Course Curriculum

(Course Structure and Syllabi)

for

Bachelor of Technology

in

Mathematics and Computing

(Second Year Onwards)

Department of Mathematics and Scientific Computing

National Institute of Technology Hamirpur

Hamirpur – 177 005 (India)

Second Year													
3rd Semester							4th Semester						
SN	Code	Subject	L	T	P	Credits	SN	Code	Subject	L	T	P	Credits
1	MA-203	Engineering Mathematics-III	3	1	0	4	1	HS-203	Organizational Behaviour	3	0	0	3
2	MA-211	Discrete Mathematics	3	1	0	4	2	MA-221	Linear Algebra and Applications	3	1	0	4
3	MA-212	Stochastic Processes	3	1	0	4	3	MA-222	Statistical Methods	3	1	0	4
4	MA-213	Computer Graphics	3	0	0	3	4	MA-223	Data Structure	3	1	0	4
5	CS-211	Object Oriented Programming	3	1	0	4	5	MA-224	Operating System	3	1	0	4
6	MA-214	Computer Graphics Lab	0	0	2	1	6	MA-225	Data Structure Lab	0	0	2	1
7	MA-215	Mathematical Software Lab	0	0	2	1	7	MA-226	Statistical Methods Lab	0	0	2	1
8	CS-214	Object Oriented Programming Lab	0	0	2	1	8	MA-227	Operating System Lab	0	0	2	1
		Total Hours = 25				22			Total Hours = 25				22

Third Year													
5th Semester							6th Semester						
SN	Code	Subject	L	T	P	Credits	SN	Code	Subject	L	T	P	Credits
1	MA-311	Operation Research	3	1	0	4	1	MA-321	Real and Complex Analysis	3	1	0	4
2	MA-312	Number Theory and Abstract Algebra	3	1	0	4	2	MA-322	Advanced Differential Equations and Applications	3	1	0	4
3	MA-313	Data Base Management Systems	3	1	0	4	3	MA-323	Time Series Analysis and Forecasting	3	1	0	4
4	MA-314	Programming in Python	3	0	0	3	4	MA-324	Soft Computing	3	0	0	3
5	OET	Open Elective-I	3	0	0	3	5	OET	Open Elective-II	3	0	0	3
6	MA-315	Data Base Management Systems Lab	0	0	2	1	6	MA-325	Numerical Computation Lab	0	0	2	1
7	MA-316	Programming in Python Lab	0	0	2	1	7	MA-326	Time Series Analysis Lab	0	0	2	1
8	MA-317	Statistical Software Lab	0	0	2	1	8	MA-329	Seminar	0	0	2	1
		Total Hours = 24				21			Total Hours = 24				21

Fourth Year												
7th Semester							**8th Semester**					
SN	**Code**	**Subject**	**L**	**T**	**P**	**Credits**	**SN**	**Code**	**Subject**	**L**	**T**	**P**	**Credits**
1	HS-404	Engineering Economics and Accountancy	3	0	0	3	1	MA-421	Artificial Intelligence	3	0	0	3
2	MA-411	Cryptography and Information Security	3	0	0	3	2	MA-422	Multivariate Statistical Analysis	3	0	0	3
3	DET	Professional Elective-I	3	0	0	3	3	DET	Professional Elective-III	3	0	0	3
4	DET	Professional Elective-II	3	0	0	3	4	DET	Professional Elective-IV	3	0	0	3
5	MA-418	Industrial Training Presentation	0	0	2	1	5	MA-428	General Proficiency	0	0	0	1
6	MA-419	Major Project (Stage-I)	0	0	12	6	6	MA-429	Major Project (Stage-II)	0	0	12	6
		Total Hours = 26				**19**			**Total Hours = 24**				**19**

Semester Wise Credits									
Semester	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**Total**
Credits	24	24	22	22	21	21	19	19	**172**
Hours/week	28	28	25	25	24	24	26	24	**204**

Professional Elective Courses

Professional Elective-I
MA-430: Game Theory
MA-431: Advanced Optimization Techniques & Applications
MA-432: Information Theory and Coding
MA-433: Graph Theory
MA-434: Analysis and Design of Algorithms

Professional Elective-II
MA-450: Digital Image Processing
MA-451: Data Mining
MA-452: Parallel Algorithms
MA-453: Design and Analysis of Experiments
MA-454: Quantum Information and Computing

Professional Elective-III
MA-440: Mathematical Foundations for Machine Learning
MA-441: Data Analysis Using Python
MA-442: Theory of Computation
MA-443: Operator Theory
MA-444: Computer Networks

Professional Elective-IV
MA-460: Deep Learning
MA-461: Financial Mathematics
MA-462: Data Science and Big Data Analytics
MA-463: Software Engineering
MA-464: Topology

Open Elective Courses

Open Elective-I
MA-370: Statistical Quality Control
MA-371: Applied Time Series Analysis

Open Elective-II
MA-380: Principles of Design of Experiments
MA-381: Numerical Methods for Partial Differential Equations

Course Name: **Engineering Mathematics-III**
Course Code: **MA-203**
Course Type: **Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To introduce the fundamental concepts relevant to function of complex variable, numerical differentiation and integration and numerical solution of linear, non-linear and system of equations.
- To have the idea of evaluation of real integrals using complex variable.
- To understand the concept of approximating & interpolating polynomials and finding values of function at arbitrary point.
- To impart knowledge of various numerical technique to solve ODE.

Unit Number	Course Content	Lectures
UNIT-01	**Functions of Complex Variable** Applications of De Moivre's theorem, Exponential, Circular, Hyperbolic and Logarithmic functions of a complex variable, Inverse Hyperbolic functions, Real and imaginary parts of Circular and Hyperbolic functions, Summation of the series-'C+iS' method. Limit and derivative of complex functions, Cauchy-Riemann equations, Analytic functions and its applications, Complex integration, Cauchy's theorem, Cauchy's integral formula, Series of complex function, Taylor series, singularities and Laurent's series, Cauchy's residue theorem and its application for the evaluation of real definite integrals.	**12 L**
UNIT-02	**Interpolation** Least square curve fit and trigonometric approximations, Finite differences and difference operators, Newton's interpolation formulae, Gauss forward and backward formulae, Sterling and Bessel's formulae, Lagrange's interpolation.	**06L**
UNIT-03	**Numerical Integration** Integration by trapezoidal and Simpson's rules 1/3 and 3/8 rule, Romberg integration, and Gaussian quadrature rule, Numerical integration of function of two variables.	**05L**
UNIT-04	**Numerical Solution of Ordinary Differential Equations** Taylor series method, Picard's method, Euler's method, Modified Euler's method, Runge- Kutta method. Predictor corrector methods, Adam Bashforth and Milnes method, convergence criteria, Finite difference method.	**07L**
UNIT-05	**Numerical Solution of Linear and Non Linear Equations** Non Linear Equations: Bisection Method, Regula Falsi Method, Newton-Raphson Method, Iteration method. Linear Equations: Jacobi and Gauss Seidel Iteration methods, Relaxation method.	**06 L**

Course Outcomes

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

CO1: Understand and analyze the concept of Numerical Solution of Linear and Non Linear Equations, Ordinary Differential Equations and Function of complex variable.
CO2: Identify an appropriate technique to solve the linear, non-linear equations, ordinary differential equations.
CO3: Formulate the problems on related topics and solve analytically.
CO4: Apply the concepts of linear, non-linear equations, differential equations and complex analysis in various engineering problems.
CO5: Demonstrate the concepts through examples and applications.

Books and References

1. Complex variables and Applications by R. V. Churchill, J. W. Brown & R. F. Verhey, McGraw Hill.
2. A first course in complex analysis with applications by Dennis G. Zill & P. D. Shanahan, Jones and Bartlett.
3. Numerical Methods for Scientific and Engineering Computation by M. K. Jain, S. R. K. Iyenger and R. K. Jain, New Age International Publishers, New Delhi
4. Numerical Methods for Engineers and Scientists (2nd Ed.) by J D Hoffman, CRC Press.
5. Numerical Analysis Mathematics and Scientific computing (3rd ed.) by D. Kincaid and W. Cheney, American Mathematical Society.

Course Name: **Discrete Mathematics**
Course Code: **MA-211**
Course Type: **Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To provide students with the foundations of set theory, graph theory, relations, functions, Boolean algebra and recurrence relations.
- To develop logical thinking and its application to computer science.
- To enhance students ability to reason and ability to present a coherent and mathematically accurate argument.

Unit Number	Course Content	Lectures
UNIT-01	**Set Theory:** Introduction to the theory of sets; combination of sets; power sets; finite and infinite sets; principle of inclusion and exclusion; selected problems from each topic. **Logic:** Proposition, predicate logic, logic operators, logic proposition and proof, method of proofs. **Mathematical Induction:** Different forms of the principle of mathematical induction. Selected problems on mathematical induction.	**06L**
UNIT-02	**Graph Theory:** Path, cycles, handshaking theorem, bipartite graphs, sub-graphs, graph isomorphism, operations on graphs, Eulerian graphs and Hamiltonian graphs, planar graphs, Euler formula, traveling salesman problem, shortest path algorithms.	**08L**
UNIT-03	**Relations and Function:** Definitions and properties; pigeonhole principle, Equivalence relations and equivalence classes; Representations of relations by binary matrices and digraphs; operations on relations; Closure of a relation; reflexive, symmetric and transitive closures. Warshall's algorithm to compute transitive closure of a relation, growth of function, big O, hash function, discrete numeric functions; asymptotic behavior; generating functions.	**08L**
UNIT-04	**Partially Ordered Sets and Lattices:** Partial order relations, POSETS, lattices, isomorphism of lattice **Boolean Algebra and Boolean Functions:** Introduction to Boolean algebra and Boolean functions; Different representations of Boolean functions; Application of Boolean functions to synthesis of circuits, circuit minimization and simplification, Karnaugh map.	**07L**
UNIT-05	**Recurrence Relations:** Linear recurrence relations with constant coefficients (homogeneous case); discussion of all the three sub-cases; linear recurrence relations with constant coefficients (non-homogeneous case); discussion of several special cases to obtain particular solutions. Solution of linear recurrence relations using generating functions.	**07L**

Course Outcomes

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

CO1: Construct simple mathematical proofs and possess the ability to verify them.
CO2: Express mathematical properties via the formal language of propositional and predicate logic.
CO3: Understand and analyze recursive definitions.
CO4: Use graph algorithms to solve real life problems.
CO5: Evaluate Boolean functions and simplify expressions using the properties of Boolean algebra.

Books and References

1. Elements of Discrete Mathematics by C. L. Liu, Tata McGraw-Hill.
2. Introductory Combinatorics by R. A. Brualdi, Pearson.
3. Discrete Mathematics for Computer Scientists and Mathematicians by J. L. Mott, A. Kandel and T. P. Baker, Prentice Hall India.
4. Graph Theory by F. Harary, Narosa.
5. Discrete Mathematics with Applications by T. Koshy, Academic Press
6. Discrete Mathematics and Its Applications by K. H. Rosen, Tata McGraw-Hill.
7. Discrete mathematical structures with applications to computer science by J. Tremblay, R. Manohar, Tata McGraw-Hill.

Course Name: **Stochastic Processes**
Course Code: **MA-212**
Course Type: **Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To provide students with the foundations of probabilistic and statistical analysis techniques used in various engineering applications.
- To define and identify some basic probability distributions and random variables.
- To introduce the fundamental concepts relevant to the modeling of experimental data.
- To enable the students to understand the physical process in real life situations in terms of probability models.

Unit Number	Course Content	Lectures
UNIT-01	**Probability and Random Variable:** Axioms of probability, Conditional probability, Total probability, Baye's theorem, Random variable, Probability mass function, probability density function, properties, Moments, Moment generating function and their properties.	**06L**
UNIT-02	**Two Dimensional Random Variables:** Joint distributions , Marginal and conditional distribution , Covariance , Correlation and regression , Function of a random variable, Transformation of random variables, Central limit theorem.	**06L**
UNIT-03	**Probability Distributions:** **Standard Discrete Distributions:** Binomial, poison, Geometric, Negative Binomial, Uniform and their properties, Probability mass function and its properties. **Standard Continuous Distributions:** Uniform, Exponential, Gamma, Weibull and Normal distributions and their properties, Probability density function and its properties.	**12L**
UNIT-04	**Random Processes & Markov Chains:** Classification and properties of stochastic processes, Stationary process, Markov process, Poisson process, Birth and death process, Markov chains, transition probabilities, Limiting distributions.	**06L**
UNIT-05	**Queuing Theory:** Markovian models – M /M/1, M/M/C, finite and infinite capacity- M/M/8 queues, Finite source model, M/G/1 queue (steady state solution only), Pollaczek–Khintchine formula, Special cases.	**06L**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Understand and analyze the theoretical and practical aspects of random variables, theoretical distributions.
CO2: Identify an appropriate theoretical distribution to fit the empirical data and find out the properties of data.
CO3: Understand and apply the concept of stationarity to the stochastic processes in various contexts.
CO4: Understand and apply the concept of queuing models in various contexts.

Books and References

1. A First Course in Probability by S. Ross, Pearson Education, Delhi.
2. Probability, Statistics and Random Processes by T. Veerarajan, Tata McGraw – Hill.
3. Fundamentals of Mathematical Statistics by S.C. Gupta, V.K. Kapoor, Sultan Chand & Sons, New Delhi.
4. Applied Statistics and Probability for Engineers by D.C. Montgomery, G.C. Runger, Wiley.
5. Probability and Statistics for Engineers and Scientists by R.E. Walpole, R.H. Myers, S. L. Myers, K.E. Ye, Pearson.
6. Probability and Statistics with Reliability, Queuing and computer science applications by K.S. Trivedi, Wiley.

Course Name: **Computer Graphics**
Course Code: **MA-213**
Course Type: **Core**

Contact Hours/Week: **3L** 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 Number	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.	**06L**
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.	**06L**
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 co-ordinate transformation, clipping operations, point clipping, line clipping, clipping circles, polygons & ellipse.	**08L**
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	**09L**
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; Multimedia: Introduction to Multimedia: Concepts, uses of multimedia, hypertext and hypermedia. Image, video and audio standards.	**07L**

Course Outcomes

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

CO1: List the basic concepts used in computer graphics.
CO2: Implement various algorithms to scan, convert the basic geometrical primitives, transformations, area filling, clipping.
CO3: Define the fundamentals of animation, virtual reality and its related technologies and To understand a typical graphics.
CO4: Design an application with the principles of virtual reality.

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: **Object Oriented Programming**
Course Code: **CS-211**
Course Type: **Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To impart knowledge about the concept of Object Oriented programming.
- To introduce the fundamental concepts relevant to Arrays, Pointers and Functions, Classes, Objects, etc.
- To enable the students to understand the standard library, exception handling, streams and files.

Unit Number	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.	**06L**
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**.**	**06L**
UNIT-03	**Classes and Objects:** Data types, operators, expressions, control structures, arrays, strings, Classes and objects, access specifiers, constructors, destructors, operator overloading, type conversion. Storage classes: Fixed vs. Automatic declaration, Scope, Global variables, register specifier, Dynamic memory allocation.	**07L**
UNIT-04	**Inheritance:** Inheritance, single Inheritance, Multiple Inheritance, Multi-level inheritance, hierarchical inheritance, hybrid inheritance, Virtual functions. Streams and Files: Opening and closing a file, File pointers and their manipulations, Sequential Input and output operations, multi-file programs, Random Access, command line argument, string class, Date class, Array class, List class, Queue class, User defined class, Generic Class.	**07L**
UNIT-05	**Exception Handling and Graphics:** List of exceptions, catching exception, handling exception. Text Mode, Graphics mode functions, Rectangles, and Lines, Polygons and Inheritance, Sound and Motion, Text in Graphics Mode. Standard Template Library**:** Standard Template Library, Overview of Standard Template Library, Containers, Algorithms, Iterators, Other STL Elements, Container Classes, General Theory of Operation, Vectors**.**	**10L**

Course Outcomes

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

CO1: Understand the concept of object oriented paradigm and programming.
CO2: Apply the concept of polymorphism and inheritance.
CO3: Implement exception handling and templates.
CO4: Handling of files and streams during programming.

Books and References

1. Object Oriented programming with C++ by E. Balagurusamy, Tata McGraw Hill.
2. The C++ programming Language by Bjarne Strustrup, Addison Wesley.
3. Object Oriented Analysis and Design with Applications by Grady Booch, Addison Wesley.
4. The Complete Reference Visual C++ by Chris H. Pappas and William H. Murray, Tata McGraw Hill.
5. C++ Primer by S. B. Lippman, Josee Lajoie and Barbara E. Moo, Pearson Education.

Course Name: **Computer Graphics Lab**
Course Code: **MA-214**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To provide comprehensive introduction about computer graphics system.
- To provide skills for writing C programs.
- To make the students familiar with techniques of clipping using programming.

List of Experiments

1. To implement DDA algorithms for line and circle.
2. To implement Bresenham's algorithms for line, circle and ellipse drawing
3. To implement Mid-Point Circle algorithm using C.
4. To implement Mid-Point Ellipse algorithm using C.
5. To perform 2D Transformations such as translation, rotation, scaling, reflection and sharing.
6. To implement Cohen–Sutherland 2D clipping and window–viewport mapping.
7. To implement Liang Barksy Line Clipping Algorithm.
8. To perform 3D Transformations such as translation, rotation and scaling.
9. To convert between color models.
10. To perform animation using any Animation software
11. To perform basic operations on image using any image editing software
12. To draw different shapes such as hut, face, kite, fish 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

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: Involve in design, development and testing of modelling, rendering, shading and animation.
CO3: Implement various graphics drawing algorithms, 2D-3D transformations and clipping techniques.

Course Name: **Mathematical Software Lab**
Course Code: **MA-215**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To understand and apply the basic principles of programming.
- To provide skills for designing flowcharts and writing MATLAB programs.
- To create simple programming scripts and functions.
- To solve basic and advanced numerical and symbolic mathematics problems.
- To visualize and present data.
- To enable the students to debug programs.

List of Experiments

1. Brief Introduction, Installation of MATLAB, History, Use of MATLAB, Key features.
2. Introduction to MATLAB Software and MATLAB window.
3. Data files and Data types: Character and string, Arrays and vectors, Column vectors, Row vectors.
4. Program for Arithmetic operations and equations, Matrix operations, and Trigonometric functions.
5. Working with script tools.
6. Writing program for Ploting and Graphics
7. Writing programs with logic and flow control and Writing functions.
8. Use of Control Flow and Conditional Control.
9. Writing user defined functions.
10. Programs for Symbolic Math.
11. Simulink Environment & Interface.

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: Represent mathematical objects as data structures.
CO2: Translate mathematical methods to MATLAB code.
CO3: Break a complex task up into smaller, simpler tasks.
CO4: Tabulate results and represent data visually.

Course Name:	**Object Oriented Programming Lab**
Course Code:	**CS-214**
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- To provide skills for designing object oriented programs.
- To provide skills for writing C++ programs.
- To enable the students to debug and implement programs involving different concepts of object oriented paradigm.

List of Experiments

1. Demonstrate simple operations and control structures.
2. Demonstrate use of array : i) Add two matrix using multi-dimensional arrays, ii) 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 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: **Organizational Behaviour**
Course Code: **HS-203**
Course Type: **Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the behavioural aspects related to professional organizations.
- To introduce the fundamental concepts relevant to understanding of individual & group behavior in the organization.
- To enable the students to understand the applied organizational themes like perception, motivation, interpersonal relationships, group dynamics, leadership theories, role of power & politics in organizational context, conflict and negotiation, organizational diversity, dynamics of personality, attitude and job satisfaction, etc.

Unit Number	Course Content	Lectures
UNIT-01	**Organizational Behavior (OB):** Concept, nature, characteristics, conceptual foundations, determinants and importance, management functions, role & skills, disciplines that contribute to the field of OB, Challenges & Opportunities for OB, diversity in Organizations, attitudes & Job satisfaction.	**04L**
UNIT-02	**Perception**: Concept, nature, process, importance, management and behavioral applications of perception. Personality: concept, nature, types and theories of personality shaping. Learning; concept and theories of learning.	**08L**
UNIT-03	**Motivation:** concept, principles, theories-content, process & contemporary, Monetary and non-monetary motivation, applications of motivation. Leadership: Concept, functions, styles, and theories of leadership- trait, behavioural, and situational.	**06L**
UNIT-04	**Group and Interpersonal Relationship:** Analysis of Interpersonal Relationship, developing interpersonal relationship, Group Dynamic: Definition of Group, stages of Group Development, Punctuated Equilibrium Model, Group Structure, Group Decision Making, understanding work teams.	**05L**
UNIT-05	**Organizational Power and Politics:** concept of power, structure of power, classification of power, contrasting leadership & power, dependence a key to power, causes & consequences of political behaviour. Organizational conflict: view of conflict, conflict process, negotiation & bargaining strategies.	**06L**
UNIT-06	**Conflict and Negotiation:** conflict definition in conflict thought: Traditional view, the Human relation view, interactionist view. Functional versus dysfunctional conflict, conflict process. Negotiation Bargaining strategies, the negotiation process and issues in negotiation.	**07L**

Course Outcomes

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

CO1: Identify the challenges of the present organization.

CO2: Describe the organizational system.

CO3: Apply the principles of organizational behavior to inculcate the habit of team work and which is essential for the organization.

CO4: Assess the role of psychological and social principal in improvement of efficiency as well as quality of empoyee life.

Books and References

1. Organizational Behavior by Robbins, S.P., Prentice Hall of India.
2. Organizational Behavior by Luthans F., McGraw-Hill.
3. Human Behavior at Work: Organizational Behavior by Davis K., Tata McGraw-Hill.

Course Name: **Linear Algebra & Applications**
Course Code: **MA-221**
Course Type: **Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To introduce concepts of linear algebra and provide wide application of this discipline within scientific field.
- To impart knowledge about linear transformations, Inner product spaces and Eigen decomposition.
- To enable the students with analytical ability to apply the theorems and results in real life engineering applications.

Unit Number	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 giving rise to Linear Systems Problems.	**06L**
UNIT-02	**Vector Space:** Fields, fields of numbers, finite 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.	**08L**
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, eigenvalue and eigenvector of an linear transformation, Discrete dynamical systems, Application to differential equations.	**07L**
UNIT-04	**Eigen Decomposition:** Diagonalizability of linear operators of finite dimensional vector spaces, simultaneous triangulization and simultaneous diagonalization, Primary decomposition theorem - diagonal and nilpotent parts, Applications to Image processing and Statistics.	**07L**
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, Adjoint of an operator, hermitian, unitary and normal operators, Singular Value Decomposition and its applications, Spectral decomposition, Applications of Inner product spaces.	**08L**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Understand fundamental concepts of system of linear equations and Vector spaces.
CO2: Understand fundamentals of Inner product space and Eigen decomposition.
CO3: Able to apply concepts of linear algebra in various engineering application problems.

Books and References

1. Linear algebra and it's applications by G. Strang, Cengage.
2. Linear Algebra and its Applications by D.C. Lay, Pearson.
3. Linear Algebra by K. Hoffman and R. Kunze, Pearson.
4. Linear Algebra: A Modern Introduction by D. Poole, Brooks/Cole.
5. Linear Algebra: A Geometric Approach by S. Kumaresan, Prentice-Hall of India.
6. Linear algebra (undergraduate text in mathematics) by S. Lang, Springer.

Course Name: **Statistical Methods**
Course Code: **MA-222**
Course Type: **Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To impart knowledge about the concept of correlation, regression and hypothesis testing.
- To introduce the fundamental concepts relevant to design of experiments and its comparison tests.
- To enable the students to understand the concept of factorial designs and comparison with experimental design.

Unit Number	Course Content	Contact Hours
UNIT-01	**Data Visualization:** Measures of central tendency, dispersion, skewness, kurtosis, data representation using Histogram, Pie Chart, Boxplot, Biplot, Multidimensional scaling.	**06L**
UNIT-02	**Order Statistics:** Different order statistics and their single and joint distribution, sampling distribution of mean, variance, random number generation, Generation of random numbers following certain distributions.	**06L**
UNIT-03	**Correlation and Regression:** Measures of relation between two variables – correlation and Rank correlation – Kendall's Tau; Partial and Multiple correlation coefficients – Regression – Curve fitting by least squares – linear and quadratic	**08L**
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.	**10L**
UNIT-05	**Multiple Comparison Tests:** Least Significant Difference, Student-Newman–Keuls test, Duncan's Multiple Range test, Tukey's test	**06L**

Course Outcomes

Upon successful completion of the course students will be able to
CO1: Identify and describe the data types and preparing 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.

Books and References

1. Fundamentals of Mathematical Statistics by S. C. Gupta and V.K. Kapoor, Sultan Chand and Sons.
2. Design and Analysis of Experiments by D.C. Montgomery, John Wiley and Sons.
3. Fundamentals of Applied Statistics by S. C. Gupta and V.K. Kapoor, Sultan Chand.
4. Statistical Inference – Testing of Hypotheses by M. K. Srivastava and N. Srivastava, Prentice Hall of India.
5. An Introduction to Probability and Statistics by V.K. Rohatgi and A. K. Saleh, John Wiley and Sons.
6. Applied Statistics and Probability for Engineers by D.C. Montgomery, G.C. Runger, John Wiley and Sons.
7. Design and Analysis of Experiments by M.N. Das and N.C. Giri, Wiley Eastern Ltd.

Course Name: **Data Structure**
Course Code: **MA-223**
Course Type: **Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To understand and remember algorithms and its analysis procedure.
- To introduce various techniques for representation of the data in the real world.
- To develop application using data structure algorithms.

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction:** Data types, data structures, 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.	**06L**
UNIT-02	**Linear Data Structures and Linked Lists:** 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.	**09L**
UNIT-03	**Sorting and Searching Techniques:** Bubble sorting, Insertion sort, Selection sort, Shell sort, Merge sort, Heap and Heap sort, Quick sort, Radix sort and Bucket sort, Sequential searching, Binary Searching	**07L**
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.	**07L**
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 tress, articulation points and biconnected components, graph matching.	**07L**

Course Outcomes

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

CO1: Assess how the choice of data structures and algorithm design methods impacts the performance of programs.
CO2: Choose the appropriate data structure and algorithm design method for a specified application.
CO3: Solve problems using data structures such as linear lists, stacks, queues, binary trees, and graphs
CO4: Solve problems using algorithm design methods.

Books and References

1. Introduction to Algorithms by T.H. Cormen, C. E. Leiserson, R. L. Rivest, C. Stein, MIT Press.
2 An Introduction to Data Structures with applications by .J.P. Tremblay, P.G. Sorenson, Tata McGraw Hill.
3. Data structures, Algorithms and Applications in C++ by by S. Sahni, Tata McGraw Hill.
4. Data Structures using C by Y. Langsam, M. J. Augenstein, A. M. Tenenbaum, Pearson Education.
5. Data Structures and Algorithmic Puzzles by N. Karumanchi, CareerMonk Publications.
6. Data Structures and Algorithms by A.V. Aho, J.D. Ullman, J.E. Hopcroft, Pearson.
7. Data Structures – A Pseudo code Approach with C by R. F. Gilberg, B. A. Forouzan, Thomson Brooks / COLE.

Course Name: **Operating System**
Course Code: **MA-224**
Course Type: **Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To understand the main components of an OS & their functions and to understand the concepts and implementation Memory management policies and virtual memory.
- To understand the working of an OS as a resource manager, file system manager, process manager, memory manager and I/O manager and methods used to implement the different parts of OS.
- To study the need for special purpose operating system with the advent of new emerging technologies.

Unit Number	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. **CPU Scheduling:** Scheduling concepts, scheduling algorithms, algorithm evaluation, multiple processor scheduling, real time scheduling.	**06L**
UNIT-02	**Concurrent Programming and Deadlocks:** 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.	**08L**
UNIT-03	**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.	**10L**
UNIT-04	**File Systems:** A Simple file system, General model of a file system, Symbolic file system, Access control verification, Logical file system, Physical file system, Allocation strategy module, Device strategy module, I/O initiators, Device handlers, Disk scheduling.	**04L**
UNIT-05	**Networks, Security and Design Principles:** Network operating system, distributed operating system, external security, operational security, password protection, access control, security kernels, hardware security, layered approach, design principle.	**08L**

Course Outcomes

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

CO1: Describe the important computer system resources and the role of operating system in their management policies and algorithms and understand the process management policies and scheduling of processes by CPU

CO2: Evaluate the requirement for process synchronization and coordination handled by operating system

CO3: Identify use and evaluate the storage management policies with respect to different storage management technologies and Identify the need to create the special purpose operating system.

Books and References

1. Operating System Concepts by J. L. Peterson and A. Silberchatz, Addison Wesley.
2. An Introduction to Operating System by H. M. Dietel, Addison Wesley.
3. Modern Operating system by A.S. Tanenbaum, Prentice Hall of India.
4. Operating Systems - A Design Oriented Approach by C. Crowley, Irwin Publishing
5. Operating systems by W. Stallings, Prentice Hall of India.
6. The design of the Unix operating systems by M.J. Back, Prentice Hall of India.
7. Operating Systems Principles by Silberschatz, Galvin, Gagne, Wiley; Seventh edition.

Course Name: **Data Structure Lab** Course Code: **MA-225**	
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- To provide skills for designing flowcharts and writing algorithms.
- To provide skills for writing C programs.
- To enable the students to understand about writing algorithms and step by step approach in solving problems with the help of fundamental data structures.

List of Experiments

1. Sorting Algorithms-Non-Recursive.
2. Sorting Algorithms-Recursive.
3. Searching Algorithm.
4. Implementation of Stack using Array.
5. Implementation of Queue using Array.
6. Implementation of Circular Queue using Array.
7. Implementation of Stack using Linked List.
8. Implementation of Queue using Linked List.
9. Implementation of Circular Queue using Linked List.
10. Implementation of Tree Structures, Binary Tree, Tree Traversal, Binary Search Tree, Insertion and Deletion in BST.
11. Graph Implementation, BFS, DFS, Minimum cost spanning tree, shortest path algorithm.

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: Ability to describe stack, queue and linked list operation.
CO3: Ability to analyze algorithms and algorithm correctness.

Course Name: **Statistical Methods Lab**
Course Code: **MA-226**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To provide skills for designing worksheet in SPSS 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 on SPSS and data analysis

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. Factorial Analysis of Variance

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 data type and suitable statistical tool for the data.
CO2: Design the data sheet as per the SPSS format so that student can run the experiment.
CO3: Do the statistical analysis using SPSS.

Course Name: **Operating System Lab**
Course Code: **MA-227**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To 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 techniques-Semaphores
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: **Operation Research**
Course Code: **MA-311**
Course Type: **Core Course**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To provide quantitative insight and understanding of fundamental methods of linear programming problems.
- To demonstrate the powerful capabilities of optimization theory to enable reducing costs, improving efficiency, optimal usage of resources and providing benefits in many other key dimensions in engineering / industry / managerial / decision making problems.
- To have flavor of both sound theoretical foundation of various methods and their actual implementations in problems solving.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Hyperplane and hyperspheres, Convex sets and their properties, Convex functions, Linear Programming Problems; Formulation through examples, Basic feasible and optimal solutions, Extreme points, Graphical Method, Simplex Method, Big-M Method, Degeneracy, Duality and Dual LPP and its properties, Dual simplex Algorithm and sensitivity analysis.	**06L**
UNIT-02	**Transportation Problem**: mathematical formulation, basic feasible solution, North-West Corner Method, Least Cost Method, Vogel's approximation Method, Optimal solution by U-V Method, Stepping Stone Method, Degeneracy in Transportation problem. **Assignment Problem:** mathematical formulation, solution by Hungarian Method, unbalanced problem, Traveling Salesman problem and its solution.	**08L**
UNIT-03	**Goal Programming Problem (GPP):** Mathematical formulation, Graphical goal attainment and Simplex method for solution of GPP	**06L**
UNIT-04	**Game Theory:** Two-Person Zero sum games, The Maximin-minimax principle, pure and mixed strategies, graphical solution, Dominance property, General solution of mxn rectangular games, Linear programming of GP**.**	**08L**
UNIT-05	**Network Analysis: PERT:** Background, development, networking, estimating activity time, Determination of earliest expected and allowable times, determination of critical path, PERT cost, scheduling of a project, CPM method, Applications of these methods	**08L**

Course Outcomes

Upon successful completion of the course, the students 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.

Books and References

1. Introduction to Operations Research by F.S. Hillier and G.J. Libermann, McGraw Hill.
2. Operations Research by K. Swarup, P.K. Gupta and Man Mohan, Sultan Chand and Sons.
3. Linear Programming by V. Chvatal, W.H. Freeman publishers.
4. Operation Research by S.D. Sharma, Kedar Nath & Co.
5. Mathematical Programming: Theory and Methods by S.M. Sinha, Elsevier Publications.
6. Linear programming by G. Hadley, Narosa Publishing House.
7. Operation Research: An Introduction by H. A. Taha, Prentice Hall of India.
8. Operations Research by V.K. Kapoor, Sultan Chand & Sons.

Course Name: **Number Theory and Abstract Algebra**
Course Code: **MA-312**
Course Type: **Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

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	**08L**
UNIT-02	**Arithmetical Functions:** Examples with some properties and their rate of growth, continued fractions and their connections with Diophantine approximations, applications to linear and Pell's equations, binary quadratic form	**08L**
UNIT-03	**Introduction to Abstract Algebra:** Groups, cyclic groups, permutation groups and applications, Subgroups, normal subgroups, quotient Groups class equations, Sylow theorems and applications.	**08L**
UNIT-04	**Rings:** Subring, Ideals, prime and maximal ideals, quotient rings, Principal Ideal Domains and Unique Factorizations Domains, Euclidean Domains and factorization of polynomial rings	**08L**
UNIT -05	**Fields:** Finite field, subfield, extension field, splitting fields and introduction to Galois theory.	**04L**

Course Outcomes

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

CO1: Identify divisibility, residue, congruence, remainder, reciprocity, primality, factorization.
CO2: Apply principles of Number Theory in cryptography.
CO3: Group theory and its applications in security systems.
CO4: Factorization of polynomials and its application in solving some of the most important problems of 18^{th} and 19^{th} centuries.

Books and References:

1. A Course in Number Theory and Cryptography by N. Koblitz, Springer Verlag.
2. An introduction to the theory of numbers by G.H. hardy, E.M. Wright, Oxford University Press.
3. An Introduction to the Theory of Numbers by I. Niven, H.S. Zucketman, H.L. Montgomery, John Wiley and Sons.
4. Contemporary Abstract Algebra by J.A. Gallian, Narosa Publishing House.
5. Topics in Algebra by I.N. Herstein, Wiley India Pvt. Ltd.

Course Name: **Data Base Management Systems**
Course Code: **MA-313**
Course Type: **Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To introduce the concepts of basic SQL as a universal Database language and to enhance knowledge to advanced SQL topics like embedded SQL, procedures connectivity.
- 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 Number	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.	**06L**
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, Functional dependences and Normalization for Relational Databases, normal forms based on primary keys, (1NF, 2NF, 3NF & BCNF), lossless join and dependency preserving decomposition	**10L**
UNIT-03	**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.	**08L**
UNIT-04	**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, Time stamp based concurrency control , Recovery Techniques, Concepts- Immediate Update- Deferred Update, Shadow Paging.	**04L**
UNIT-05	**Current Trends:** Introduction to Distributed and parallel databases, Deductive Databases, Multimedia Databases, Real-Time Databases.	**08L**

Course Outcomes

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

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

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 data base by formulating complex queries in SQL.

CO3: Analyze the existing design of a database schema and apply concepts of normalization to design an optimal databaseandf 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. Principals 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: **Programming in Python**
Course Code: **MA-314**
Course Type: **Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- Understand how to write algorithms for the concepts on computational problems.
- Know the basics of python programming such as tokens, data types etc.
- Get idea on the control statements, how to use functions and the string handling mechanisms in python language.
- Recognize with the concepts of tuples and dictionaries in python language.

Unit Number	Course Content	Lectures
UNIT-01	**Fundamental Algorithms:** Programs and algorithms, Problem-Solving aspect, top-down design, implementation of algorithms, program verification and efficiency of algorithms and analysis of algorithms. Exchanging the values of two variables, counting, summation, factorial, sine function computation, generation of Fibonacci sequence, reversing the digits/strings, base conversion.	**09L**
UNIT-02	**Basics of Python Programming:** Introduction to Python, Python character set, Tokens, Core data types, variables, Assignment of values to variables, Writing simple programs in Python. Operators and Expressions: Arithmetic operators, Operator precedence and associativity, Bitwise operators and Boolean operators.	**07L**
UNIT-03	**Control Flow, Functions and Strings: Decision Statements:** if statement, if-else statement, nested if statement, multi-way if-elseif-else statement; **Loop Statements:** while loop, range() function, for loop, nested loops, break and continue statements; **Functions:** Syntax and basics of a function, parameters and arguments in a function, return statement, recursive functions, Lambda function; **Strings:** Basic Python functions for string, String operators, String operations	**07L**
UNIT-04	**Lists, Tuples and Dictionaries:** Lists: Creating lists, Slicing lists, List methods, Lists and strings, Lists with functions, Searching and sorting in lists; **Tuples:** Creating tuples, inbuilt functions for tuples, Lists and tuples. Dictionaries: Basics of dictionaries, Creating a dictionary, Formatting dictionaries, Methods of dictionary class	**07L**
UNIT-05	**File Handling, Modules and Packages: File Handling:** Introduction, Working with text files; **Modules:** Definition, Creating a module, Standards modules of Python; **Packages:** Definition, Importing * from packages, Packages in multiple directories	**06 L**

Course Outcomes

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

CO1: Write algorithms for computational problems.

CO2: Work with basic programs in python.

CO3: Write programs in python for looping structures, functions and string handling mechanisms.

CO4: Execute programs on creation of lists, tuples and dictionaries using python language.

CO5: Implement file handling mechanisms, modules and packages of python language .

Books and References

1. Think Python: How to Think Like a Computer Scientist- Allen B. Downey.
2. Python Programming – An Introduction to computer science, John Zelle, JimLeisy.
3. Programming Python, Mark Lutz, O'Reilly, 3rd Edition, 2006.
4. Core Python Programming, Wesley J Chun, PH, 2nd Edition.
5. Python Programming: A Compatible Guide for Beginners to Master and Become an Expert in python programming Language, Brain Draper, Create Space Independent Publishing Platform, 2016.

Course Name: **Data Base Management Systems Lab**
Course Code: **MA-315**

Contact Hours/Week: **2P** Course Credits: **01**

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 group function.
   e) Manipulating data.
   f) Creating and managing tables.
4. Normalization
5. Creating cursor
6. Creating procedure and functions
7. Creating packages and triggers
8. Design and implementation of payroll processing system
9. Design and implementation of Library Information System
10. Design and implementation of Student Information System
11. Automatic Backup of Files and Recovery of Files ii. List process file from the system

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: 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: **Programming in Python Lab**
Course Code: **MA-316**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To understand and apply the basic principles of programming.
- To identify/characterize/define a problem.
- To design a program to solve the problem.
- To read more Python code.

List of Experiments

1. To read two numbers and perform an arithmetic operation based on the option chosen by the user.
2. Write a NumPy program to create a 2D array with 1 on the border and 0 inside.
3. Write a NumPy program to get the number of nonzero elements in an array.
4. Write a NumPy program to compute the multiplication of two given matrixes.
5. Write a NumPy program compute the inverse of a given matrix.
6. Write a program to calculate factorial of a given number and store result into variable.
7. Write a function that tests if a number is prime. Test it by writing out all prime numbers less than 50.
8. Generate two array of same length and plot on x axis and y-axis.
9. Write a NumPy program to get the element-wise remainder of an array of division.
10. Write a program to generate a multiplication table for a given number.
11. Write a program to find the distance between two points, area of a circle.
12. Write a program to find the factorial of a number using recursion. And also find the GCD of two numbers using recursion.
13. Consider the string str = 'Hello Word'. Write statements in Python to implement the following
    i. To display the last four characters.
    ii. To display the substring starting from index 2 and ending at index 6.
    iii. To check whether string has alphanumeric characters or not.
    iv. To trim the last four characters from the string.
    v. To trim the first four characters from the string.
    vi. To display the starting index for the substring 'He'.
    vii. To change the case of the given string.
    viii. To check if the string is in title case.
    ix. To replace all the occurrences of letter 'o' in the string with '*'.

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: Write python basic programs using conditional and looping structures.
CO2: Execute programs in python for string handling, functions, create modules and work with packages.

Course Name: **Statistical Software Lab**
Course Code: **MA-317**

Contact Hours/Week: **2P** Course Credits: **01**

Course Objectives

- To provide skills to use the Statistical Software.
- To provide skills for analyzing data with appropriate techniques.
- To enable the students to visualize data.

List of Experiments

1. An Overview of Statistical Software: Mouse and keyboard processing, frequently–used dialog boxes, Editing output, Printing results, Creating and editing a data file.
2. Managing Data: Listing cases, replacing missing values, computing new variables, recording variables, exploring data, selecting cases, sorting cases, merging files.
3. Graphs: Creating and editing graphs and charts.
4. Frequencies: Frequencies, bar charts, histograms, percentiles.
5. Descriptive Statistics I: measures of central tendency, variability, deviation from normality, size and stability.
6. Descriptive Statistics II: Cross Tabulation and chi-square analyses, The means procedure.
7. Bivariate Correlation: Bivariate Correlation,
8. The T-test procedure: Independent –samples, paired samples, and one sample tests.
9. The one way ANOVA procedure: One way analysis of variance.
10. General Linear model: Two–way analysis of variance.
11. General Linear model: Simple Linear Regression.
12. General Linear model: Multiple Linear Regression.

Course Outcomes

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

CO1: Import, review, manipulate and summarize data-sets with statistical software.
CO2: Explore data-sets to create testable hypotheses and identify appropriate statistical tests.
CO3: Perform appropriate statistical tests using statistical software.
CO4: Create and edit visualizations with statistical software.

Course Name: **Real & Complex Analysis**
Course Code: **MA-321**
Course Type: **Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To impart knowledge about the Riemann integration, Improper integral, Metric spaces, Complex integration.
- To introduce the fundamental concepts relevant to Real and Complex Analysis.
- To enable the students to understand the factors that causes the integrability and convergence.

Unit Number	Course Content	Lectures
UNIT-01	**Riemann Integration:** Riemann Integration, Partition and Riemann sums, necessary and sufficient conditions for Riemann integrability of a function, first and second mean value theorems of integral calculus, fundamental theorem of integral calculus.	**06L**
UNIT-02	**Improper Integrals:** Improper integrals of first and second type, Beta function, Gamma function, their properties, relation between Beta and Gamma function, Convergence of improper integrals**,** comparison test, μ-test, Abel's test, Dirichlet's test.	**07L**
UNIT-03	**Metric Spaces:** Definition and examples, open, closed and bounded sets, Interior, closure and boundary, convergence and completeness, continuity and uniform continuity, connectedness, compactness and Seperability, Heine-Borel theorem.	**12L**
UNIT-04	**Preliminaries to Complex Analysis:** Basic properties: convergence, compactness, connectedness, Power series of complex valued function, radius of convergence.	**04L**
UNIT-05	**Complex Functions:** Poisson's integral formula for a circle, Cauchy's inequality, Fundamental theorem of integral calculus for complex valued function. Fundamental theorem of algebra, argument principle, Rouche's theorem.	**07L**

Course Outcomes

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

CO1: Identify the factors that cause integrability and convergence.
CO2: Describe the basic concepts of Real and Complex Analysis.
CO3: Apply principles of Real and Complex Analysis to test the integrability and convergence.
CO4: Assess the benefit of Real and Complex analysis.

Books and References

1. Advanced Engineering Mathematics: by Erwin Kreyszig, John Wiley and Sons.
2. Advanced Engineering Mathematics, R. K. Jain & S. R. K Iyengar, Narosa Pub. House.
3. Complex Analysis for Mathematics and Engineering by J.H. Mathews and R.W. Howell, Narosa Publishing House.
4. Complex Variables and Applications by J.W. Brown and R.V. Churchill, McGraw Hill.
5. Mathematical Analysis by T. M. Apostol,, Addison-Wesley Publishing Company.
6. Mathematical Analysis by S.C. Malik & Savita Arora,, New Age International (P) Ltd.

Course Name: **Advanced Differential Equations and Applications**
Course Code: **MA-322**
Course Type: **Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To study the linear and nonlinear ordinary differential equations and their solutions.
- To study the linear and nonlinear partial differential equations and their solutions.
- To understand the method of solution for higher order differential equations.

Unit Number	Course Content	Lectures
UNIT-01	**First Order Ordinary Differential Equations:** Revisiting basic concepts, Some models arising in ordinary differential equations, Existence and uniqueness of solution: Picard's Theorem, Solutions to system of linear differential equations, eigenvalue-eigenvector method of finding solutions, Fundamental matrix, Nonhomogeneous equations.	**08L**
UNIT-02	**Second Order Ordinary Differential Equations:** Second order differential equations with constant and variable coefficients, Wronskian, reduction of order method of finding solutions, Series solutions of ordinary differential equations, regular point and singular point, Frobenius method and some special functions.	**08L**
UNIT-03	**First Order Partial Differential Equations:** Well-posed problems and classical solutions, Transport equation, Pfaffian Differential equations, Cauchy's Problem for First -order Equations, Characteristics, Cauchy's Method of Characteristics, Compatible Systems of First -order Equations, Jacobi's Method.	**08L**
UNIT-04	**Second Order Linear Partial Differential Equations:** Second order partial differential equations in two variables and their classification, reduction of linear partial differential equation to canonical form; Cauchy, Dirichlet and Neumann problems; fundamental solutions of Laplace equations, Heat equation, Duhamel's principle for inhomogeneous problems	**08L**
UNIT-05	**Some Higher Dimensional Partial Differential Equations:** Solutions of Heat, Wave and Laplace equations in two or higher dimensions using Laplace and Fourier transforms.	**04L**

Course Outcomes

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

CO1: Understand Important Concepts of Ordinary Differential Equations in Detail.
CO2: Classify PDEs and transform into canonical form.
CO3: Apply analytical methods to solve PDE's and physically interpret the solutions.

Books and References

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

Course Name: **Time Series Analysis & Forecasting**
Course Code: **MA-323**
Course Type: **Core**

Contact Hours/Week: **3L + 1T** Course Credits: **04**

Course Objectives

- To impart knowledge about the areas of time series statistics.
- To apply the concepts of time series statistics to real data sets.
- To enable the students to assimilate data applied to real, scientific and interesting problems.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Time-series as discrete parameter stochastic process, auto covariance and autocorrelation functions and their properties.	**04L**
UNIT-02	**Exploratory Time Series Analysis:** Components of time series, Messurements of trend, Measurement of seasonal fluctuation, Mesurement of cyclic movement, tests for trend and seasonality, exponential and moving average smoothing. Holt and Winters smoothing, forecasting based on smoothing.	**08L**
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.	**06L**
UNIT-04	**Modeling 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. **Spectral analysis:** Spectral analysis of weakly stationary process, peridogram and correlogram analyses, computations based on Fourier transform.	**12L**
UNIT-05	**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	**06L**

Course Outcomes

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

CO1: Understand and analyze 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.

Books and References

1. Time Series Analysis: Forecasting and Control by G. Box and Jenkins, Palgrave Macmillan.
2. Introduction to Time Series and Forecasting by P.J. Brockwell and R.A. Davis, Springer.
3. Time Series Analysis by J. D. Hamilton, Princeton University Press.

Course Name: **Soft Computing**
Course Code: **MA-324**
Course Type: **Core**

Contact Hours/Week: **3L** 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.
- To develop skills to gain basic understanding of neuro-fuzzy modeling and applications.

Unit Number	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.	**06L**
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.	**09L**
UNIT-03	**Genetic Algorithms:** Concept of "Genetics" and "Evolution" and it's 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.	**08L**
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.	**07L**
UNIT-05	**Neuro-fuzzy Modeling:** Introduction of Neuro-Fuzzy Systems: Architecture of Neuro Fuzzy Networks, Neuro-fuzzy inference system, Rule base structure identification, Neuro fuzzy controls, Application of Neuro-fuzzy hybrid systems.	**06L**

Course Outcomes

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

CO1: Understand the concepts of fuzzy logic and fuzziness involved in various systems.
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.

Books and References

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. Fuzzy Logic with Engineering Applications by T.J. Ross, John Wiley & Sons.
5. Foundations of Neural Networks, Fuzzy systems and Knowledge Engineering by N.K. Kasabov, MIT Press.
6. An Introduction to Genetic Algorithms by M. Mitchell, MIT Press.

Course Name: **Numerical Computation Lab** Course Code: **MA-325**	
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- To impart knowledge to develop algorithm and C++/ MATLAB codes for numerical methods.
- To prepare students with the skill to create function files and call the same.
- To enable the students to handle problems numerically, which are difficult to be solved manually.

List of Experiments

1. To find the roots of non-linear equation using Bisection method
2. To find the roots of non-linear equation using Regular Falsi method
3. To find the roots of non-linear equation using Newton-Raphson method
4. To solve the system of linear equations using Gauss-Elimination method
5. To solve the system of linear equations using Jacobi iteration method
6. To solve the system of linear equations using Gauss-Seidal method
7. To Interpolate the dependent variable by Newton's interpolation formulae
8. To Interpolate the dependent variable by Gauss interpolation formulae
9. To integrate numerically using Trapezoidal rule
10. To integrate numerically using Simpson's rules
11. To integrate numerically using Romberg integration
12. To find numerical solution of ordinary differential equations by Euler's method
13. To find numerical solution of ordinary differential equations by Runge- Kutta method
14. To find numerical solution of ordinary differential equations by Adam Bashforth predictor corrector method

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: Develop algorithms and consequently codes for various numerical methods.
CO2: Learn to create and call function files.
CO3: Learn to control error in numerical computations
CO4: Use their computational skills efficiently with desired level of accuracy.

Course Name: **Time Series Analysis Lab** Course Code: **MA-326**	
Contact Hours/Week: **2P**	Course Credits: **01**

Course Objectives

- To provide skills to apply the time series methods to data.
- To provide skills for analyzing data with appropriate time series techniques.
- To enable the students to visualize time series data.

List of Experiments

1. Understanding Time Series Data: descriptive analysis, association techniques.
2. Time Series Decompostion.
3. Autocorreation Function (ACF) & Partial Autocorreation Function (ACF).
4. Tests for Trend and Seasonality.
5. Exponential smoothing and forecasting based on smoothing.
6. Moving average smoothing and forecasting.
7. Holt and Winter's Smooting and forecasting.
8. Application of Moving Average (MA) Time Series Models to data.
9. Application of Autoregrssive (AR) Time Series Models to data.
10. Application of Autoregrssive Moving Average (ARMA) and Autoregressive Integrated Moving Average Time Series Models to data.
11. Application of Seasonal Autoregrssive Moving Average (SARMA) Time Series Models to data.
12. Spectral Analysis of Time Series Data.

Course Outcomes

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

CO1: Import, review, manipulate and summarize time series data-sets.
CO2: Explore data-sets to create testable hypotheses and identify appropriate time series methods.
CO3: Perform appropriate Time Series Models for Forecasting.
CO4: Check the stationarity of time series in terms of its spectral density function.

Course Name: **Engineering Economics and Accountancy**
Course Code: **HS-404**
Course Type: **Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

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

Unit Number	Course Content	Lectures
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, Isoquant, Least Cost combination, Laws of Returns to Scale. Economics and Diseconomies of Scale of production, Cost and Cost curves, Revenue and Revenue curve, 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	**05L**
UNIT-04	**Markets**: Meaning, Types of Markets, Characteristics (Perfect Competition, Monopoly, Monopolistic Competition, Oligopoly) Price and Output Determination; Product Differentiation; Selling Costs; Excess Capacity.	**05L**
UNIT-05	**Money**: Meaning, Functions, Types; Monetary Policy- Meaning, Objectives, Tools; Fiscal Policy:-Meaning, Objectives, Tools. **Banking:** Meaning, Types, Functions, Central Bank: its Functions, concepts CRR, Bank Rate, Repo Rate, Reverse Repo Rate, SLR.	**04L**
UNIT-06	**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-07	**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.	**06L**

Course Outcomes

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

CO1: Identify the challenges of the economy as entrepreneur/manufacturer as well as consumer
CO2: Describe the economic system at the micro and macro level
CO3: Apply principles of economics and accountancy in the professional, personal and societal life
CO4: Assess the role of engineering economics and accounting in attaining economic efficiency

Books and References

1. Principles of Micro Economics by William A. Mceachern and Simrit Kaur, Cengage Publication.
2. Managerial Economics by Craig Peterson and 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 E. Paul DeGarmo, Prentice Hall.
7. Financial Accounting–A Managerial Perspective by R. Narayanaswamy, PHI.
8. Introduction to Accounting by J.R. Edwards and Howard J Mellett, 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: **Cryptography & Information Security**
Course Code: **MA-411**
Course Type: **Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To understand the fundamentals of cryptography and network security.
- To be able to secure a message over insecure channel by various means.
- To understand various key distribution and management schemes.

Unit Number	Course Content	Lectures
UNIT-01	I**ntroduction**: Overview on Modern Cryptography, Probability and Information Theory, Number theory.	**04L**
UNIT-02	**Crypto Systems:** Classical Cryptosystems, Cryptanalysis of Classical Cryptosystems, Shannon's Theories. Symmetric Key Ciphers, Modern Block Ciphers (DES and AES).	**08L**
UNIT-03	**Cryptanalysis:** Linear, Differential and other Cryptanalysis Techniques, Overview on S-Box Design Principles, Modes of operation of Block Ciphers, Stream Ciphers, Pseudorandom functions **Asymmetric Key Ciphers:** Construction and Cryptanalysis.	**08L**
UNIT-04	**Primality Testing, Factoring Algorithms:** The RSA Cryptosystem, Other attacks on RSA and Semantic Security of RSA, The Discrete Logarithm Problem (DLP) and the Diffie Hellman Key Exchange algorithm The ElGamal Encryption Algorithm Cryptanalysis of DLP, Hash functions: The Merkle Damgard Constructio Message Authentication Codes (MACs)	**08L**
UNIT-05	**Signature Schemes**: Elliptic curve based cryptography, Secret Sharing Schemes. A Tutorial on Network Protocols, Kerberos, Pretty Good Privacy (PGP), Secure Socket Layer (SSL), Intruders and Viruses, Firewalls.	**08L**

Course Outcomes

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

CO1: Analyze the vulnerabilities in any computing system and hence be able to design a security solution.
CO2: Identify the security issues in the network and resolve it.
CO3: Implement various networking protocols.

Books and References

1. Cryptography Theory and Practice by D. Stinson, Chapman & Hall/CRC.
2. Cryptography & Network Security by B. A. Forouzan, Tata Mc Graw Hill.
3. Cryptography and Network Security by W. Stallings, Pearson Education.
4. Modern Cryptography, Theory & Practice by W. Mao, Pearson Education.
5. An Introduction to Mathematical Cryptography by J. Hoffstein, J. Pipher, J.H. Silvermman, Springer.
6. Number Theory by S. G. Telang, Tata Mc Graw Hill.
7. Protocols for Authentication and Key Establishment by C. Boyd, A. Mathuria, Springer.

Course Name: **Artificial Intelligence**
Course Code: **MA-421**
Course Type: **Core**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To present an overview of artificial intelligence (AI) principles and approaches.
- To develop a basic understanding of the building blocks of AI as presented in terms of intelligent agents: Search, knowledge representation, Knowledge acquisition.
- To implement knowledge of AI in some applications.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Introduction to AI, AI techniques, level of model, criteria for success, Turing test, Reactive, deliberative, goal-driven, utility-driven, and learning agents Artificial Intelligence programming techniques	**06L**
UNIT-02	**Problem Solving:** Problem as a space, search, production system, problem characteristics, production system characteristics, issues in the design of search programs, Solving problems by searching, Heuristic search techniques, constraint satisfaction problems, stochastic search methods.	**08L**
UNIT-03	**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.	**08L**
UNIT-04	**Representing and Reasoning with Uncertain Knowledge:** Probability, connection to logic, independence, Bayes rule, Bayesian networks, probabilistic inference	**08L**
UNIT-05	**Machine Learning and Knowledge Acquisition:** Overview of different forms of learning, learning decision tress, Learning from memorization, Learning nearest neighbor, naive Bayes, Introduction to Natural language Processing.	**06L**

Course Outcomes

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

CO1: Design a knowledge based system

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

CO3: Formulate and solve problems with uncertain information using Bayesian approaches.

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

Books and References

1. Artificial Intelligence: A Modern approach by S. Russell, P. Norvig, Prentice Hall of India.
2. Artificial Intelligence by S. Kaushik, Cengage Learning India Pvt Ltd.
3. Principles of Artificial Intelligence by N.J. Nilsson, Narosa Publishing House.
4. Artificial Intelligence by E. Rich, K. Knight and S.B. Nair, Tata McGraw Hill International.
5. Logic and Prolog Programming by S. Kaushik, New Age International Pvt. Ltd, 2012.

Course Name: **Multivariate Statistical Analysis**
Course Code: **MA-422**
Course Type: **Core**

Contact Hours/Week: **3L** 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	**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.	**06L**
UNIT-02	**Wishart's Distribution:** Wishart matrix – its distribution and properties, distribution of sample generalized variance, null and non-null distribution of multiple correlation coefficients.	**06L**
UNIT-03	**Hotelling's T^2 Distribution:** Hotelling's T^2 and its sampling distribution, application in test on mean vector for one and more multivariate normal population and also on equality of components of a mean vector in multivariate normal population.	**06L**
UNIT-04	**Classification problem:** Standards of good classification, procedure of classification based on multivariate normal distributions.	**06L**
UNIT-05	**Discriminant analysis:** Classification of observations into one or two or more groups. Estimation of the misclassification probabilities. Test associated with discriminate functions. **Principal Component Analysis:** Principal components, dimension reduction, canonical variates and canonical correlation—definition, use, estimation and computation.	**12L**

Course Outcomes

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

CO1: Derive various multivariate sampling distributions.
CO2: Understand how the Wishart distribution arises in multivariate sampling and how to use it.
CO3: Understand how to use various multivariate statistical methods.
CO4: Assess the multivariate nature of the data sets and drive their properties.

Books and References

1. An Introduction to Multivariate Statistical Analysis by T.W. Anderson, John Wiley and Sons.
2. Applied Multivariate Statistical Analysis by N.C. Giri, Academic Press.
3. Applied Multivariate Statistical Analysis by R.A. Johnson and D.W. Wichern, Prentice Hall of India.
4. Multivariate data analysis by J.F. Hair, W.C. Black, B.J. Babin, R.E. Anderson, Pearson.

Course Name: **Game Theory**
Course Code: **MA-430**
Course Type: **Professional Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To provide an introduction to Game Theory
- To explain in depth the standard equilibrium concepts.
- To explain and predict how individuals behave in a specific strategic situation.

Unit Number	Course Content	Lectures
UNIT-01	**Two Person Zero Sum Games:** The nature of games, Matrix Games – Dominance and Saddle point, Mixed strategies, Game trees, Application to business – Competitive decision making, utility theory, Games against nature.	**08L**
UNIT-02	**Two Person Zero Sum Games and Applications:** Nash equilibrium and Non-cooperative solutions, the Prisoner's Dilemma, Application to Social Psychology – trust, suspicion, and the F-scale.	**07L**
UNIT-03	**Strategic Moves:** Basic of Strategic moves, Application to Biology – evolutionarily stable strategies, the Nash arbitration scheme and cooperative solutions, Application to Business – Management-Labor arbitration.	**06L**
UNIT-04	**N-Person Games:** Introduction to N-Person games, Application to Politics – Strategic voting, N-Person's Dilemma, Application to Athletics – Prisoner's Dilemma and the Football Draft.	**08L**
UNIT-05	**Imputations, Dominance and Stable Sets:** Application to Anthropology – Pathan organization, the core, the shapely value, Application to Politics – the shapley-shubik power index.	**07L**

Course Outcomes

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

CO1: Identify strategic situations and represent them as games.
CO2: Solve simple games using various techniques.
CO3: Analyse economic situations using game theoretic techniques.

Books and References

1. Game Theory and Strategy by P. D. Straffin , Mathematical Association of America.
2. Linear programming by G. Hadley,, Narosa Publishing House.
3. Operation Research: Theory, Methods and Applications by S.D. Sharma and H. Sharma,, Kedar Nath & Company.
4. Fundamentals of Operation Research: An Introduction by H.A. Taha, Prentice Hall of India.
5. Operations Research for Management by G.V. Shenoy, U.K. Srivastava, S C Sharma, New Age International (P) Ltd.
6. Game theory and its applications by W. F. Lucas, Mathematical Association of America.

Course Name: **Advanced Optimization Techniques & Applications**
Course Code: **MA-431**
Course Type: **Professional Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the principles and methods of mathematical modeling for studies of complex systems in science, engineering, and business.
- To compare modeling results to observations and how models can be improved.
- To learn how to model "real" problems and prepare the mathematical models for analysis.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Gradient vectors; Examples; Optimization of function of multiple variables subject to equality constraints; Lagrangian function; Optimization of function of multiple variables subject to equality constraints; Hessian matrix formulation; Eigen values; Kuhn-Tucker Conditions; Examples.	**06L**
UNIT-02	**Non Linear Programming:** Unconstrained optimization techniques, Direct search methods, Descent methods, 2nd order methods, constrained optimization, Direct and indirect methods, Kuhn Tucker conditions.	**10L**
UNIT-03	**Dynamic Programming:** Sequential optimization; Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality; Recursive equations – Forward and backward recursions; Computational procedure in dynamic programming (DP); Discrete versus continuous dynamic programming; curse of dimensionality in DP, example.	**08L**
UNIT-04	**Integer and Quadratic Programming:** Linear integer program formulations and applications, cutting plane algorithm, branch and bound algorithms; Quadratic programming Problems (QPP), Wolfe's method, dual of QPP, applications of QPP in portfolio and support vector machines.	**06L**
UNIT-05	**Stochastic Programming:** Basic Properties of SP and its Theory, The value of information and stochastic solution. Two Stage Linear resource Problem, Non-Linear approaches to two-stage recourse problem	**06L**

Course Outcomes

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

CO1: Create mathematical models of empirical or theoretical phenomena.
CO2: Draw inferences from models .
CO3: Take an analytical approach to problems in their future endeavours.

Books and References

1. Engineering Optimization: Theory and Practice by S.S. Rao, New Age International (P) Ltd.
2. Numerical optimization with applications by S. Chandera, Jaydeva, and A. Mehta,, Narosa publications.
3. An Introduction to optimization by Edvin K.P. Chong, and Stanislaw H. Zak, John Wiley Publisher.
4. Optimization theory and practice by M. C. Joshi, K. M Moudgalya,, Narosa publications.
5. Introduction to Linear Optimization by D. Bertsimas , J. N. Tsitsiklis, Athena Scientific.
6. Linear Programming: Foundations and Extensions by R.J. Vanderbei, Springer.

Course Name: **Information Theory and Coding**
Course Code: **MA-432**
Course Type: **Professional Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To introduce information theory
- To give an overview of coding theory and practice
- To illustrate ideas with a large range of practical applications

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Information measure and source coding, Information measure, Entropy and Information rate, Coding for a discrete memory less source, Predictive coding for sources with memory, Information transmission on discrete channels, Mutual information.	**06L**
UNIT-02	**Discrete Channels:** Classification of channels. Information processed by a channel. Calculation of channel capacity. Decoding schemes. The ideal observer. The fundamental theorem of Information Theory and its strong and weak converses. **Continuous Channels:** The time-discrete Gaussian channel. Uncertainty of an absolutely continuous random variable. The converse to the coding theorem for time-discrete Gaussian channel. The time-continuous Gaussian channel. Band-limited channels.	**08L**
UNIT-03	**Noiseless Coding:** Ingredients of noiseless coding problem. Uniquely decipherable codes. Necessary and sufficient condition for the existence of instantaneous codes. Construction of optimal codes. **The Coding Problem:** Types of codes, Block codes, Types of codes such as repetition codes, Parity check codes and their error-detection and correction capabilities. Hamming metric, Relationship of error detection/correction with hamming distance, Maximum likelihood decoding procedure, Decoding by syndrome decoding and Coset leaders, Standard array.	**08L**
UNIT-04	**Linear Codes (Binary and Non-Binary):** Minimum distance, Dimension, Modular representation of linear codes, Description of linear codes by matrices, Polynomial codes, Generator and parity check polynomials and matrices. **Dual Codes:** Self duality, Weight distribution of dual of binary linear codes, Macwilliam identity(binary case) extending, Expurgating and augmenting a code, Lee metric, Convolutional codes, Description using matrices and polynomials, Encoding using (4,3,2) encoder.	**08L**
UNIT-05	**Hamming Codes (Binary and Non-Binary):** Properties, Perfect and quasi-perfect codes. Golay codes as perfect codes, Bounds on minimum distance for block codes, Plotkin bound, Hamming sphere.	**06L**

Course Outcomes

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

CO1: Design the channel performance using Information theory.
CO2: Comprehend various error control code properties
CO3: Apply linear block codes for error detection and correction
CO4: Apply convolution codes for performance analysis.

Books and References

1. An Introduction to Information Theory by F.M. Reza, MacGraw-Hill Book Company Inc.
2. On Measures of Information and their Characterizations by J. Aczel , Z. Daroczy,, Academic Press.
3. Information Theory by R. Ash, Inderscience Publishers.
4. Error-Correcting Codes by W.W. Peterson and E.J. Weldon, Jr., M.I.T. Press.

Course Name: **Graph Theory**
Course Code: **MA-433**
Course Type: **Professional Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To present a rigorous introduction to the fundamentals of graph theory
- To enable the students to model various applications of from science and engineering using graphs.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction to Graphs**: Basic Terminology, walks, paths, circuits, connectedness, Handshaking lemma, Isomorphism, Sub graphs, Reach ability, Union and interaction of graphs, Euler graph, Shortest path problem, Hamiltonian graph, Traveling sales man problem, Bipartite graphs.	**08L**
UNIT-02	**Trees:** Introduction to Trees, characterizations, Rooted trees, spanning trees, fundamental circuits, counting of minimum spanning tree, cut set and cut vertices.	**06L**
UNIT-03	**Paths and Distance in Graphs:** Basic Definitions, center and median of a graph, activity digraph and critical path.	**06L**
UNIT-04	**Graph Coloring:** vertex coloring, chromatic polynomials, edge coloring, planar graph coloring.	**07L**
UNIT-05	**Matching and Factorizations:** maximum matching in bipartite graphs, maximum matching in general graphs, Hall's marriage theorem, factorization. **Networks:** The Max-flow min-cut theorem, connectivity and edge connectivity, Menger's theorem; Graph and Matrices.	**09L**

Course Outcomes

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

CO1: Apply principles and concepts of graph theory in practical situations.
CO2: Understand graphs as models.
CO3: Understand various types of trees and graph coloring.

Books and References

1. Introduction to graph theory by D.B. West, Pearson.
2. Applied and algorithmic graph theory by G Chatrand and O.R, Ollermann, McGraw Hill.
3. Graph Theory by J. A. Bondy and U.S.R. Murty, Springer.
4. Graph theory with applications to Engineering and computer science by N. Deo, Prentice Hall of India.

Course Name: **Analysis and Design of Algorithms**
Course Code: **MA-434**
Course Type: **Professional Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

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
- To teach various advanced design and analysis techniques such as greedy algorithms, dynamic programming & Know the concepts of tractable and intractable problems and the classes P, NP and NP-complete problems.

Unit Number	Course Content	Lectures
UNIT-01	**Algorithms Introduction:** Algorithm Design paradigms- motivation, concept of algorithmic efficiency, run time analysis of algorithms, Asymptotic Notations.	**06L**
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.	**06L**
UNIT-03	**Greedy Algorithms:** Optimal storage on tapes, Knapsack problem, Job sequencing with deadlines, Minimum Spanning trees: Prim's algorithm &Kruskal's algorithm, Huffman codes. **Dynamic Programming:** Overview, difference between dynamic programming and divide and conquer, Matrix chain multiplication, Traveling salesman Problem, longest Common sequence, 0/1 knapsack.	**10L**
UNIT-04	**Graph Algorithms:** Representation of graphs, BFS, DFS, Topological sort, strongly connected components; single source shortest paths: Bellmen-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.	**10L**
UNIT-05	**Computational Complexity:** Complexity measures, Polynomial Vsnonpolynomial time complexity; NP-hard and NP-complete classes, examples.	**04L**

Course Outcomes

Upon successful completion of the course, the students 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: **Digital Image Processing**
Course Code: **MA-450**
Course Type: **Professional Elective-II**

Contact Hours/Week: **3L** 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) and advanced image analysis (e.g. image compression, image segmentation, Pattern Recognition).
- 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.	**05L**
UNIT-02	**Image Enhancement and Restoration:** Image Enhancement in the Spatial Domain: Background, Basic gray 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. 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.	**09L**
UNIT-03	**Image Compression:** Coding redundancy, Inter-pixel redundancy, fidelity criteria, Image compression models, Error-free compression, Variable length coding, Bit-plane coding, Loss-less predicative coding, Lossy compression, Image compression standards, Fractal Compression, Real-Time image transmission, JPEG and MPEG.	**07L**
UNIT-04	**Image Segmentation:** Detection of discontinuities, Edge linking and boundary detection, Thresholding, Otsu's threshold, Region oriented segmentation, Use of motion in segmentation, Spatial techniques, and Frequency domain techniques.	**07L**
UNIT-05	**Pattern Recognition:** Classification and description, Structure of a pattern recognition system, feature extraction, Classifiers, Decision regions and boundaries, discriminate functions, Supervised and Unsupervised learning, PR-Approaches statistics, syntactic and neural. Statistical Pattern Recognition: Statistical PR, Classifier Gaussian Model, Classifier performance, Risk and error, Maximum likelihood estimation, Bayesian parameter estimation approach, clustering for unsupervised learning and classifiers.	**08L**

Course Outcomes

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

CO1: Learn different techniques employed for the enhancement of images.
CO2: Understand the need for image compression and to learn the spatial and frequency domain techniques of image compression.
CO3: Learn different feature extraction techniques for image analysis and recognition.
CO4: Understand the rapid advances in Machine vision.

Books and References

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.
4. Feature Extraction and Image Processing for Computer Vision by M. Nixon, Academic Press.
5. Introductory Computer Vision and Image Procession by A. Low, McGraw Hill.
6. Pattern Recognition-Statistical, Structural and neural approach by R. Schalkoff, John Willey & Sons.
7. Handbook of Mathematical Methods in Imaging by Scherzer, Springer.
8. Image Processing: Analysis and Machine Vision by Milan Sonka, Roger Boyle, and Vaclav Hlavac

Course Name: **Data Mining**
Course Code: **MA-451**
Course Type: **Professional Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To identify the scope and necessity of Data Mining & Warehousing.
- To develop further interest in research and design of new Data Mining techniques.
- To develop ability to design various algorithms based on data mining tools.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Motivation for Data Mining, its importance, Role Data in Data Mining, Data Mining functionalities.	**03L**
UNIT-02	**Patterns in Data Mining:** Type of patterns, Classification of Data Mining Systems, Major issues in Data Mining, Data cleaning & transformation, data synchronization with operational databases.	**06L**
UNIT-03	**Data Warehousing and OLAP:** OLAP Technology for Data Mining, Data Mining Languages, and System Architectures, Concept Description: Characterization and Comparison, Mining Association Rules in Large Databases.	**07L**
UNIT-04	**Classification Techniques:** Classification and Prediction, Cluster Analysis, Mining Complex Data, Applications and Trends in Data Mining Characteristics of data warehouse, Data Mart, Online Analytical Processing, OLAP tools**,** LIFT charts and ROC curves.	**10L**
UNIT-05	**Data Warehouse:** Architecture, Organizational Issuer, Tools for Data warehousing, Performance consideration, case studies. Special topics in data mining and data ware housing.	**10L**

Course Outcomes

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

CO1: Demonstrate an understanding of the importance of data mining and the principles of business intelligence,
CO2: Implement the appropriate data mining methods like classification, clustering or Frequent Pattern mining on large data sets.
CO3: Organize and Prepare the data needed for data mining using pre preprocessing techniques

Books and References

1. Data Mining – Concepts and Techniques by J. Han, M. Kamber and J. Pei, Elsevier.
2. Multimedia Data Mining: A Systematic Introduction to Concepts and Theory by Z. Zhang, R. Zhang, Chapman & Hall.
3. Statistical Language Models for Information Retrieval by C. Zhai, Morgan and Claypool.
4. Link Mining: Models, Algorithms and Applications by P. S. Yu, J. Han, and C. Faloutsos, Springer.

Course Name: **Parallel Algorithms**
Course Code: **MA-452**
Course Type: **Professional Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To introduce principles and design techniques of parallel algorithms.
- To develop algorithms and implement them in parallel computers.
- To introduce data structures for various parallel architectures.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction to Parallel Algorithms and Architectures:** EREW, CREW, CRCW PRAMs and interconnection network models, Need for Parallel Processing , Data and Temporal Parallelism, Models of Computation, RAM and PRAM Model, Shared Memory and Message Passing Models, Processor Organizations, PRAM Algorithms, Analysis of PRAM Algorithms- Parallel Programming Languages.	**08L**
UNIT-02	**Parallelization of Algorithm:** Parallel Programming Models, PVM (Parallel Virtual Machine), MPI (Message Passing Interface) and its routines, Brent's Theorem, Message passing algorithm, Load balancing and termination detection, programming with shared memory, programming for Distributed shared memory.	**07L**
UNIT-03	**Basic Parallel Algorithmic Techniques** Divide-and-Conquer, Partitioning, pipelining, Accelerated Cascading, Symmetry Breaking, Synchronization (Locked, Lock-free) Parallel Algorithms and Data organization for shared/distributed memory, Min/Max,Sum Searching, Merging, Sorting.	**06L**
UNIT-04	**Parallel Sorting and Sorting Networks:** Parallel Insertion Sort, Even-odd Merge Sort, Bitonic Merge Sort, Prefix operations, Parallel algorithms on network, Addition of Matrices, Multiplication of Matrices.	**08L**
UNIT-05	**Parallel Programs Using GPU:** Introduction to Graphics Processing Units (GPUs), CUDA Programming Model, CUDA API, Simple Matrix Multiplication in CUDA, CUDA Memory Model, Shared Memory Matrix Multiplication, Additional CUDA API Features, and Optimization Techniques: Understanding threads and blocks execution, Memory Bank Conflicts, Parallel Thread Execution, Control Flow, Precision, Optimizing CPU-GPU usage.	**07L**

Course Outcomes

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

CO1: Describe and use the main design techniques for sequential algorithms
CO2: Design, prove the correctness and analyze the computational complexity of sequential algorithms
CO3: Understand the difference between sequential and parallel algorithms

Books and References

1. Parallel Programming Techniques and Applications by W. Barry , M. Allen, Pearson.
2. An Introduction to Parallel Algorithms by J. Jaja, Addison-Wesley Professional.
3. CUDA by Example: An Introduction to General-Purpose GPU Programming by J. Sanders and E. Kandrot,, Nvidia.
4. Parallel Computers architecture and programming by V. Rajaraman and C.S.R Murthy, Prentice Hall of India.
5. Programming Massively Parallel Processors: A Hands-on Approach by D. Kirk and Wen-mei Hwu, Elsevier.

Course Name: **Design and Analysis of Experiments**
Course Code: **MA-453**
Course Type: **Professional Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the desining the experiments under certain layouts and their analysis.
- To introduce the fundamental concepts relevant to designed experiments.
- To enable the students to understand the factors that cause the response variable under designed experiments.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Analysis of basic designs, relative efficiency, analysis of covariance for CRD and RBD. Assumptions of analysis of variance.	**06L**
UNIT-02	**Missing Plot Techniques:** Missing plot techniques in designs of experiments: completely randomized design and randomized block design.	**04L**
UNIT-03	**Factorial Experiments:** Factorial experiments: 2^n, 3^2 and 3^3 systems. Complete and partial confounding, fractional factorial designs in 2^n system alongwith construction of the design and analysis.	**08L**
UNIT-04	**Incomplete Block Designs:** Balanced incomplete block designs, simple lattice designs, split plot designs, strip plot designs, alongwith construction of the designs and analysis.	**06L**
UNIT-05	**Response Surface Designs:** Response surface areas, first and second order designs blocking in response surfaces, optimal designs for response surfaces. **Expeiments with Random Factors:** Random effects model, two – factor factorial with random factors, two – factor mixed model, sample size determination with random effects.	**12L**

Course Outcomes

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

CO1: Identify the basic structues and principles of design of experiments.
CO2: Describe various kind of design of experiments.
CO3: Apply principles of various kind of design of experiments where data are from various and evolving dimensions.
CO4: An understanding of the relationship between the purpose of a model and and the appropriate level of accuracy.

Books and References

1. Design and Analysis of Experiments by D.C. Mongomery, John Wiley and Sons.
2. Statistical Design by G. Casella, Springer.
3. A First course in Design and Analysis of Experiments by G.W. Oehlert, University of Minnesota

Course Name: **Quantum Information And Computing**
Course Code: **MA-454**
Course Type: **Professional Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the fundamental concepts of Physics and Mathematics needed to understand the concept of quantum computing.
- To introduce the fundamental concepts relevant to quantum computing such as quantum bit, quantum machine.
- To enable the students to understand quantum information theory, quantum cryptograpy etc.

Unit Number	Course Content	Lectures
UNIT-01	**Mathematical Tools of Quantum Mechanics:** Hilbert space, Dirac notations, Operators and their expectation values, representation of discrete bases, representation of continuous bases, Orthogonality of Eigen Functions	**07L**
UNIT-02	**Postulates of Quantum Mechanics:-** The Basic Postulates of Quantum Mechanics, The State of a System, Observables and Operators, Measurement in Quantum, Time Evolution of the System's State.	**07L**
UNIT-03	**Introduction to Quantum Computation:** Quantum bits, Bloch sphere representation of a qubit, multiple qubits	**06L**
UNIT-04	**Quantum Circuits:** single qubit gates, multiple qubit gates, design of quantum circuits	**06L**
UNIT-05	**Quantum Information, Cryptography and Algorithms:** Comparison between classical and quantum information theory. Bell states. Quantum teleportation. Quantum Cryptography, no cloning theorem, Deutsch's algorithm, Deutsch's-Jozsa algorithm	**10L**

Course Outcomes

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

CO1: Identify the applications of quantum computing.
CO2: Describe the quantum machines, measurements in quantum and qubit.
CO3: Descrive the advantages of quantum information theory and quantum cryptography and can apply these concepts.

Books and References

1. Quantum Computation and Quantum Information by M A Nielsen, Cambridge University Press.
2. Quantum Physics by S Gasiorowicz, John Wiley & Sons.
3. A Text Book of Quantum Mechanics by P M Mathews , K Venkatesan, Tata McGraw Hill.
4. Quantum Mechanics, A. Ghatak A, S Lokanathan, Macmillan India Ltd.

Course Name: **Mathematical Foundations for Machine Learning**
Course Code: **MA-440**
Course Type: **Professional Elective-III**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To introduce the mathematical topics, techniques and results that form the backbone of some major ML algorithms
- To make the student appreciate both the utility and aesthetics of the different fields in Mathematics.
- To provide a firm theoretical foundation for existing methods.
- To equip the students with the skills necessary to further their research in Machine Learning.

Unit Number	Course Content	Lectures
UNIT-01	**Data Representation:** Eigenvalues, Eigenvectors, Linear Regression, Principal Component Analysis (PCA), Singular value decomposition (SVD), Fischer Discriminant	**06L**
UNIT-02	**Theory of Machine Learning:** Functionals, Hilbert Spaces, Riesz Representation Theorem, Kernel Trick, Kernel PCA, Kernel SVM.	**06L**
UNIT-03	**Sparse Approximation:** Norm Minimization, Sparse Representation Theory, Dimensionality Reduction	**08L**
UNIT-04	**Supervised Learning:** Convex Optimization, Primal-Dual Transformations, Karush-Kuhn-Tucker Conditions, SVM, Probability and Measures, Types of Convergences, Statistical Learning Theory, VC dimension and Capacity, Blackwell's approachability	**08L**
UNIT-05	**Unsupervised Learning:** Expectation Maximization, EM-based Clustering, C-means clustering, Fuzzy CM clustering. Operator Theory, Decomposition of Operators and Subspaces.	**08L**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Understand mathematical concepts used in Machine learning algorithms.
CO2: Learn theoretical concept of supervised and unsupervised learning in ML algorithms.
CO3: Apply the skills neccessary to do further research in the field of ML.

Books and References

1. Foundations of Machine Learning by M. Mohri, A. Rostamizadeh, A. Talwalkar,, MIT Press.
2. The elements of Statistical learning, Data Mining, Inference and Prediction by T. Hatsei, R. Tibshirani, J. Friedman, Springer Series in Statistics.
3. Pattern Recognition and Machine Learning by C.M. Bishop, Springer (India).
4. Machine Learning by T.M. Mitchell,, McGraw-Hill.

Course Name: **Data Analysis Using Python**
Course Code: **MA-441**
Course Type: **Professional Elective-III**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To use indexing and slicing to access data in Python programs.
- To use exception handling in Python applications for error handling.
- To enable the students to understand the factors that why Python is a useful.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Pandas Data Frame Basics – loading, sub setting rows and columns, grouped and aggregated, Basic Plot, Pandas Data Structures – creating a series and data frame, Boolean sub setting: series, broadcasting, marketing changes to series and data frames, exporting and importing data.	**06L**
UNIT-02	**Introduction to Plotting:** Introduction, matplotlib, statistical graphics using matplotib, seaborn, Pandas objects, seaborn themes and styles. Data manipulation: data assembly, missing data, tidy data.	**10L**
UNIT-03	**Data Mining:** Data types, converting types, categorical data, string and text data, string methods, string formatting, regular expressions – match, find, substituting and compiling a pattern.	**08L**
UNIT-04	**Data Modeling:** Linear Models – introduction, simple linear regression, multiple regressions, generalized linear models – logistic regression, poisson regression, survival analysis.	**06L**
UNIT-05	**Model Diagnostics:** Residuals, comparing multiple models, k-fold cross validation, regularization – LASSO regression, ridge regression, clustering – k-means, hierarchical clustering.	**06L**

Course Outcomes

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

CO1: Have problem solving and programming capability.
CO2: Apply Regression algorithms.
CO3: Apply Classification algorithms.

Books and References

1. Pandas for everyone – Python Data Analysis by D.Y. Chen, Pearson.
2. Think Python How to Think Like a Computer Scientist by A. Downey, Green Tea Press
3. Online source: Python for Beginners- https://www.python.org/about/gettingstarted

Course Name: **Theory of Computation**
Course Code: **MA-442**
Course Type: **Professional Elective-III**

Contact Hours/Week: **3L** 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.	**06L**
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.	**08L**
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.	**07L**
UNIT-04	**Computability and Undecidibility:** Basic concepts, primitive & partial recursive function, Recursive function, Decidability, Kleen's theorem. Undecidibility: Properties of recursive & recursively enumerable languages, Universal Turing machine and undecidable problem, Rice's theorem & some more undecidable problems.	**07L**
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.	**08L**

Course Outcomes

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

CO1: Analyse 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: **Operator Theory**
Course Code: **MA-443**
Course Type: **Professional Elective-III**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To introduce basic operator theoretic methods as a second course in functional analysis.
- To understand the relevance of operator theory in quantum mechanics.

Unit Number	Course Content	Lectures
UNIT-01	**Banach Algebras:** Basics, The spectrum, The holomorphic function calculus, The Banach algebra	**06L**
UNIT-02	**C*-Algebras:** Introduction to C*-algebras, non-commutative states and representations, Gelfand-Neumark representation theorem.	**08L**
UNIT-03	**Normal Operators:** Spectral Theorem for normal operators and its applications to operators on a Hilbert space, Von-Neumann Algebras; Projections, Double Commutant theorem, L^{∞} functional Calculus.	**08L**
UNIT-04	**Compact Operators**: C*-algebras of Compact operators, Compact operators on Hilbert Spaces: The theory of Fredholm operators: spectral theory of compact operators (Fredholm Alternative). Operator matrices: Invariant and Reducing subspaces, the theory of ideals of compact operators	**10L**
UNIT-05	**Toeplitz Operators:** Toeplitz operators	**04L**

Course Outcomes

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

CO1: Understand and apply fundamental theorems from the theory of normed and Banach space

CO2: Understanding of main topics of Banach Algebras and Spectral Theory: spectrum and resolvent, adjoint operators, compact operators, self-adjoint and normal operators, Gelfand Representation, Riesz-Fredholm Theory, C*-Algebras.

CO3: This course open ways to different research areas in this branch particularly and also in the area of functional analysis broadly, like representation theory , operators on different function spaces etc..

Books and References

1. Kadison and Ringrose, Fundamentals of operator theory, Vol. I and II, Academic press.
2. Rickart, General theory of Banach Algebras, Van Nostrand.
3. W. Arveson, An invitation to C*-Algebras, Springer-Verlag.
4. Palmer, Banach Algebras and the general theory of C*-algebras, Cambridge University Press.
5. N. Dunford and J.T. Schwarts, Linear Operators – 3, John Wiley and Sons.
6. A . Taylor and D. Lay, Introduction to Functional Analysis, John Wiley and Sons.

Course Name: **Computer Networks**
Course Code: **MA-444**
Course Type: **Professional Elective-III**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the principles of networking and internetworking.
- To introduce the fundamental concepts relevant to design issues of different network layers

Unit Number	Course Content	Lectures
UNIT-01	**Introductory Concepts**: Goals and Applications of Networks, LAN, WAN, MAN, Wireless network, Network software: Protocol hierarchies, design issues of layers, Interfaces and services. Reference Model: The OSI reference model, TCP/IP reference model, Example networks: The ARPANET, The Internet.	**06L**
UNIT-02	**Physical Layer**: Fourier analysis, Maximum data rate of a channel, Transmission media, Wireless transmission, Virtual circuits, Circuit switching.	**04L**
UNIT-03	**Data Link Layer**: Data link layer design issues, services provided to network layers, Framing, Error control, Flow control, Error detection and correction, Elementary data link protocols, An unrestricted Simplex protocol, A Simplex Stop-and-Wait protocol, Simplex Protocol for a noisy channel, Sliding Window protocols, A one-bit Sliding protocol, A protocol using go-back-N, A protocol using selective repeat.	**14L**
UNIT-04	**Medium Access Sub-layer**: Channel Allocations, Static and dynamic allocation in LAN and MAN, Multiple Access protocols, ALOHA, Carrier Sense multiple access protocols, Wireless protocols, Collision free protocols, Limited contention protocols, IEEE standard 802.3 and Ethernet, IEEE standard 802.4, Token bus IEEE standard 802.5, Token Ring, Distributed Queue Dual bus, Logical link control, bridges, High speed LAN. **Network Layer**: Network Layer design issue, Routing algorithms, Congestion Control Algorithms, Internetworking	**06L**
UNIT-05	**Transport Layer**: Transport services, Design issues, elements of transport protocols, simple transport protocols, Connection management, TCP, UDP. **Session, Presentation and Application Layer**: Session Layer - Design issues, remote procedure call. Presentation Layer - Design issues. Application Layer - File Transfer, Access and Management, Electronic mail.	**06L**

Course Outcomes

CO1: Understand network layers, models and architectures.
CO2: Analyze the performance of various MAC, 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. Ross, Addison-Wesley.
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: **Deep Learning**
Course Code: **MA-460**
Course Type: **Professional Elective-IV**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the concepts of deep learning in data analysis.
- To introduce the fundamental concepts relevant to different linear factor models and regularization.
- To enable the students to understand convolutional neural networks and its applications.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** History of Deep Learning, Deep Learning Success Stories, McCulloch Pitts Neuron, Thresholding Logic, Perceptrons, Perceptron Learning Algorithm, Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent, Feedforward Neural Networks, Representation Power of Feed forward Neural Networks Back propagation	**08L**
UNIT-02	**Optimization for Training Deep Models:** Challenges in neural network optimization, Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, Algorithms for Adaptive learning rates (AdaGrad, RMSProp, Adam)	**08L**
UNIT-03	**Linear Factor Models:** Eigenvalues and eigenvectors, Eigenvalue Decomposition, Basis Principal Component Analysis and its interpretations, Singular Value Decomposition Autoencoders and relation to PCA, Regularization in autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive autoencoders	**06L**
UNIT-04	**Regularizations:** Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout. Greedy Layerwise Pre-training, Better activation functions, Better weight initialization methods, Batch, Normalization	**07L**
UNIT-05	**Convolutional Neural Networks:** Convolution Neural Network, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet, Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks	**07L**

Course Outcomes

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

CO1: Select and implement machine learning techniques that are suitable for applications under consideration.
CO2: Perform expirements using deep learning algorithms for real world data.
CO3: Understand modern notions in data analysis oriented computing.

Books and References

1. Deep Learning by I. Goodfellow, Y. Bengio, A. Courville, MIT Press.
2. Deep Learning, A Practitioners Approach by J. Patterson, A. Gibson, O' Reilly Media Inc.
3. Neural Networks and Deep Learning: A Textbook by C.C. Aggarwal, Springer International Publishing.

Course Name: **Financial Mathematics**
Course Code: **MA-461**
Course Type: **Professional Elective-IV**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To determine and select the most appropriate standard mathematical, statistical and computing methods appropriate for specifying mathematical problems in banks and other financial institutions through a critical understanding of the relative advantages of these methods.
- To develop extensions to these methods appropriate for the solution of non-standard problems.
- To undertake a piece of directed research in mathematical finance.

Unit Number	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.	**06L**
UNIT-02	**Portfolio Modeling 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).	**08L**
UNIT-03	**Probability Essentials:** Probability spaces, filtrations as information content, random variables, conditional expectations, Definition and classification of random processes, martingales.	**06L**
UNIT-04	**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.	**08L**
UNIT-05	**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, Brownian motion, martingales.	**08L**

Course Outcomes

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

CO1: Know the main features of models commonly applied in financial firms, be able to express these mathematically and be able to appraise their utility and effectiveness.

CO2: Explain and critically appraise the rationale for the selection of mathematical tools used in the analysis of common financial problems.

CO3: Demonstrate an ability to select and apply numerical methods appropriate for the solution of financial problems.

Books and References

1. Mathematics for Finance: An Introduction to Financial Engineering by M. Capinski and T. Zastawniak, Springer.
2. Options, Futures and Other Derivatives by J. C. Hull, Pearson Education.
3. Stochastic Calculus for Finance by S. Shreve, Springer.
4. Probability and Random Processes by G. R. Grimmett and D. R. Stirzaker, Oxford University Press.
5. Measure, Integral and Probability, M. Capinski and P.E. Kopp, Springer.
6. Mathematics of Financial Markets by R. J. Elliott and P. E. Kopp, Springer.

Course Name: **Data Science and Big Data Analytics**
Course Code: **MA-462**
Course Type: **Professional Elective-IV**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the unstructured data into actionable insights, improved decision making, and competitive advantage.
- To teach the fundamental techniques and principles in achieving big data analytics with scalability and streaming capability.
- To learn the main concept in relation to Big Data storage and analytics, and security issues.
- To enable students to have skills that will help them to solve complex real-world problems in for decision support.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Introduction to Big Data and data science, the rising and importance of data science, big data analytics in industry verticals.	**04L**
UNIT-02	**Data Analytics:** Lifecycle and methodology: Business Understanding, Data Understanding, Data Preparation, Modeling, Evaluation, Communicating results, Deployment, Data exploration **&** preprocessing, Measures and evaluation	**08L**
UNIT-03	**Data Analytics:** Theory & Methods, Supervised learning: Linear/Logistic regression, Decision trees, Naïve Bayes, Unsupervised learning: K-means clustering, Association rules,	**08L**
UNIT-04	**Unstructured Data Analytics**: Technologies & tools, Text mining, Web mining	**08L**
UNIT-05	**The Endgame:** Operationalizing an Analytics project, Data Visualization Techniques, Creating final deliverables	**08L**

Course Outcomes

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

CO1: Understand what Big Data is and why classical data analysis techniques are no longer adequate.
CO2: Understand conceptually how Big Data is stored.
CO3: Communicate with data scientists.
CO4: Apply several newer algorithms for Clustering Classifying and finding associations in Big Data.

Books and References

1. Foundations of Data Science by A/ Blum, J. Hopcroft, R. Kannan, Cambridge University Press.
2. Introduction to Linear Regression Analysis by Douglas C. Montgomery, E.A. Peck, G.G. Vining, Wiley.
3. Statistical Inference by P. J. Bickel , K. A. Docksum, Prentice Hall.
4. Introduction to Machine Learning by A. Smola , S.V.N. Vishwanathan. Cambridge University Press.
5. Introduction to Machine Learning: E. Alpaydın, Prentice Hall of India.
6. Data Mining Concepts and Techniques by J. Han, M. Kamber, J. Pei, Morgan Kaufmann Publishers.

Course Name: **Software Engineering**
Course Code: **MA-463**
Course Type: **Professional Elective-IV**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- This course covers practices which are applied during software development.
- These practices help in developing large size and complex software.
- With concepts and knowledge gained from this course, one can easily become part of industrial software production.

Unit Number	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.	**09 L**
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.	**07L**
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.	**07L**
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.	**07L**
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.	**06 L**

Course Outcomes

Upon completing the course, the student will be able to:

CO1: Get familiar with various software development process models, requirement engineering concepts and software design principles.
CO2: Understand software project metrics, quality concepts and estimate effort in software development.
CO3: Understand software design and principles.
CO4: Understand coding practices, styles and software testing approaches.
CO5: Develop software cooperatively in a team with an understanding about software risk.

Books and References

1. Roger S. Pressman, “Software Engineering: A Practitioner's Approach”, 7th International edition, Mc Graw Hill, 2009 2.
2. Pankaj Jalote, “An Integrated Approach to Software Engineering”, Narosa publishing House, New Delhi, 1995. 3.
3. Fairley, R.E. “Software Engineering Concepts”, McGraw Hill, 1992.
4. Sommerville, “Software Engineering”, Addison Wesley, 1999.

Course Name: **Topology**
Course Code: **MA-464**
Course Type: **Professional Elective-IV**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the introduction to theory of topological spaces with emphasis on those topics that is important to higher mathematics.
- To introduce the fundamental concepts relevant for the student to understand the basic concept of topology
- To enable the students to understand properties of continuous mapping, selected type of topological space (compact space, connected space, etc.) and some basic theorem on topology.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Finite, countable, uncountable sets, functions, relations, axiom of choice, Zorn's Lemma	**03L**
UNIT-02	**Topological Spaces and Continuous Functions:** Definition and examples of metric space, Definition and examples of topological spaces, types of topologies, Subspaces and relative topology, Hereditary	**10L**
UNIT-03	**Base and Some Topological Spaces:** Base and sub base for topology, order topology, product topology. T_0, T_1, T_2 –spaces and its characteristics properties.	**04L**
UNIT-04	**Countability and Separation Axioms:** Countability axioms, separation axioms, regular and normal spaces, Urysohn's Lemma, Urysohn Metrization Theorem, Tietze Extension Theorem, Tychonoff Theorem.	**12L**
UNIT-05	**Connectedness and Compactness:** Separated sets, connected and disconnected set, Connected and compactness space and their properties, Bolzano Weierstrass property.	**07L**

Course Outcomes

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

CO1: Identify that the given family is a topology, given function is continuous and given set is open, closed, dence, compact, connected.

CO2: Describe method and techniques of proving basic theorems on topological spaces and continuous mapping.

CO3: Know the important of topology in Mathematics and its applications in physics, biology and human science.

Books and References

1. Topology by J. R. Munkres, Prentice-Hall.
2. Introduction to Topology and Modern Analysis by G. F. Simmons, McGraw Hill.
3. Introduction to Topology by T. W. Gamelin and R. E. Greene, Dover Publications.
4. Introduction to Topology by M. J. Mansfield, D. Van Nostrand Co., Inc., Princeton.
5. Introduction to General Topology by K. D. Joshi, Wiley Eastern Ltd.
6. Introduction to Topology by B. Mendelson, Dover Publications.

Course Name: **Statistical Quality Control**
Course Code: **MA-370**
Course Type: **Open Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To understand the basic concepts of quality monitoring.
- To understand the statistical underpinnings of quality monitoring.
- To learn various available statistical tools of quality monitoring.
- To learn the statistical and economical design issues associated with the monitoring tools.
- To demonstrate the ability to design and implement these tools.

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	**05L**
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	**06L**
UNIT-03	**Control Charts for Attributes** – p, np, c and u charts – their construction and analysis	**05L**
UNIT-04	**Product Control:** Acceptance sampling by attributes; Producer's and Consumer's risk; Notions of AQL, LTPD and AOQL **Modified Control Charts for Mean**: CUSUM chart – technique of V-mask – Weighted Moving average charts – multivariate control charts – Hotelling's T^2 control charts and Economic design of X-bar chart	**14L**
UNIT-05	**Sampling Plans:** OC, AOQ, ASN, ATI curves for Single and double sampling plans – Concept of Sequential sampling plan for attributes.	**06L**

Course Outcomes

Upon successful completion of the course, the students 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.

Books and References

1. Introduction to Statistical quality control by D.C. Montgomery, John Wiley & Sons..
2. Fundamentals of Applied Statistics by S.C. Gupta and V.K. Kapoor, Sultan Chand and Sons.
3. Process Quality Control by E.R. Ott, Mc Graw Hill.

Course Name: **Applied Time Series Analysis**
Course Code: **MA-371**
Course Type: **Open Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the areas of practical time series statistics.
- To apply the concepts of practical time series statistics to real data sets.
- To enable the students to assimilate data applied to real, scientific and interesting problems.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Components of time series, trend, periodic changes, irregular component, analysis of time series, uses of time series, time series decomposition.	**06L**
UNIT-02	**Measurement of Trend:** Graphic method, Method of semi-averages, method of curve fitting by principles of least squares, growth curves and their fitting, moving average method.	**06L**
UNIT-03	**Measurement of Seasonal Fluctuations:** Method of simple averages, ratio to trend method, ratio to moving average method, link relative method, measurement of cyclic movement.	**06L**
UNIT-04	**Auto – Regression Series:** First order auto – regression (Markoff's Series), Second order autoregressive series (Yule's Series), General auto – regression, auto – correlation and correlogram, random component in time series, variate difference method.	**06L**
UNIT-05	**Simple Regression:** Least square estimation, the coreelation coefficient, simple regression and the correlaton coefficient, Residulas, outliers and influential observations, correlation and causation, inference and forecasting with simple regression **The Box Jenkins Methodology:** Examining correlation in time series data, stationarity of time seris data, ARIMA models for time series data	**12L**

Course Outcomes

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

CO1: Understand and analyze the theoretical & practical aspects of time series data.
CO2: Understand the basic structure of time series and its components.
CO3: Identify and decompose time series model into its components.
CO4: Understand the genesis of the Box Jenkins Methodology and models based on it.

Books and References

1. Time Series Analysis: Forecasting and Control by George E.P. Box, G.M. Jenkins, G.C. Reinsel, G.M. Ljung, John Wiley & Sons.
2. Introduction to Time Series and Forecasting by P.J. Brockwell, R.A. Davis, Springer.
3. Time Series Analysis by J.D. Hamilton, Princeton University Press.

Course Name: **Principles of Design of Experiments**
Course Code: **MA-380**
Course Type: **Open Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the issues and principles of Design of Experiments (DOE)
- To introduce the fundamental concepts relevant to Experimental Designs and Multiple Comparison tests
- To enable the students to understand the factors that cause the Factorial Experiments and block designs …

Unit Number	Course Content	Lectures
UNIT-01	**Basic Principles for Designing Statistical Experiments:** Randomization, Replication and local control techniques - Determination of experimental units and notion of experimental error - Analysis of variance with one–way and two–way classifications - Models and Methods of analysis.	**08L**
UNIT-02	**Experimental Designs:** Completely Randomized Design (CRD) and Randomized Block Design (RBD)- Models and estimates of parameters and their standard error - Analysis of data arising from such designs, Analysis when one or two observations are missing. Latin Square Design (LSD) – Model – Estimation of parameters – Method of analysis – Missing Plot technique in LSD	**10L**
UNIT-03	**Multiple Comparison Tests:** Least Significant Difference, Student-Newman–Keuls test, Duncan's Multiple Range test, Tukey's test.	**04L**
UNIT-04	**Factorial Experiments:** 2^2, 2^3 and 3^2 designs; estimation of main effects and interactions and their standard errors	**04L**
UNIT-05	**Balanced Incomplete Block Design (BIBD):** Types of BIBD – Simple construction methods – Concept of connectedness and balancing – Intra Block analysis of BIBD – Recovery of Inter Block information – Partially Balanced Incomplete Block Design with two associate classes – intra block analysis only - Split plot and strip plot design and their analysis.	**10L**

Course Outcomes

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

CO1: Identify the experimental designs in CRD, RBD and LSD
CO2: Describe the relationship among designs and factorial experiments
CO3: Apply principles of multiple comparison tests and block designs with examples

Books and References

1. Design and Analysis of Experiments by M.N. Das, M.N., N.C. Giri, Wiley eastern.
2. Design of Experiments by D.C. Montgomery, John Wiley and Sons.
3. An Introduction to Linear Statistical Models by F.A. Graybill, Mc-Graw Hill.
4. An Outline of statistical theory by A.M. Goon, M.K.Gupta, B. Dasgupta, World Press Calcutta.
5. Fundamentals of Applied Statistics by S.C. Gupta, V.K. Kapoor, Sultan Chand & Sons.
6. Applied Statistics by P. Mukhopadhyay, Books and Allied (P) Ltd.

Course Name: **Numerical Methods for Partial Differential Equations**
Course Code: **MA-381**
Course Type: **Open Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the various numerical methods to solve the partial differential equations.
- To enable the students to examine the compatibility, convergence and stability of the numerical schemes.
- Detailed study of finite difference methods to solve PDEs of parabolic, elliptic and hyperbolic type.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction to Partial Differential Equations:** Classification of PDE, Standard forms of PDE, Boundary conditions.	**04L**
UNIT-02	**Introduction of Numerical Methods for Partial Differential Equations:** Taylor's series expansion, Analysis of truncation error, Finite difference approximation, Order of approximation, Polynomial fitting and one sided approximation, Finite difference method, finite element method, quadrature method, Exposure to MATLAB and computational experiments based on algorithms.	**12L**
UNIT-03	**Solution of Parabolic Equation:** Explicit and Implicit scheme for 1D parabolic equation, Compatibility, convergence and stability conditions, Derivative boundary condition with example, Explicit and implicit scheme for 2D parabolic equation, Alternating direction implicit (ADI) Scheme for 2D parabolic equation.	**08L**
UNIT-04	**Solution of Elliptic Equation:** Solution of Laplace equation using standard five point formula and diagonal five point formula, Successive over relaxation (SOR) and Alternating direction implicit (ADI) methods for elliptic equation.	**06L**
UNIT-05	**Solution of Hyperbolic Equation:** Explicit and implicit scheme for hyperbolic equations, Stability analysis of scheme, Characteristics of PDE and their significance, Method of characteristic, Lax-Wendroff's method, Wendroff's method, Stability analysis of methods.	**06L**

Course Outcomes

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

CO1: Use numerical methods to obatin the approximate solutions of initial and bondary value problems
CO2: Classify PDE's and to obatin their numerical solutions
CO3: Assess the compatibility, convergence and stability of numerical schemes

Books and References

1. Applied numerical analysis by C.F. Gerald and P.O. Wheatley, Pearson.
2. Numerical solution of partial differential equations: Finite Difference Method by G.D. Smith, Clarendon press.
3. Numerical analysis of differential equations by M.K. Jain, Wiley Earstern.
4. Computational methods in ordinary differential equations by J.D. Lambert, Wiley.
5. The Finite Difference Method in Partial Differential Equations by A.R. Mitchell and R. Wait,, John Wiley & Sons.
6. Numerical Methods for Engineers by S.C. Chapra and R.P. Canale, McGraw Hill Education.
7. Numerical Analysis of Partial Differential Equations by C.A. Hall and T. A. Porsching, Prentice Hall.