राष्ट्रीय प्रौद्योगिकी संस्थान हमीरपुर
हमीरपुर (हि॰प्र॰) – 177 005 (भारत)
[भारत सरकार शिक्षा मंत्रालय के तहत एक राष्ट्रीय महत्व का संस्थान]
NATIONAL INSTITUTE OF TECHNOLOGY HAMIRPUR
HAMIRPUR (H.P.) - 177 005 (INDIA)
[An Institute of National Importance under Ministry of Education (Shiksha Mantralaya)]

{Department of Mathematics & Scientific Computing}

Programme: B.Tech. in Mathematics & Computing

Semester 3

Course No.	Course Name	L	T	P	C	Course Type
MA-211	Numerical Methods and Computations	3	0	0	3	Discipline core
MA-212	Discrete Mathematics	3	1	0	4	
MA-213	Probability and Stochastic Processes	3	1	0	4	
MA-214	Computer Organization & Architecture	3	0	0	3	
MA-215	Data Structures	3	0	0	3	
MA-216	Data Structures Lab	0	0	4	2	
MA-217	Numerical Computations with MATLAB Lab	0	0	2	1	
	Total				20	

Semester 4

Course No.	Course Name	L	T	P	C	Course Type
MA-221	Linear Algebra and Applications	3	0	0	3	Discipline core
MA-222	Real and Complex Analysis	3	1	0	4	
MA-223	Object Oriented Programming	3	0	0	3	
MA-224	Applied Statistics and Statistical Inference	3	0	0	3	
MA-225	Applied Statistical Methods Lab	0	0	2	1	
MA-226	Object Oriented Programming Lab	0	0	4	2	
MA-24X	Discipline Elective-1	3	0	0	3	Discipline Elective
SA-20X	LA/CA	1	0	0	1	Institute Elective
	Total				20	

Semester 5

Course No.	Course Name	L	T	P	C	Course Type
MA-311	Number Theory and Abstract Algebra	3	0	0	3	Discipline core
MA-312	Operations Research	3	0	0	3	
MA-313	Computer Networks	3	0	0	3	
MA-314	Database Management Systems	3	0	0	3	
MA-315	Database Management Systems Lab	0	0	4	2	
MA-35X	Discipline Elective-2	3	0	0	3	Discipline Elective
XX-30X	Open Elective	3	0	0	3	Institute Electives
	Total				20	

Semester 6

Course No.	Course Name	L	T	P	C	Course Type
MA-321	Analysis and Design of Algorithms	3	1	0	4	Discipline Core
MA-322	Machine Learning	3	1	0	4	
MA-323	Machine Learning Lab	0	0	4	2	
MA-34X	Discipline Elective -3	3	0	0	3	Discipline Elective
MA-36X	Discipline Elective -4	3	0	0	3	
MA-381	Internet of Things	2	0	0	2	Stream Core
HS-321	Engineering Economics and Acountancy	2	0	0	2	Institute Core
	Total				20	

Semester 7

Course No.	Course Name	L	T	P	C	Course Type
MA-411	Advanced Differential Equations	3	0	0	3	Discipline Core
MA-412	Theory of Computation	3	0	0	3	
MA-413	Operating Systems	3	0	0	3	
MA-414	Operating System Lab	0	0	4	2	
MA-415	Summer Training	0	0	0	2	
MA-43X	Discipline Elective-5	3	0	0	3	Discipline Elective
MA-451	Deep Learning	2	0	0	2	Stream Core
MA-471	Blockchain Technology	2	0	0	2	
	Total				20	

Semester 8

Course No.	Course Name	L	T	P	C	Course Type
MA-498	Holistic Assessment	0	0	0	2	Institute Core
MA- 46X	Stream Elective -1	3	0	0	3	Stream Elective
MA- 48X	Stream Elective -2	3	0	0	3	
MA-499	UG Project*	0	0	0	12	Discipline Elective
	Total				20	

Open Elective

MA-301	Cyber Security
MA-302	Statistical Data Analysis
MA-303	Finite Element Method

Discipline Elective-1

MA-241	Integral Transform and Applications
MA-242	Mathematical Modeling and Simulation
MA-243	Mathematical Methods
MA-244	Calculus of Variations and Optimal Control

Discipline Elective-2

MA-351	Digital Design
MA-352	Computer Graphics
MA-353	Digital Image Processing
MA-354	Software Engineering

Discipline Elective-3

MA-341	Soft Computing
MA-342	Data Mining
MA-343	Cryptography and Network Security
MA-344	Compiler Design

Discipline Elective-4

MA-361	Financial Mathematics
MA-362	Optimization Techniques
MA-363	Applied Multivariate Statistical Analysis
MA-364	Time Series Analysis and Forecasting

Discipline Elective-5

MA-431	Functional Analysis
MA-432	Fractional Differential Systems
MA-433	Topology
MA-434	Measure Theory

Stream Elective-1

MA-461	Mathematical Biology
MA-462	Data science
MA-463	Natural Language Processing

Stream Elective-2

MA-481	Fractals and Chaos
MA-482	Statistical Quality Control
MA-483	Cloud Computing

Minor in Mathematics

Course No.	Course Name	L	T	P	C	Semester
MA-310	Algebra	3	0	0	3	5th
MA-320	Analysis	3	0	0	3	6th
MA-410	Differential Equations	3	0	0	3	7th
MA-420	Statistics	3	0	0	3	8th

Syllabus

Course Name: Numerical Methods and Computations
Course Code: MA-211
Course Type: Discipline Core

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives:

- To increase the problem-solving skills of engineering students using powerful tools of numerical methods.
- To enhance the capability of handling large systems of equations that are common in engineering practice.
- To learn to interpolate data useful in computer visualization.
- To introduce the numerical methods for solving ordinary differential equations.

Unit No.	Course Content	Lectures
UNIT-01	**Numerical Solution of Linear Equations:** Errors: Definition and sources of errors, Relative and Percentage error, Round-off and Truncation errors. Linear Equations: Diagonally dominant systems, Jacobi and Gauss Seidel Iteration methods, Necessary and sufficient conditions for convergence of iteration methods.	8
UNIT-02	**Numerical Solution of Non-Linear Equations:** Non-Linear Equations: Bisection Method, Regula-Falsi Method, Newton-Raphson Method, Iteration method, Order of convergence.	4
UNIT-03	**Curve fitting:** Least square curve fitting: Linear, Reducible to linear, Quadratic, and Exponential fit. Evenly and unevenly spaced data points,	5
UNIT-04	**Interpolation:** Finite differences and difference operators, Lagrange's interpolation, Newton's forward, backward and, divided difference interpolation formulae.	5
UNIT-05	**Numerical Integration:** Newton-Cotes general formula: Trapezoidal rule, Simpson's-1/3 rule, Simplson's-3/8 rule and their composite formulas, Errors in integration, Romberg integration method.	6
UNIT-06	**Numerical Solution of Ordinary Differential Equations:** Euler's method, Modified Euler's method, Runge- Kutta of second and fourth order method, Predictor corrector method: Adams-Bashforth-Moulton method of fourth order.	8

Course Outcomes

Upon successful completion of the course, the student will be able

CO1: Understand numerical techniques to find the roots of non-linear equations.

CO2: Understand difference operators and use of interpolation.

CO3: Understand numerical differentiation and integration and numerical solutions of ordinary differential equations.

Text Books: -

1. M. K. Jain, S. R. K. Iyengar and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, New age International Publisher, India, 5th edition, 2007.
2. B. Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
3. Richard L. Burden, J. Douglas Faires - Numerical Analysis, 9th Edition, Cengage India Private Limited (2010)

Reference Book:

4. K.E. Atkinson, W. Han, Elementary Numerical Analysis, 3rd Edition, Wiley, 2003.

Course Name: Discrete Mathematics
Course Code: MA-212
Course Type: Discipline Core

Contact Hours/Week: 03L +01T **Course Credits: 04**

Course Objectives:

- To introduce the concepts of mathematical logic.
- To introduce the concepts of sets, relations, and functions.
- To relate practical examples of the appropriate set, function, or relation model.
- To use graph theory for solving problems.

Unit No.	Course Content	Lectures
UNIT-01	**Logic:** Proposition, predicate logic, logic operators, logical equivalences, quantifiers and proof methods **Set Theory:** Sets, set operations, fuzzy set, principle of inclusion and exclusion **Induction**: Principle of mathematical induction, weak and strong forms.	8
UNIT-02	**Functions:** Functions, piecewise functions, spcial functions: floor, ceiling etc, Bijection, The Pigeonhole Principle, Composition of Functions, discrete numeric functions, Growth of Functions: Big-Oh, Little-oh notations.	8
UNIT-03	**Relations**: Boolean Matrices, Boolean operations, Adjacency Matrix, Digraph, Properties of relations: reflexive, symmetric, transitive, transitive closure, Warshall's Algorithm, Equivalence relation, Partial order relation, POSET, Comparable elements, Hasse diagram.	8
UNIT-04	**Recurrence relations:** Recursive problems: handshake problem, tower of brahma, Fibonacci numbers etc, solution of recurrence relations, Linear Homogeneous and Nonhomogeneous Recurrence Relations with Constant Coefficients, Generating functions	8
UNIT-05	**Graph Theory:** Simple graph, Subgraph, complete graph, cycle, wheel, bipartite graph, weighted graph, isomorphic graph, path, cycle, circuits, Eulerian, Hamiltonian graphs, Planar graph, graph coloring, chromatic number.	8
UNIT-06	**Tree:** Introduction to Trees, Forest, Spanning trees, Bipartite matching, vertex cover, edge cover, independent set, M-alternating path, Hall's Theorem, König-Egeváry Theorem, Gallai's Theorem	8

Course Outcomes: Upon successful completion of the course, the student will be able to

CO1: Ability to apply mathematical logic to solve problems.
CO2: Understand sets, relations, functions, and discrete structures.
CO3: Able to solve the real-world problems using graphs and trees.

Books and References

1. Discrete Mathematics with Applications by T. Koshy, Academic Press.
2. R. Diestel, Graph theory, Fourth edition, Graduate Texts in Mathematics, 173, Springer, Heidelberg, 2010.
3. Discrete Mathematics and Its Applications by K. H. Rosen, Tata McGraw-Hill.

Course Name: Probability and Stochastic Processes
Course Code: MA-213
Course Type: Discipline Core

Contact Hours/Week: 03L+01T **Course Credits: 04**

Course Objectives:

- To understand the language of probability theory and to solve probabilistic problems in engineering.
- To understand the basic concepts of probability theory, random variables, conditional probability.
- To introduce students to basic methodology, distributions and apply it to problems.
- To impart knowledge of analysis of random processes.

Unit Number	Course Content	Lectures
UNIT- 01	**Introduction to Probability:** Probability Space, Axioms of probability, Conditional probability, Total probability, Bayes theorem.	3
UNIT- 02	**Random variables and Distribution Functions:** Types of Random variables, Probability mass function, probability density function, properties, Moments, Moment generating function, Characteristic function and their properties.	6
UNIT- 03	**Two Dimensional Random Variables:** Joint distributions, Marginal and conditional distribution, Covariance, Function of a random variable, Transformation of random variables, Central limit theorem.	9
UNIT- 04	**Discrete Distributions:** Uniform, Bernoulli, Binomial, Poison, Negative Binomial, Geometric and their properties.	7
UNIT- 05	**Continuous Distributions:** Rectangular, Normal, Exponential, Gamma, Weibull distributions and their properties.	8
UNIT- 06	**Random Processes & Markov Chains:** Definition of Stochastic process, Classification and properties of stochastic processes, Random Walk, Transition Probability Matrix, Classification of States and Chains, Transient and Persistent.	5
UNIT- 07	**Markov Process with discrete State Space:** Discrete and continuous time Markov chains, Classification of states, Limiting distribution, Poisson process and related distributions.	5
UNIT- 08	**Generalization of Poisson Process:** Pure Birth and pure death processes, Birth and death process, Chapman Kolmogorov Equations, Ergodicity of homogeneous Markov process, Erlang process.	5

Course Outcomes

Upon successful completion of the course, the student will be able to:
CO1: Understand probabilities and to solve an appropriate sample space.
CO2: Compute various operations like expectations from probability density functions and probability distribution functions.
CO3: Explain the concept of random process, Stochastic Process.
CO4: Apply the principles of random process and application to various fields.

Text Books

1. An Introduction to Probability and Statistics, VK Rohatgi, AK Saleh, Wiley, 2008.
2. SC Gupta and VK Kapoor, Fundamentals of Mathematical Statistics, S. Chand Publications, India, 10th Edition, 2019.
3. J Medhi, Stochastic Processes, New age International Publisher, India, 4th Edition, 2017

Reference Books

1. Irwin Miller and Marylees Miller, John E. Freund's Mathematical Statistics with Applications, Pearson Education.
2. R. V. Hogg and A. T. Craig, Introduction to Mathematical Statistics, Fourth edition, McMillan Publishing Company, 1978.

Course Name: Computer Organization & Architecture
Course Code: MA-214
Course Type: Discipline Core

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To impart basic concepts of computer architecture and organization.
- To explain key skills of constructing cost-effective computer systems.
- To familiarize the basic CPU organization.
- To help students in understanding various memory devices.
- To facilitate students in learning IO communication.

Unit No.	Course Content	Lectures
UNIT-01	**Introduction:** Historical overview, economic trends, underlying technologies, Data Representation- Data Types, Complements. Fixed-Point Representation, Floating-Point Representation. Error Detection and Correction, Addition, Subtraction, Multiplication and Division algorithms and hardware.	6
UNIT-02	**Register Transfer and Micro operations:** Register transfer language, Inter-Register Transfer, Arithmetic Microoperations, Logic and Shift micro-operations Language, Control functions. **Arithmetic Logic Unit:** Arithmetic, logic and shift micro operations. Constructing an arithmetic logic shift unit.	8
UNIT-03	**Basic Computer Architecture and Design:** Computer registers, Computer Instructions-Instruction Set Completeness. Classifying Instruction Set Architecture. Basic steps of Instruction Execution, Hardwired Control, Micro programmed Control. Horizontal and Vertical Microprogramming. Interrupts.	5
UNIT-04	**Central Processing Unit:** General Register Organization. Stack Organized CPU. Instruction Formats, Addressing Modes. Data Transfer and Manipulation. RISCVs CISC.	5
UNIT-05	**Memory Organization:** Memory Systems: principle of locality, principles of memory hierarchy Caches, associative memory, main memory, Virtual memory, Paging and Segmentation, Memory Interleaving.	5
UNIT-06	**Input Output Organization:** I/O performance measures, types and characteristics of I/O devices, I/O ModesProgrammed I/O, Interrupt Initiated I/O and DMA. Buses: connecting I/O devices to processor and memory, interfacing I/O devices to memory, processor, and operating system.	7

Course Outcomes

Upon successful completion of the course, the student will be able to

CO1: Learn the fundamentals of computer organization and its relevance to classical and modern problems of computer design.

CO2: Identify where, when and how enhancements of computer performance can be accomplished.

CO3: Learn the sufficient background necessary to read more advance texts as well as journal articles on the field.

CO4: See how to use concepts of computer organization in real-life settings using various PC performance improvements.

Books and References

1. Computer System Architecture, M.M. Mano, Pearson Education, 3rd Edition 1993.

2. Computer Organization & Design-The Hardware/Software Interface, David A. Patterson and John L. Hennessy, Morgan Kaufmann, 2nd Edition 1997.

3. Computer Organisation and Architecture, Designing for Performance, William Stallings, Pearson Education Asia, 6th Edition 2003.

4. Fundamentals of Parallel Processing, Harry F. Jordan and Gita Alaghband, Pearson Education, 1st Edition 2003.

5. Parallel Programming, Barry Wilkinson Michael Allen, prentice hall, 1999.

Course Name: Data Structures
Course Code: MA-215
Course Type: Discipline Core

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To impart the basic concepts of data structures and algorithms.
- To understand concepts about searching and sorting techniques.
- To understand basic concepts about queues, lists, trees and graphs.
- To understanding about writing algorithms and step by step approach in solving problems with the help of fundamental structures.

Unit No.	Course Content	Lectures
UNIT-01	**Introduction:** Data types, abstract data types, the running time of a program, the running time and storage cost of algorithms, complexity, asymptotic complexity, big O notation, obtaining the complexity of an algorithm. Development of Algorithms: Notations and Analysis.	7
UNIT-02	**Linear Data Structures:** Storage structures for arrays - sparse matrices - structures and arrays of structures. Stacks and Queues: Representations, implementations and applications, singly linked lists, Linked stacks and queues, operations on Polynomials, Doubly Linked Lists, Circularly Linked Lists, Operations on linked lists- Insertion, deletion and traversal, dynamic storage management – Garbage collection and compaction.	9
UNIT-03	**Sorting and Searching Techniques:** Bubble sorting, Insertion sort, Selection sort, Shell sort, Merge sort, Heap sort, Quick sort, Radix sort and Bucket sort, Sequential searching, Binary Searching	8
UNIT-04	**Trees:** Basic terminology, General Trees, Binary Trees, Tree Traversing: in-order, pre-order and post- order traversal, building a binary search tree, Operations on Binary Trees - Expression Manipulations - Symbol Table construction, Height Balanced Trees (AVL), B-trees, B+ -trees.	6
UNIT-05	**Graphs:** Basic definitions, representations of directed and undirected graphs, the single-source shortest path problem, the all-pair shortest path problem, traversals of directed and undirected graphs, directed acyclic graphs, strong components, minimum cost spanning trees, articulation points and bi-connected components, graph matching.	6

Course Outcomes

Upon successful completion of the course, the student will be able to :-

CO1: Analyze algorithms and algorithms correctness.
CO2: Summarize searching and sorting techniques.
CO3: Describe, stack, queue, and linked list operation.
CO4: Have knowledge of tree and graph concepts.

Books and References:

1. Aho, Hopcraft and Ullman. Data structures and Algorithms, Addison Wesley.
2. Horowitz and Sahni, Fundamentals of Data Structures, Computer Science Press.
3. Wirth, Algorithms + Data Structures = Programs, PHI.
4. Cormen, Leiserson, Rivest and Stein, Introduction to algorithms, Prentice Hall.
5. Data structure with C, Seymour Lipschutz TMH.
6. Data structures using C, Reema Tharej, Oxford.

Course Name: Data Structures Lab
Course Code: MA-216
Course Type: Discipline Core

Contact Hours/Week: 04P **Course Credits: 02**

Course Objectives

- To understand the basics of writing different types of programs.
- To learn sorting method to arrange a list of integers.
- To perform various operations.

List of Experiments

1. Write a program that uses functions to perform the following:
   a) Create a single linked list of integers.
   b) Delete a given integer from the above linked list.
   c) Display the contents of the above list after deletion.
2. Write a program that uses functions to perform the following:
   a) Create a doubly linked list of integers.
   b) Delete a given integer from the above doubly linked list.
   c) Display the contents of the above list after deletion.
3. Write a program that uses stack operations to convert a given infix expression into its postfix equivalent, Implement the stack using an array.
4. Write programs to implement a double ended queue ADT using
   a) array and
   b) doubly linked list respectively.
5. Write a program that uses functions to perform the following:
   a) Create a binary search tree of characters.
   b) Traverse the above Binary search tree recursively in post-order.
6. Write a program that uses functions to perform the following:
   a) Create a binary search tree of integers.
   b) Traverse the above Binary search tree non recursively in in-order.
7. Write programs for implementing the following sorting methods to arrange a list of integers in ascending order:
   a) Insertion sort
   b) Merge sort.
8. Write programs for implementing the following sorting methods to arrange a list of integers in ascending order:
   a) Quick sort
   b) Selection sort.
9. Write a program to perform the following operation:
   a) Insertion into a B-tree
   b) Write a C program for implementing Heap sort algorithm for sorting a given list of integers in ascending order.
10. Write a program to implement all the functions of a dictionary (ADT) using hashing.

Note: The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.

Course Outcomes

Upon successful completion of the course, the students will be able to: -
CO1: Identify and abstract the programming task involved for a given problem.
CO2: Design and develop object-oriented programming skills.
CO3: Trace and debug a program.

Course Name: Numerical Computations with MATLAB Lab
Course Code: MA-217
Course Type: Discipline Core

Contact Hours/Week: 02P **Course Credits: 01**

Course Objectives

- To understand basic representation of vectors in MATLAB.
- To learn basic programming structures in MATLAB.
- To become conversant with 2D as well as 3D graphics in MATLAB.
- To understand how to develop algorithm to solve algebraic as well as transcendental equations.

List of Experiments

1. Introduction to MATLAB interface: Desktop, Variables, Data Types, Vectors and Arrays, Script and Function Files, Two- and Three-dimensional Plotting, Conditional Statements (if-else, while, switch) and Loops, Symbolic Computations.
2. Develop algorithm and codes to solve algebraic and transcendental equations using
    a. Bisection method
    b. Regula-Falsi Method
    c. Newton Raphson method.
3. To develop algorithm and codes to solve system of linear equations by
    a. Gauss Jacobi iteration method
    b. Gauss Seidel iteration method.
4. Develop codes for finding value of dependent variable at particular point by
    a. Newton's forward interpolation,
    b. Newton's backward interpolation.
5. Develop codes for finding definite integrals using
    a. Trapezoidal rule
    b. Simpson's 1/3 and 3/8 rule
    c. Romberg Integration.
6. Developing codes to find numerical solution of ordinary differential equation using
7. Euler's method,
8. Runge-Kutta (4th order) Method,
9. Explore the inbuilt functions (ODE23, ODE45 etc).

Note: The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.

Course Outcomes: At the end of the course student will be able to: -

CO1: Explain the various programming structures, functions in MATLAB.
CO2: Develop an understanding of MATLAB for designing systems.
CO3: Apply MATLAB for real time applications with ability to plot on graphics.

Course Name: Linear Algebra and Applications
Course Code: MA-221
Course Type: Discipline Core

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To learn various system of linear equations, matrices and elementary row operations.
- To understand vector space and its application to different equations and Markov chains.
- To learn linear transformation, representation of linear transformation and application to differential equations.
- To understand inner product spaces, various operators and application of inner product spaces.

Unit No.	Course Content	Lectures
UNIT-01	**System of Linear Equations:** Matrices and elementary row operations, Row reduced echelon matrices, Homogeneous system of linear equations, Elementary matrices, LU Decomposition, some applications of Linear Systems.	5
UNIT-02	**Vector Space**: Fields, Vector Spaces over R and C, subspaces, linear independence, basis, and dimension of a vector space, ordered basis and co-ordinates. Application to difference equations and Markov chains.	7
UNIT-03	**Linear Transformation**: Linear transformations, Rank and Nullity of linear transformation, Algebra of linear transformation, Isomorphism, Invertible linear transformations, Dual and double dual of a vector space and transpose of a linear transformation, Matrix representation of Linear Transformation	8
UNIT-04	**Diagonalization:** Eigenvalue, and eigenvector of a linear transformation, Diagonalizability of linear operators of finite dimensional vector spaces, Application of eigen values and eigen vector	5
UNIT - 05	**Inner Product Spaces**: Gram-Schmidt orthogonalization, best approximation of a vector by a vector belonging a given subspace and application to least square problems	5
UNIT - 06	**Operator:** Adjoint of an operator, Hermitian, unitary, and normal operators, Singular Value Decomposition, Spectral decomposition, Applications of Inner product spaces, Applications of Linear algebra in data science, machine learning and real life**.**	6

Course Outcomes

Upon successful completion of the course, the student will be able to-

CO1: Understand various system of linear equations, matrices, and elementary row operations.
CO2: Describe vector space and its application to different equations and Markov chains.
CO3: Explain linear transformation, representation of linear transformation and application to differential equations.
CO4: Describe inner product spaces, various operators and application of inner product spaces.

Books and References

1. Geory Nakos and David Joyner: Linear algebra with Applications, Brooks/ Cole Publishing Company, International Thomson Publishing, Asia, Singapore, 1998,
2. David C. Lay: Linear algebra and its applications (3rd Edition), Pearson Education Asia, Indian Reprint, 2007,
3. Stephen H, Friedberg, Arnold J, Insel and LE, Spence- Linear Algebra, 4th edition, PHI, New Delhi, 2004.
4. Gilbert Strang, Introduction to Linear Algebra, Wellesley-Cambridge Press, 2016.

Course Name: Real and Complex Analysis
Course Code: MA-222
Course Type: Discipline Core

Contact Hours/Week: 03+01T **Course Credits: 04**

Course Objectives

- To impart knowledge about real number system and its various properties.
- To understand the sequence and series of real valued functions.
- To provide an introduction to the theories of functions of a complex variable. In particular, the notion of analyticity, completeness, compactness with some fundamental theorems.
- To provide knowledge of singularities, residues and various series expansions of complex valued functions.

Unit No.	Course Content	Lectures
UNIT-01	**Real Number System:** Sets, functions, real number system and its completeness property, order property, Nested Intervals Property.	5
UNIT-02	**Sequences and Series:** Sequence, convergence, monotone sequence, Subsequences, Bolzano-Weiestrass theorem, Cauchy criterion, Convergence of series, Comparison test, Ratio test	5
UNIT-03	**Limit and Continuity:** Cluster point, Limit of a function, Limit theorem, Sequential criterion, continuity, composition of continuous maps, uniform continuity, continuity on intervals, minimum maximum theorem, uniform continuity,	5
UNIT-05	**Differentiability:** The derivative, Caratheodory'sTheorem, Chain rule, Mean value theorem, L'Hospital rule,	5
UNIT-06	**Riemann Integration:** Tagged partition, Riemann sum, Cauchy Criterion, Squeeze Theorem, Fundamental Theorems of Calculus.	6
UNIT-07	**Complex valued functions:** Functions of a complex variable: continuity, differentiability, analytic functions, harmonic functions; Complex integration: Cauchy's integral theorem and formula; Liouville's theorem, maximum modulus principle, Morera's theorem; zeros and singularities;	10
UNIT-08	**Complex valued functions:** Power series, radius of convergence, Taylor's series and Laurent's series; Residue theorem and applications for evaluating real integrals; Rouche's theorem, Argument principle, Schwarz lemma; Conformal mappings, Mobius transformations.	12

Course Outcomes:

Upon successful completion of the course, the student will be able to :-

CO1: Learn about some of the classes and properties of Riemann integrable functions.

CO2: Learn about analytic functions and their importance.

CO3: Learn about Cauchy criterion for uniform convergence and Weierstrass M-test for uniform convergence.

CO4: Learn about Power series of complex valued functions and formulas to find radius of convergence for them.

Books and References

1. Introduction to Real Analysis , R.G. Bartle & D.R. Sherbert, Wiley.
2. Complex Analysis, E.M. Stein & R. Shakarchi, Princeton University Press.
3. Complex Analysis for Mathematics and Engineering by J.H. Mathews and R.W. Howell, Narosa Publishing House.
4. Mathematical Analysis by T. M. Apostol, Addison-Wesley Publishing Company.

Course Name: Object Oriented Programming
Course Code: MA-223
Course Type: Discipline Core

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To learn the basic concepts of object-oriented programming and differentiate between structured and OOPs languages.
- To learn about arrays, pointers and functions.
- To identify and understand data types, operators and various classes and objects.
- To learn and understand about various types of inheritances.
- To learn files and exception handling.

Unit No.	Course Content	Lectures
UNIT-01	**Concepts of Object-Oriented Programming**: Object Oriented Programming Paradigm, Basic concepts of OOPs, Benefits of OOPs, and Introduction to object-oriented design and development, Design steps, Design example, Object oriented languages, Comparison of structured and object-oriented programming languages.	6
UNIT-02	**Arrays, Pointers, and Functions:** Arrays, Storage of arrays in memory, Initializing Arrays, Multi- Dimensional Arrays, Pointers, accessing array elements through pointers, passing pointers as function arguments, Arrays of pointers, Pointers to pointers, Functions, Arguments, Inline functions, Function Overloading Polymorphism.	6
UNIT-03	**Classes and Objects:** Data types, operators, expressions, control structures, arrays, strings, Classes and objects, access specifiers, constructors, destructors, operator overloading, type conversion.	8
UNIT-04	**Inheritance:** Inheritance, single Inheritance, Multiple Inheritance, Multi-level inheritance, hierarchical inheritance, hybrid inheritance, Virtual functions.	7
UNIT-05	**Files and Exception Handling**: Opening and closing a file, File pointers and their manipulations, Sequential Input and output operations, multi-file programs List of exceptions, catching exception, handling exception, Standard Template Library.	9

Course Outcomes

Upon successful completion of the course, the student will be able to-

CO1: Explain the basic concepts of object-oriented programming and compare structed and OOPs languages.

CO2: Understand about arrays, pointers and functions.

CO3: Identify various classes and objects.

CO4: Understand and identify various types of inheritances.

CO5: Understand files and exception handling techniques.

Books and References

1. Bjarne Stroustrup, The C++ Programming Language, 3rd, Pearson Education
2. Lipman, S. B. C++ Primer, 3rd ed. Pearson Education.
3. H. M. Deitel, P.J Deitel, "Java: how to program", Fifth edition, Prentice Hall of India private limited.
4. Herbert Schildt, "The Java 2: Complete Reference", Fourth edition, TMH.

Course Name: Applied Statistics and Statistical Inference
Course Code: MA-224
Course Type: Discipline Core

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To compute various measures of central tendency, dispersion, skewness, kurtosis and normality of data.
- To impart knowledge about the concept of correlation, regression and hypothesis testing.
- To introduce the fundamental concepts relevant to Hypothesis testing and its comparison tests.
- To enable the students to understand the concept of Non-Parametric tests

Unit Number	Course Content	Lectures
UNIT- 01	**Introduction:** Data collection Types of data, sources of data collection -discussion of different situations.Measures of central tendency, dispersion, skewness, kurtosis, data representation using Histogram, Pie Chart, Boxplot, Biplot, Multidimensional scaling.	04
UNIT- 02	**Estimation:** Problem of estimation; point estimation, interval estimation, criteria for a good estimator, unbiasedness, consistency, efficiency and sufficiency with examples. Method of moments and maximum likelihood and application of these methods for obtaining estimates of parameters of binomial, Poisson and normal distributions, properties of M.L.E's (without proof), merits and demerits of these methods.	08
UNIT- 03	**Correlation and regression analysis:** Simple correlation and linear regression model, curve fitting by least squares, tests of significance of correlation and regression coefficients, coefficient of determination, spearman's rank correlation.	04
UNIT- 04	**Hypothesis Testing:** Types of errors and power - most powerful tests, Test for equality of means and variances – t and F test; Chi-square test for goodness of fit and independence of attributes, Analysis of variance with one–way and two–way classifications.	10
UNIT- 05	**Multiple Comparison Tests:** Least Significant Difference, Student-Newman–Keuls test, Duncan's Multiple Range test, Tukey's test	04
UNIT- 06	**Non Parametric Tests:** Sign test, Signed rank test, Median test ,Mann-Whitney test, Run test and One sample Kolmogorov – Smirnov test	06

Course Outcomes

Upon successful completion of the course, the student will be able to-

CO1: Identify and describe the data types and prepare the hypothesis according to the given data.
CO2: Apply statistical tests to the real time data set and draw the conclusions.
CO3: Write the statistical interpretation of the data.

Test Books

1. D.C. Montgomery, G.C. Runger, Applied Statistics and Probability for Engineers, 5th Edition, John Wiley and Sons, 2011.
2. S. C. Gupta and V.K. Kapoor, Fundamentals of Applied Statistics, Sultan Chand.
3. George Casella and Roger L Berger, Statistical Inference, 2nd Edition, Duxbury - Thomson Learning Co.Ltd.

Reference Books

1. Snedcor, G. W. and Cochran, W. G., Statistical Methods, 7th Edition, Iowa State University Press, 1982.
2. Irwing W. Burr, Applied Statistical Methods, Academic Press, 1970.

Course Name: Applied Statistical Methods Lab
Course Code: MA-225
Course Type: Discipline Core

Contact Hours/Week: 02P **Course Credits: 01**

Course Objectives

- To provide skills for designing worksheets and data import and export from different formats.
- To provide skills to write/create the hypothesis by observing the data.
- To enable the students to work and analyze the data.

List of Experiments

1. Introduction to SPSS and setting Up a Data File
2. SPSS Analysis: Windows Method versus Syntax Method and Missing data
3. Programs to Methods of MULT RESPONSE Procedures, Example of the Multiple-Dichotomy Method, Example of the Multiple-Response Method, Cross-Tabulations
4. Testing Statistical Significance between Two Correlation Coefficients Obtained from Two Samples
5. Spearman Rank Order Correlation Coefficient
6. Prediction Equation of Linear Regression and Multiple regression Analysis
7. Chi-Square Test for Single Variable Experiments and test of Independence between Two Variables
8. t Test for Independent Groups
9. Paired-Samples t Test
10. Analysis of Variance – One-way and Two -way
11. Post Hoc Comparisons of ANOVA
12. Non-parametric tests: Kolmogorov Smirnov test, Mann-Whitney U test, Median test for k-sample problem, Kruskal Wallis test and Friedman's test

Note: The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on the above generic list.

Course Outcomes:

Upon successful completion of the course, the student will be able:

CO1: to identify and abstract the data type and suitable statistical tool for the data.

CO2: to design the data sheet.

CO3: to understand statistical analysis and writing interpretations.

Course Name: Object Oriented Programming Lab
Course Code: MA-226
Course Type: Discipline Core

Contact Hours/Week: 04P **Course Credits: 02**

Course Objectives

- To learn about the simple operations and control structures of object-oriented programming.
- To learn the use of array, structure and union and function for various purposes.

List of Experiments

1. Demonstrate simple operations and control structures.
2. Demonstrate use of array :
   a) Add two matrix using multi-dimensional arrays,
   b) Searching in arrays, Array of Class, Operations on strings as arrays and to access array elements using pointers.
3. Demonstrate use of structure and union.
4. Demonstrate use of function by i) To swap numbers in cyclic order using call by reference and to check prime number by creating a function, ii) To find the multiplication values and the cubic values using inline function, iii) To calculate the area of circle, rectangle and triangle using function overloading.
5. Read and print students detail using class and object.
6. Demonstrate example of friend function with class.
7. Demonstrate increment ++ and decrement - - variables by using operator overloading.
8. Write a program to demonstrate the single inheritance, multilevel inheritance, multiple inheritances, hybrid inheritance and hierarchical inheritance.
9. Write a program that shows that two files named 'Source 1' and 'Source 2' contains sorted list of integers. Read the content of both the files and stores the merged list in sorted form in a new file named 'Target'.
10. Write a function template to perform linear search in an array.
11. Write a program containing a possible exception. Use a try block to throw it and a catch block to handle it properly.
12. Write a program to demonstrate container i) using the find algorithm to locate the position of a specified value in a sequence container, ii) using the algorithm count to count how many elements in a container have a specified value.
13. Write a program to implement Vector in STL.

Note: The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.

Course Outcomes

Upon successful completion of the course, the student will be able:
CO1: to use arrays for different kinds of operations and structures.

Course Name: Number Theory and Abstract Algebra
Course Code: MA-311
Course Type: Discipline Core

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To impart knowledge about the Euclidean algorithm, residue, congruence inversion formula, recurrence function.
- To enable the students to understand the factors that causes the cryptography.
- To introduce the concepts of group, ring, ideal and factorization of polynomial ring which have vital applications in system security algorithms.

Unit Number	Course Content	Lectures
UNIT-01	**Number Theory and Congruences:** Basic definition and properties of number theory, solutions of congruences, theorems of Fermat, Euler & Wilson, linear congruences and Chinese remainder theorem, quadratic congruences.	7
UNIT-02	**Arithmetical Functions:** Review of Arithmetic functions, Examples with some properties and their rate of growth, finite continued fractions and their connections with Diophantine approximations, applications to linear equations.	7
UNIT-03	**Group Theory**: Groups, subgroups, normal subgroups, quotient groups, homomorphisms, automorphisms; cyclic groups, permutation groups, Group action, Sylow's theorems and their applications;	8
UNIT-04	**Ring Theory:** Rings, ideals, prime and maximal ideals, quotient rings, unique factorization domains, Principle ideal domains, Euclidean domains, polynomial rings, Eisenstein's irreducibility criterion;	7
UNIT-05	**Fields:** Fields, finite fields, field extensions, algebraic extensions, algebraically closed fields	7

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Identify divisibility, residue, congruence, remainder, reciprocity, primality, factorization.
CO2: Group theory and its applications in security systems.
CO3: Factorization of polynomials and its application in solving some of the most important problems.

Books and References

1. David M. Burton, "Elementary Number Theory", (Fifth Edition) International Edition, McGraw Hill
2. Topics in Algebra by I.N. Herstein, Wiley India Pvt. Ltd.
3. Algebra Vol. 1, by Ramji Lal, Infosys Science Foundation Series. Springer Nature Singapore.
4. Contemporary Abstract Algebra by Joseph Gallian (Ninth edition ed.) Cengage Learning Boston.

Course Name: Operations Research
Course Code: MA-312
Course Type: Discipline Core

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To provide quantitative insight and understanding of fundamental methods of linear programming problems.
- To demonstrate various methods to solve such problems.
- To introduce the transportation and assignment problems, arising in real life.
- To give flavor of both sound theoretical foundation of various methods and their actual implementations in problems solving.

Unit No.	Course Content	Lectures
UNIT-01	**Linear Programming Problems:** Linear programming models, convex sets, extreme points; Basic feasible solution, graphical method, simplex method, two phase methods, revised simplex method ; Infeasible and unbounded linear programming models, alternate optima; Duality theory, weak duality and strong duality;	12
UNIT-02	**Transportation Problems:** Balanced and unbalanced transportation problems, Initial basic feasible solution of balanced transportation problems (least cost method, north-west corner rule, Vogel's approximation method); Optimal solution by U-V Method, modified distribution method; Stepping Stone Method, Degeneracy in Transportation problem.	8
UNIT-03	**Assignment Problems:** Mathematical formulation, solution by Hungarian Method, unbalanced problem, maximization problem, Traveling Salesman problem and its solution.	8
UNIT-04	**Network Analysis:** Background, development, networking, estimating activity time, Determination of earliest expected and allowable times, determination of Critical Path, PERT cost, scheduling of a project, CPM and application of these methods.	8

Course Outcomes

Upon successful completion of the course, the student will be able to
CO1: Understand the characteristics of different types of decision-making environments and the appropriate decision-making approaches and tools to be used in each type.
CO2: Build and solve Transportation and Assignment Models.
CO3: Design new simple models, like: CPM, PERT to improve decision –making and develop critical thinking and objective analysis of decision problems.

Text Books

1. F.S. Hillier and G.J. Libermann, Introduction to Operations Research, McGraw Hill, 5th Edition, 2001.
2. S.D. Sharma, Operation Research, Kedarnath Ramnath & Co., 2002.
3. J. K. Sharma, Operations Research: Theory and Applications, Macmillan India Ltd., 3rd Edition, 2007.
4. P. Paneerselvam, Operations Research, 2/e, PHI Learning Private Limited, 2011

References Books

1. Hamdy A. Taha, Operation Research: An Introduction, Prentice Hall of India, 10th Edition, 2017
2. S. S. rao, Engineering Optimization: Theory and practice, New Age International Publishers, 3rd Edition, 2013.

Course Name: Computer Networks
Course Code: MA-313
Course Type: Discipline Core

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To introduce the concepts of basic Networks.
- To provide basic knowledge of the data link layer.
- To provide an overview of the Network layer and its applications layer.

Unit Number	Course Content	Lectures
UNIT-01	**Introductory**: Goals and Applications of Networks, LAN, WAN, MAN, reference models: OSI, TCP/IP, Internet, Connection oriented network - X.25, frame relay, ARPANET, INTERNET.	5
UNIT-02	**The Physical Layer:** Theoretical basis for communication, transmission media, wireless transmission, Virtual circuits, Circuit switching.	6
UNIT-03	**Data Link Layer:** Design issues, error detection and correction, elementary data link protocols, sliding window protocols, example data link protocols - HDLC, the data link layer in the internet.	6
UNIT-04	**Network Layer**: Network Layer design issue, Routing algorithms, Congestion Control Algorithms, Internetworking.	7
UNIT-05	**Transport Layer:** Transport services, Design issues, elements of transport protocols, simple transport protocols, Connection management, TCP, UDP.	6
UNIT-06	**Application Layer**: Domain name system, electronic mail, World Wide Web, remote procedure call, Simple Network Management Protocol, File Transfer Protocol, Simple Mail Transfer Protocol, Telnet.	6

Course Outcomes

Upon successful completion of the course, the student will be able to
CO1: Understand network layers, models, and architectures.
CO2: Analyze the performance of various routing and transport protocols.
CO3: Solve basic network design problems using knowledge of different layers in networking.

Books and References

1. Computer Networks by A.S. Tanenbaum, Prentice Hall of India.
2. Computer Networking: A Top-Down Approach Featuring the Internet by J. Kurose, K.W. Ro.
3. Data and Computer Communication by W. Stallings, Prentice Hall of India.
4. Data Communication and Networking by Forouzan, 5 edition, McGraw Hill Education.

Course Name: Database Management Systems
Course Code: MA-314
Course Type: Discipline Core

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To introduce the concepts of basic SQL as a universal Database.
- To demonstrate the principles behind systematic database design approaches by covering conceptual design, logical design through normalization.
- To provide an overview of physical design of a database system, by discussing Database indexing techniques and storage techniques.

Unit No.	Course Content	Lectures
UNIT-01	**Basic Concepts**: Introduction to File and Database systems- Database system structure – concepts and architecture, date models, schemas & instances, DBMS architecture & data independence, database languages & interfaces, Data Model, ER model.	7
UNIT-02	**Relational Models**: SQL – Data definition- Queries in SQL-relational model concepts, relational model constraints, relational algebra, SQL- a relational database language: date definition in SQL, view and queries in SQL, specifying constraints and indexes in SQL; relational database management systems-Updates, Views, Integrity and Security, Relational Database design,	8
UNIT-03	**Normalizations:** Functional dependencies and Normalization for Relational Databases, normal forms based on primary keys, (1NF, 2NF, 3NF & BCNF), lossless join and dependency preserving decomposition	7
UNIT-04	**Data Storage and Query Processing:** Record storage and Primary file organization- Secondary storage Devices, Operations on Files, Heap File, Sorted Files, Hashing Techniques, Index Structure for files, Different types of Indexes- B-Tree – B + Tree, Query Processing.	8
UNIT-05	**Transaction Management**: Transaction Processing, Need for Concurrency control, Desirable properties of Transaction, Schedule, and Recoverability, Serializability and Schedules; Concurrency Control, Types of Locks, Two Phases locking, Deadlock, Timestamp-based concurrency control, Recovery Techniques, Concepts- Immediate Update- Deferred Update, Shadow Paging.	6

Course Outcomes

Upon successful completion of the course, the student will be able to

CO1: Explain the features of database management systems and Relational databases.

CO2: Create and populate a RDBMS for a real-life application, with constraints and keys, using SQL and retrieve any type of information from a database by formulating complex queries in SQL.

CO3: Analyze the existing design of a database scheme and apply concepts of normalization to design an optimal database and build indexing mechanisms for efficient retrieval of information from a database.

Books and References

1. Database System Concepts by A. Silberschatz, H.F. Korth, S. Sudarshan, Tata McGraw-Hill.
2. Fundamental Database Systems by R. Elmasri, S. B. Navathe, Pearson Education.
3. An introduction to database concepts by B. Desai, Galgotia publications.
4. An introduction to database systems by C.J. Date, Addison Wesley.
5. Fundamentals of database systems by E. Ramez, N. Samkanth, Pearson Education.
6. Principles of database systems by J.D. Ullman, Galgotia Publications.
7. Database System Implementation by H. Garcia–Molina, J. D.Ullman and J. Widom, Pearson Education.

Course Name: Database Management Systems Lab
Course Code: MA-315
Course Type: Discipline Core

Contact Hours/Week: 04P **Course Credits: 02**

Course Objectives

- To present an introduction to database management systems using programming.
- To provide skills for writing programs.
- Familiar with basic database storage structures and access techniques.

List of Experiments:

1. Installing oracle/ MYSQL
2. Creating Entity-Relationship Diagram using case tools
3. Writing SQL statements Using ORACLE /MYSQL:
    a) Writing basic SQL SELECT statements
    b) Restricting and sorting data
    c) Displaying data from multiple tables
    d) Aggregating data using a group function
    e) Manipulating data
    f) Creating and managing tables
4. Normalization
5. Study and implementation of different types of constraints
6. Creating procedure and functions
7. Creating packages and triggers
8. Study and implementation of Rollback, Commit, and Savepoint commands
9. Design and implementation of Library Information System
10. Design and implementation of Student Information System
11. Study and implementation of Database Backup and Recovery commands

Note: The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on the above generic list.

Course Outcomes

Course Outcomes Upon successful completion of the course, the students will be able to
CO1: Describe the fundamental elements of relational database management systems.
CO2: Design ER-models to represent simple database application scenarios.
CO3: Improve the database design by normalization.

Course Name: Analysis and Design of Algorithms
Course Code: MA-321
Course Type: Discipline Core

Contact Hours/Week: 03L +01T **Course Credits: 04**

Course Objectives

- To teach paradigms and approaches used to analyze and design algorithms and to appreciate the impact of algorithm design in practice.
- To make students understand how the worst-case time complexity of an algorithm is defined, how asymptotic notation is used to provide a rough classification of algorithms.
- To explain different computational models (e.g., divide-and-conquer), order notation and various complexity measures (e.g., running time, disk space) to analyze the complexity/performance of different algorithms.

Unit No.	Course Content	Lectures
UNIT-01	**Algorithms Introduction**: Algorithm Design paradigms- motivation, concept of algorithmic efficiency, run time analysis of algorithms, Asymptotic Notations.	6
UNIT-02	**Divide and Conquer Approach**: Structure of divide-and-conquer algorithms: sets and disjoint sets: Union and Find algorithms, quick sort, Finding the maximum and minimum, Quick Sort, Merge sort, Heap and heap sort.	6
UNIT-03	**Greedy Algorithms**: Optimal storage on tapes, Knapsack problem, Job sequencing with deadlines, **Minimum Spanning trees**: Prim's algorithm and Kruskal's algorithm, Huffman codes.	6
UNIT-04	**Dynamic Programming**: Overview, difference between dynamic programming and divide and conquer, Matrix chain multiplication, Traveling salesman Problem, longest Common sequence, 0/1 knapsack.	6
UNIT-05	**Graph Algorithms**: Representation of graphs, BFS, DFS, Topological sort, strongly connected components; single source shortest paths: Bellman-Ford algorithm, Dijkstra's algorithm; All pairs shortest path: The Warshall's algorithm, Backtracking, Branch and Bound: 8-Queen Problem, Sum of subsets, graph coloring, Hamiltonian cycles. Branch and bound: LC searching Bounding, FIFO branch and bound, LC branch and bound application: 0/1 Knapsack problem, Traveling Salesman Problem.	7
UNIT-06	**Computational Complexity**: Complexity measures, Polynomial Vs Non Polynomial time complexity; NP-hard and NP-complete classes, examples.	5

Course Outcomes

Upon successful completion of the course, the student will be able to

CO1: Choose appropriate algorithm design techniques for solving problems and to understand how the choice of data structures and the algorithm design methods impact the performance of programs.

CO2: Clear up troubles the usage of set of rules design methods including the grasping approach, divide and overcome, dynamic programming, backtracking and department and certain.

CO3: Understand the variations among tractable and intractable problems and to introduce P and NP classes.

Books and References

1. Introduction to Algorithms by T. H. Cormen, C. E. Leiserson, R. L. Rivest, C. Stein, MIT Press.
2. Fundamentals of Computer Algorithms by E. Horowitz and S. Sahni, S. Rajasekaran, Universities Press.
3. The Design and Analysis of Computer Algorithms by A.V. Aho, J.E. Hopcroft and J.D. Ullman, Pearson.
4. Data Structures and Algorithmic Puzzles by N. Karumanchi, CareerMonk Publications.
5. The Algorithm Design Manual by S. S Skiena, Springer.
6. Introduction to the Design and Analysis of Algorithms by A. Levitin, Pearson.

Course Name: Machine Learning
Course Code: MA-322
Course Type: Discipline Core

Contact Hours/Week: 03L+01T **Course Credits: 04**

Course Objectives

- To learn the concepts of searching for AI problems.
- To learn about agents and knowledge representation.
- To get introduced to fundamentals of machine learning.
- To learn about the possibilities of Supervised and Unsupervised learning

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Introduction to ML and AI, AI techniques, level of model, criteria for success, Turing test, Reactive, deliberative, goal-driven, utility-driven, and learning agents Artificial Intelligence programming techniques	**6**
UNIT-02	Foundations for ML: ML Techniques overview, Validation Techniques (Cross-Validations), Feature Reduction/Dimensionality reduction,	**8**
UNIT-03	**Machine Learning and Knowledge Acquisition:** Overview of different forms of learning, Regression and classification, learning decision tress, Support vector machine, Learning nearest neighbor, naive Bayes.	**8**
UNIT-04	**Problem Solving:** Problem as a space, search, production system, problem characteristics, production system characteristics, solving problems by searching, Heuristic search techniques, constraint satisfaction problems, stochastic search methods.	**6**
UNIT-05	Knowledge Representation and Reasoning: Ontologies, foundations of knowledge representation and reasoning, representing, and reasoning about objects, relations, events, actions, time, and space; frame representation, semantic network, predicate logic, resolution, natural deduction, situation calculus, description logics, reasoning with defaults, reasoning about knowledge.	**8**

Course Outcomes

Upon successful completion of the course, the student will be able to

CO1: Understand the concept of artificial intelligence (AI) principles and its approaches

CO2: Analyze and formalize the problem as a state space, graph, design heuristics and select amongest different search or game-based techniques to solve them.

CO3: Formulate and solve problems with uncertain information in machine learning using various techniques.

CO4: Apply knowledge representation, reasoning, and machine learning techniques to real-world problems.

CO5: Include the concept of artificial intelligence in various practical/engineering/scientific situations.

Books and References

1. Artificial Intelligence by S. Kaushik, Cengage Learning India Pvt Ltd (2022).
2. Principles of Artificial Intelligence by N.J. Nilsson, Narosa Publishing House (1982).
3. Artificial Intelligence by E. Rich, K. Knight & S.B. Nair, McGraw Hill International (2017).
4. Machine Learning, Tom Mitchell, Tata McGraw Hill India (2017).
5. Artificial and Machine Learning, Vinod Chandra SS, Anand Hareendran S, PHI Learning.

Course Name: Machine Learning Lab
Course Code: MA-323
Course Type: Discipline Core

Contact Hours/Week: 04P **Course Credits: 02**

Course Objectives

- To introduce students to the basic concepts and techniques of Machine Learning. .
- To become familiar with regression methods. .
- To become familiar with Dimensionality reduction Techniques.

List of Experiments

1. Implementation of Python Basic Libraries such as Statistics, Math, Numpy and Scipy.
2. Implementation of Python Libraries for ML application such as Pandas and Matplotlib.
3. Creation and Loading different datasets in Python
4. Write a python program to compute Mean, Median, Mode, Variance, and Standard Deviation using Datasets.
5. Write a python program to compute reshaping the data, filtering the data, merging the data and handling the missing values in datasets.
6. Write a Python program to implement Simple Linear Regression and plot the graph.
7. Implementation of Multiple Linear Regression for House Price Prediction using sklearn.
8. Implementation of Logistic Regression for iris using sklearn.
9. Implementation of random forest algorithm
10. Implementation of naive bayes classifier algorithm and plot the graph.
11. Implementation of SVM classification and plot the graph.
12. Implementation of PCA and LDA
13. Implementation of k-means clustering, hierarchical clustering, and Q-learning.
14. Performance analysis on a specific dataset (Mini Project).

Note: The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.

Course Outcomes

Upon successful completion of the course, the students will be able to: -

CO1: To introduce students to the basic concepts and techniques of Machine Learning.
CO2: To become familiar with regression methods.
CO3: To implement classification and clustering methods.
CO4: To become familiar with Dimensionality reduction Techniques.

Course Name: Internet of Things
Course Code: MA-381
Course Type: Stream Core

Contact Hours/Week: 02L **Course Credits: 02**

Course Objectives:

- To understand the fundamentals of Internet of Things
- Differentiate between IoT and M2M
- To learn about the basics of IOT protocols
- Understand IoT architecture and IoT design constraints
- To build a small low cost embedded system using Raspberry Pi

Unit NO.	Course Content	Lectures
UNIT-01	**Basic Concepts:** Sensing, Actuation, Networking basics, Communication Protocols, Sensor Networks, Machine-to-Machine Communications, IoT Definition, Characteristics. IoT Functional Blocks, Physical design of IoT, Logical design of IoT, Communication models & APIs.	6
UNIT-02	**M2M to IoT:** The Vision-Introduction, From M2M to IoT, M2M towards IoT-the global context, a use case example, Differing Characteristics. Definitions, M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT.	6
UNIT-03	**M2M vs IoT An Architectural Overview:** Building architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations. Reference Architecture and Reference Model of IoT.	6
UNIT-04	**IoT Reference Architecture:** Getting Familiar with IoT Architecture, Various architectural views of IoT such as Functional, Information, Operational and Deployment. Constraints affecting design in IoT world- Introduction, Technical design Constraints.	7

Course Outcomes

Upon successful completion of the course, the student will be able

CO1: Understand general concepts of Internet of Things (IoT) also recognize various devices, sensors and applications..

CO2: Apply design concept to IoT solutions and analyze various M2M and IoT architectures..

CO3: Evaluate design issues in IoT applications and Create IoT solutions using sensors, actuators and Devices.

Text Books: -

1. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, “From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence”, 1st Edition, Academic Press,2014.

Reference Book:

1. Vijay Madisetti and Arshdeep Bahga, “Internet of Things (A Hands-on- Approach)”, 1st Edition, VPT, 2014 2.
2. Francis daCosta, “Rethinking the Internet of Things: A Scalable Approach to Connecting Everything”, 1st Edition, Apress Publications, 2013 3.
3. Cuno Pfister, Getting Started with the Internet of Things, O‟Reilly Media, 2011, ISBN: 978-1- 4493- 9357-1

Course Name: Engineering Economics and Accountancy
Course Code: HS-321
Course Type: Institute Core

Contact Hours/Week: 2L **Course Credits: 02**

Course Objectives

- To impart knowledge about Economics and its applicability to the Engineers
- To introduce the fundamental concepts of economics
- To enable the students to understand the factors that cause the changes in economic conditions of the entrepreneur.

Unit Number	Course Content	Contact Hours
UNIT-01	Introduction to Engineering Economics: Definitions, Nature, Scope and application; Difference between Micro Economics and Macro Economics; Theory of Demand & Supply: Meaning, Determinants, Law of Demand, Elasticity of demand, Demand Forecasting, Law of Supply, Equilibrium between Demand & Supply.	06L
UNIT-02	Production and Cost: Production functions, Least Cost combination, Laws of Returns to Scale. Cost and Cost curves, Revenue and Revenue curves, Break even analysis.	06L
UNIT-03	Costing and Appraisal:Cost elements, Economic cost, Accounting cost, Standard cost, Actual cost, Overhead cost, Cost control, Criteria of project appraisal, Social cost benefit analysis	03L
UNIT-04	Money: Meaning, Functions, Types. Banking: Meaning, Types, Functions, Central Bank: its Functions, concepts CRR, Bank Rate, Repo Rate, Reverse Repo Rate, SLR.	03L
UNIT-05	Depreciation: Meaning of depreciation, causes, object of providing depreciation, factors affecting depreciation, Methods of Depreciation: Straight line method, Diminishing balance method, Annuity method and Sinking Fund method	04L
UNIT-06	Financial Accounting: Double entry system (concept only), Rules of Double entry system, Journal(Sub-division of Journal) , Ledger, Trial Balance Preparation of final accounts-Trading Account. Profit and Loss account, Balance Sheet.	04L

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Familiarize with the concepts of Engineering economics i.e. economic theory, decision making and management.

CO2: Understand and apply the fundamentals of microeconomics in achieving the consumers and entrepreneurs/manufacturers motive of maximize satisfaction & maximize profit respectively by using by optimization techniques.

CO3: Learn about the various concepts of cost and their role in determining the producer's behavior.

CO4: Money, Banking helps in increasing the trade in the economy and telling how it is going to affect the cost and profitability of the entrepreneur

CO5: Understand the concept of depreciation, and valuation.

CO6: The Trading , Profit and loss account and the Balance sheet that a manufacturer needs to submit to the government and to attract the investors for making the investment in their company by purchasing the shares and debentures issued by them.

Books and References

1. Principles of Micro Economics by Mceachern & Kaur, Cengage Publication.
2. Managerial Economics: by Craig Peterson & W Cris Lewis, PHI Publication.
3. Modern Microeconomics: by A. Koutsoyiannis, Macmillan.
4. Managerial Economics Theory and Applications: by D. M. Mithani. Himalaya Publication House.
5. Fundamental of Managerial Economics: Mark Hirschey, South Western Educational Publishing.
6. Engineering Economics: by Degramo, Prentice Hall.
7. Financial Accounting – A Managerial Perspective by R. Narayanaswamy, PHI.
8. Introduction to Accounting by J.R. Edwards, Marriot, Sage Publication.
9. Cost Accounting by Jawahar Lal, Tata McGraw Hill.
10. Project planning Analysis, Selection, Implementation and Review:by Prasanna Chandra,Tata McGraw Hill

Course Name: Advanced Differential Equations
Course Code: MA-411
Course Type: Discipline Core

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To study the linear and nonlinear ordinary differential equations and their solutions in the form of power series.
- To introduce the Sturm-Liouville eigenvalue problems and its applications.
- To understand the method of solution for linear and nonlinear partial differential equations and its applications in engineering.

Unit Number	Course Content	Lectures
UNIT-01	**Ordinary Differential Equations**: Review of first order ordinary differential equations, existence and uniqueness theorems for initial value problems, linear ordinary differential equations of higher order with constant coefficients; Second order linear ordinary differential equations with variable coefficients; series solutions (power series, Frobenius method); Legendre and Bessel functions and their orthogonal properties;	8
UNIT-02	Systems of linear first order ordinary differential equations, fundamental matrix, fundamental solution, Sturm's oscillation and separation theorems, Sturm-Liouville eigenvalue problems, Planar autonomous systems of ordinary differential equations: Stability of stationary points for linear systems with constant coefficients, Linearized stability, Lyapunov functions.	8
UNIT-03	**Partial Differential Equations:** Well-posed problems and classical solutions, Method of characteristics for first order linear and quasilinear partial differential equations; Higher order partial differential equations in two independent variables: classification and canonical forms, method of separation of variables for Laplace equation in polar coordinates, heat and wave equations in one space variable; Duhamel's principle for inhomogeneous problems	7
UNIT-04	Wave equation: Cauchy problem and d'Alembert formula, domains of dependence and influence, non-homogeneous wave equation; Heat equation: Cauchy problem; Laplace and Fourier transform methods.	5
UNIT-05	**Applications:** Applications of ordinary differential equations in Population dynamics, in fluid flow, in economy, in mechanical spring system, in finance. Applications of partial differential equations in wave equations, heat transfer, fluid dynamics, reaction-diffusion equations, black-scholes equation, climate modeling etc.	8

Course Outcomes

Upon successful completion of the course, the student will be able to
CO1: Learn to analyze and solve first-order ordinary differential equations.
CO2: Learn to solve partial differential equations in using various methods.
CO3: Learn to apply partial differential equations in various branches of engineering

Books and References

1. Differential Equations and their Applications by Martin Braun, Springer Verlag Berlin
2. Partial Differential Equations by L C Evans, American Mathematical Society
3. Ordinary Differential Equations by B Rai and D P Choudhary and H I Freedman, Narosa Publication
4. Elements of Partial Differential equations by I. N Seneddon, Dover Publications.

Course Name: Theory of Computation
Course Code: MA-412
Course Type: Discipline Core

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To introduce students to the mathematical foundations of computation including automata theory; the theory of formal languages and grammars; the notions of algorithm, decidability, complexity, and computability.
- To enhance/develop students' ability to understand and conduct mathematical proofs for computation and algorithms.
- To understand basic properties of Turing machines and computing with Turing machines.

Unit Number	Course Content	Lectures
UNIT-01	**Machines**: Basic machine, FSM, Transition graph, Transition matrix, Deterministic and non- deterministic FSM'S, Equivalence of DFA and NDFA, Mealy & Moore machines, minimization of finite automata, Two-way finite automata.	6
UNIT-02	**Grammars:** Regular Sets and Regular Grammars: Alphabet, words, Operations, Regular sets, Finite automata and regular expression, Pumping lemma and regular sets, Application of pumping lemma, closure properties of regular sets. Formal Grammars & Languages: Basic definitions and examples oF languages, Chomsky hierarchy, Regular grammars, context free & context sensitive grammars, context free languages, non-context free languages, Chomskey normal forms, binary operations on languages.	8
UNIT-03	**Turing Machines & Pushdown Automata**: TM model, representation and languages acceptability of TM Design of TM, Universal TM & Other modification, composite & iterated TM, Pushdown automata, Acceptance by PDA.	7
UNIT-04	**Computability and Undecidability:** Basic concepts, primitive & partial recursive function, Recursive function, Decidability, Kleen's theorem. Undecidability: Properties of recursive & recursively enumerable languages, Universal Turing machine and undecidable problem, Rice's theorem & some more undecidable problems.	7
UNIT-05	**Computational Complexity Theory**: Definition, linear speed-up, tape compression & reduction in number of tapes, Hierarchy Theorem, Relation among complexity measures, Transition lemmas & non deterministic hierarchies, properties of general complexity measures, the gap, speed-up, union theorem, Automatic complexity theorem.	8

Course Outcomes

Upon successful completion of the course, the student will be able to

CO1: Analyze and design finite automata, pushdown automata, Turing machines, formal languages, and grammars.

CO2: Demonstrate the understanding of key notions, such as algorithm, computability, decidability, and complexity through problem solving.

CO3: Prove the basic results of the Theory of Computation.

Books and References

1. Introduction to Automata theory, Langauges & Computation by J. E. Hopcroft, J.D. Ullman, Narosa Publishers.
2. Theory of computer Science by K.L.P. Mishra, Prentice Hall of India.
3. Introductory Theory of Computer science by E.V. Krishnamurthy, East West Press.
4. Introduction to Languages and the Theory of Computation by J. Martin, McGraw-Hill Education.
5. An introduction to formal languages and automata by P. Linz, Narosa.

Course Name: Operating Systems
Course Code: MA-413
Course Type: Discipline Core

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To trace the evolution of operating system.
- To learn about the different types of operating system, CPU scheduling.
- To understand about the concurrent programming and deadlocks.
- To learn the memory allocation and management.
- To learn about basic and general models of file system, protection and security.

Unit No.	Course Content	Lectures
UNIT-01	**Evolution of operating systems:** Evolution of operating systems, Types of operating systems. The process concept, system programmer's view of processes, operating system's views of processes, operating system services for process management.	7
UNIT-02	**CPU Scheduling**: Scheduling concepts, scheduling algorithms, algorithm evaluation, multiple processor scheduling, real time scheduling.	6
UNIT-03	**Concurrent Programming and Deadlock:** Critical regions, Conditional critical regions, Monitors, Interprocess communication, Messages, Pipes, Semaphores, Modularization, Synchronization, Concurrent languages. Deadlocks: Characterization, Prevention, Avoidance, Detection and Recovery, Combined approach to Deadlock Handling, precedence graphs.	8
UNIT-04	**Memory Management:** Memory Management, Contiguous allocation, static-swapping, overlays, dynamic partitioned memory allocation, demand paging, page replacement, segmentation. Non- contiguous allocation, paging, Hardware support, Virtual Memory.	9
UNIT-05	**File Systems:** A Simple file system, General model of a file system, Symbolic file system, Logical and Physical file systems, Access methods, Directory and Disk structure, Allocation methods, Disk scheduling.	6
UNIT-06	**Protection and Security:** Goals and Principles of protection, Domain of protection, the security problem, programs threats, systems and network security threats, cryptography as a security tool and user authentication and Computer security.	5

Course Outcomes

Upon successful completion of the course, the student will be able to-
CO1: Provide an overview of the evolution of the operating system.
CO2: Describe and understand various types of operating system and CPU scheduling.
CO3: Understand the concurrent programming and deadlocks.
CO4: Know about memory allocation and management.
CO5: Understand the file system and principles of protections and security threats.

Books and References

1. Maurice J. Bach, Design of the UNIX Operating System, Prentice Hall, 1986.
2. Gary Nutt, Kernel Projects for Linux, Addison Wesley, 2001.
3. William Stallings, Operating Systems: Internals and Design Principles (5th ed.), Prentice-Hall of India, 2006.
4. D.M. Dhamdhere, Operating Systems: A Concept Based Approach (2nd ed.), Tata McGraw-Hill, 2007.

Course Name: Operating Systems Lab
Course Code: MA-414
Course Type: Discipline Core

Contact Hours/Week: 04P **Course Credits: 02**

Course Objectives

- To provide students knowledge of memory management and deadlock handling algorithms.
- To provide skills for writing programs.
- To learn different types of operating systems along with concept of file systems.

List of Experiments

1. Study of hardware and software requirements of different operating systems (UNIX,LINUX,WINDOWS XP, WINDOWS7/8
2. Execute various UNIX system calls for
    i. Process management
    ii. File management
    iii. Input/output Systems calls
3. Implement CPU Scheduling Policies:
    i. SJF
    ii. Priority
    iii. FCFS
    iv. Multi-level Queue
4. Implement file storage allocation technique:
    i. Contiguous(using array)
    ii. Linked –list(using linked-list)
    iii. Indirect allocation (indexing)
5. Implementation of contiguous allocation techniques:
    i.) Worst-Fit ii) Best- Fit iii) First- Fit
6. Calculation of external and internal fragmentation
    i. Free space list of blocks from system
    ii. List process file from the system
7. Implementation of compaction for the continually changing memory layout and calculate total movement of data
8. Implementation of resource allocation graph RAG)
9. Implementation of Banker's algorithm
10. Conversion of resource allocation graph (RAG) to wait for graph (WFG) for each type of method used for storing graph.
11. Implement the solution for Bounded Buffer (producer-consumer)problem using inter process communication techniquesSemaphores
12. Implement the solutions for Readers-Writers problem using inter process communication technique –Semaphore

Note: The concerned Course Coordinator will prepare the actual list of experiments/problems at the start of semester based on above generic list.

Course Outcomes

Upon successful completion of the course, the students will be able to

CO1: Make students able to implement CPU scheduling algorithms and Bankers algorithm used for deadlock avoidance and
prevention.

CO2: Implement various algorithms required for management, scheduling, allocation and communication used in operating
system.

CO3: Implement page replacement and memory management algorithms.

Course Name: Deep Learning
Course Code: MA-451
Course Type: Stream Core

Contact Hours/Week: 02L **Course Credits: 02**

Course Objectives

- To introduce the idea of artificial neural networks and their architecture
- To introduce techniques used for training artificial neural networks
- To enable design of an artificial neural network for classification
- To enable design and deployment of deep learning models for machine learning problems

Unit Number	Course Content	Lectures
UNIT-01	Artificial Neural Networks- The Neuron-Expressing Linear Perceptrons as Neurons-Feed-Forward Neural Networks- Linear Neurons and Their Limitations –Sigmoid – Tanh – and ReLU Neurons -Softmax Output Layers – Training Feed-Forward Neural Networks-Gradient Descent-Delta Rule and Learning Rates-Gradient Descent with Sigmoidal Neurons- The Backpropagation Algorithm-Stochastic and Minibatch Gradient Descent – Test Sets – Validation Sets – and Overfitting- Preventing Overfitting in Deep Neural Networks – Implementing Neural Networks in Tensor Flow.	8
UNIT-02	Local Minima in the Error Surfaces of Deep Networks- Model Identifiability- Spurious Local Minima in Deep Networks- Flat Regions in the Error Surface – Momentum-Based Optimization – Learning Rate Adaptation.	8
UNIT-03	Convolutional Neural Networks(CNN) – Architecture -Accelerating Training with Batch Normalization- Building a Convolutional Network using Tensor Flow- Visualizing Learning in Convolutional Networks – Embedding and Representation Learning -Autoencoder Architecture-Implementing an Autoencoder in Tensor Flow – Denoising Sparsity in Autoencoders Models for Sequence Analysis – Recurrent Neural Networks- Vanishing Gradients Long Short-Term Memory (LSTM) Units- Tensor Flow Primitives for RNN Models-Augmenting Recurrent Networks with Attention.	9

Course Outcomes

Upon successful completion of the course, the student will be able to

CO1: To understand the mathematics behind functioning of artificial neural networks.

CO2: To analyze the given dataset for designing a neural network based solution.

CO3: To carry out design and implementation of deep learning models for signal/image processing applications.

Text Books: -

1. Nikhil Buduma, “Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithm”, O’Reilly, 2017.
2. Ian Good fellow, Yoshua Bengio and Aaron Courville, “Deep Learning”, MIT Press, 2016.

Reference Book:

1. Aurélien Géron, “Hands-On Machine Learning with Scikit- Learn and Tensor Flow”, O’Reilly, 2017.
2. Nikhil Ketkar, “Deep Learning with Python: A Hands-on Introduction”, Apress, 2017.

Course Name: Blockchain Technology
Course Code: MA-471
Course Type: Stream Core

Contact Hours/Week: 02L **Course Credits: 02**

Course Objectives

- To introduce the fundamental concept of blockchain technology.
- To have the idea of bitcoin basic and Ethereum basic.
- To learn the privacy security issues in blockchain.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Need for Distributed Record Keeping, Modeling faults and adversaries, Byzantine Generals problem, Consensus algorithms and their scalability problems, Nakamoto's concept with Blockchain based cryptocurrency, Technologies Borrowed in Blockchain – hash pointers, consensus, byzantine fault-tolerant distributed computing, digital cash.	9
UNIT-02	**Basic Distributed Computing & Crypto primitives:** Atomic Broadcast, Consensus, Byzantine Models of fault tolerance, Hash functions, Puzzle friendly Hash, Collision resistant hash, digital signatures, public key crypto, verifiable random functions, Zero-knowledge systems.	9
UNIT-03	**Bitcoin basics:** Bitcoin blockchain, Challenges and solutions, proof of work, Proof of stake, alternatives to Bitcoin consensus **Ethereum basics:** Ethereum and Smart Contracts, The Turing Completeness of Smart Contract Languages and verification challenges, using smart contracts to enforce legal contracts, comparing Bitcoin scripting vs. Ethereum Smart Contracts.	9
UNIT-04	**Privacy, Security issues in Blockchain:** Pseudo-anonymity vs. anonymity, Zcash and Zk-SNARKS for anonymity preservation, attacks on Blockchains: Sybil attacks, selfish mining, 51% attacks advent of algorand; Sharding based consensus algorithms to prevent these attacks	9

Course Outcomes

Upon successful completion of the course, the student will be able to
CO1: Understand the elementary concept of blockchain technology.
CO2: Analyses the privacy, security issues in blockchain.
CO3: Implement the crypto primitives in blockchain technology.

Books and References

1. Andreas M. Antonopoulos, "Mastering Bitcoin: Unlocking Digital Cryptocurrencies", O'Reilly Media Inc, 2015.
2. Melanie Swa "Blockchain", First Edition, O'Reilly Jan 2015.

Course Name: Cyber Security
Course Code: MA-301
Course Type: Open Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives:

- Know the need of Cyber Security
- Understand the Objectives of cyber security
- Emphasis on cyber security policies
- Understand the cyber forensics investigation process and laws

Unit Number	Course Content	Lectures
UNIT- 01	Cyber Attacks, Viruses, Worms and other Malware, Intrusion Detection and Prevention Introduction to Cyber Security, Domains of Cyber Security Policies, Cyber Security Evolution- Productivity, Internet, e-commerce, Counter Measures, Challenges.	08
UNIT- 02	Cyber Security Objectives – Cyber Security Management – Metrics, Security Management goals, Counting Vulnerabilities, Security Frame work, Security Policy Objectives, Guidance for decision Makers, Catalogue Approach.	08
UNIT- 03	Cyber Governance Issues – Cyber user Issues –Cyber Conflict Issues – Cyber Infrastructure Issues - Cyber security's role in National Security.	09
UNIT- 04	Cyber Forensics, Computer Forensics and Investigations as a Profession- Understanding Computer Forensics-Preparing for Computer Investigations, Understanding Computer Investigations-Preparing a Computer Investigation-Taking a Systematic Approach-Procedures for Corporate High-Tech Investigations-Understanding Data Recovery Workstations and Software, Data Acquisition-Understanding Storage Formats for Digital Evidence-Determining the Best Acquisition Method-Validating Data Acquisitions-Performing RAID Data Acquisitions.	08

Course Outcomes

Upon successful completion of the course, the student will be able
CO1: Understand the importance of cyber security
CO2:Obtain knowledge on objectives of cyber security
CO3: Become familiar with cyber security policies
CO4: Explain the cyber forensics investigation process

Text Books: -

1. Cyber Security Policy Guidebook, Jennifer L. Bayuk, Jason Healey, Paul Rohmeyer and Marcus Sachs John Wiley & Sons, Kindle Edition, 2012. References
2. Cyber Forensics, Albert J Marcella, Jr. Doug Menendez, Auerbach Publicaitons, Second Edition

Reference Book:

1. Cyber Security and Cyberwar, P.W.Singer and Allan Friedman Oxford University Press, Kindle Edition, 2014.
2. Cyber Security Essentials, James Graham, Ryan Olson and Rick Howard , CRC Press, Kindle Edition, 2014.
3. Network Security and Cryptography, Bernard Menezes , Cengage Learning

Course Name: Statistical Data Analysis
Course Code: MA-302
Course Type: Open Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives:

- To impart knowledge about the different types of data sets and form the questionnaire.
- To apply the concepts of correlation and regression and ANOVA to the data sets .
- To enable the students to assimilate data applied to real, science and interesting problems

Unit Number	Course Content	Lectures
UNIT- 01	**Introduction:** Definition of statistics – Scope and limitations of statistics – Types of data – Nominal, Ordinal, Ratio, Interval scale data - Primary and Secondary data – Data presentation tools –One dimensional, two dimensional data presentation – line diagram – Box plots – stem and Leaf plots – Scatter plots.	05
UNIT- 02	**Statistical Measures:** Collection and presentation of data – summarizing data – frequency distribution – Measures of location, Measures of dispersion, and Skewness, Kurtosis and their measures.	05
UNIT- 03	**Probability:** Events - Sample Space - Mathematical and Statistical definitions of Probability – Axiomatic definition of Probability – Addition and multiplication theorems - Conditional probability – Bayes' Theorem - Simple problems.	05
UNIT- 04	**Correlation and Regression:** Partial and Multiple correlation coefficients (three variables only) – regression– Curve fitting by least squares – linear and quadratic.	06
UNIT- 05	**Hypothesis Testing:** Types of errors and power - most powerful tests, Test for equality of means and variances – t and F test; Chi-square test for goodness of fit and independence of attributes, Analysis of variance with one–way and two–way classifications.	10

Course Outcomes

Upon successful completion of the course, the student will be able to:

CO1. Identify and source data for use in evidence-based decision making in statistics.

CO2. Distinguish different types of data and understand how the data plays an important role in statistical decision making.

CO3. Determine which hypothesis testing to use to in their own research.

CO4. Demonstrate the concepts through examples and applications

Text Books

1. SC Gupta and VK Kapoor, Fundamentals of Mathematical Statistics, S. Chand Publications, India, 10th Edition, 2019.
2. Fundamentals of Applied Statistics by Gupta .S.C. and Kapoor.V.K, Sultan Chand.

Reference Books

1. Irwin Miller and Marylees Miller, John E. Freund's Mathematical Statistics with Applications, Pearson Education.
2. R. V. Hogg and A. T. Craig, Introduction to Mathematical Statistics, Fourth edition, McMillan Publishing Company, 1978.

Course Name: Finite Element Method
Course Code: MA-303
Course Type: Open Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives:

- Understand the theoretical foundations of the Finite Element Method.
- Develop proficiency in applying the Finite Element Method to solve engineering problems.
- Gain practical experience in mesh generation, analysis, and interpretation of results using FEM software**.**

Unit Number	Course Content	Lectures
UNIT- 01	**Introduction:** Overview of numerical methods in engineering, Historical background and development of the Finite Element Method, Advantages of FEM over finite difference method	07
UNIT- 02	**Finite element formulation:** Review of weighted residual methods, Variational methods and calculus of variations, Weak form of partial differential equations (PDEs), Basic concepts of FEM: discretization, interpolation, and approximation, Shape functions and numerical integration	08
UNIT- 03	**Mesh Generation:** Introduction to mesh generation techniques, Structured and unstructured meshes, Quality measures and refinement strategies, Linear static analysis using FEM, Application to truss and frame structures, Introduction to dynamic analysis: eigenvalue problems	07
UNIT- 04	**Heat Transfer Analysis:** Steady-state and transient heat conduction, Convection and radiation boundary conditions, Application of FEM to heat transfer problems and reaction diffusion equations.	07
UNIT- 05	**Advanced Topics:** Basics of fluid mechanics, Navier-Stokes equations and their weak form, Finite Element Method for fluid flow problems, Nonlinear finite element analysis, Introduction to optimization using FEM, Applications in other engineering disciplines	07

Course Outcomes

Upon successful completion of the course, the student will be able to:

CO1. Demonstrate comprehension of the mathematical principles underlying FEM, including variational methods and numerical integration.

CO2: Apply FEM techniques to solve structural, heat transfer, and fluid dynamics problems, demonstrating proficiency in mesh generation, element selection, and boundary conditions implementation.

CO3: Analyze and interpret FEM results, evaluating their accuracy, validity, and relevance to real-world engineering applications.

Text and Reference Books

1. J. N. Reddy, An introduction to the Finite Element Method, 3rd edition, McGraw-Hill, 2006.
2. O. C. Zienkiewicz and R. L. Taylor, The Finite Element Method, 7th edition, Butterworth-Heinemann, 2013.
3. T. J. R. Hughes, The Finite Element Method, Prentice-Hall, 1986.
4. Vidar Thomee, Galerkin Finite Element Methods for Parabolic Problems, Springer-Verlag, 2006.

Course Name: Integral Transforms and Applications
Course Code: MA-241
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To introduce the concept of Fourier series, periodic functions, and its properties.
- To understand various special waveforms such as Euler's formula, Dirichlet's conditions, theorem for the convergence of Fourier series.
- To learn Fourier transform and properties of Fourier transform.
- To understand Laplace transform and application in various functions.

Unit No.	Course Content	Lectures
UNIT-01	**Fourier Series:** Introduction, Periodic functions: Properties, Even & Odd functions, Special wave forms: square wave, Half wave Rectifier, Saw-toothed wave, Euler's Formula for Fourier Series, Fourier Series for functions of arbitrary period, Dirichlet's conditions, Theorem for the convergence of Fourier Series (statement only). Fourier Series of a function with its periodic extension. Half range Fourier series, Parseval's identity (statement only).	8
UNIT-02	**Fourier Transform**: Fourier Integral Theorem (statement only), Fourier Transform of a function, Fourier Sine and Cosine Integral Theorem (statement only), Fourier Cosine & Sine Transforms, Fourier Cosine & Sine Transforms of elementary functions.	8
UNIT-03	**Application of Fourier Transform:** Properties of Fourier Transform: Linearity, Shifting, change of scale, Modulation, Fourier Transform of Derivatives, Convolution Theorem (statement only), Inverse of Fourier Transform. Solution of partial differential equations	4
UNIT-04	**Laplace Transform:** Introduction of Laplace transform, Functions of Exponential order, The Laplace integral for functions of Exponential order, Convergence of the Laplace integral for the general case, Linear combinations of Laplace transforms, Laplace transform of some typical functions, Elementary properties of F(s), The Shifting theorems, Laplace transform of derivatives and integrals of a function.	8
UNIT-05	**Application of Laplace Transform:** Initial and final value theorems, Inverse Laplace transform by different methods, convolution theorem, solving Ordinary differential equations by Laplace Transform method**.**	4
UNIT-06	**Z-transforms:** Introduction to Z-transform and its elementary properties. Application to difference equations.	4

Course Outcomes

Upon successful completion of the course, the student will be able to-

CO1: Explain Fourier series, periodic functions, and its properties.

CO2: Understand and use various special wave forms such as Euler's formulae, Dirichlet's conditions, theorem for the convergence of Fourier series.

CO3: Explain Fourier transform and properties of Fourier transform.

CO4: Understand Laplace transform and its application in various function.

CO5: Describe Z-transform, elementary properties, and application in solution of various equations.

Books and References

1. L. Debnath and D.D. Bhatta, Integral Transforms and Their Applications, Book World Enterprises, 2006.
2. A.D Poularikas, The Transforms and Applications Handbook, CRC Press, 1996.
3. M. Ya. Antimirov, A.A. Kolyshkin, R. Valliancourt, Applied Integral Transforms, CRM Monograph Series, American Mathematical Society, 2007.
4. Pathak R. S., Integral transforms of generalized functions and their applications, Gordon and Breach Science Publishers, Amsterdam, 1997

Course Name: Mathematical Modeling and Simulation
Course Code: MA-242
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- Develop proficiency in understanding various types of models including finite, statistical, stochastic, verbal, and mechanical analogies.
- Master the formulation of models by applying laws and conservation principles to discrete and continuous systems, along with constitutive relations.
- Enhance analytical skills by manipulating models into their respective forms, evaluating them through case studies, and rendering variables dimensionless for simplification and insight into solutions.

Unit No.	Course Content	Lectures
UNIT-01	Model and its different types; Finite models; Statistical models; Stochastic models; Verbal models and mechanical analogies; Fuzzy subsets	7
UNIT-02	Formulation of a model; Laws and conservation principles; Discrete and continuous models; Constitutive relations; Difference and differential equations	7
UNIT-03	Manipulation into its most respective form; Evaluation of a model; Case studies; Rendering variables and parameters dimensionless; Reducing the number of equations and simplifying them; Gaining partial insights into the form of the solution	7
UNIT-04	Continuum model; Transport phenomena; Diffusion and air pollution models	5
UNIT-05	Microwave heating; Communication and Information technology; Applications in finance, healthcare, and environmental science	5
UNIT-06	Further case studies; Advanced topics in modeling and simulation; Optimization techniques in modeling; Sensitivity analysis; Validation and verification of models	5

Course Outcomes

Upon successful completion of the course, the student will be able to-
CO1: Learn to form models.
CO2: Learn to analyze them and numerically simulate the models.
CO3: Learn various real life models like diffusion, transport models.

Books and References

1. R. Aris, Mathematical Modelling Techniques, Dover, 1994.
2. C. L. Dym and E. S. Ivey, Principles of Mathematical Modelling, Academic Press, 1980.
3. M. S. Klamkin, Mathematical Modelling: Classroom Notes in Applied Mathematics, SIAM, 1986.
4. A. Friedman and W. Littman, Industrial Mathematics for Undergraduates, SIAM, 1994.

Course Name: Mathematical Methods
Course Code: MA-243
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To introduce the techniques for solving differential equations using power series solutions, special functions, and integral transforms with a focus on recurrence relations and orthogonality properties.
- To understand the concept and application of Green's function in solving ordinary and partial differential equations, along with properties and methods.
- To develop proficiency in Fourier analysis, including Fourier series, Fourier cosine and sine series, Fourier integrals, and various transforms for solving differential equations and integral equations.

Unit No.	Course Content	Lectures
UNIT-01	Power series solutions, Bessel functions, Modified Bessel functions, Legendre polynomial, Laguerre polynomial, Chebyshev polynomial, Hermite polynomials, Recurrence relations, Orthogonality	7
UNIT-02	Concept and calculation of Green's function, Properties, Green's function method for ordinary and partial differential equations	6
UNIT-03	Fourier Series, Fourier Cosine series, Fourier Sine series, Fourier integrals	6
UNIT-04	Fourier transform, Laplace transform, Hankel transform, Finite Hankel transform, Mellin transform, Solution of differential equations by integral transform methods	7
UNIT-05	Construction of kernels of integral transforms on a finite interval through Sturm-Liouville problem	5
UNIT-06	Occurrence of integral equations, Regular and singular integral equations, Volterra integral equations, Fredholm integral equations, Volterra and Fredholm equations with different types of kernels	5

Course Outcomes

Upon successful completion of the course, the student will be able to-
CO1: Learn Fourier series, periodic functions, and its properties.
CO2: Learn Green's function and its application in solving partial differential equations.
CO3: Explain Fourier transform and properties of Fourier transform.

Books and References

1. G. N. Watson, A Treatise on the Theory of Bessel Functions, Cambridge University Press, 1944.
2. Mathematical Methods, MC Potter, Prentice Hall India Learning Private Limited; 2nd edition, 2000.
3. G. F. Roach, Green's Functions, Cambridge University Press, 1995.
4. A. D. Poularikas, The Transforms and Applications Handbook, CRC Press, 1996.
5. L. Debnath and D.D. Bhatta, Integral Transforms and Their Applications, Chapman and Hall/CRC, 2011.
6. J. W. Brown and R. Churchill, Fourier Series and Boundary Value Problems, McGraw Hill, 1993.
7. F.G Tricomi, Integral Equations, Dover Publications Inc. New York, 1985.

Course Name: Calculus of Variations and Optimal Control
Course Code: MA-244
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- Understand variational principles and their applications in solving problems with fixed and moving boundaries.
- Explore optimal control theory, including controllability, isoperimetric problems, and necessary conditions for optimal controls.
- Develop analytical and computational skills for solving variational and optimal control problems using methods such as the Rayleigh-Ritz and Galerkin methods.

Unit No.	Course Content	Lectures
UNIT-01	The concept of variation and its properties, Variational problems with fixed boundaries, The Euler equation, Variational problems in parametric form	6
UNIT-02	Variational problems with moving boundaries, Reflection and refraction extremals, Sufficient conditions for an extremum, Canonical equations and variational principles	6
UNIT-03	Complementary variational principles, The Hamilton-Jacobi equation, Direct methods for variational problems, Rayleigh-Ritz method, Galerkin method, shape functions.	6
UNIT-04	Introduction to optimal control problems, Controllability and optimal control, Isoperimetric problems, Bolza problem	6
UNIT-05	Optimal time of transit, Rocket propulsion problem, Linear autonomous time-optimal control problem, Existence theorems for optimal control problems	6
UNIT-06	Necessary conditions for Optimal controls, The Pontryagin maximum principle	6

Course Outcomes

Upon successful completion of the course, the student will be able to-
CO1: Learn to solve variational problems.
CO2: Learn to use population methods like Galerkin method.
CO3: Learn about real world problems like rocket propulsion problem.

Books and References

1. A. S. Gupta, Calculus of Variation with Applications, Prentice-Hall, India, 1997.
2. G. M. Ewing, Calculus of Variations with Applications, Dover, 1985.
3. H. Sagan, Introduction to Calculus of Variations, Dover, 1967.
4. J. L. Troutman, Variational Calculus and Optimal Control, 2nd edition, Springer Verlag, 1996.

Course Name: Digital Design
Course Code: MA-351
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To teach various number systems, binary codes and their applications
- To familiarize the students the importance of error detection and error correction codes.
- To inculcate concepts of K-MAP to simplify a Boolean expression
- To facilitate students in designing a logic circuit

Unit No.	Course Content	Lectures
UNIT-01	Digital System And Binary Numbers: Number System and its arithmetic, Signed binary numbers, Binary codes, Cyclic codes, Hamming Code, the map method up to five variable, Don't care conditions, POS simplification, NAND and NOR implementation, Quine Mc-Clusky method (Tabular method).	7
UNIT-02	Combinational Logic: Combinational Circuits: Analysis Procedure, Design procedure, Binary adder-subtractor, Decimal adder, Binary multiplier, Magnitude comparator, Multiplexers, Demultiplexers, Decoders, Encoders.	7
UNIT-03	Sequential Logic And Its Applications: Storage elements: latches & flip flops, Characteristic Equations of Flip Flops, Flip Flop Conversion, Shift Registers, Ripple Counters, Synchronous Counters, Other Counters: Johnson & Ring Counter.	7
UNIT-04	Synchronous & Asynchronous Sequential Circuits: Analysis of clocked sequential circuits with state machine designing, State reduction and assignments, Design procedure. Analysis procedure of Asynchronous sequential circuits, circuit with latches, design procedure, Reduction of state and flow table, Race-free state assignment, Hazards.	8
UNIT-05	Memory & Programmable Logic Devices: Digital Logic Families: DTL, DCTL, TTL, ECL & CMOS etc., Fan Out, Fan in, Noise Margin; RAM, ROM, PLA, PAL; Circuits of Logic Families, Interfacing of Digital Logic Families, Circuit Implementation using ROM, PLA and PAL; CPLD and FPGA.	7

Course Outcomes

Upon successful completion of the course, the student will be able to-

CO1: Use number systems and complements

CO2. Identify the importance of canonical forms in the minimization or other optimization of Boolean formulas in general and digital circuits.

CO3. Minimize functions using any type of minimizing algorithms (Boolean algebra, Karnaugh map or Tabulation method).

CO4. Analyze the design procedures of Combinational and Sequential circuits.

Books and References

1. M. Morris Mano and M. D. Ciletti, "Digital Design", Pearson Education.
2. David J. Comer, "Digital Logic & State Machine Design", Oxford University Press.
3. RP Jain, "Modern Digital Electronics", Tata McGraw Hill Publication.

Course Name: Computer Graphics
Course Code: MA-352
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To introduce use of components of a graphics system and become familiar with building approach of graphics system components and algorithms related with them.
- To discuss the application of computer graphics concepts in the development of computer games, information visualization, and business applications.
- To comprehend and analyze the fundamentals of animation, virtual reality, underlying technologies, and principles.

Unit No.	Course Content	Lectures
UNIT-01	**Introduction to Computer Graphics:** Overview of Graphics Systems, Display Devices, Hard copy Devices. Interactive Input Devices, Display Processors, The Graphical Kernel System, Output Primitives, **Graphics Hardware**: Display technology, random scan, raster scan display processing, input devices for interaction.	5
UNIT-02	**Points and Lines:** Points & lines, Line drawing algorithms; DDA algorithm, Bresenham's line algorithm, Circle generation algorithm; Ellipse generating algorithm; scan line polygon, fill algorithm, boundary fill algorithm, flood fill algorithm.	6
UNIT-03	**2D Transformations**: Basic transformations: translation, rotation, scaling; Matrix representations & homogeneous coordinates, transformations between coordinate systems; reflection shear; Transformation of points, lines, parallel lines, intersecting lines. Viewing pipeline, Window to viewport coordinate transformation, clipping operations, point clipping, line clipping, clipping circles, polygons & ellipses.	7
UNIT-04	**3D Transformations**: translation, rotation, scaling & other transformations. Rotation about an arbitrary axis in space, reflection through an arbitrary plane; general parallel projection transformation; clipping, viewport clipping, 3D viewing **Curves:** Curve representation, surfaces, designs, Bezier curves, B-spline curves, end conditions for periodic B-spline curves, **Hidden Surfaces:** Depth comparison, Z-buffer algorithm, Back face detection, BSP tree method, the Printer's algorithm, scan-line algorithm; Hidden line elimination	8
UNIT-05	**Visible Lines and Visible Surfaces**: Visual Realism, Hidden line and hidden surface removal: depth buffer algorithm, geometric computations, scan line coherence algorithms, area coherence algorithms, priority algorithm, shading and color models, Modeling methods. **Color & shading models**: Light & color model; interpolative shading model; Texture;	6
UNIT-06	**Multimedia:** Introduction to Multimedia: Concepts, uses of multimedia, hypertext, and hypermedia. Image, video, and audio standards.	4

Course Outcomes

Upon successful completion of the course, the student will be able to
CO1: List the basic concepts used in computer graphics.
CO2: Implement various algorithms to scan, transformations, area filling, clipping.
CO3: Define the fundamentals of animation, virtual reality, and its related technologies.

Books and References

1. Procedural Elements for Computer Graphics by D.F. Rogers, Tata McGraw Hill.
2. Computer Graphics by D.D. Hearn, M.P. Baker, Prentice Hall of India.
3. Computer Graphics - A programming approach by S. Harrington, Tata McGraw Hill.
4. Mathematical Elements for Computer Graphics by D.F. Rogers, Tata McGraw Hill.

Course Name: Digital Image Processing
Course Code: MA-353
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To study the image fundamentals and mathematical transforms necessary for image processing.
- To design and implement algorithms that perform basic image processing (e.g. noise removal and image enhancement).
- To assess the performance of image processing algorithms and systems.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Digital image representation, Fundamental steps in image processing, Elements of Digital Image processing systems, Elements of visual perception, Image model, Image sampling and quantization, Relationship between pixels, Imaging geometry.	**5**
UNIT-02	**Image Enhancement and Restoration:** Image Enhancement in the Spatial Domain: Background, Basic grey level transformation, Histogram processing, Basics of spatial filtering, Smoothing and Sharpening Spatial filters, Frequency domain and Image Enhancement: Introduction to Fourier Transform and the Frequency Domain, Discrete Fourier Transform, Smoothing and Sharpening Frequency-Domain filters.	**13**
UNIT-03	**Image Restoration:** Image Degradation/Restoration Process, Types of degradations in digital images, Noise models. Restoration in presence of noise using filters: Mean filter, Minimum Mean Square Filtering, Geometric mean filter, Geometric transformations.	**9**
UNIT-04	**Edge Detection and Segmentation:** First and second order edge detection operators, Detection of discontinuities, Edge linking and boundary detection, Thresholding, Otsu's threshold, Region oriented segmentation, Spatial techniques, and Frequency domain techniques.	**9**

Course Outcomes

Upon successful completion of the course, the student will be able to
CO1: Learn different techniques employed for the enhancement of images.
CO2: Learn image restoration in presence of noise using filters.
CO3: Understand the rapid advances in machine vision.

Text Books

1. Digital Image Processing by R. Gonzalez and R. E. Wood, Prentice Hall of India.
2. Digital Image Processing by W.K. Pratt, McGraw Hill.
3. Fundamentals of Digital Image Processing by A. K. Jain, Prentice Hall of India.

Reference Books

1. Introductory Computer Vision and Image Procession by A. Low, McGraw Hill.
2. Handbook of Mathematical Methods in Imaging by Scherzer, Springer.
3. Image Processing: Analysis and Machine Vision by Milan Sonka, Roger Boyle, and Vaclav Hlavac.

Course Name: Software Engineering
Course Code: MA-354
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To introduce the elementary concepts of Software Engineering and Software Process.
- To understand the various models of Software development processes.
- To acquire the knowledge of Software Metrics, Requirement Engineering and Software Planning.
- To have the basic idea of Software design, Coding and Testing, Software Quality Assurance.

Unit No.	Course Content	Lectures
UNIT-01	**Introduction to Software Engineering and Software Process:** Introduction to Software Engineering: Program Vs Software; Characteristics of Software; Evolution of Software Engineering, Software categories, Software Development life cycle, Software Quality. Software Development Processes: Waterfall model, Incremental Models – Iterative Model and RAD Model, Evolutionary Models – Prototype and Spiral Model, Component Based Development, Unified Process, Rapid Software Development.	9
UNIT-02	**Software Metrics, Requirement Engineering and Software Planning:** Introduction: Software Measurement and Metrics, Software Quality Concepts, Requirement Engineering: Activities and approaches, Software Requirement specification; Software sizing approaches: Size oriented metrics, Function oriented metric, and evaluation techniques. Software Project Planning: Cost Estimation and Evaluation techniques.	7
UNIT-03	**Software Design:** Introduction to Software Design: Objectives and Principles, Module level concepts Coupling and Cohesion, Design notation and specification; Architectural Design, Component Level Design, Interface Design; Structured Design Methodology, Design Heuristics, Verification, Concepts of Object-Oriented Design.	7
UNIT-04	**Coding and Testing:** Coding: Programming practices and styles. Testing: Introduction to software testing, Testing Fundamentals, Test cases and test criteria. Black box testing, White box testing: Structural testing, Code Verification, Code Coverage and Cyclomatic Complexity.	7
UNIT-05	**Software Quality Assurance:** Quality Assurance Plans, Project Monitoring Plans, Risk Management, Software Reliability, Software Maintenance, Software Quality Assurance & International Standards, Clean Room Software Engineering, CASE Tools.	6

Course Outcomes

Upon successful completion of the course, the student will be able to

CO1: Understand and analyse the elementary concepts of Software Engineering and Software Process.
CO2: have the knowledge of various models of Software development processes.
CO3: Learn the Software Metrics, Requirement Engineering and Software Planning.
CO4: Demonstrate Software design, Coding and Testing, Software Quality Assurance.
CO5: Incorporate the concept of Software Engineering in various practical/engineering/scientific situations.

Books and References

1. Software Engineering: A Practitioner's Approach by Roger S. Pressman, Mc Graw Hill (2009).
2. An Integrated Approach to Software engineering by Pankaj Jalote, Narosa publishing House (1995).
3. Software Engineering Concepts by R.E. Fairley, MacGraw Hill (1992).
4. Software Engineering by Sommerville, Addison Wesley (1999).

Course Name: Soft Computing
Course Code: MA-341
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To understand the fundamental theory and concept of soft computing methods.
- To introduce concept of Fuzzy logic, various fuzzy systems and their functions.
- To understand basics of an evolutionary computing paradigm known as genetic algorithms.
- To introduce concept of artificial neural networks and its implementation for engineering applications.

Unit No.	Course Content	Lectures
UNIT-01	**Introduction to Soft Computing:** Concept of computing systems, "Soft" computing versus "Hard" computing, Characteristics of Soft computing, Some applications of Soft computing techniques.	6
UNIT-02	**Fuzzy Logic:** Introduction to Fuzzy Logic, Classical and Fuzzy Sets: Overview of Classical Sets, Membership Function, Fuzzy rule generation. Operations on Fuzzy Sets: Compliment, Intersections, Unions, Combinations of Operations, Aggregation Operations. Fuzzy Arithmetic, Fuzzy Logic: Classical Logic, Multivalued Logics, Fuzzy Propositions, Fuzzy Qualifiers, Linguistic Hedges, Fuzzy Inference, Defuzzification techniques, Fuzzy logic controller design, some applications of fuzzy logic.	10
UNIT-03	**Genetic Algorithms:** Concept of "Genetics" and "Evolution" and its applications to probabilistic search techniques, Basic GA framework and different GA architectures, GA operators: Encoding, Crossover, Selection, Mutation etc., Single objective Optimization problem using GA.	10
UNIT-04	**Artificial Neural Networks:** Overview of biological Neuro-system, Mathematical Models of Neurons, ANN architecture, learning rules, Learning Paradigms-Supervised, Unsupervised and reinforcement Learning, ANN training Algorithms- Training rules, Delta, Back Propagation Algorithm, Multilayer Perceptron Model, Hopfield Networks, Associative Memories, Applications of Artificial Neural Networks.	10

Course Outcomes

Upon successful completion of the course, the student will be able to

CO1: Understand the concepts of fuzzy logic and fuzziness involved in various system.
CO2: Solve single objective optimization problems using Genetic algorithm.
CO3: Analyze various neural network architectures.
CO4: Use soft computing methods to solve various engineering application problems.

Text Books

1. Principles of Soft Computing by S.N. Sivanandam, S. N. Deepa, John Wiley & Sons.
2. Neural Networks and Learning Machines by S. Haykin, Prentice Hall of India.
3. Genetic Algorithms in Search, Optimization and Machine Learning by D.E. Goldberg, Pearson.
4. Soft Computing with MATLAB Programming by NP Padhy and SP Simon, Oxford University Press.

Reference Books

1. Fuzzy Logic with Engineering Applications by T.J. Ross, John Wiley & Sons.
2. Foundations of Neural Networks, Fuzzy systems, and Knowledge Engineering by N.K. Kasabov, MIT Press.
3. Neuro-Fuzzy & Soft Computing by JSR Jang, CT Sun and E Mizutani, Pearson.

Course Name: Data Mining
Course Code: MA-342
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives:

- To presents the methods for mining frequent patterns, associations, and correlations.
- To describes methods for data classification and prediction, and data–clustering.
- To learn about various types of data stores such as spatial, textual, multimedia, streams.

Unit NO.	Course Content	Lectures
UNIT-01	**Data Mining:** Data–Types of Data, Data Mining Functionalities– Interestingness Patterns– Classification of Data Mining systems– Data mining Task primitives –Integration of Data mining system with a Data warehouse–Major issues in Data Mining–Data Preprocessing.	7
UNIT-02	**Association Rule Mining:** Mining Frequent Patterns–Associations and correlations – Mining Methods– Mining Various kinds of Association Rules– Correlation Analysis– Constraint based Association mining. Graph Pattern Mining, SPM.	8
UNIT-03	**Classification:** Classification and Prediction – Basic concepts–Decision tree induction–Bayesian classification, Rule–based classification, Lazy learner	7
UNIT-04	**Clustering and Applications:** Cluster analysis–Types of Data in Cluster Analysis–Categorization of Major Clustering Methods– Partitioning Methods, Hierarchical Methods– Density–Based Methods, Grid–Based Methods, Outlier Analysis.	7
UNIT-05	**Advanced Concepts:** Basic concepts in Mining data streams–Mining Time–series data—Mining sequence patterns in Transactional databases– Mining Object– Spatial– Multimedia–Text and Web data – Spatial Data mining– Multimedia Data mining–Text Mining– Mining the World Wide Web.	7

Course Outcomes

Upon successful completion of the course, the student will be able

CO1: Ability to understand the types of the data to be mined and present a general classification of tasks and primitives to integrate a data mining system.

CO2: Apply preprocessing methods for any given raw data and Extract interesting patterns from large amounts of data.

CO3: Discover the role played by data mining in various fields and Evaluate the accuracy of supervised and unsupervised models and algorithms.

Text Books: -

1. Data Mining – Concepts and Techniques, Jiawei Han & Micheline Kamber, 3rd Edition Elsevier.
2. Data Mining Introductory and Advanced topics – Margaret H Dunham, PEA.

Reference Book:

1. Ian H. Witten and Eibe Frank, Data Mining: Practical Machine Learning Tools and Techniques (Second Edition), Morgan Kaufmann, 2005.

Course Name: Cryptography and Network Security
Course Code: MA-343
Course Type: Stream Core

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To introduce the fundamental concepts relevant to Cryptography and Information Security.
- To understand the most common type of Crypto systems and various techniques and principles related to cryptanalysis.
- To learn different encryption techniques along with hash functions, MAC, digital signatures, and their use in various protocols for network security and system security.
- To learn about how to maintain the Confidentiality, Integrity, and Availability of a data.

Unit Number	Course Content	Lectures
UNIT-01	Introduction to cryptography, Classical Cryptosystem, Block Cipher, Data Encryption Standard (DES), Triple DES, Modes of Operation, Stream Cipher, LFSR based Stream Cipher, Mathematical background, Abstract algebra, Number Theory	09
UNIT-02	Modular Inverse, Extended Euclid Algorithm, Fermats Little Theorem, Euler Phi-Function, Eulers theorem, Advanced Encryption Standard (AES), Introduction to Public Key Cryptosystem, Diffie-Hellman Key Exchange, Primarily Testing, ElGamal Cryptosystem, Elliptic Curve over the Reals, Elliptic curve Modulo a Prime.	09
UNIT-03	Generalized ElGamal Public Key Cryptosystem, Rabin Cryptosystem, Message Authentication, Digital Signature, Key Management, Key Exchange, Hash Function, Cryptographic Hash Function, Secure Hash Algorithm (SHA), Digital Signature Standard (DSS).	09
UNIT-04	Cryptanalysis, Time-Memory Trade-off Attack, Differential and Linear Cryptanalysis, Cryptanalysis on Stream Cipher, Modern Stream Ciphers, Shamirs secret sharing and BE, Identity-based Encryption (IBE), Side-channel attack, The Secure Sockets Layer (SSL), Pretty Good Privacy (PGP), Introduction to Quantum Cryptography	09

Course Outcomes

Upon successful completion of the course, the student will be able to

CO1: Understand the fundamental concepts relevant to Cryptography and Information Security.

CO2: Understand the most common type of crypto systems and various techniques and principles related to cryptanalysis.

CO3: Learn different encryption techniques along with hash functions, MAC, digital signatures, and their use in various protocols for network security and system security.

CO4: Learn about how to maintain the Confidentiality, Integrity, and Availability of data.

CO5: Incorporate the concept of cryptography and information security in various practical/engineering/scientific situations.

Books and References

1. Cryptography and Network Security: Principles and Practice by W. Stallings, Pearson Education India (2017).
2. Understanding Cryptography: A Textbook for Students and Practitioners by C. Paar & J. Pelzl, Springer Science & Business Media (2009).
3. Cryptography and Network Security by A. Kahate, Tata McGraw-Hill (2005).
4. Cryptography & Network Security by B. A. Forouzan, Tata Mc Graw Hill (2011).

Course Name: Compiler Design
Course Code: MA-344
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives:

- To teach the students the basic techniques that underlies the practice of Compiler Construction.
- To explore the principles, algorithms, and data structures involved in the design and construction of compilers.
- To introduce the theory and tools that can be standardly employed in order to perform syntax-directed translation of a high-level programming language into an executable code.

Unit NO.	Course Content	Lectures
UNIT-01	**Introduction:** Compilers and Translators, Overview of the Compiling Process, Syntactic and Lexical Structure of a Language.	7
UNIT-02	**Lexical Analysis**: Regular Expression, Finite Automata, Specification and Recognition of Tokens, Simple Approaches to Lexical Analyzer Design.	8
UNIT-03	**Syntactic Analysis:** Context free grammar, Syntax and Parse Trees, Derivation of parse trees, ambiguity, Top-Down and Bottom-Up Parsing, Basic parsing techniques: shift reduce, operator- precedence, predictive parsing, LR Parsers.	7
UNIT-04	**Intermediate Code:** Postfix notation, syntax trees, three address code (quadruples, triples and indirect triples), Syntax directed translation, Symbol table organization, Run time storage management, Error detection and recovery.	7
UNIT-05	**Code Generation and Optimization:** Basic issues in code generation and optimization, Elementary idea about loop optimization, DAG, Global data flow analysis, Register utilization, usage count analysis, heuristic ordering algorithm for DAG and optimal ordering algorithm for trees, peephole optimization.	7

Course Outcomes

Upon successful completion of the course, the student will be able

CO1: Ability to understand direct application to the construction of compilers and optimization.
CO2: Apply various aspects of run-time environment into which the high-level code is translated.
CO3: To provide the experience of the design and construction of a working compiler.

Text Books: -

1. The Theory and Practice of Compiler Writing: -Trembley and Sorenson
2. Principles of Compiler Design: -Aho and Ullman
3. Compilers: Principles, Techniques and Tools -Aho, Ullman and Sethi

Reference Book:

1. The Essence of Compilers -Robin Hunter

Course Name: Financial Mathematics
Course Code: MA-361
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To provide an introduction to Financial Mathematics.
- To have an idea of various Portfolio Modelling and their Analysis.
- To introduce Stochastic Process under Finance.
- To introduce Stochastic Calculus for the problems of Financial Mathematics.

Unit No.	Course Content	Lectures
UNIT-01	**Basics of Financial Markets:** Introduction and main theme of mathematical finance, financial markets and terminology, time value of money, interest rate, discount rate, bonds and bonds pricing, yield curves, duration and convexity, term structure of interest rates, spot and forward rates, net present value, net future value, financial instruments, underlying and derivative securities, types of derivatives, options, forwards, futures, swaps, concept of arbitrage.	6
UNIT-02	**Portfolio Modelling and Analysis:** Portfolios, returns and risk, risk-reward analysis, asset pricing models, mean variance portfolio optimization, Markowitz model and efficient frontier calculation algorithm, Capital Asset Pricing Models (CAPM).	6
UNIT-03	**Stochastic Process:** Definitions and Simple Stochastics Processes, Brownian Motion and its Properties, Processes Derived from Brownian Motion, Filtration and Martingale.	6
UNIT-04	**Stochastics Calculus**: Introduction, variation of real-valued function , variation of Brownian Motion, Stochastic Integral and its Properties, Ito-Doeblin Formula and its variants, Stochastic differential equation.	6
UNIT-05	**Discrete-Time Finance:** Pricing by arbitrage, risk-neutral probability measures, valuation of contingent claims, and fundamental theorem of asset pricing, Cox-Ross-Rubinstein (CRR) model, pricing and hedging of European and American derivatives as well as fixed-income derivatives in CRR model, general results related to prices of derivatives.	6
UNIT-06	**Continuous-Time Finance:** Black-Scholes-Merton model of stock prices as geometric Brownian motion, derivation of the Black-Scholes-Merton partial differential equation, the Black-Scholes formula and simple extensions of the model, self-financing strategies and model completeness, risk neutral measures, the fundamental theorems of asset pricing, continuous time optimal stopping and pricing of American options, forwards and futures in Black-Scholes-Merton model.	6

Course Outcomes

Upon successful completion of the course, the student will be able

CO1: To understand the fundamentals of financial markets.

CO2: To apply and analyse various Portfolio Models.

CO3: Gain familiarity in the knowledge of Markov property and Martingale property its applications in the problems involving Mathematical Finance.

CO4: Gain knowledge in the solution of Stochastic differential equations and Ito Calculus.

Text Books

1. D.G. Luenberger Investment Science, Oxford University Press-2009.
2. B. Oksendal, Stochastic Differential Equations An Introduction with Application, Springer-Verlag-2003
4. S. M. Ross, An Introduction to Mathematical Finance, Cambridge University Press, 1999.

References Book

1. Options, Futures and Other Derivatives by J. C. Hull, Pearson Education (2003).
2. Mathematics for finance. An Introduction by M. Capinski & T. Zastawniak, Springer (2003).

Course Name: Optimization Techniques
Course Code: MA-362
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To understand the theory of convex set, function and conditions to attain optimality.
- To understand the concept of quadratic programming and separate methods.
- To introduce the optimality and duality concepts in nonlinear programming.
- To enable the students to understand unconstraint and constraint programming problems with solution methods.

Unit Number	Course Content	Lectures
UNIT- 01	**Convex Optimization:** Convex set, Convex Function, Properties of Convex Functions, Convex Optimization Problem, Optimality Condition: Motivation from calculus.	6
UNIT- 02	**Quadratic Programming:** Wolf's Method for quadratic programming, Beale's method for quadratic programming, Separable Programming.	4
UNIT- 03	**Optimality and Duality**: Introduction, Feasible directions and linearizing cone, Basic Constraint qualification, Lagrangian and Lagrangian Multipliers, Karsh-Kune-Tunker Necessary/Sufficient optimality condition, Duality in nonlinear programming.	6
UNIT- 04	**Unconstrained Optimization**: Introduction, Basic Scheme and Certain Desirable Properties, Line search method for unimodal Function, Steepest Descent Method, Newton's Methods, Conjugate Gradient Method.	8
UNIT- 05	**Constrained Optimization Techniques:** Introduction, Characteristics of a Constrained Problem, DIRECT METHODS: Random Search Methods, Sequential Linear Programming, Basic Approach in the Methods of Feasible Directions, Sequential Quadratic Programming.	6
UNIT- 06	**Constrained Optimization Techniques:** INDIRECT METHODS-Transformation Techniques, Basic Approach of the Penalty Function Method, Interior Penalty Function Method, Exterior Penalty Function Method	6

Course Outcomes

Upon successful completion of the course, the student will be able to

CO1: Understanding the traits of convex functions and optimization requires employing suitable decision-making methodologies.

CO2: Acquire an understanding of quadratic programming problems along with optimal solution techniques.

CO3: Understanding the necessary and sufficient optimality conditions, as well as duality in nonlinear programming, and their implementation.

CO4: Acquiring knowledge and comprehending the algorithms of unconstrained and constrained nonlinear programming.

Text Books

1. E. K. P. Chong and S. H. Zak, An Introduction to Optimization, 4th Ed., Wiley, 2013.
2. Mokhtar S. Bazaraa, Hanif D. Sherali, and C.M. Shetty, Nonlinear Programming: Theory and Algorithms, Second Edition, John Wiley & Sons, NewYork 1993.
3. John E. Dennis and Robert B. Schnabel, Numerical Methods for Unconstrained Optimization and Nonlinear Equations, SIAM, Philadelphia, 1996..

Reference Books:

1. J. Nocedal and S. J. Wright, Numerical Optimization, Springer, 1999
2. Anthony V. Fiacco and Garth P. McCormick, Nonlinear Programming: Sequential Unconstrained Minimization Techniques, SIAM. Philadelphia,1990.

Course Name: Applied Multivariate Statistical Analysis
Course Code: MA-363
Course Type: Discipline Core

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To impart knowledge about the multivariate statistical analysis, both theory and methods
- To introduce the fundamental concepts relevant to multivariate distributions.
- To enable the students to understand the classification problem in context of multivariate data.

Unit Number	Course Content	Lectures
UNIT- 01	**Introduction:** Multivariate descriptive statistics, statistical distance, mean and covariance matrix, partition of covariance matrix, linear combination of random variables.	5
UNIT- 02	**Simple Geometry and random sampling:** Geometry of sample, random samples and expected values of sample mean and covariance matrix, generalized variance, Sample mean, Covariance and Correlation as a matrix operations	8
UNIT- 03	**Multivariate random variables:** Joint multivariate distribution function, mass and density functions, joint and marginal functions, Moment generating function for multivariate random variable and its properties	8
UNIT- 04	**Multivariate Normal Distribution:** Multivariate normal distribution and its properties. Random sampling from multivariate normal distribution. Maximum likelihood estimators of parameters, distribution of sample mean vector	9
UNIT- 05	**Hotelling T^2 Distribution:** Hotelling T^2 statistic, derivation and its distribution –Uses of T^2 statistic - relation between T^2 and D^2 – Mahalanobis D^2 statistic and its distribution	9
UNIT- 06	**Classification problems:** Classification into one of two populations and one of several populations – Fisher's Linear discriminant function. **Principle Component Analysis:** Population principle components, sample variation, large sample inferences, monitoring quality with principle components **Factor Analysis:** Mathematical mode, Estimation of Factor Loadings, Concept of factor rotation – Varimax criterion	9

Course Outcomes:

Upon successful completion of the course, the student will be able to

CO1: Derive various multivariate sampling distributions.

CO2: Understand how the distribution arises in multivariate sampling and how to use it

CO3: Understand how to use the classification methods

CO4: Assess the multivariate nature of the data sets and dimension reduction techniques.

Text Books

1. T.W. Anderson, An Introduction to Multivariate Statistical Analysis, John Wiley and Sons, 2003.
2. R.A. Johnson and D.W. Wichern, Applied Multivariate Statistical Analysis, 6th Edition, Prentice Hall of India, 2007.

Reference Books

1. J.F. Hair, W.C. Black, B.J. Babin, R.E., Multivariate data analysis, Anderson, Pearson.
2. N.C. Giri, Applied Multivariate Statistical Analysis, Academic Press

Course Name: Time Series Analysis and Forecasting
Course Code: MA-364
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To introduce the fundamental of time series analysis and forecasting.
- To learn the importance of time series models and their applications in various fields.
- To get acquainted with the main concepts of Time Series theory and methods of analysis.
- To familiar with models for stationary time series.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction**: Time-series as discrete parameter stochastic process, auto covariance and auto-correlation functions and their properties.	4
UNIT-02	**Exploratory Time Series Analysis**: Components of time series, Measurements of trend, Measurement of seasonal fluctuation, Measurement of cyclic movement, tests for trend and seasonality, exponential and moving average smoothing. Holt and Winters smoothing, forecasting smoothing.	10
UNIT-03	**Models for Stationary Time Series**: (1) moving average (MA), (2) auto regressive (AR), (3) ARMA and (4) AR integrated MA (ARIMA) models. Box-Jenkins models, choice of AR and MA periods.	6
UNIT-04	**Modelling Seasonal Time Series**: Seasonal ARIMA models, estimation, and forecasting, Fitting ARIMA models with Box-Jenkins procedure, Identification, Estimation, Verification, Test for white noise, Forecasting with ARMA models.	8
UNIT-05	**Spectral analysis**: Spectral analysis of weakly stationary process, periodogram and correlogram analyses, computations based on Fourier transform	4
UNIT-06	**Multivariate Time Series**: Stationary multivariate time series, Cross-covariance and Cross-Correlation Matrices, Covariance Stationary, Vector white nose process, Moving average representation of a stationary vector process	4

Course Outcomes

Upon successful completion of the course, the student will be able to
CO1: Understand and analyse the theoretical & practical aspects of time series data.
CO2: Understand the components of time series and measure these components.
CO3: Identify an appropriate time series model to fit the empirical data and use it for forecasting.
CO4: Understand the genesis of the multivariate time series analysis.

Text Books

1. G. E. P. Box, G.M. Jenkins G.C. Reinsel, & G.M. Ljung, Time Series Analysis: Forecasting and Control, Palgrave Macmillan, 2015.
2. Brockwell & R.A. Davis, Introduction to Time Series and Forecasting, Springer, 2002.

Reference Book

1. Time Series Analysis by J. D. Hamilton, Princeton University Press, 2020.

Course Name: Functional Analysis
Course Code: MA-431
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To understand basics of normed vector spaces and its applications in different fields.
- To give the idea of linear operator in normed vector spaces and the properties.
- To view basics of Hilbert spaces and discuss some theorem and its properties.
- To have the idea of linear operator in Hilbert spaces and the properties.

Unit Number	Course Content	Lectures
UNIT-01	Normed linear spaces, examples and its topological properties, Banach spaces, linear operators.	5
UNIT-02	Spaces of continuous linear operators from a linear space to a Banach space, linear functionals, dual spaces.	5
UNIT-03	Hahn-Banach theorem, Open mapping theorem, Closed graph theorem, Banach- Steinhaus theorem (or the Uniform boundedness principle).	8
UNIT-04	Conjugate spaces, natural embedding of N in N**, conjugate of an operator, simple applications to reflexive separable spaces.	8
UNIT-05	Hilbert Spaces, Schwarz's inequality, orthogonal complement, Bessel's inequality, orthonormal sets, continuous linear functionals on Hilbert spaces.	5
UNIT-06	Riesz- representation theorem, reflexivity of Hilbert Spaces, adjoint of an operator on a Hilbert space, Self-adjoint and normal operators, unitary operators on a Hilbert space.	5

Course Outcomes

Upon successful completion of the course, the student will be able to

CO1: Explain the fundamental concept of functional analysis and their role in modern mathematics and applied concepts.

CO2: Demonstrate accurate and efficient use of functional analysis techniques.

CO3: Demonstrate capacity for mathematical reasoning through analysis proving and explain concept from functional analysis.

Books and References

5. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill, 1963.
2. S. Ponnusamy, Foundations of Functional Analysis, Narosa Publishing House, New Delhi, 2002.
3. E. Kreyszig, Introductory functional analysis with applications, Wiley Classics Library, John Wiley & Sons, Inc., New York.
4. B.V. Limaye, Functional Analysis, New Age International Publishers, 3rd Ed., 2014.

Course Name: Fractional Differential Systems
Course Code: MA-432
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To impart an understanding of special functions in fractional calculus, including the Gamma function, Mittag-Leffler function, and Wright function.
- To introduce the concepts and techniques of fractional derivatives and integrals, and their application in solving differential equations.
- To provide knowledge in applying fractional calculus to real-world problems in various fields such as finance, economics, physics, and engineering.

Unit No.	Course Content	Lectures
UNIT-01	Special functions of fractional calculus: Gamma function, Mittag-Leffler function, Wright function.	5
UNIT-02	Fractional derivatives and integrals: Grunwald-Letnikov fractional derivatives, Riemann-Liouville fractional derivatives, geometric and physical interpretation of fractional integration and differentiation.	6
UNIT-03	Laplace, Fourier, and Mellin transforms of fractional derivatives.	5
UNIT-04	Linear fractional differential equations: Equation of a general form, existence and uniqueness theorem as a method of solution, dependence of a solution on initial conditions, Laplace transform method, standard fractional differential equations, sequential fractional differential equations.	8
UNIT-05	Some methods for solving fractional order equations: Mellin transform, power series, orthogonal polynomials, numerical evaluation of fractional derivatives, approximation of fractional derivatives.	6
UNIT-06	Application-oriented case studies, real-world applications of fractional calculus, and advanced topics in fractional differential equations.	6

Course Outcomes

Upon successful completion of the course, the student will be able to-

CO1: Learn various fractional order derivatives of their importance vis-à-vis integral order derivatives.

CO2: Learn about fractional order differential equations and their solutions.

CO3: Learn various applications of fractional theory.

Books and References

1. Basic Theory of Fractional Differential Equations, Y. Zhou, World Scientific, 2014.
2. Fractional Differential Equations, I. Podlubny, Academic Press, 1998.
3. The Fractional Calculus: Theory and Applications of Differentiation and Integration to Arbitrary Order, K.B. Oldham and J. Spanier, Dover Publications, 2006.
4. An Introduction to the Fractional Calculus and Fractional Differential Equations, K.S. Miller and B. Ross, Wiley-Interscience, 1993.

Course Name: Topology
Course Code: MA-433
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To impart understanding of fundamental concepts in topology, including topological spaces, bases, closure, interior, and boundary of sets, as well as dense and nowhere dense sets.
- To introduce the concepts of continuity, homeomorphism, and various topological properties such as compactness, connectedness, and separation axioms.
- To explore the applications of topology in various branches of mathematics.

Unit No.	Course Content	Lectures
UNIT-01	Topological spaces, Bases and sub-bases for a topology, Limit point, closure, interior, boundary of a set, dense and nowhere dense sets	6
UNIT-02	Continuity, Homeomorphism, Subspace, Product and Quotient topologies, Compact-open topology	6
UNIT-03	Countability axioms, Separation axioms, Regular spaces, Normal spaces	6
UNIT-04	Connectedness; Components, path connectedness, locally connected spaces, totally disconnected spaces	6
UNIT-05	Compactness; Tychonoff's theorem, locally compact spaces, one-point compactification	6
UNIT-06	Urysohn's lemma, Tietze's extension theorem, Urysohn's metrization theorem, Baire category theorem, Stone-Čech compactification	6

Course Outcomes

Upon successful completion of the course, the student will be able to-
CO1: Learn the concept related to topology: continuity, compactness, connectedness etc.
CO2: Learn various results and theorems of topology.
CO3: Learn some applications of topology in other branches of mathematics.

Books and References

1. J. R. Munkres: Topology, Pearson India, 2015.
2. C. W. Patty, Foundations of Topology, Second Edition, Jones & Barlett Student Edition, 2010.
3. G. F. Simmons: Introduction to Topology and Modern Analysis, McGraw-Hill India, 2017

Course Name: Measure Theory
Course Code: MA-434
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To introduce various mathematical concepts, require to understand Measure Theory.
- To develop the familiarity with measure on the real line.
- To acquire the knowledge for integrate the Functions of a Real Variable and their properties.
- To illustrate some convergence theorems.

Unit Number	Course Content	Lectures
UNIT-01	Countable and uncountable sets, cardinality of sets, Semi-algebras, algebras, monotone class, σ-algebras, measure, and outer measures, Caratheödory extension process of extending a measure on a semi-algebra to generated σ - algebra.	**10**
UNIT-02	Lebesgue outer measure and Lebesgue measure on *R*, translation invariance of Lebesgue measure, existence of a non-measurable set, characterizations of Lebesgue measurable sets.	**10**
UNIT-03	Measurable functions on a measure space and their properties, Lebesgue measurable functions, simple functions and their integrals on *R*, Lebesgue integral on *R* and its properties, Introduction to L^p Spaces.	**08**
UNIT-04	Bounded convergence theorem, Fatou's lemma, Lebesgue monotone convergence theorem, Lebesgue dominated convergence theorem.	**08**

Course Outcomes

Upon successful completion of the course, the student will be able to
CO1: Understand the preliminaries that are required for measure theory.
CO2: Familiar with measures, Lebesgue integration and convergence.
CO3: Describe and apply the notion of measurable functions and sets and use Lebesgue monotone and dominated convergence theorems.
CO4: Determine questions related to different kinds of convergence.
CO5: Demonstrate the concepts through examples and applications.

Books and References

1. Real Analysis by H. L. Royden & P. M. Fitzpatrick, Prentice Hall (2010).
2. Measure Theory by P. R. Halmos, Grand Text Mathematics, Springer (1994).
3. Real and Abstract Analysis by E. Hewit & K. Stromberg, Springer (1975).
4. Introduction to Probability and Measure by K. R. Parthasarathy, Hindustan Book Agency, New Delhi (2005).
5. An Introduction to Measure and Integration by I. K. Rana, Narosa House, New Delhi (2005).
6. Measure Theory and Integration, G. Debarra, New Age International Publishers, 2013.

Course Name: Mathematical Biology
Course Code: MA-461
Course Type: Stream Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To provide students with a comprehensive understanding of ordinary differential equations (ODEs), and the ability to perform qualitative analysis of autonomous systems.
- To equip students with the necessary skills to analyze stability and phase portraits of ODE systems, including the classification of critical points and phase plane analysis for nonlinear systems.
- To introduce students to advanced topics in dynamical systems theory, including bifurcation theory, chaos theory, and the modeling of population dynamics and infectious diseases using ODEs.

Unit No.	Course Content	Lectures
UNIT-01	Review of first-order and higher-order linear ordinary differential equations (ODEs); Qualitative analysis of autonomous systems; Stability analysis and phase portraits, Classification of critical points; Phase plane analysis for nonlinear systems; Limit cycles and periodic orbits	7
UNIT-02	Introduction to bifurcation theory; Analysis of saddle-node, transcritical, pitchfork, and Hopf bifurcations; Chaos theory: deterministic chaos, strange attractors, and fractals	5
UNIT-03	Modeling single species population dynamics using ordinary differential equations (ODEs); Equilibrium analysis; Stability and bifurcations	6
UNIT-04	Modeling infectious diseases using compartmental models (e.g., SIR, SIS); Epidemic modeling and analysis; Disease control strategies and vaccination models	6
UNIT-05	Introduction to spatially structured models; Pattern formation and Turing instability; Analysis of Turing bifurcations; Application to tumor modeling and pattern formation	6
UNIT-06	Stochastic birth and death processes; Branching processes and their applications in population dynamics and epidemiology; Applications of ODEs and stochastic processes in finance, ecology, and engineering	6

Course Outcomes

Upon successful completion of the course, the student will be able to-

CO1: Learn to solve and analyze first-order and higher-order linear ODEs and performing qualitative analysis of autonomous systems

CO2: Learn to analyze phase portraits of ODE systems and interpret their behavior, including identifying limit cycles, periodic orbits

CO3: Learn to apply bifurcation theory to analyze and understand the behavior of dynamical systems, including the identification and analysis of saddle-node, transcritical, pitchfork, and Hopf bifurcations.

Books and References

1. William E. Boyce, Richard C. DiPrima, and Douglas B. Meade, Elementary Differential Equations, John Wiley & Sons, 2017.
2. Nicholas F. Britton, Essential Mathematical Biology, Springer Science & Business Media, 2012
3. Mark Kot, Elements of Mathematical Ecology, Cambridge University Press, 2001.

Course Name: Data Science
Course Code: MA-462
Course Type: Stream Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To introduce the concept of Data Science and Big Data Analytics.
- To able to form Lifecycle and methodology for Data Analytics.
- To have the idea of Theory, Methods and Supervised learning for Data Analytics.
- To acquire the knowledge of Unstructured Data Analytics and concept of Endgame.

Unit No.	Course Content	Lectures
UNIT-01	**Introduction of Big Data Analytics:** Definition of Big Data, Characteristics of Big Data (Volume, Velocity, Variety, Veracity, Value), Importance and impact of Big Data in various industries, Overview of data analytics Types of analytics (Descriptive, Diagnostic, Predictive, Prescriptive), Data exploration and visualization techniques	**6**
UNIT-02	**Basics of Statistics and Mathematics:** Descriptive statistics, Inferential statistics, Probability concepts, basics of Linear algebra, Linear Algebra Computation in Large Scale, Introduction to modeling: numerical vs. probabilistic vs. Bayesian, Introduction to Optimization Problems, Batch and stochastic Gradient Descent	**6**
UNIT-03	Overview of machine learning, Supervised vs. unsupervised learning, Model evaluation and validation, Feature engineering, Ensemble methods, Time series analysis	**4**
UNIT-04	**Big Data Tools and Technologies:** Introduction to Hadoop ecosystem (HDFS, MapReduce), Overview of NoSQL databases, Apache Spark and its components, Analysis of real-world big data use cases, Successful implementations and challenges faced, Industry-specific applications, Implementing machine learning models on big data, Exposure to real-world applications and challenges	**7**
UNIT-05	**Regression Analysis:** Linear regression, Polynomial regression, Regularization techniques (e.g., Lasso, Ridge), Classification Techniques: Logistic regression, Decision trees and random forests, Support vector machines (SVM), Clustering and Dimensionality Reduction: K-means clustering, Hierarchical clustering, Principal Component Analysis (PCA), Introduction to Deep Learning: Neural networks basics, Deep learning frameworks (e.g., TensorFlow, PyTorch), Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), Natural Language Processing (NLP), Reinforcement Learning	**8**
UNIT-06	Application of data science techniques to real-world datasets, Industry applications of data science (e.g., finance, healthcare, marketing), Ethical considerations in data science	**5**

Course Outcomes

Upon successful completion of the course, the student will be able to
CO1: Understand the concept of Data Science and Big Data Analytics
CO2: Develop Lifecycle and methodology for Data Analytics.
CO3: Learn the idea of Theory , Methods and Supervised learning for Data Analytics.
CO4: Implement the idea of Unstructured Data Analytics and concept of Endgame.

Reference books

1. Foundations of data science by a/ blum, j. Hopcroft, r. Kannan, Cambridge University Press.
2. Introduction to Linear Regression Analysis by Douglas C. Montogomery, E.A. Peck,C.G. Vining, Wiley.
3. Statistical Inference by P.J Bickel, K.A. Docksum, Prentice Hall.
4. Introduction to Machine Learning: E. Alpaydin, Prentice Hall of India.

Course Name: Natural Language Processing
Course Code: MA-463
Course Type: Stream Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- Identify and discuss the characteristics of different NLP techniques
- Identify and discuss the characteristics of machine learning techniques used in NLP
- Implement a hidden Markov model for part-of-speech tagging

Unit No.	Course Content	Lectures
UNIT-01	Introduction: Stages of NLP, N-grams, Words: Structure (Spellcheck, morphology using FSTs), Words: Semantics (Lexical Semantics, WordNet and WordNet based Similarity measures, Distributional measures of similarity, Concept mining using Latent Semantic Analysis), Word Sense Disambiguation (supervised, unsupervised and semi supervised approaches)	**6**
UNIT-02	Words: Part of Speech (POS) tagging using Brill's Tagger and HMMs. Sentences: Basic ideas in compositional semantics, classical parsing (Bottom up, top down, Dynamic Programming, CYK Parser, parsing using probabilistic Context Free Grammars and EM based approaches for learning PCFG parameters.	**6**
UNIT-04	Word Embeddings (Word2Vec, GloVe, LDA, TF-IDF), Skip-gram model, CBOW, Topic modelling: Latent Dirichlet Allocation, Gibbs sampling for LDA, LDA variations and applications, Semantic Analysis: Introduction, Affective lexicons (Learning and Computation), Language modelling: Basic ideas and smoothing techniques	**7**
UNIT-05	Information Extraction: Introduction to Named Entity Recognition and Relation Extraction, relation between Information Retrieval and NLP. Summarization (Single document, Multiple documents, query based), Question answering.	**8**

Course Outcomes

Upon successful completion of the course, the student will be able
CO1: Identify and discuss the characteristics of different NLP techniques
CO2: Identify and discuss the characteristics of machine learning techniques used in NLP
CO3: Implement a hidden Markov model for part-of-speech tagging
CO4: Understand what constitutes a probabilistic language model and understand the difference in assumptions between different types of such models (e.g. bag-of-words, n-gram, HMM, topic model)

Text Books: -

1. Daniel Jurafsky and James H. Martin. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition, Upper Saddle River, NJ: Prentice-Hall, 2nd Edition, 2009/ Latest Edition
2. Natural Language Processing and Information Retrieval: Tanvier Siddiqui, U.S. Tiwary, Oxford University Press,2008/Latest Edition

Reference Book:

1. Christopher D. Manning and Hinrich Schuetze. Foundations of Statistical Natural Language Processing. Cambridge, MA: MIT Press.Latest Edition.
2. Allen, J:" Natural Language Understanding.". Latest Edition, The Benajmins/Cummings Publishing Company Inc. 1994. ISBN 0-8053-334-0.

Course Name: Fractals and Chaos
Course Code: MA-481
Course Type: Stream Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- Gain a comprehensive understanding of fractals, including their various types such as Cantor set, Sierpinski triangle.
- Develop proficiency in iterated function systems (IFS) and chaos theory fundamentals, including the dynamics of complex polynomials, chaotic maps, and bifurcation theory.
- Explore applications of fractals and chaos theory across diverse fields such as computer graphics, finance, biology, and geology.

Unit No.	Course Content	Lectures
UNIT-01	Fractals: Cantor set, Sierpinski triangle, Von Koch curve, Hilbert and Peano curves, Weierstrass function. Self-similarity, Scaling, Similarity dimension, Box-counting dimension, Information dimension, Capacity dimension. Fractal dimension estimation methods, Fractal interpolation.	**6**
UNIT-02	Foundations of iterated function systems (IFS), Classical fractals generated by IFS, Contractions mapping principle, Collage theorem, some applications of Fractals. Iterated function systems in computer graphics, Fractal image compression.	**6**
UNIT-03	Chaos: One-dimensional maps, periodic points, sensitive dependence on initial conditions, chaos, Sarkoviskii theorem, Logistic map, Henon map. Bifurcation theory, Period doubling route to chaos, Feigenbaum constants.	**6**
UNIT-04	Dynamics of complex polynomials, Julia sets, Fatou sets, Mandelbrot set, characterization of Julia sets. Iterated function systems in computer graphics, Fractal image compression. Applications in cryptography, Signal processing with fractals.	**6**
UNIT-05	Dynamics of Newton method. Applications in biology (fractal geometry of natural forms), Finance (fractal analysis of financial time series), Geology (fractal analysis of geological structures), and more.	**6**
UNIT-06	Further exploration of fractals and chaos theory with advanced topics and case studies. Advanced chaos theory concepts such as strange attractors, chaos control methods, and applications in diverse fields. Advanced fractal geometry topics like multifractals, fractional dimensions, and applications.	**6**

Course Outcomes

Upon successful completion of the course, the student will be able to
CO1: Learn about fractals, chaos and its various applications.
CO2: Learn the mathematical concepts like Julia set, Fatou sets related to the fractals and chaos.
CO3: Learn various methods to solve such problems.

Reference books

1. M. F. Barnsley, Fractals Everywhere, Second Edition, Academic Press, 1995.
2. R. L. Devaney, An Introduction to Chaotic Dynamical Systems, Second Edition, Addision-Wesley, 1989.
3. K. Falconer, Fractal Geometry - Mathematical Foundations and Applications, Third Edition, Wiley, 2013.

Course Name: Statistical Quality Control
Course Code: MA-482
Course Type: Discipline Elective

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To introduce the elementary concepts relevant to Statistical Quality Control.
- To learn various available statistical tools of quality control.
- To have the idea of sampling plans for different attributes.
- Construction and analysis of various control charts.

Unit Number	Course Content	Lectures
UNIT-01	Introduction: Concept of Quality – Quality movement in India – Standardization for Quality – Quality movement – Quality management – Quality circles – Total Quality Management – ISO 9001; Need for SQC in industries.	5
UNIT-02	Process Control: Chance and assignable causes of variation - specification and tolerance limits; process capability- Statistical basis for control charts: X-bar, R, and standard deviation charts - their construction and analysis.	6
UNIT-03	Control Charts for Attributes – p, np, c, and u charts – their construction and analysis.	5
UNIT-04	Product Control: Acceptance sampling by attributes; Producer's and Consumer's risk; Notions of AQL, LTPD and AOQL.	8
UNIT-05	Modified Control Charts for Mean: CUSUM chart – technique of V-mask – Weighted Moving average charts – multivariate control charts – Hotelling's T2 control charts.	6
UNIT-06	Sampling Plans: OC, AOQ, ASN, ATI curves for Single and double sampling plans – Concept of Sequential sampling plan for attributes.	6

Course Outcomes

Upon successful completion of the course, the student will be able to

CO1: Understand the philosophy and basic concepts of quality improvement.
CO2: Demonstrate the ability to use the methods of statistical process control.
CO3: Demonstrate the ability to design, use, and interpret control charts for variables.
CO4: Perform analysis of process capability and measurement system capability.
CO5: Design, use, and interpret exponentially weighted moving average and moving average control charts.

Text Books

1. D. C. Montgomery, Introduction to Statistical Quality Control, John Wiley & Sons.
2. Fundamentals of Applied Statistics by S.C. Gupta and V.K.Kapoor, Sultan Chand and Sons.

Reference Books

1. Mittage, H.J and Rinne, H, Statistical Methods of Quality Assurance, Chapmann Hall, London, UK, 1993.
2. Edward G. Schilling, Dean V. Neubauer, Acceptance Sampling in Quality Control, Second Edition, Taylor & Francis, 2009.

Course Name: Cloud Computing
Course Code: MA-483
Course Type: Stream Elective

Contact Hours/Week: 03 **Course Credits: 03**

Course Objectives:

- Classify different computing paradigms
- Explain the available services and deployment models used in cloud computing architecture.
- Describe the virtualization, migration model and related operations.
- Build the capacity planning to meet SLA and legal issues.
- Asses the risks and cloud security issues.

Unit NO.	Course Content	Lectures
UNIT-01	**Evolution of Cloud Computing:** Computing paradigms -Distributed Computing, Grid Computing, Cluster Computing, Utility Computing; Overview of Cloud Computing -Introduction to Cloud Computing, properties, characteristics and disadvantages.	7
UNIT-02	**Cloud Computing Architecture:** Architecture- Cloud Computing Stack, Microsoft Azure Platform, Amazon EC2 Platform, Architecture for Elasticity, Best Practices in Architecture; Service Models –SaaS, PaaS, IaaS, general overview of everything as a service; Deployment Models - Public, Private, Hybrid and Community.	8
UNIT-03	**Virtualization:** Virtual Machines, Role of Virtualization, Types of Virtualization, VM primitive Operations, Virtualization Middleware, Virtualization of Clusters and Data centers, Virtual machines provisioning, VM Migration services, Management of Virtual machines for Cloud Infrastructures, OS-OpenStack and its components.	7
UNIT-04	**Service Management in Cloud Computing:** Scheduling Techniques for Advance Reservation of Capacity, Service Level Agreement (SLA), Capacity Management to Meet SLA Commitments, Cloud Economics, Data Management, MapReduce- Model, Fault Tolerance, Efficiency, Applications.	7
UNIT-05	**Change Management and Cloud Security:** Organizational Readiness, Change management in the Cloud age, Infrastructure Security, data security and Storage, Identity and Access Management, Access Control and Trust, reputation and Risk, Introduction to Cloud Simulator.	7

Course Outcomes

Upon successful completion of the course, the student will be able

CO1: Identify current computing paradigm of the real-time applications.

CO2: Manage and schedule the virtually created computational resources in cloud environment.

CO3: Assess the legal issues and security risks related cloud resources and use cloud computing platforms for their startups at low cost.

Text Books: -

1. Cloud Computing: Principles and Paradigms by Rajkumar.
2. Cloud Application Architectures: Building Applications and Infrastructure in the Cloud. George Reese, O'RedI SPD, rp2Oll.
3. Cloud Computing, Soumya Kanti Gosh, NPTEL.2017.

Reference Book:

1. Enterprise Cloud Computing Gautam Shroif, Cambridge University Press. 2010.
2. Cloud Computing: Implementation, Management and Security, John W. Rittinouse, James F Ransome. CRC Press, rp2012.

Course Name: Algebra
Course Code: MA-310
Course Type: Minor in Mathematics

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives:

- Understand the fundamental concepts and properties of groups, including subgroups, normal subgroups, quotient groups, and homomorphisms.
- Gain proficiency in applying group theory concepts to analyze and solve problems in various mathematical contexts, such as cyclic groups, permutation groups, and Sylow's theorems.
- Develop a solid foundation in ring theory, including rings, ideals, prime and maximal ideals, quotient rings, and properties of special types of rings like unique factorization domains and polynomial rings.

Unit NO.	Course Content	Lectures
UNIT-01	Number Theory: Congruences, theorems of Fermat, Euler & Wilson, linear congruences and Chinese remainder theorem, Diophantine equations.	7
UNIT-02	Groups, subgroups, normal subgroups, quotient groups, homomorphisms, automorphisms; cyclic groups, permutation groups, Sylow's theorems and their applications;	7
UNIT-03	Ring Theory: Rings, ideals, prime and maximal ideals, quotient rings, unique factorization domains, Principle ideal domains, Euclidean domains, polynomial rings, Fields: Fields, finite fields,	7
UNIT-04	Vector Space: Fields, Vector Spaces over R and C, subspaces, linear independence, basis, and dimension of a vector space, ordered basis and co-ordinates. Application to difference equations and Markov chains.	7
UNIT-05	Linear Transformation: Linear transformations, Rank and Nullity of linear transformation, Algebra of linear transformation, Isomorphism, Invertible linear transformations, Dual and double dual of a vector space and transpose of a linear transformation, Matrix representation of Linear Transformation, Eigen values and Diagonalization	8

Course Outcomes

Upon successful completion of the course, the student will be able

CO1: Demonstrate a comprehensive understanding of group theory concepts, including the ability to identify and analyze different types of groups, subgroups, and homomorphisms in mathematical structures.

CO2: Apply group theory techniques to solve problems related to permutations, cyclic groups, and Sylow's theorems, demonstrating proficiency in theorem applications and proofs.

CO3: Analyze and solve problems in ring theory, including properties of rings, ideals, quotient rings, and applications to factorization domains and polynomial rings, showcasing the ability to manipulate algebraic structures effectively.

Text and Reference Books: -

1. Contemporary Abstract Algebra by Joseph Gallian (Ninth edition ed.) Cengage Learning Boston.
2. Gilbert Strang, Introduction to Linear Algebra, Wellesley-Cambridge Press, 2016.
3. Hoffman, Kunze, Linear Algebra, Pearson, 2018.
4. Herstein, Topics in Algebra, Wiley, 2006.

Course Name: Analysis
Course Code: MA-320
Course Type: Minor in Mathematics

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To impart knowledge about real number system and its various properties.
- To understand the sequence and series of real valued functions.
- To provide an introduction to the theories of functions of a complex variable. In particular, the notion of analyticity, completeness, compactness with some fundamental theorems.
- To provide knowledge of singularities, residues and various series expansions of complex valued functions.

Unit No.	Course Content	Lectures
UNIT-01	**Real Number System:** Logic**,** Sets, functions, real number system and its completeness property, order property, Nested Intervals Property.	5
UNIT-02	**Sequences and Series:** Sequence, convergence, monotone sequence, Subsequences, Bolzano-Weiestrass theorem, Cauchy criterion, Convergence of series, Comparison test, Ratio test	5
UNIT-03	**Limit and Continuity:** Cluster point, Limit of a function, Limit theorem, Sequential criterion, continuity, composition of continuous maps, uniform continuity, continuity on intervals, minimum maximum theorem, uniform continuity,	5
UNIT-05	**Differentiability:** The derivative, Caratheodory's Theorem, Chain rule, Mean value theorem, L'Hospital rule,	5
UNIT-06	**Riemann Integration:** Tagged partition, Riemann sum, Cauchy Criterion, Squeeze Theorem, Fundamental Theorems of Calculus.	6
UNIT-07	**Complex valued functions:** Functions of a complex variable: continuity, differentiability, analytic functions, harmonic functions; Complex integration: Cauchy's integral theorem and formula; Morera's theorem; zeros and singularities; Laurent's series, Residue theorem, Rouche's theorem, Argument principle	10

Course Outcomes:

Upon successful completion of the course, the student will be able to :-

CO1: Learn about some of the classes and properties of Riemann integrable functions.

CO2: Learn about analytic functions and their importance.

CO3: Learn about Cauchy criterion for uniform convergence and Weierstrass M-test for uniform convergence.

CO4: Learn about Power series of complex valued functions and formulas to find radius of convergence for them.

Books and References

1. Introduction to Real Analysis , R.G. Bartle & D.R. Sherbert, Wiley.
2. Complex Analysis, E.M. Stein & R. Shakarchi, Princeton University Press.
3. Complex Analysis for Mathematics and Engineering by J.H. Mathews and R.W. Howell, Narosa Publishing House.
4. Mathematical Analysis by T. M. Apostol, Addison-Wesley Publishing Company.

Course Name: Differential Equations
Course Code: MA-410
Course Type: Minor in Mathematics

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives

- To study the linear and nonlinear ordinary differential equations and their solutions in the form of power series.
- To introduce the Sturm-Liouville eigenvalue problems and its applications.
- To understand the method of solution for linear and nonlinear partial differential equations and its applications in engineering.

Unit Number	Course Content	Lectures
UNIT-01	**Ordinary Differential Equations**: Review of first order ordinary differential equations, existence and uniqueness theorems for initial value problems, linear ordinary differential equations of higher order with constant coefficients; Second order linear ordinary differential equations with variable coefficients; series solutions (power series, Frobenius method); Legendre and Bessel functions and their orthogonal properties;	8
UNIT-02	Systems of linear first order ordinary differential equations, fundamental matrix, fundamental solution, Sturm-Liouville eigenvalue problems, Laplace transform methods.	8
UNIT-03	**Partial Differential Equations:** Well-posed problems and classical solutions, Method of characteristics for first order linear and quasilinear partial differential equations; Higher order partial differential equations in two independent variables: classification and canonical forms, method of separation of variables for Laplace equation in polar coordinates, heat and wave equations in one space variable	7
UNIT-04	Wave equation: Cauchy problem and d'Alembert formula, domains of dependence and influence, non-homogeneous wave equation; Heat equation: Cauchy problem; Fourier transform methods.	5
UNIT-05	**Applications:** Applications of ordinary differential equations in Population dynamics, in fluid flow, in economy, in mechanical spring system, in finance. Applications of partial differential equations in wave equations, heat transfer, fluid dynamics, reaction-diffusion equations, black-scholes equation, climate modeling etc.	8

Course Outcomes

Upon successful completion of the course, the student will be able to
CO1: Learn to analyze and solve first-order ordinary differential equations.
CO2: Learn to solve partial differential equations in using various methods.
CO3: Learn to apply partial differential equations in various branches of engineering

Books and References

1. Differential Equations and their Applications by Martin Braun, Springer Verlag Berlin
2. Partial Differential Equations by L C Evans, American Mathematical Society
3. Ordinary Differential Equations by B Rai and D P Choudhary and H I Freedman, Narosa Publication
4. Elements of Partial Differential equations by I. N Seneddon, Dover Publications.
5. Ordinary And Partial Differential Equations, M D Raisinghaniya, S Chand, 2020.

Course Name: Statistics
Course Code: MA-420
Course Type: Minor in Mathematics

Contact Hours/Week: 03L **Course Credits: 03**

Course Objectives:

- Grasp basic probability concepts such as probability rules, axioms, conditional probability, and independence.
- Learn point estimation methods and understand the properties of estimators.
- Understand hypothesis testing concepts and apply them to analyze data.

Unit NO.	Course Content	Lectures
UNIT-01	**Probability and Probability Distributions:** Basic concepts of probability, Probability rules and axioms, Conditional probability and independence, Discrete probability distributions (e.g., binomial, Poisson), Continuous probability distributions (e.g., normal, exponential), Properties and characteristics of distributions, Central Limit Theorem	8
UNIT-02	**Estimation**: Point estimation, methods and properties, Interval estimation: confidence intervals, Properties of estimators, Method of Moments and MLE. **Hypothesis Testing**: Basic concepts of hypothesis testing, One-sample and two-sample tests, Type I and Type II errors, Power of a test, Neyman-Pearson Lemma	8
UNIT-03	**Correlation and Regression Analysis**: Correlation analysis: Pearson correlation coefficient, Spearman's rank correlation, Simple linear regression, Multiple linear regression, Model fitting and interpretation, Residual analysis	8
UNIT-04	**Sampling Theory and Applications**: Simple random sampling, Stratified sampling, Cluster sampling, Sampling distributions Margin of error and confidence intervals in sampling Application of statistical methods to real-world data sets Discussion of ethical considerations in statistical analysis	7
UNIT-05	**Applications of statistical tools in engineering:** Quality Control, Reliability Analysis, Process Optimization, Data Analysis, Risk Analysis	5

Course Outcomes

Upon successful completion of the course, the student will be able

CO1: Demonstrate comprehension of basic probability concepts and their applications.

CO2: Exhibit proficiency in point estimation methods and interpret the properties of estimators.

CO3: Apply hypothesis testing procedures to analyze data and make statistical inferences.

Text and Reference Book:

1. SC Gupta and VK Kapoor, Fundamentals of Mathematical Statistics, S. Chand Publications, India, 10th Edition, 2019.
2. Fundamentals of Applied Statistics by Gupta .S.C. and Kapoor.V.K, Sultan Chand.
3. R. V. Hogg and A. T. Craig, Introduction to Mathematical Statistics, Fourth edition, McMillan Publishing Company, 1978.
4. Rohatgi, Saleh, An Introduction to Probability and Statistics, Wiley, 2008.