrier function method

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC406: Finite Element Methods	**L**	**T**	**P**	Knowledge of linear algebra, differential equations & Scientific Computing
	3	**1**	**0**	

Course Objective: This course provide the fundamental concepts of the theory of the finite element method to give understanding of the fundamental theory of the FEA method to develop the ability to generate the governing FE equations for systems governed by partial differential equations and enhance the ability use of the basic finite elements for structural applications using truss, beam, frame, and plane elements and understand the application and use of the FE method for heat transfer problems.

Course Outcome (CO):

CO1	Describe the fundamental concepts of function spaces, including continuous, integrable, and Sobolev spaces, and explain the existence, uniqueness, and regularity of weak solutions for elliptic boundary value problems.
CO2	Apply finite element methods using piecewise linear basis functions, calculate and assemble the stiffness matrix, and demonstrate the Galerkin orthogonality and Cea's lemma in solving self-adjoint elliptic problems.
CO3	Analyze polynomial approximation in Sobolev space, evaluate error bounds in the energy norm, identifying the sources of variational crimes in finite element methods.
CO4	Assess the reliability, efficiency, and adaptivity of finite element solutions using a posteriori error analysis by duality and apply this knowledge to optimize computational methods.
CO5	Design finite element approximations for initial boundary value problems, ensuring energy conservation, stability, and dissipation, and develop appropriate strategies for solving evolution problems in computational mechanics.

S. No.	Contents	Contact Hours
UNIT 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.	**7**
UNIT 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**
UNIT 3	Piecewise polynomial approximation: construction of finite element spaces, polynomial approximation in Sobolev space: The Bramble-Hilbert lemma, optimal error bounds in the energy norm, variational crimes. A posteriori error analysis by duality: reliability, efficiency and adaptivity.	**12**
UNIT 4	Finite element approximation of initial boundary value problems, Energy dissipation, conservation and stability. Analysis of finite element methods for evolution problems.	**11**
	TOTAL	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1	Endre Suli and David Mayerf, An introduction to numerical analysis, Cambridge University Press,2nd Ed.	2006
2	S. C. Brenner and R. L. Scott, The Mathematical Theory of Finite Element Methods, Springer-Verlag, New York, 2nd Ed.	2002
3	P.G. Ciarlet, The Finite Element Methods for Elliptic Problems, North Holland, Amsterdam.	1978
4	C. Johnson, Numerical solutions of Partial Differential Equations by Finite Element Methods, Cambridge University Press, Cambridge.	1987
5	M. Ainsworth and J. T. Oden, A Posteriori Error Estimation in Finite Element Analysis, John Wiley and Sons.	2000
6	V. Thomee, Galerkin, Finite Element Methods for Parabolic Problems, Springer-Verlag, Berlin, 2nd Ed.	2006

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC407: Numerical Methods for ODE	**L**	**T**	**P**	Some knowledge of numerical methods, ODE and Matlab/Python
	3	**1**	**0**	

Course Objective: The objective of the course is to learn how to solve real life problems.

Course Outcome (CO):

CO1	Interpret the basics of numerical methods for initial value problems.
CO2	Analyse the various error involved in the numerical scheme.
CO3	Differentiate and apply appropriate techniques for numerical techniques for solving ODE.
CO4	Solve initial value problem with explicit or implicit methods as appropriate.
CO5	Analyze the stability of the numerical schemes applied to various types of BVP's.

S. No.	Contents	Contact Hours
UNIT 1	Initial Value Problems: Euler's method, modified Euler's method, Taylor series method, Runge-Kutta methods and their convergence.	**10**
UNIT 2	Multistep methods: Trapezoidal method, 2-step Adams-Bash forth method, Two-step method: consistency, zero stability, local and global analysis. Concept of A-stability.	**10**
UNIT 3	Absolute Stability for system of Ordinary Differential Equations, Stiff Ordinary Differential Equations: Numerical difficulties, Characterizations of stiffness, Numerical methods for stiff problems, A-stability, L-stability.	**10**
UNIT 4	Shooting method, Finite difference method (forward, backward and central) for two-point boundary value problems, Consistency, stability and their convergence.	**12**
	TOTAL	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1	Randall Leveque, Finite difference methods for ordinary and partial differential equations, SIAM	2007
2	David F. Griffiths, Desmond J. Higham, Numerical methods for ordinary differential equations, springer	2010
3	A. Iserles, A first course in the Numerical analysis of differential equations, Cambridge	2008
4	M.K. Jain and S.R.K. Iyenger, Numerical methods for Scientific and Engineering. Computation, New Age International Publishers	2007

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC408: Statistical Quality Control and Decision Making	**L**	**T**	**P**	Basic knowledge of probability and statistics
	3	**1**	**0**	

Course Objective: The objective of this course is to equip students with a foundational understanding of quality management principles and to provide practical skills in using Statistical Process Control (SPC) techniques for process improvement, decision-making, and production control, with an emphasis on statistical analysis and measurement tools.

Course Outcome (CO):

CO1	Identify and list the various elements associated with managing processes and products in connection to a particular industrial or engineering issue.
CO2	Assess and interpret data pertaining to process control.
CO3	Develop an effective sampling strategy to investigate and analyse issues related to industrial output based on the acquired data.
CO4	Examine the time series data and recommend an appropriate forecasting model to enhance resource management and offer valid solutions.
CO5	Evaluate industrial production models to align them with technological advancements, ensuring adaptability and efficiency in manufacturing processes.

S.No.	Contents	Contact Hours
UNIT 1	Introduction to statistical quality control (SQC), process control and product control. Tools for SQC. Control charts for variables. Control charts for attributes. Natural tolerance limits and specification limits.	**8**
UNIT 2	Acceptance sampling plans for attributes: Types of sampling plans. Single sampling plans, Double sampling plans, Multiple sampling plans and their comparison. Chain sampling plan and sequential sampling plan. Acceptance sampling plans for variables: Advantages and disadvantages, variable sampling plans for a process parameter and for estimating Lot Proportion Nonconforming	**10**
UNIT 3	Introduction to multiple regression: Developing and evaluating multiple regression models, Multiple regression residual analysis, Inferences about the population regression coefficients-Tests of hypothesis, Confidence interval estimation.	**6**
UNIT 4	Components and analysis of time series. Measurement of trend, seasonal variations and cyclic variations. Auto-regression series. Auto-correlation and correlogram. Choosing an appropriate forecasting model. Time series forecasting of seasonal data.	**10**
UNIT 5	Decision making. Pay off table. Decision trees. Maximax payoff, Maxmin payoff. Expected monetary value. Expected opportunity loss. Return-to-risk ratio. Decision making with sample information.	**8**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	David M. Levine, David F. Stephen, and Kathryn A. Szabat, Statistics for Managers, 9th Edition, Pearson.	2019
2	Walpole, Myers, Myers, and Ye, Probability and Statistics for Engineers & Scientists, 9th Edition, Pearson.	2010
3	Douglas C. Montgomery, Introduction to Statistical Quality Control, John Wiley & Sons.	2008
4	C. Kahraman and S. Yanik, Intelligent Decision Making in Quality Management: Theory and Applications, First Edition, Springer.	2016
5	Introduction to Probability, Statistical Methods, Design of Experiments and Statistical Quality Control, D. Selvamuthu, D. Das, Second Edition, Springer.	2018
6	Amitava Mitra, Fundamentals of Quality Control and Improvement, 4th Edition, John Wiley & Sons.	2016

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC409: Tensor Calculus	**L**	**T**	**P**	Basic knowledge of calculus, differential equations, vector calculus
	3	**1**	**0**	

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

Course Outcome (CO):

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

S.No.	Contents	Contact Hours
UNIT 1	**Tensor Algebra:** Generalized N- dimensional space, Transformation of coordinates, Definition of tensor, Summation convention, Invariants, Contravariant and Covariant tensors, Mixed tensor, Kronecker delta, Addition and Subtraction of tensors, Contraction, outer multiplication, Inner producttensors, Symmetric and skew-symmetric tensors, Quotient's law, Conjugate tensor.	**10**
UNIT 2	**Riemannian metric:** Riemannian metric, metric tensor, Length of a curve and null curve, Associated tensors, raising and lowering of indices, magnitude of vector, Levi-Civita tensor, Relative and absolute tensor, hypersurfaces, congruence of curves, Curvilinear Co-ordinates.	**10**
UNIT 3	**Tensor Calculus:** Christoffel symbols, properties and transformation laws of Christoffel symbols, Covariant differentiation of tensors, Gradient, divergence and curl, Geodesics, Null geodesics, Parallel transport.	**8**
UNIT 4	**Riemannian Geometry:** Riemann-Christoffel tensor, Riemannian curvature tensor and properties, Riemannian symbols of second kind, Covariant form, Ricci tensor, Scalar curvature, Bianchi identities, Einstein tensor, Weyl tensor, Bianchi identities,	**8**
UNIT 5	**Some advanced topics in tensor:** Lie derivative, killing vectors and equations, Applications to General Relativity and Cosmology.	**6**
	TOTAL	**42**

Suggested Books:

S. No.	Name of Books/Authors/Publishers	Year of Publication
1	A.J. Mc Connel, Application of Tensor analysis, Dover Publications	2011
2	J.L. Singe and A. Schild, Tensor Calculus, Dover Publications	1978
3	D. C. Aggarwal, Tensor Calculus and Riemannian Geometry, Krishna Prakashan.	1989
4	C.E. Weatherburn, Introduction of Riemannian Geometry and Tensor Calculus, Cambridge	2008
5	M. Dalarsson and N. Dalarsson, Tensor Calculus, Relativity and Cosmology, Elsevier	2005
6	S. Weinberg, Gravitation and Cosmology, Wiley Publication	2007
7	J.V. Narlikar, Introduction to General Relativity, Cambridge University Press, 1st Ed.	2012

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC410: Game Theory	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: This course is intended to provide students with a comprehensive treatment of game theory with specific emphasis on applications in Economics and Engineering. The aim of this course is to introduce students to the novel concepts of Game Theory with special emphasis on its applications in diverse fields and current research.

Course Outcome (CO):

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

S.No.	Contents	Contact Hours
UNIT 1	Two-Person Zero Sum Games Maximin and minimax criterion of optimality, Saddle point, Pure and mixed strategies, Dominance property.	**8**
UNIT 2	Solution Methods for Matrix Games, Algebraic method, Graphical method for solving 2×n and n×2 games, Invertible matrix games, Symmetric games, Linear Programming Method in Matrix Games.	**9**
UNIT 3	Two-Person Non-zero sum Games 2×2 Bimatrix Games, Interior Mixed Nash Points by Calculus, Nonlinear Programming Method for Nonzero Sum Two-Person Games	**9**
UNIT 4	Cooperative Game Theory, Coalitions and Characteristic Function, The Nucleolus, The Shaple Value, Bargaining	**8**
UNIT 5	N-Person Non-zero sum Games with a Continuum of Strategies. Economic Applications of Nash Equilibrium, Duels, Auctions – Complete Information	**8**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	E.N. Barron, Game Theory: An Introduction, John Wiley & Sons.	2008
2	Osborne M.J., An Introduction to Game Theory, Oxford University Press.	2004
3	A. Mas-Colell, M.D. Whinston and J.R. Green, Microeconomic Theory, Oxford University Press.	1995
4	Auction Theory, V. Krishna, Second Edition, Academic Press Inc.	2009
5	Some Topics in Two-Person Games, T. Parthasarathy, T.E.S. Raghavan, American Elsevier Publishing Company.	1971
6	R.A. Gibbons, Primer in Game Theory, Pearson Education.	1992

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC411: Statistical Inference	**L**	**T**	**P**	A course in Statistics with sound knowledge of random variable, expectation and variance, m.g.f. and probability distribution.
	3	**1**	**0**	

Course Objective: The objective of the course is to understanding of various statistical parameters and type of estimation for analysis and predict and validate the claim by testing of hypothesis.

Course Outcome (CO):

CO1	Identify and analyze the characteristics of a good estimator.
CO2	Designing and testing of statistical hypothesis associated with the analysis of a problem of social/environmental/industrial interest.
CO3	Apply the skills of inference and testing for investigation of problems and providing valid conclusion for management of resources and finance .
CO4	Decide the distribution governing the phenomenon and analyse further for meaningful conclusion.
CO5	Apply the test to analyse the random process.

S.No.	Contents	Contact Hours
UNIT 1	Point and Interval Estimation, Characteristics of Estimators, Unbiasedness, Consistency, Efficiency, Sufficiency, Maximum Likelihood Estimation, Confidence Interval and Confidence Limits.	**8**
UNIT 2	Statistical Hypotheses, Critical Region, Two Types of Errors, Level of Significance, Power of the Test, Optimum Test Under Different Situation, Inference Concerning One Mean, Operating Characteristic Curves, Inference Concerning Two Means.	**9**
UNIT 3	Estimation of Variance, Hypothesis Concerning One and Two Variances. Estimation of Proportions, Hypothesis Concerning One and Several Proportions, Analysis of r×c Tables, Goodness of Fit.	**9**
UNIT 4	Least Square Estimator of the Regression Parameters, Statistical Inferences about the Regression Parameters, Curvilinear Regression, Multiple Regression, Coefficients of Determination and Correlation, Adequacy of the Model, Logistic Regression Models.	**9**
UNIT 5	Non Parametric Methods, Wald-Wolfowitz Run Test, Test for Randomness, Median Test, Sign Test.	**7**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	Miller & Freund: Probability and Statistics For Engineers, Pearson Education.	2017
2	Sheldon M. Ross: Introduction to Probability and Statistics For Engineers and Scientists, Academic Press, 6e.	2020
3	Levine, Stephan & Szabat: Statistics for Managers, PHI Learning.	2014

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC412: Information Theory and Coding	**L**	**T**	**P**	Probability and Statistics
	3	**1**	**0**	

Course Objective: This Course provide Design the channel performance using Information theory, comprehend various error control code properties, apply linear block codes for error detection and correction, apply convolution codes for performance analysis & cyclic codes for error detection and correction, design BCH & RS codes for Channel performance improvement against burst errors.

Course Outcome (CO):

CO1	Identify and measure the uncertainty associated with discrete random experiments to analyse and interpret the data.
CO2	Describe the theoretical model associated with the various blocks of the communication system to investigate the problems for suitable designing.
CO3	Analyze the constraints associated with the encoding/decoding of information sources to facilitate in finding the logical solutions.
CO4	List and design the various types of block codes suitable and analyze their errors detection and correction capabilities.
CO5	Reframe the generalized coding and decoding techniques and to correlate the theoretical models with the practical aspects.

S.No.	Contents	Contact Hours
UNIT 1	Discrete information sources, entropy, joint and conditional entropy, chain rule. Source coding, mapping functions and efficiency, mutual information, prefix codes, instantaneous decoding, construction of Huffman codes. Lempel-Ziv coding.	**8**
UNIT 2	Discrete memoryless channel model, transition probability matrix, channel capacity, symmetric channels. Block coding, equivocation. Entropy rate, channel-coding theorem. Markov chains and data processing.	**9**
UNIT 3	Data translation coding, prefix codes and block codes, fixed and variable length block codes, the Kraft inequality. Channel coding for error correction. Error rates and error distribution for the binary symmetric channel, Error detection and correction	**9**
UNIT 4	Maximum likelihood decoding principle. Linear block codes, Hamming weight, Hamming distance, and the Hamming cube. Syndrome decoders and the parity-check matrix.	**8**
UNIT 5	Cyclic codes, polynomial representation of cyclic codes, polynomial modulo arithmetic. Generator, parity-check, and syndrome polynomials. Systematic cyclic codes, the Hamming codes.	**8**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication / Reprint
1	G.A. Jones and J.M. Jones, Information and Coding Theory, Springer Undergraduate Mathematics Series.	2000
2	W.C. Huffman and V. Pless, Fundamental of Error Correcting Codes, Cambridge University Press.	2010
3	R.B. Wells, Applied Coding and Information Theory for Engineers, Pearson Education.	1999
4	T.M. Cover and J.M. Thomas, Elements of Information Theory, Wiley Student Edition.	2006
5	Robert B. Ash, Information Theory, Dover Publications.	1990

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC413:	**L**	**T**	**P**	Database Management Systems
Big Data Analytics	**3**	**0**	**2**	

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

Course Outcome (CO):

CO1	Define and explain Big Data Concepts.
CO2	Apply Big Data storage and processing techniques.
CO3	Apply Machine Learning techniques for Big Data analytics and evaluate their performances in large-scale data scenarios.
CO4	Design optimized workflows for performance and scalability.
CO5	Develop an End-to-End Big Data Pipeline by Integrating its tools.

S.No.	Contents	Contact Hours
UNIT 1	**Introduction to Big Data:** Definition and Characteristics: 3Vs, 5Vs of Big Data, Evolution of Data and Data Growth Trends, Traditional Data Processing vs. Big Data Processing, Applications of Big Data in Various Industries, Challenges in Big Data Management, Types of Big Data: Structured, Semi-Structured, Unstructured, Big Data Processing Architectures: Batch Processing, Stream Processing.	**8**
UNIT 2	**Hadoop Environment:** Overview of the Hadoop Ecosystem, Hadoop Architecture, Components and examples - MapReduce Framework, Yet Another Resource Negotiator; Hadoop Distributed File System, Data Blocks, Replication, and Fault Tolerance, File Operations in HDFS, Data Ingestion in Hadoop: Sqoop, Flume.	**10**
UNIT 3	**Data Processing with MapReduce:** Introduction to MapReduce, Map and Reduce Phases, Writing MapReduce Programs. **Data Processing with Apache Spark:** Apache Spark Overview, Spark Core and Resilient Distributed Datasets, Spark SQL and Data Frames, Apache Hive for Structured Querying, fundamentals of HBase and ZooKeeper. **NoSQL Databases for Big Data**: Introduction to NoSQL, MongoDB: Document-based NoSQL, CRUD Operations, Indexing, Aggregation, Replication, Cassandra: Column-family NoSQL.	**10**
UNIT 4	**Machine Learning (ML) for Big Data:** Introduction to ML for Big Data, Scalable ML Frameworks, Deep Learning Techniques in Big Data, Overview of Real-time Big Data Processing, Streaming Data Sources: Kafka, Flume. Case Studies & Industry Applications of Big Data.	**8**
UNIT 5	**Big Data in Cloud:** Cloud service for Big data: AWS, Google Cloud, Azure; Amazon S3, Google BigQuery, Azure Data Lake, Serverless Computing for Big Data: AWS Lambda, Azure Functions.	**6**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	White, T. Hadoop: The definitive guide. O'Reilly Media, 4th Edition, ISBN: 978-1491901632.	2015
2	Marz, N., & Warren, J. Big data: Principles and best practices of scalable real-time data systems. Manning Publications, 1st Edition, ISBN: 978-1617290343.	2015
3	Eaton, C., DeRoos, D., Deutsch, T., Lapis, G., & Zikopoulos, P. Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data. McGraw Hill Publishing, 7th Edition, ISBN: 978-0071790533.	2012
4	Wampler, D., Capriolo, E., & Rutherglen, J. Programming Hive: Data warehouse and query language for Hadoop. O'Reilly Media, 1st Edition, ISBN: 978-1449319335.	2012
5	Galeano, M. I. F. (2021). Big data processing with Apache Spark. Packt Publishing, 1st Edition, ISBN: 978-1800561466.	2021
6	Kulkarni, P. (2016). Machine learning with big data. Springer, 1st Edition, ISBN: 978-3319431608.	2016
7	Bahga, S., & Madisetti, V. (2014). Cloud computing for big data: Principles and best practices. CreateSpace Independent Publishing, 1st Edition, ISBN: 978-1494435141.	2014
8	Sbarski, P. Serverless architectures on AWS. Manning Publications, 1st Edition, ISBN: 978-1617293825.	2017

PRACTICALS LIST	
1	Write a program to set up a Hadoop in a single-node system and perform basic file operations like uploading a dataset to HDFS and retrieving and deleting files from HDFS.
2	Write a program to develop a simple MapReduce program to count word occurrences in a large text file. Also, compare the performance with and without MapReduce.
3	Write a program to perform the following tasks using Spark's Resilient Distributed Dataset and DataFrame API: a) Load a CSV dataset into Spark. b) Perform basic transformations (filter, map, reduce). c) Execute SQL-like queries using Spark SQL. d) Save processed data in different formats (CSV, Parquet).
4	Write a program to implement real-time data ingestion and processing.
5	Write NoSQL-based Insert, update, and retrieve operations to work with unstructured data using PyMongo.
6	Write a program to perform sentiment analysis on Twitter data using Spark MLlib and analyze the performance.
7	Write a program to build a recommendation engine for e-commerce using Apache Mahout.
8	Write a program to perform querying with structured data using Hive & SQL. Also, optimize the queries using partitions and bucketing.
9	Write a program to define a Workflow for cloud-based big data solutions.

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC414: Natural Language Processing	**L**	**T**	**P**	Data Structures, Analysis and Design of Algorithms
	3	**0**	**2**	

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

Course Outcome (CO):

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

S.No.	Contents	Contact Hours
UNIT 1	**Introduction:** Introduction to NLP, Origins and History of NLP, Language Analysis, Phases in Language Analysis, Major Challenges of NLP, NLP and Machine Learning, Natural Language and Grammar, Applications of NLP, Tasks of NLP, Simple NLP Implementation Using Python.	**8**
UNIT 2	**Language Modeling:** Statistical Language Models, N-gram models, Smoothing Techniques, Maximum Likelihood Estimation, Markov Models, Hidden Markov Models, Continuous Space Models, Dimensionality Reduction using Latent Semantic Analysis, Word Embeddings, Grammar Based Language Models.	**8**
UNIT 3	**Lexical Analysis:** Initial Steps of Lexical Analysis: Tokenization, Stop Word Removal, Stemming, Lemmatization, Regular Expression, Finite State Automata, Morphological Analysis: Rule-based Morphological Analysis, Finite-State Transducers, Part-of-speech tagging: Rule-based POS Tagging, Machine Learning-Based Tagging, Hidden Markov Model (HMM) based POS tagging, Maximum Entropy (MaxEnt) Model, Brill Tagger, Spelling Error Detection and Correction: Dictionary Lookup Technique, N-gram Analysis Technique, Levenshtein Distance Method.	**9**
UNIT 4	**Syntactic Analysis:** Constituency - Phrase Level Constructions, Sentence Level Constructions, Context-free Grammar - Chomsky Normal Form, Greibach Normal Form, Probabilistic Context-Free Grammar (PCFG); Treebanks, Parsing-Top-down parsing, Bottom-up Parsing, Probabilistic Parsing: Introduction to Probabilistic parsing, Inside-Outside Algorithm for PCFGs, Viterbi Algorithm for PCFGs; Structural Ambiguity and Resolution, The Cocke–Younger–Kasami Algorithm.	**9**

UNIT 5	**Semantic Analysis:** Meaning Representation, Vector Space Models, Knowledge Graphs, Formal Representations of Meaning - Propositional Logic, First-Order Predicate Logic, Semantic Vector Models, Lexical Semantics, Semantic Ambiguity, Semantic relatedness, Similarity measures. **Tasks in NLP:** Word Sense Disambiguation, Machine Translation, Keyphrase Extraction, Advancements in NLP	**8**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	Jurafsky, D., & Martin, J. H. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition with Language Models. 3rd Edition	2024
2	Manning, C. D. Foundations of Statistical Natural Language Processing. MIT Press, ISBN: 978-0262133609.	1999
3	Tiwari, U. S., & Siddiqui, T. Natural Language Processing and Information Retrieval. Oxford University Press, ISBN: 978-0195692327.	2008
4	Allen, J. Natural Language Understanding. Pearson Education, ISBN: 978-0805303346.	2003
5	Bird, S., Klein, E., & Loper, E. Natural Language Processing with Python: Analyzing Text with Natural Language Toolkit. O'Reilly, ISBN: 978-0596516499.	2009

PRACTICALS LIST	
1	Implement a bigram language model using a given text corpus and calculate the probability of a given sentence.
2	Implement the Hidden Markov Model to tag parts of speech in a given text.
3	Implement the Levenshtein distance method in a given paragraph.
4	Build a PCFG using a small treebank of syntactically annotated sentences.
5	Implement the Path Length and Lin's similarity to compare the similarity between the words using WordNet.
6	Find top-k similar words using Word2Vec embeddings on a given text corpus.
7	Generate daily weather reports on collected data using weather API.
8	Fine-tune a pre-trained BERT model on a custom sentiment analysis dataset.
9	Extract keywords from a set of articles using TF-IDF or other statistical methods.
10	Predict the next word in a sequence of text data using an LSTM-based language model based on given prompts.

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC415: Data Warehousing and Data Mining	**L**	**T**	**P**	Probability and Statistics Linear Algebra
	3	**0**	**2**	

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

Course Outcome (CO):

CO1	Recall the fundamental concepts of data warehousing and data mining and basic data mining techniques.
CO2	Explain the design, implementation, and maintenance of data warehousing systems and association rule mining, classification, and prediction in data mining.
CO3	Apply data mining techniques to analyze large databases and extract meaningful insights.
CO4	Analyze and compare various data mining algorithms and their applications to different types of data, such as spatial, multimedia, and time-series data.
CO5	Evaluate the performance of data mining models and systems. Critique trends in data mining.

S.No.	Contents	Contact Hours
UNIT 1	**Data Warehousing:** Basic concepts in data warehousing, Collecting the requirements of data warehouse, Data Warehouse Architecture, Design, Implementation & Maintenance, OLAP in data warehouse, Data warehousing and the web, Data Cube Technology, From Data Warehousing to Data Mining.	**8**
UNIT 2	**Data Mining Concepts:** Data mining primitives, Basics of data mining, Query language, Architectures of data mining systems	**8**
UNIT 3	**Mining Association Rules in Large Databases:** Association Rule Mining, Mining Single Dimensional Boolean Association Rules from Transactional Databases, Mining Multilevel Association Rules from Transaction Databases, Mining Multidimensional Association Rules from Relational Databases and Data Warehouses, From Association Mining to Correlation Analysis, Constraint Based Association Mining.	**9**
UNIT 4	**Classification and Prediction:** Issues Regarding Classification and Prediction, Classification by Decision Tree Induction, Bayesian Classification, Classification by Back propagation, Classification Based on Concepts from Association Rule Mining, Other Classification Methods, Prediction, Classifier Accuracy.	**8**

UNIT 5	**Cluster Analysis in Data Mining:** Types of Data in Cluster Analysis. A Categorization of Major Clustering Methods, Partitioning Methods, Density Based Methods, Grid Based Methods, Model Based Clustering Methods, Outlier Analysis. Mining Complex Types of Data: Multidimensional Analysis and Descriptive Mining of Complex Data Objects, Mining Spatial Databases, Mining Multimedia Databases, Mining Time Series and Sequence Data, Mining Text Databases. **Applications and trends in Data Mining:** Applications, Systems products and research prototypes, Additional themes in data mining, Trends in Data mining, spatial mining, and Web Mining.	**9**
	Total	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	Ponnian, P. Data Warehousing Fundamentals. John Wiley, ISBN: 978-0471412540.	2001
2	Dunham, M. H. Data Mining: Introductory & Advanced Topics. Pearson Education, ISBN: 978-0130888921.	2002
3	Han, J., & Kamber, M. Data Mining: Concepts & Techniques. Morgan Kaufmann, ISBN: 978-1558609013.	2006
4	Berry, M., & Linoff, G. Mastering Data Mining. John Wiley, ISBN: 978-0471331230.	2004

PRACTICALS LIST	
1	Write a program to implement the Apriori algorithm or use libraries like mlxtend to extract frequent itemsets and generate association rules. Set different support and confidence thresholds to generate rules. Use a dataset like the Groceries dataset or any other market basket dataset.
2	Write a program to implement the Apriori algorithm to mine rules at different levels of the hierarchy (e.g., category level, sub-category level).Use a dataset that contains multiple levels of categories (e.g., product categories).
3	Write a program to apply the Apriori or FP-Growth algorithm to mine multidimensional association rules.Use a multidimensional dataset (e.g., product, customer, region) from a relational database.
4	Write a program to analyze how these measures differ from support and confidence in determining interestingness. Use the association rules generated earlier, calculate the Lift, Conviction, and Leverage for each rule.
5	Write a program to implement or use a library (e.g., scikit-learn) to build a decision tree classifier. Evaluate the accuracy, precision, recall, and F1-score of the classifier. Use a dataset like the Iris dataset or a binary classification problem.

6	Write a program to implement the Naive Bayes algorithm using libraries like scikit-learn. Evaluate classifier accuracy and compare it with other classifiers. Use a dataset like SMS Spam Collection to classify messages as spam or ham.
7	Write a program to build and train a neural network with multiple layers using a deep learning framework (e.g., TensorFlow, PyTorch). Compare the performance of the neural network with traditional methods like decision trees and Naive Bayes. Use a dataset like MNIST (handwritten digits) or Fashion MNIST for classification.
8	Write a program to implement multiple classifiers (e.g., K-Nearest Neighbors, Support Vector Machines, and Random Forest) on a dataset of your choice. Evaluate and compare the performance of these classifiers on the same dataset.
9	Write a program to implement both linear regression and decision tree regression to predict continuous outcomes. Compare the results of both models based on mean squared error and R-squared metrics. Use a dataset like house prices or weather data for a regression task.
10	Write a program to apply the K-Means clustering algorithm using scikit-learn and evaluate the clustering results. Implement the K-Medoids algorithm (e.g., using the PAM method) and compare its results with K-Means. Choose a dataset (e.g., Iris or Mall Customers).
11	Write a program to implement DBSCAN using scikit-learn and experiment with different parameters like eps and min_samples. Analyze the results to identify clusters and outliers. Use a dataset suitable for density-based clustering (e.g., circles or moons dataset).

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC417: Cryptography and Network Security	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To explore various traditional and modern encryption algorithms, including key management and key exchange methods and study different authentication techniques and digital signature algorithms. The course also helps to understand network security protocols and strategies for protecting against network threats.

Course Outcome (CO):

CO1	Understand the various classical encryption techniques.
CO2	Describe, analyse, and apply modern block ciphers, public key cryptosystems and key exchange algorithms.
CO3	Explain and apply various message authentication algorithms and their applications.
CO4	Compare various key management policies and digital signature algorithms.
CO5	Elaborate the concept of IP security and web security and describe various security protocols (SSL, TLS, TSP, SET etc.), firewall and VPN.

S.No.	Contents	Contact Hours
UNIT 1	**Introduction to cryptography**, Introduction to Group, Rings and Fields, Euclidean algorithm: basic and extended, modular arithmetic classical encryption techniques: substitution ciphers and transposition ciphers, cryptanalysis, steganography, stream, and block ciphers.	**8**
UNIT 2	Modern block cipher principles, Shannon's theory of confusion and diffusion, feistel and non-feistel cipher structure, Data Encryption Standard (DES), strengths and weaknesses of DES, double and triple DES, International Data Encryption Algorithm (IDEA), Advanced Encryption Standard (AES).	**8**
UNIT 3	Fermat's and Euler's theorems, primality testing, chinese remainder theorem, discrete logarithm problem, principles of public key cryptosystems, RSA cryptosystem, security of RSA, key management, Diffie-Hellman key exchange algorithm, introductory idea of Elliptic curve cryptography, ElGamal encryption algorithm.	**8**
UNIT 4	Authentication requirement, authentication functions, Message Authentication Codes (MAC), Hash functions, message digest algorithm (MD5), Secure Hash Algorithm (SHA), Digital Signatures, authentication protocols, digital signature standards (DSS), proof of digital signature algorithm**.** **Authentication Applications:** Kerberos and X.509, directory authentication service, electronic mail security, pretty good privacy (PGP), S/MIME.	**10**

UNIT 5	**IP Security:** Architecture, Authentication header, encapsulating security payloads, combining security associations, key management. Web Security: Secure socket layer (SSL) and transport layer security (TLS), secure electronic transaction (SET), electronic money, WAP security, firewall design principles, virtual private network (VPN) security, Advanced attacks like DDoS, Zero-day attacks, etc.	**8**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	Stallings, W. Cryptography and Network Security: Principles and Practices. Pearson Publication, 8th Edition, ISBN: 978-1292437484.	2023
2	Forouzan, B. A. Cryptography and Network Security. McGraw Hill Education, 3rd Edition, ISBN: 978-9339220945.	2015
3	Kahate, A. Cryptography and Network Security. McGraw Hill Education, 4th Edition, ISBN: 978-9353163303.	2019
4	Stinson, D. R. Cryptography: Theory and Practice. Chapman and Hall/CRC, 2nd Edition, ISBN: 978-1584882060.	2002

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC419: Differential Geometry	**L**	**T**	**P**	Basic knowledge of calculus, differential equations, vector calculus, Linear Algebra
	3	**1**	**0**	

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

Course Outcome (CO):

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

S. No.	Contents	Contact Hours
UNIT 1	**Geometry of space curves**: Parametric representation of space curves, Arc length, Tangent vectors and vector fields in space, Tangent line, Osculating plane, Inflexion point, Normal plane, Principle normal, Binormal, Curvature and torsion, Fundamental theorem for space curves, Frenet-Serret formulae, Osculating circle, Osculating sphere, Spherical indicatrix, Frenet approximation.	**9**
UNIT 2	**Geometry of surfaces:** Parametrization, Arc length, Tangent plane, Differentials, First and Second fundamental forms, Curves in surfaces, Normal and geodesic curvature, Ruled surface, Developable surface, Edge of regression.	**9**
UNIT 3	**Curves on surface:** Gauss curvature, Gauss characteristic equation, Gauss and Weingarten formula, Mainardi-Codazzi equations, Fundamental existence theorem for surfaces, Parallel surfaces.	**8**
UNIT 4	**Geometry of Geodesic:** Geodesic, Geodesic property, Differential equation of geodesic, Surface of revolution, Torsion of geodesic, Geodesic polar co-ordinates, Normal property of geodesics, Bonnet's theorem, Bonnet's formula	**8**
UNIT 5	**Global result about surfaces:** The Gauss-Bonnet theorem, Theorem of parallels, Fundamental existence theorem for surfaces.	**8**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	T.J. Willmore, An Introduction to Differential Geometry, Dover Publication	1997
2	Erwin Kreyszig, Differential Geometry, Dover Publication.	2003
3	Nirmala Prakash, Differential Geometry-An Integrated Approach, Tata McGraw Hill.	1981
4	D. Somasundaram, Differential Geometry, Narosa Publishing House	2004
5	B. O'Neil, Elementary Differential Geometry, Academic Press,2nd Ed.	2006
6	M.P. do Carmo, Differential Geometry of Curves and Surfaces, Dover Publication, 2nd Ed.	2016

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC421: Topology	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: The objective of the course is to impart knowledge of Topological Spaces, Connectedness, Compact Spaces, Countability axioms, etc.

Course Outcome (CO):

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

S.No.	Contents	Contact Hours
UNIT 1	Topological Spaces, The order topology, Local Base at a point, Base for a Topology, Limit points, Interior, Exterior and Frontier points, Separable Spaces, Subspaces.	**9**
UNIT 2	Continuity, Homeomorphism, Separated sets, Connectedness, Components, Locally Connected Space.	**8**
UNIT 3	Compact spaces, Compactness in R, Countable Compactness, Local Compactness, One Point Compactification.	**7**
UNIT 4	Countability axioms, Separation axioms, Urysohn's Lemma, Urysohn's metrization theorem, Tietze extension theorem.	**10**
UNIT 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
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	1964
4.	J.G. Hocking and G.S. Young, Topology, Addison-Wesley 1961	1961

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC423: Functional Analysis	**L**	**T**	**P**	Linear Algebra, Real Analysis
	3	**1**	**0**	

Course Objective: The objective of this course is to impart knowledge of different spaces such as Normed linear spaces, Banach spaces and Hilbert spaces. It also includes all the important theorems, with applications, in the theory of Banach and Hilbert spaces.

Course Outcome (CO):

CO1	Analyze how ideas from different areas of mathematics in line with functional analysis combined to produce new concepts that are more effective than existing ones.
CO2	Apply the logical skills developed in various computer applications.
CO3	Describe and apply the theory of linear operators on a Hilbert space, including adjoint operators, self-adjoint and unitary operators with their spectra to evolve innovative modals.
CO4	Formulate, solve and analyze interdisciplinary real-world problems for higher study and research.
CO5	Demonstrate an understanding of all new concepts and proofs of the theorems.

S.No.	Contents	Contact Hours
UNIT 1	Metric spaces: Definition and examples, Holder inequality and Minkowsky inequality, Separable metric spaces, Convergence, Cauchy sequence, Completeness, Complete and Incomplete metric spaces with examples, Completion of metric spaces.	**9**
UNIT 2	Linear spaces, Linear independence, basis and dimension, Normed linear spaces, Examples, Schwarz inequality, Banach spaces, Spaces and Subspaces of finite dimensions, Convex sets in Normed linear spaces, Quotient spaces.	**9**
UNIT 3	Linear operators, basic classes of linear operators, Elementary properties of linear operators, Linear operators in finite dimensional spaces, Spaces of continuous linear operators, Spectrum of a bounded and self adjoint operator, Spectrum of a completely continuous operators	**8**
UNIT 4	Linear functionals, Hahn-Banach theorem, Conjugate spaces, Uniform boundedness principle, Strong convergence of sequence of operators, Weak convergence of sequence of functionals.	**8**
UNIT 5	Inner product spaces, properties of inner product spaces, Hilbert spaces, Examples, Orthogonality, Orthonormality, Riesz representation theorem.	**8**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1.	B. K. Lahiri; Elements of Functional Analysis, World Press	2005
2.	John B Conway; A course in Functional Analysis, Springer New York	2019
3.	Walter Rudin; Functional Analysis, McGraw Hill Education	2017
4.	E. Kreyszig; Introductory Functional Analysis with Applications, John Wiley & Sons	1989
5.	M. Thamban Nair; Functional Analysis: A First Course, PHI Learning	2021

Details of Course:

Course Title	Course Structure			Pre-Requisite
MC425: Compiler Design	**L**	**T**	**P**	NIL
	3	**1**	**0**	

Course Objective: To study the design of all the phases of the compiler in detail.

Course Outcome (CO):

CO1	Explain the phases and structure of a typical compiler.
CO2	Identify lexical tokens of any programming language and design and implement a lexical analyzer for the same.
CO3	Describe the role of a parser in a compiler and design and compare the performance and design trade-offs of various parsers.
CO4	Demonstrate a semantic analyzer and create a syntax-directed definition and an annotated parse tree.
CO5	Design and implement an intermediate code generator based on given code patterns.

S.No.	Contents	Contact Hours
UNIT 1	**Introduction:** Definition , Phases and Passes, Finite State Machines, Regular Expressions and their application to Lexical Analysis, Implementation of Lexical Analyzers, Lexical- Analyzer Generator, Lex – Compiler.	**6**
UNIT 2	**Syntax Analysis:** Formal Grammar and their application to Syntax Analysis, BNF Notation, Syntactic specification of Languages: CFG, Derivation and Parse Trees, Shift Reduce Parsing, Operator precedence parsing, top down Parsing, Predictive Parsers.	**7**
UNIT 3	**Parsers:** LR Parsers, the canonical collection of LR(0)items, constructing SLR Parsing Tables, Constructing canonical LR Parsing tables and LALR parsing tables , An Automatic Parser Generator, YACC.	**7**
UNIT 4	**Syntax Directed Translation**: Syntax directed Translation Schemes, Implementation of Syntax directed translators, Intermediate Code, Postfix notation, Parse Trees and Syntax Trees, Three address Code, Quadruple & Triples, Translation of Assignment Statements, Boolean expressions, Control Statements, Array Reference Books in Arithmetic expressions , Procedure Calls , Declarations and Case statements Translations.	**8**
UNIT 5	**Symbol Tables**: Data Structure for Symbol Tables, representing scope information.Run Time Administration: Implementation of simple Stack allocation scheme, storage allocation in block structured language.	**7**
UNIT 6	**Error detection and Recovery:** Lexical phase errors,syntax phase errors,semantic errors.And Error recovery techniques, Code Optimization: Loop optimization, the DAG representation of basic blocks, value numbers and Algebraic Laws, Global Data – Flow Analysis and Code generation.	**7**
	TOTAL	**42**

Suggested Books:

S.No.	Name of Books/Authors/Publishers	Year of Publication
1	Aho, A. V., Lam, M. S., Sethi, R., & Ullman, J. D. Compilers: Principles, Techniques, and Tools. 2nd Edition, Addison Wesley, ISBN: 978-0321486813.	2006
2	Dhamdhere, D. M. Compiler Construction: Principles and Practice. 2nd Edition, Macmillan India, ISBN: 978-0333904060.	1997