DEPARTMENT OF COMPUTER APPLICATIONS
SMIT, MAJHITAR

Syllabus Schema For

MASTER OF COMPUTER APPLICATION (MCA)

(COURSE CURRICULUM)

[2 Years Postgraduate Programme]
[*with Lateral Entry to 2nd Year*]
[Based on AICTE APH 2024-25 to 2026-27]

Total Credits:
21+21+24+16 = 82

SMU SIKKIM MANIPAL UNIVERSITY
(University under Section 2(f) of the UGC Act)

2025 BATCH

Master of Computer Application (MCA)

The AICTE-approved MCA curriculum at SMIT/SMU offers comprehensive education and training for students seeking professional preparation in the applications of computer science. This curriculum covers a broad range of subjects, including programming languages, data structures, data management, software engineering, formal languages and automata theory, operating systems, distributed systems, machine learning, network and information security, data science, cloud computing, artificial intelligence computer networks etc.

SMIT MCA students are equipped for careers in industry and business environments. Upon successful completion of the course, students gain a robust understanding of the field of Computer Applications. They develop a solid foundation in computer applications and technology vocabulary, enabling them to collaborate effectively with professionals from other disciplines. Additionally, they are well-prepared to continue their education and can pursue advanced degree programs such as M. Tech. or Ph.D.

As per AICTE Approval Process Handbook (2024-25 to 2026-27), admission criteria for MCA are:

A. Master of Computer Application [MCA 1st Year]

- Passed any graduation degree (e.g.: B.E. / B.Tech./B.Sc. / B.Com. / B.A./ B. Voc./ BCA etc.,) preferably with Mathematics at 10+2 level or at Graduation level
- Obtained at least 50% marks (45% marks in case of candidates belonging to reserved category) in the qualifying examination.

(*For students having **no** Mathematics background, compulsory bridge course on Mathematics will be offered by the Department of Computer Applications. Additional bridge courses related to computer subjects may be offered by the department as per the requirements.*).

B. Master of Computer Application [MCA Second Year Lateral Entry]

- B Tech/B.E. (CSE/IT) subject to availability of seats and BCA (4 Years)

MCA Program Objectives are:

- MCA graduates will apply their knowledge and skills to succeed in their career and/or obtain an advanced degree.
- MCA graduates will understand Ethical issues and provide engineering solutions for solving social problems. They will involve as full participants in our profession and our society.
- MCA graduates will demonstrate strong communication skills and the ability to function effectively in multi-disciplinary teams.
- MCA graduates will apply basic principles and practices of computing grounded in mathematics and science to successfully complete software related projects to meet customer business objectives and/or productively engage in research.

MCA Program Educational Objectives (PEO):

- MCA graduates will have a successful career based on their understanding of formal and practical methods of applications development using the concepts of computer programming, software and design principles.
- MCA graduates will be prepared for pursuing higher studies in their related field.
- MCA graduates will demonstrate analytical and design skills including the ability to generate creative solutions and foster team-oriented professionalism.
- MCA graduates will exhibit effective work ethics and be able to adapt to the challenges of dynamic professional environment.

Specializations Offered:

MCA students at Sikkim Manipal Institute of Technology have the opportunity to specialize in Data Science, Cloud Technology, or Cyber Security. These specializations, developed in collaboration with industry and academic experts and aligned with market trends, are available as group electives. Each specialization consists of three theory courses, each worth 3 credits, offered in the II/III semester. Foundational concepts are introduced in the "Latest Trends in Computer Applications" course during the first semester.

MCA SYLLABUS SCHEMA – SEMESTER WISE

I YEAR - I SEMESTER					
Subject Code	**Subject Title**	**Teaching Department**	**Theory Hours**	**Practical/Tutorial Hours**	**Credit Points**
MA506A1	MATHEMATICAL FOUNDATIONS FOR COMPUTING	MATHS	3L	1T	3
CA501A1	LATEST TRENDS IN COMPUTER APPLICATION	CA	3L	1T	3
CA502A1	DATABASE MANAGEMENT SYSTEM	CA	3L	1T	3
CA503A1	OPERATING SYSTEMS	CA	3L	1T	3
CA504A1	JAVA PROGRAMMING	CA	3L	1T	3
BA511A1	ACCOUNTING AND MANAGERIAL ECONOMICS	MGMT	3L	1T	3
CA505A4	OPERATING SYSTEMS LAB	CA	-	2P	1
CA506A4	JAVA PROGRAMMING LAB	CA	-	2P	1
CA507A4	DATABASE MANAGEMENT SYSTEM LAB	CA	-	2P	1
Total Credits					**21**

I YEAR - II SEMESTER					
Subject Code	**Subject Name**	**Teaching Department**	**Theory Hours**	**Practical/Tutorial Hours**	**Credit Points**
MA502A1	QUANTITATIVE ANALYSIS FOR COMPUTER APPLICATIONS	MATHS	3L	1T	3
CA509A1	UNIX/LINUX INTERNAL	CA	3L	1T	3
CA510A1	.NET FRAMEWORK	CA	3L	1T	3
CA511A1	COMPUTER NETWORK	CA	3L	1T	3
CA***A3	ELECTIVE –I	CA	3L	1T	3
CA***A3	ELECTIVE- II	CA	3L	IT	3
CA512A4	UNIX/LINUX INTERNAL LAB	CA	-	2P	1
CA513A4	COMPUTER NETWORK LAB	CA	-	2P	1
CA514A4	.NET LAB	CA	-	2P	1
Total Credits					**21**

II YEAR - III SEMESTER					
Subject Code	**Subject Name**	**Teaching Department**	**Theory Hours**	**Practical/Tutorial Hours**	**Credit Points**
CA601A1	DESIGN & ANALYSIS OF ALGORITHMS	CA	3L	1T	3
CA602A1	SOFTWARE ENGINEERING AND UNIFIED MODELLING LANGUAGE	CA	3L	1T	3
CA***A3	ELECTIVE-III	CA	3L	1T	3
CA***A3	ELECTIVE-IV	CA	3L	1T	3
CA607A1	FORMAL LANGUAGES AND AUTOMATA THEORY	CA	3L	1T	3
CA603A4	SOFTWARE ENGINEERING AND UML LAB	CA	-	2P	1
CA604A4	DESIGN & ANALYSIS OF ALGORITHMS LAB	CA	-	2P	1
CA605A5	MINOR PROJECT	CA	-	-	6
CA606A9	INDUSTRIAL TRAINING / COURSEWORK	CA	-	-	1
Total Credits					**24**

II ND YEAR-IV TH. SEMESTER					
Subject Code	**Subject Name**	**Teaching Department**	**Duration**		**Credit Points**
CA607A6	MAJOR PROJECT	CA/External Agencies	16 weeks	-	16
Total Credits					**16**

LIST OF ELECTIVES IN II SEMESTER (ELECTIVE-I)	
SUB. CODE	**SUBJECT**
CA551A3	BIOINFORMATICS
CA552A3	DIGITAL IMAGE PROCESSING
CA553A3	MANAGEMENT INFORMATION SYSTEM
CA554A3	OPTIMIZATION TECHNIQUE
CA555A3	MOBILE APPLICATION DEVELOPMENT
CA556A3	ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEM
CA557A3	IT LAW AND PRACTICES
CA558A3	COMPUTER ORGANIZATION AND ARCHITECTURE
CA559A3	PYTHON PROGRAMMING
CA560A3	ANGULAR JS, REACT JS AND VUE JS

LIST OF ELECTIVES IN II SEMESTER		
SPECIALISATION – GROUP ELECTIVES		
Elective II	**DATA SCIENCE**	
	CA561A3	DATA SCIENCE
	CLOUD TECHNOLOGY	
	CA562A3	CLOUD COMPUTING
	CYBER SECURITY	
	CA563A3	PRINCIPLES OF CYBER SECURITY

LIST OF ELECTIVES IN III SEMESTER		
GROUP ELECTIVES – SPECIALISATION		
Elective III & Elective IV	**DATA SCIENCE**	
	CA651A3	STATISTICAL FOUNDATIONS OF DATA SCIENCE
	CA652A3	DATA WAREHOUSING AND DATA MINING
	CA653A3	DATA ANALYTICS USING PYTHON
	CA654A3	MACHINE LEARNING
	CA655A3	SECURITY AND PRIVACY FOR DATA SCIENCE
	CA656A3	IMAGE ANALYTICS AND VISUALIZATION
	CA657A3	DEEP LEARNING
	CA658A3	NATURAL LANGUAGE PROCESSING
	CA659A3	BIG DATA ANALYTICS
	CA660A3	BUSINESS INTELLIGENCE AND ANALYTICS
	CLOUD TECHNOLOGY	
	CA661A3	SCHEDULING IN CLOUD COMPUTING
	CA662A3	CLOUD ARCHITECTURE AND TECHNOLOGY
	CA663A3	BIG DATA AND ITS APPLICATIONS IN CLOUD
	CA664A3	DISTRIBUTED SYSTEM
	CA665A3	CLOUD COMPUTING AND SECURITY
	CA666A3	EDGE AND FOG COMPUTING
	CA667A3	VIRTUALIZATION CONCEPTS
	CA668A3	CLOUD APPLICATION DEVELOPMENT
	CA669A3	CLOUD ANALYTICS
	CA670A3	PRIVATE CLOUD DEPLOYMENT AND MANAGEMENT

	CYBER SECURITY	
	CA671A3	CRYPTOGRAPHY
	CA672A3	PRIVACY AND SECURITY IN WEB APPLICATION
	CA673A3	NETWORK AND INFORMATION SECURITY
	CA674A3	COMPUTATIONAL NUMBER THEORY & CRYPTOGRAPHY
	CA675A3	INTERNET SECURITY AND PRIVACY
	CA676A3	IOT SECURITY AND PRIVACY
	CA665A3	CLOUD COMPUTING AND SECURITY
	CA677A3	BLOCKCHAIN TECHNOLOGY
	CA678A3	EMBEDDED AND CYBER PHYSICAL SYSTEMS SECURITY
	CA679A3	GAME THEORY

Dr. S. Borah
CA, SMIT, Chairman (BOS)

Dr. G. Thapa
CA, SMIT, Member (BOS)

Dr. K. V. K. Singh
CA, SMIT, Member (BOS)

Dr. K. Sharma
Dept. of CSE, SMIT, Member (BOS)
(Internal – Cross Departmental)

Dr. S. Savapondit
Dept. of Maths, SMIT, Member (BOS)
(Internal – Cross Departmental)

Dr. Kushal Pokhrel
Member (BOS), CDOE, SMU

Mr. Tirupati Bhattacharya
Member (BOS), CDOE, SMU

Dr. R. K. Mandal
Dept. of CS, NBU, Siliguri
(External Member, BOS- Academia)

Dr. Pethuru Raj Chelliah
Chief Architect and Vice President,
Reliance Jio Platforms Ltd., Bangalore
(External Member, BOS- Industry)

Mr. Debashis Bhattacharjee
Automation Architect, Orica, India
(External Member, BOS - Industry)

Mr. Adoniram Joshua Mishra
Director of Engineering- Consultant
ROSHN l روشن, Saudi Arabia
(External Member, BOS - Alumni)

University Nominee

MA505A1 **(2L + 1T Hrs./week)**

MATHEMATICAL FOUNDATIONS FOR COMPUTING

Questions to be set: 05 (All Compulsory)

Course Objectives: This course is designed to equip the students with basic mathematical tools which are frequently used in many areas of computing. The students will have sufficient knowledge to understand and tackle the problems such as data classification, analysis of algorithms.

Pre-requisites: Basics Class XII level Mathematics

CO1	To understand basic set theory, functions, and counting techniques.
CO2	To learn concepts of limits, continuity, differentiation, and integration.
CO3	To perform matrix operations and solve linear algebraic equations.
CO4	To understand data types, sampling methods, and data presentation.
CO5	To calculate and interpret statistical measures and correlation techniques.

Module	Topics to be covered	Topics	Hrs
Module 1: Discrete Mathematics	in class	Basic Set Theory, Counting Techniques, relations, basic Properties of functions	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Calculus	in class	Limit, Continuity, Derivatives, First Principle of Derivative; Differentiation of Algebraic, Trigonometric, Logarithmic and Exponential functions; Differentiation of Product of two Functions in X, Differentiation of Division of two Functions in X; Integration of Simple Functions, Integration by Parts	[12]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Basics of Linear Algebra	in class	Matrices: Operations, Algebra of matrices, Determinants, solutions of linear algebraic systems	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Descriptive Statistics	in class	Importance of statistics, concepts of statistical population and a sample; Methods of Random and Non-Random Sampling; Quantitative and Qualitative data; Measurement scales - nominal, ordinal, interval, and ratio; Primary and secondary	[8]

		data; Classification and tabulation of data; Diagrammatic and graphical representation of data – Histograms and Frequency Polygons.	
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Data Description	in class	Measures of Central tendency – mean, median and mode; Measures of Dispersion, Range, Quartile deviation, Mean Deviation, Standard Deviation; The coefficient of Variation; The Scatter Plot; Karl Pearson's Coefficient of Correlation; Spearman's Rank Correlation; Regression lines and coefficients; The coefficient of Determination; Residuals; The standard error of Estimate.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Differential and Integral Calculus, Das and Mukherjee, U N Dhur Publications.
2. Schaum's Outline of Set Theory and Related Topics, Seymour Lipschutz, Second Edition, 2020.

Reference Books:

1. Statistical Methods (Vol I and II) by N.G. Das,
2. Schaum's Outline of Linear Algebra, Seymour Lipschutz, Second Edition, 2001

CA501A1 **(2L + 1T Hrs./week)**

LATEST TRENDS IN COMPUTER APPLICATION

Questions to be set: 05 (All Compulsory)

Objectives: This course gives an introduction to recent trends in computer applications and their existing techniques, issues. The topics to be covered are divided into four main areas: Cloud technology, Information Security, Data science and Machine learning. The course aim is to introduce the latest concepts of computing applications and mechanism for development of high-performance computing systems.

Pre-requisites: There are no prerequisites for this subject.

Course Outcomes (CO):

CO1	Students will be able to understand the concept of recent topics included in cloud technology and Data science.
CO2	Students will be able to use latest techniques in their programming.
CO3	Students will be able to learn fundamental programming on MATLAB.
CO4	Students will be able to learn latest tools for recent software
CO5	Students will be able to understand Machine learning concepts and their application areas

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction to Cloud Computing	in class	The age of Internet Computing, Scalable computing Trends and New Paradigms, Internet of Things and Cyber-Physical Systems, Clusters of Cooperative Computers, Grid Computing Infrastructures, Peer-to-Peer Network Families, Cloud Computing over the Internet	[7]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Software Environments	in class	Software Environments for Distributed Systems and Clouds, Service-Oriented Architecture (SOA), Trends towards Distributed Operating Systems, Parallel and Distributed Programming Models, Performance Metrics and Scalability Analysis, Fault-Tolerance and System Availability, Network Threats and Data Integrity, Energy-Efficiency in Distributed Computing.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Introduction to Information Security	in class	Introduction and Security Trends, General Security Concepts, Operational Security and People's Role in Information Security, Cryptography: encryption, authentication, hashing, symmetric and asymmetric	[10]

		cryptography, Internet Standards and Physical Security, Network Security and Infrastructure.	
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Data Science	in class	Introduction to large-scale distributed systems, Big-data processing and storage infrastructures. Fundamental trade-offs in distributed systems, techniques for exploiting parallelism, Big-data computation and storage models, Design and implementation of various well-known distributed systems infrastructures, Introduction on open-source infrastructures for data processing and storage systems.	[10]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Machine Learning	in class	Introduction: What is ML? Problems, data, and tools, Linear regression, Gradient descent; Features, Training, validation, test data, Introduction to Matlab, Classification problems, Decision boundaries, Nearest Neighbour methods, Supervised and Unsupervised learning.	[10]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Barrie Sosinsky, "Cloud Computing Bible", Wiley India.
2. Wm. Arthur Conking, Gregory B. White, et al, Principles of Computer Security: Security and Beyond, McGraw Hill, 2010.
3. Shai Shalev-Shwartz, Shai Ben-David, Understanding Machine Learning: From Theory to Algorithms, Cambridge University Press, 2014.

Reference Books:

1. George Reese, "Cloud Application Architectures", O'Reilly.
2. Sandy Ryza, Uri Laserson, Sean Owen & Josh Wills, Advanced Analytics with Spark: Patterns for Learning from Data at Scale, O'Reilly, ISBN-10: 1491912766.
3. Yves Kodratoff, Ryszard S. Michalski, Machine Learning: An Artificial Intelligence Approach, Elsevier, 2014.

CA502A1 **(2L + 1T Hrs./week)**

DATABASE MANAGEMENT SYSTEM

Questions to be set: 05 (All Compulsory)

Objective: This course provides the basic information about relational Database Management System and their development. The major objective of the course is to provide an introduction of DBMS and their use, be familiar with the basic DBMS architecture, components, and interfaces, have experience using at least one modern Database Management System, understand and use database models in database and application design.

Pre-requisites: Programming Concepts.

Course Outcomes (CO):

CO1	Students will be able to understand database concept, develop ER diagram, relational schema mapping of ER diagram with relational schema.
CO2	Students will be able to understand normalization and its application in database and have the ability to use of UML and its support for database design specification
CO3	Students will be able to perform SQL queries and work with relational algebra.
CO4	Students will be able to understand transactions process and concurrency control.
CO5	Students will be able to understand database security and authorization.

Module	Topics to be covered	Topics	Hrs
Module 1: Database Concepts and Entity-Relationship (ER) Data model	in class	Introduction to Database Management System, Database models, Schemas and Instances, Three-Schema architecture and data independence, Concepts of Entity-Relationship model, ER diagram design issue, Specialization and generalization, Constraints and characteristics of Specialization an Generalization.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Relational Model and Normalization	in class	Relational model concepts an constraints, Mapping ER diagram to relational schema, Functional dependency theory and Normalization, Normal Form-1NF, 2NF,3NF, Boyce-Codd Normal Form, Multivalued dependencies and forth normal form. Database Design and Implementation Process, Use of UML and its support for database design specification, UML base design tools.	[12]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: SQL Concepts and	in class	Basics of SQL, Aggregate functions, Built-in functions- numeric, date, string functions, set operations, sub-queries, correlate sub-queries, Use of -Group by, Having, Order by, Join and its type, View	[7]

Relational Algebra		and its types, Transaction control commands- Commit, Rollback, Savepoint, PL/SQL concepts- cursors, store procedures, store functions, database triggers, Relational Algebra- Unary an Binary Relational Operations, Additional Relational Operations.	
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Transaction Processing and Concurrency Control	in class	Introduction to transaction processing and system concepts, Desirable properties of transactions, Schedules and Recoverability, Serial-ability, Transaction support in SQL, Locking techniques for concurrency control, Recovery concepts.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Database Security and Authorization	in class	Levels of database security, Access control, Discretionary access control, Mandatory Access Control, Multilevel security	[5]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Elmasri and Navathe, Fundamentals of database systems, Addison Wesley
2. Silberschatz, Korth, Sudarshan, Database System Concepts, McGraw-Hill Higher Education.

Reference Books:

1. Thomas Connolly, Carolyn Begg, Database Systems – A Practical Approach to Design, Implementation, and Management, Pearson Education.
2. Jefrey D.Ulman, Jenifer Widom, A First Course in Database Systems, Pearson Education.
3. Bipin C Desai, An Introduction to Database Systems, Galgotia.
4. Atul Kahate, Introduction to Database Management systems, Pearson

CA503A1 **(2L + 1T Hrs./week)**

OPERATING SYSTEMS

Questions to be set: 05 (All Compulsory)

Objective: The principles and concepts that govern the design of modern computer operating systems are studied. Managing computing resources such as the memory, the processor and the Input/output devices are covered. Algorithms for CPU scheduling, memory and general resource allocation; process coordination and management; deadlocks and memory management techniques; case studies of several operating systems are also covered.

Pre-requisites: Programming language concepts.

Course Outcomes (CO):

CO1	Students will understand the basic concepts of Operating Systems and its types.
CO2	Students will understand the process concepts, scheduling algorithms and its threads.
CO3	Students will understand the deadlock and synchronization problems.
CO4	Students will understand in detail about memory management and I/O management.
CO5	Students will be able to understand the files system interface and UNIX OS.

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction	in class	Simple batch systems, multi-programmed batch system, Time sharing, Parallel, Distributed system, Real time system.	[4]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Processes and CPU scheduling	in class	Process concepts, Scheduling, Operation on process, Cooperating processes, Threads, Scheduling criteria, Scheduling algorithms	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Process Synchronization and Deadlock	in class	Critical section problems, Synchronization Hardware, Semaphores, Classical problems of synchronization Deadlock characterization, Deadlock prevention, Avoidance, Detection and recovery.	[10]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Memory Management & Virtual Memory	in class	Logical versus physical address space, Swapping, Contiguous allocation, Paging, Segmentation. Introduction, Demand paging, Page replacement, Page replacement algorithms.	[11]
	Assignment Topics	To be provided by the concern faculty members	

Module 5: File System Interface The UNIX Operating System	in class	File concepts, Access methods, File Protection Design principles, Programmer & user interface, Process management, Memory management, File system.	[9]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Silberschatz and Galvin, Operating System concepts, Wiley.
2. Achynt Godbole, Operating Systems, Tata McGraw-Hill.

Reference Books:

1. System Programing by J. J. Donovan, Tata McGraw Hill.
2. S. E. Madwick & J. J. Donovan, Operating Systems, Tata McGraw-Hill.
3. H. M. Diatel, An introduction to Operating System, Wiley
4. Chales Crowley, Operating Systems- A design- oriented approach, Tata McGraw-Hill.

CA504A1 **(2L + 1T Hrs./week)**

JAVA PROGRAMMING

Questions to be set: 05 (All Compulsory)

Objective: The Java Programming Language course provides students with a solid foundation for programming with JAVA. It also highlights the creation of graphical user interfaces (GUIs), exceptions, file input/output (I/O), and threads, and network programming.

Pre-requisites: Object Oriented Programming.

Course Outcomes (CO):

CO1	Students will be able to understand the various features of java, control statements, Lexical issue, data types, variables, literals, arrays and various relational, Boolean and logical operations.
CO2	Students will learn the use of class and object in java, use of reference variable, constructor, garbage collection stack class.
CO3	Students will learn the various method used in java including overloading of functions, recursion, access control.
CO4	Student will be able to handle various string handling mechanism like string construction, string length string comparison, string buffer and string builder.
CO5	Student will learn inheritance, type of inheritances, static and dynamic methods and applying inference and use of packages.

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction to Java, Class	in class	Evolution and features of java, Overview of java, Two control statements, Lexical issues, Data types, Variables and arrays, Literals, Variables, Type conversion and casting, Type promotion in expression, Arrays, Operators, Bitwise operators, Relational operators, Boolean and logical operators, Assignment Operators, The '?' operator, Operator precedence, JAVA statements. Class fundamentals, Declaring objects, assigning object, Reference Variables, introducing methods, Constructors, 'this' keyword, Garbage collection, The finalize () method, stack class.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Methods, String Handling	in class	Overloading methods and constructors, using object as parameters, Argument passing, Returning objects, Recursion, Access control, Static methods, Nested and inner classes, Command line argument. String constructors, String length, Special string operators, Character extraction, String comparison, String searching, String modification, Changing case	[8]

		of characters within a string, Compression and String buffer, String builder.	
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Inheritance, Interfaces and Packages	in class	Basics of inheritance, Types of inheritance, Using super keyword, Method overriding, Dynamic method dispatch, Abstract class, using final with inheritance, The object class, Defining and implementing interfaces, Extending interfaces, Nested interfaces, Applying interfaces, Defining and creating packages, Access protection, Importing packages.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Exception Handling Input/Output and file handling	in class	Fundamentals, Exception types, Uncaught exceptions, Using try and catch, Multiple catch clauses, Nested try statements, Throws, Finally, Java's built in exceptions, Creating own exception classes. Java I/O classes and interfaces, The stream classes, Byte streams, The character streams, The console class, File class, Byte-stream class, Random access files	[11]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Network programming Event Based Programming	in class	Networking basics, Networking classes and interfaces, The Inet Address class, Inet4Address, TCP socket, URL, URL Connection, HTTP/URL Connection, TCP/IP server sockets, Datagram Socket and Datagram Packet. The applet class, Repaint (), The HTML applet tag, Passing parameter to applet, Event handling, Using delegation event model, Abstract Window Toolkit, AWT classes, Windows fundamentals, Working with frame windows, Creating a windowed program, Displaying information within a window, AWT controls,	[9]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. E. Balagurusamy, Programming With JAVA, Tata McGraw Hill.
2. Herbert Schildt, Java: The Complete Reference, Tata McGraw Hill.

Reference Books:

1. K. Arnold and J. Gosling, The Java Programming Language, Sams Publishing.
2. Allamaraju, Professional java Server Programming, Wrox Press.
3. Patrick Naughton and Herbert Schildt, JAVA2: The Complete Reference, Tata McGraw Hill.
4. R. Krishnamoorthy and S. Prabhu, Internet & Java Program, New Age International.

BA000A1 **(2L + 1T Hrs./week)**

ACCOUNTING AND MANAGERIAL ECONOMICS

Questions to be set: 05 (All Compulsory)

Objective

i. **Accounting:** The objective of this segment is to enable the students of computer application to understand the basic concepts in book-keeping and accounting and utilize the same in planning, controlling and decision-making process of a business firm.

ii. **Managerial Economics:** The objective of this segment is to enable the students to understand relevance of the basic concepts and techniques in micro-economics which are of utmost significance in day-to-day business system.

Course Outcomes (CO):

CO1	Students will be able to understand the techniques of bookkeeping and accounting.
CO2	Students will be able to develop software on decision making for a firm.
CO3	Students will be able to understand the concepts of micro-economics.
CO4	Students will be able to understand the concepts of regression analysis and will be able to use the concept of regression in real world.
CO5	Students will be able to understand the operations of organisations through the application of management accounting techniques

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction to Bool-keeping & Accounting	in class	Introduction to Book-keeping, Objectives and Needs of Book-keeping, Introduction to Accounting, Objectives, Significance, Accounting Process, Branches of Accounting, Difference between Book-keeping and Accounting, Users of Financial Statements.	[3]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Double Entry System and Single-Entry System	in class	Double Entry System and its characteristics, advantages and disadvantages, Single Entry System and its characteristics, advantages and disadvantages. Difference between Double Entry System and Single-Entry System.	[2]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Accounts & Trail Balance	in class	Account, Types of Account, Rules of debiting and crediting, Books of Accounts, Journal and its features and advantages, Ledger and its features and advantages, Types of Journals and Ledger, Difference between Journal and Ledger, Preparation of Journal	[9]

		and Ledger. Trail Balance and its characteristics, advantages and disadvantages, Preparation of Trial Balance	
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Introduction to Economics Theory of Consumer Behaviour Ordinal Utility Approach Elasticity of Demand	in class	Nature and Scope of Managerial Economics - Business Decisions and Economic Analysis Theory of Demand -- Analysis of Consumer Behaviour - Cardinal Utility Approach, Law of Demand, Exceptions; Determinants of Market Demand, Demand Function Ordinal Utility Approach - Meaning of Indifference Curve - Marginal Rate of Substitution - Consumer Equilibrium - Income Effect, Substitution Effect, Price Distinctions Price Elasticity of Demand, Income Elasticity - Cross Elasticity - Practical Importance of Elasticity of Demand,	[12]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Demand Forecasting Theory of Production Theory of Cost and Break-Even Analysis Market Structure	in class	Demand Forecasting – Importance, Methods of Forecasting - Direct and Indirect Methods. Theory of Production- Production Function - Laws of Production - Internal & External, Economies of Scale. Theory of Cost and Break-Even Analysis - Cost Concepts - Cost Output Relation, Importance of Break-Even Analysis in business decision making Market Structure and Pricing Theory.	[14]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. R. L. Gupta and V. K. Gupta, Principles and Practices of Accountancy, Sultan Chand & Sons
2. S. N. Maheshwari & S. K. Maheshwari, Financial Accounting, Vikas Publishing House
3. Yogesh Maheshwari, Managerial Economics, PHI Learning
4. H.L. Ahuja, Managerial Economics, S. Chand Publishing
5. M.L. Seth, Principles of Economics, Lakshmi Narain Agarwal, Educational Publishers

Reference Books:

1. Ashok Banerjee, Financial Accounting, Excel Books India
2. P. C. Tulsian, Financial Accounting, Pearson Education
3. Sarma and Gupta, Financial Management, Kalyani Publishers
4. Peterson & Lewis, Managerial Economics, Pearson Education

CA505A4 **(2 Hrs./week)**

OPERATING SYSTEMS LAB

Objective: At least 10 experiments covering the entire syllabus of the corresponding theory paper to be carried out using the theory studied /programming skill of the subject concerned to get insight into the practical applications of the theoretical studies. The outcome of the lab classes must lead to a skilled and self-sustained program developer.

Pre-requisites: Corresponding theory paper CA20103A - Operating System and associated prerequisites.

Course Outcomes (CO)

CO1	Students will understand the basic concepts of Operating Systems and its types.
CO2	Students will understand the process concepts, scheduling algorithms and its threads.
CO3	Students will understand the deadlock and synchronization problems.
CO4	Students will understand in detail about memory management and I/O management.
CO5	Students will be able to understand the files system interface and UNIX OS.

CA506A4 **(2 Hrs./week)**

JAVA PROGRAMMING LAB

Objective: At least 10 experiments covering the entire syllabus of the corresponding theory paper to be carried out using the theory studied /programming skill of the subject concerned to get insight into the practical applications of the theoretical studies. The outcome of the lab classes must lead to a skilled and self-sustained program developer.

Pre-requisites: Corresponding theory paper CA20104A - Java Programming and associated prerequisites.

Course Outcomes (CO)

CO1	Students will be able to understand the various features of java, control statements, Lexical issue, data types, variables, literals, arrays and various relational, Boolean and logical operations.
CO2	Students will learn the use of class and object in java, use of reference variable, constructor, garbage collection stack class.
CO3	Students will learn the various method used in java including overloading of functions, recursion, access control.
CO4	Student will be able to handle various string handling mechanism like string construction, string length string comparison, string buffer and string builder.
CO5	Student will learn inheritance, type of inheritances, static and dynamic methods and applying inference and use of packages.

CA507A4 **(2 Hrs./week)**

DATABASE MANAGEMENT SYSTEM LAB

Objective: At least 10 experiments covering the entire syllabus of the corresponding theory paper to be carried out using the theory studied /programming skill of the subject concerned to get insight into the practical applications of the theoretical studies. The outcome of the lab classes must lead to a skilled and self-sustained program developer.

Pre-requisites: Corresponding theory paper CA20102A - Database Management System and associated prerequisites.

Course Outcomes (CO)

CO1	Students will be able to understand database concept, develop ER diagram, relational schema mapping of ER diagram with relational schema.
CO2	Students will be able to understand normalization and its application in database and have the ability to use of UML and its support for database design specification
CO3	Students will be able to perform SQL queries and work with relational algebra.
CO4	Students will be able to understand transactions process and concurrency control.
CO5	Students will be able to understand database security and authorization.

MA502A1 **(2L + 1T Hrs./week)**

QUANTITATIVE ANALYSIS FOR COMPUTER APPLICATIONS

Questions to be set: 05 (All Compulsory)

Objectives: The student of MCA needs powerful analytical tools to analyse the algorithms and computer systems. Before analysing the algorithm or system, various probability distributions have to be specified. For computer system serving a large number of users, several types of random phenomena need to be considered, such as large population of diverse users, the arrival patterns of jobs. The theory of stochastic process is required to evaluate various measures of system effectiveness, response time, reliability and availability. To study different engineering subjects like Information Transmission and Coding Theory, Image Processing and Artificial Neural Network the help of Probability & Statistics is needed.

Pre-requisites: Set theory, Calculus, Permutation and Combination.

Course Outcomes (CO):

CO1	Students will be able to understand about discrete and continuous.
CO2	Students will be able to understand the concept of Coding theory, Image processing and ANN.
CO3	Students will be able to understand the stochastic concept.
CO4	Students will be able to understand about population and their patterns.
CO5	Students will be able to apply the concepts of statistics in real world applications.

Module	Topics to be covered	Topics	Hrs
Module 1: Probability &	in class	Axioms and Models of Probability, Conditional Probability, Bayes Rule – Examples. Random Variables – Simple Examples, Discrete and Continuous random variable, jointly distributed Random Variables, Distribution of random variables – examples. Expectation – Moments, Variance, Transform Methods, MTTF, Inequalities and Limit theorems – Examples, Conditional Distribution and Conditional Expectation.	[8]
	Assignment Topics	To be provided by the concerned faculty members	
Module 2: Statistics	in class	Elements of Statistics, Frequency Distribution, Measure of Central tendency, Covariance, Correlation Coefficient, Regression, Least Square Curve Fitting. Random Sampling, Sampling Distribution, Parameter Estimation and testing of Hypothesis	[8]
	Assignment Topics	To be provided by the concern faculty members	

Module 3: Stochastic Processes & Queuing Theory	in class	Stochastic Process – Classification, Poisson and Renewal Process.	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Markov Chain	in class	Discrete parameter Markov Chain.	[10]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Queuing Theory	in class	Concept of queue. Markovian Models with M/M/1 with infinite and finite capacities, M/M/c parallel servers. Examples.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. R Walpole, R Myers: Probability and Statistics for Engineers and Scientists, Pearson Education, Ninth Edition, 2014.
2. K.S. Trivedi: Probability, Statistics and Reliability, Queuing and Computer Science Applications, Prentice Hall of India – 1988.

Reference Books:

1. P.L. Meyer: Introductory Probability Theory and Statistical Applications, Oxford IBH Publishers.

CA509A1 **(2L + 1T Hrs./week)**

UNIX/LINUX INTERNAL

Questions to be set: 05 (All Compulsory)

Objectives: This course focuses on the principles and techniques of UNIX Operating System's concepts and terminologies, including file system programming and shell programming which includes advance UNIX commands and utilities, process management, signal management, Inter-process Communication issues and techniques.

Pre-requisites: Data Structures, Operating Systems and Programming language concepts. This course assumes that the student is familiar with C language and has some exposure to program writing in C language.

Course Outcomes (CO):

CO1	Identify the core components of UNIX/Linux operating systems.
CO2	Analysing the design of modern operating systems including offered services, their architectures, and design principles. Executing various important commands for creating and viewing and accessing the files and directories.
CO3	Utilize the concept of the file system, a virtual file system memory hole for saving data in computer memory with its efficient utilization of available space.
CO4	Demonstrate system call and their utilization for various administrative use such as file management, user management, memory management, etc.
CO5	Compare the key characteristics of multiple approaches used for the design and development of the operating system.

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction & UNIX Important Commands	in class	Evolution of UNIX Operating System, Introduction to Multi-user System, Features and benefits of UNIX, Versions of UNIX, Standards and flavours of UNIX, User perspective services, Operating System perspective services, Assumptions about hardware, Kernel architecture of UNIX Operating System. Changing directories, making files and directories, Commands used for user management, File management, changing file permission, process management, foreground and back ground processes. Creating commands by user.	[8]
	Assignment Topics	To be provided by the concern faculty members.	
Module 2: UNIX File	in class	UNIX file systems and file hierarchies, Internal structure of a file systems, Mounting,	[8]

System and Hierarchy & System calls for file systems		I-nodes and file attributes and permissions, The dirent structure, Manipulating directories and i-nodes, introduction to the file descriptors. Open, Close, File creation, Special files creation, Read, Write, File and record locking, Adjusting the position of file I/O, lseek, Change Directory, Change Root, Change Owner and Change Mode, Applications of stat and fstat system calls.	
	Assignment Topics	To be provided by the concern faculty members.	
Module 3: Process creation and process control	in class	Introduction to a process, process creation, fork, vfork system calls, Process identifiers - Process relationships, Process image, Process States and Transitions, Manipulation of Process address space, Sleep and termination of a process, User-ID of a Process, Chain and tree of a process. Changing the size of a Process, The Shell, System Boot and INIT process.	[6]
	Assignment Topics	To be provided by the concern faculty members.	
Module 4: Inter-process Communications & Sharing of files among processes	in class	Process memory management, inter process communication using pipe named pipe, Shared memory concepts and implementation, inter-process communication using socket for remote machines. Applications of Pipes, Dup and Dup2 systems calls, Mounting and un-mounting the file system, Link and Unlink the file System, The maintenance of file system.	[10]
	Assignment Topics	To be provided by the concern faculty members.	
Module 5: Signals	in class	Basics of signals, Types of signals and its applications, raising a signal, Designing a signal handler with UNIX system calls. Inter-process Communication using signal.	[8]
	Assignment Topics	To be provided by the concern faculty members.	

Textbooks:

1. Sumitabha Das, “UNIX Concepts and Applications”, McGraw Hill.
2. W. Richard Stevens, Advanced programming in the UNIX environment, Addison Wesley, 1999.
3. Karee Christian, “The Unix Operating System”, John Wiley & Sons.

Reference Books:

1. Vahalia, “UNIX Internals: The New Frontiers”, Pearson Education Inc, 2003.
2. Uresh Vahalia, "UNIX Internals: The New Frontiers", Prentice Hall, 2000.
3. M. Beck, et.al, “Linux Kernel Programming”, Pearson Education Asia, 2002.

CA510A1 **(2L + 1T Hrs./week)**

.NET FRAMEWORK

Questions to be set: 05 (All Compulsory)

Objectives: It covers the technique of creating.NET applications both for windows and web. In the course students will learn how to create a windows and web form, object-oriented aspects of C# and VB .NET.

Pre-requisites: Basic programming skill on C, C++ and Java.

Course Outcomes (CO):

CO1	To implement object-oriented concepts in C#.
CO2	To develop C# programs that connect to a database and access or store data.
CO3	To develop C# web applications employing OOP concepts and utilizing the features of the .NET Framework.
CO4	To implement exception handling mechanisms in C#
CO5	To realize multitasking using C#

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction to C#	in class	Introducing C#, Understanding .NET, Overview of C#, Literals, Variables, Data Types, Operators, Expressions, Branching, Looping, Methods, Arrays, Strings, Structures, Enumerations. Classes, Objects, Inheritance, Polymorphism, Interfaces, Operator Overloading, Delegates, Events, Errors and Exceptions.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Data Access using ADO.NET	in class	Characteristics of ADO.NET, Comparing ADO and ADO.NET, Creating a connection, Select command, Using a command with a data reader, Updating data, Accessing, modifying, updating disconnected data, Selecting multiple tables. Programming Web Applications with Web Forms, Programming Web Services.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: State Management, Files, Streams and Email	in class	Getting file system information in ASP.NET, Reading, writing files with streams, File Uploading, Sending mail inASP.NET.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Module 4: Exception Handling	in class	Basic Concept, Type of exception, Exception class, Try, catch, final, throw, Checked and unchecked, Creating user defined exception.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Thread Management	in class	Process, Thread, Multithreading, Thread class mutex class, Creating and starting thread, scheduling a thread, Synchronizing threads, Thread pooling.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. E. Balagurusamy, "Programming in C#", Tata McGraw-Hill, 2004.
2. J. Liberty, "Programming C#", 2nd ed., O'Reilly, 2002.

Reference Books:

1. Herbert Schildt, "The Complete Reference: C#", Tata McGraw-Hill, 2004.
2. Robinson et al, "Professional C#", 2nd ed., Wrox Press, 2002.
3. Andrew Troelsen, "C# and the .NET Platform", A! Press, 2003.
4. Jesse Liberty, Dan Hurwitz, Programming .NET Windows Applications, O'Reilly.

CA511A1 **(2L + 1T Hrs./week)**

COMPUTER NETWORK

Questions to be set: 05 (All Compulsory)

Objectives: This course emphasizes on several computer network concepts, applications and protocols in OSI as well as TCP/IP layered architecture. It also covers the various protocols of various layers, their operations and applications.

Pre-requisites: Communication Technique and Data Communication.

Course Outcomes (CO):

CO1	Students will be able to understand the concept of data communication protocols and standards.
CO2	Students will be able to understand the complexity of networks, their structure and utility.
CO3	Students will be able to understand the concept of open Systems and Application Support Protocols.
CO4	Identify the different types of network topologies and protocols
CO5	Students will be able to learn about sub netting and super netting.

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction	in class	Introduction of Computer Network: Definition, Data Communication System Model, Network Categories; Network Topologies; Network Reference Models: ISO-OSI Model, and TCP/IP Model; Physical layer: Transmission Modes, Transmission Media, Transmission Impairments; Switching Techniques;	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Data Link Layer, Medium Access Control Sub Layer	in class	Data Link Layer Design Issues; Error Detection and Correction; Elementary Data Link Protocol: Simplex, Stop-and-Wait ARQ, Sliding Window ARQ Protocol: One Bit Sliding Window ARQ, Go-back-N ARQ, Selective Repeat ARQ; Multiple Access Control (MAC) Protocol: ALOHA, Slotted ALOHA, CSMA Protocols;	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Network Layer	in class	Introduction: Network Layer Design Issue; Addressing: IP Address, Classless and Class full Addressing; Routing: Definition, Static vs, Dynamic Routing, Routing Table; Routing Algorithm: Introduction, Optimality Principle, Shortest Path, Flooding, Distance Vector Routing, Link State	[8]

		Routing; General Principle of Congestion Control: Leaky Bucket Algorithm, Token Bucket Algorithm; Need of Sub Network, Hierarchical Addressing Scheme, Role of Gateway, Subnet Mask in Packet Transmission. Concepts of Super Netting and Slack Route;	
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Transport layer	in class	The Transport Services: Services Provided to Upper Layer, Transport Service Primitives; Element of transport protocols; Congestion Control; TCP: Introduction, TCP Service Model, TCP Protocol, TCP Segment Header, TCP Connection Establishment, TCP Connection Release, TCP Connection Management, Transmission Policy, Congestion Control; UDP- Introduction, RPC, RTTP.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Application layer	in class	DNS; Email- SMTP, POP3; World Wide Web (WWW): HTTP; Mobile Web; FTP, TELNET, P2P Network.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. B. Forouzan, Data Communication and Networking, Tata McGraw Hill
2. James F. Kurose, Keith W. Ross, Computer Networking: A Top-Down Approach, 6th Edition, Pearson Publication.

Reference Books:

1. Leon-Garcia and Didjaja, Communication Network, Tata McGraw Hill
2. Black Vymos, Computer Networks, PHI.
3. Peterson & others, Computer Networks, New Age International.
4. Choudhury D R., Networks & Systems, New Age International.

CA*A3** **(2L + 1T Hrs./week)**

ELECTIVE - I

No. of questions to be set: 05 (All Compulsory)

Objectives and Pre-requisites are given under Elective course details

To be chosen/offered from the list of electives for second semester.

CA*A3** **(2L + 1T Hrs./week)**

ELECTIVE - II

No. of questions to be set: 05 (All Compulsory)

Objectives and Pre-requisites are given under Elective course details

To be chosen/offered from the list of electives for second semester.

CA512A4 **(2 Hrs./week)**

UNIX/LINUX INTERNAL LAB

Objective: At least 10 experiments covering the entire syllabus of the corresponding theory paper to be carried out using the theory studied /programming skill of the subject concerned to get insight into the practical applications of the theoretical studies. The outcome of the lab classes must lead to a skilled and self-sustained program developer.

Pre-requisites: Corresponding theory paper CA20110 – Unix/Linux Internal Data Structure and associated prerequisites.

Course Outcomes (CO):

CO1	Identify the core components of UNIX/Linux operating systems.
CO2	Analysing the design of modern operating systems including offered services, their architectures, and design principles. Executing various important commands for creating and viewing and accessing the files and directories.
CO3	Utilize the concept of the file system, a virtual file system memory hole for saving data in computer memory with its efficient utilization of available space.
CO4	Demonstrate system call and their utilization for various administrative use such as file management, user management, memory management, etc.
CO5	Compare the key characteristics of multiple approaches used for the design and development of the operating system.

CA513A4 **(2 Hrs./week)**

COMPUTER NETWORK LAB

Objective: At least 10 experiments covering the entire syllabus of the corresponding theory paper to be carried out using the theory studied /programming skill of the subject concerned to get insight into the practical applications of the theoretical studies. The outcome of the lab classes must lead to a skilled and self-sustained program developer.

Pre-requisites: Corresponding theory paper CA20107A - Computer Network and associated prerequisites.

Course Outcomes (CO):

CO1	Students will be able to understand the concept of data communication protocols and standards.
CO2	Students will be able to understand the complexity of networks, their structure and utility.
CO3	Students will be able to understand the concept of open Systems and Application Support Protocols.
CO4	Identify the different types of network topologies and protocols
CO5	Students will be able to learn about sub netting and super netting.

CA514A4 **(2 Hrs./week)**

.NET LAB

Objective: At least 10 experiments covering the entire syllabus of the corresponding theory paper to be carried out using the theory studied /programming skill of the subject concerned to get insight into the practical applications of the theoretical studies. The outcome of the lab classes must lead to a skilled and self-sustained program developer.

Pre-requisites: Corresponding theory paper CA20106A - .NET Framework and associated prerequisites.

Course Outcomes (CO):

CO1	To implement object-oriented concepts in C#.
CO2	To develop C# programs that connect to a database and access or store data.
CO3	To develop C# web applications employing OOP concepts and utilizing the features of the .NET Framework.
CO4	To implement exception handling mechanisms in C#
CO5	To realize multitasking using C#

CA601A1 **(2L + 1T Hrs./week)**

DESIGN & ANALYSIS OF ALGORITHMS

Questions to be set: 05 (All Compulsory)

Objectives: To Introduce various designing techniques and methods for algorithms, performance analysis of Algorithms using asymptotic and empirical approaches, demonstrate a familiarity with major algorithms and data structures, to give clear idea on algorithmic design paradigms like Divide-and-Conquer, Dynamic Programming, Greedy, Branch and Bound etc.

Pre-requisites: Data Structures, Programming Knowledge

Course Outcomes (CO):

CO1	Students will understand algorithm design techniques and complexity analysis.
CO2	Students will apply sorting, searching, and graph algorithms to solve problems.
CO3	Students will analyze the efficiency of algorithms using asymptotic notations.
CO4	Students will try to design new algorithms using appropriate paradigms.
CO5	Students will evaluate different algorithms based on performance and optimization.

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction	in class	What is an Algorithm? Fundamentals of Algorithmic Problem Solving, Important Problem Types, Fundamental Data Structures. Fundamentals of the Analysis of Algorithm: Efficiency Analysis Framework, Asymptotic Notations and Basic Efficiency Classes.	[10]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Searching & Sorting	in class	Brute Force and Exhaustive Search: Selection Sort and Bubble Sort, Sequential Search and Brute-Force String Matching, Exhaustive Search, Depth First Search, Breadth First Search.	[10]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Divide & Conquer, Decrease & Conquer	in class	Merge sort, Quicksort, Binary Search, Binary tree traversals and related properties. Decrease and Conquer: Insertion Sort, Topological Sorting	[8]

	Assignment Topics	To be provided by the concern faculty members	
Module 4: Transform and Conquer	in class	Balanced Search Trees, Heaps and Heapsort.	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Dynamic Programming	in class	The Knapsack Problem and Memory Functions, Optimal Binary search tree.	[6]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Introduction to Algorithms, Thomas H. Cormen, Charles E. Leiserson, Ronal L. Rivest, Clifford Stein, 2ndEdition, PHI, 2006.
2. Introduction to Algorithms. Cormen Thomas H. 3rd Edition, PHI Learning, latest edition.

Reference Books:

1. Computer Algorithms by Horowitz E., Sahni S., Rajasekaran S., Galgotia Publications, 2001.
2. Introduction to the Design and Analysis of Algorithms A Strategic Approach, R.C.T. Lee, S.S. Tseng, R.C. Chang & Y.T.Tsai, TMH, 2005.

CA602A1 **(2L + 1T Hrs./week)**

SOFTWARE ENGINEERING & UNIFIED MODELLING LANGUAGE

Questions to be set: 05 (All Compulsory)

Objectives: This course will offer a wide perspective on software development covering the full life cycle of software development. This would be inclusive of requirements analysis, technical design, estimating, testing, quality measures and management issues. This course deals with the processes of both object-oriented analysis and object-oriented design using UML as the notation language to provide a common, standard notation for recording both analysis models and design artefacts.

Pre-requisites: Algorithm concept and Database Management System.

Course Outcomes (CO):

CO1	Students will be able to understand the concepts of software engineering and its paradigms.
CO2	Students will be able to learn about the proficiency in software development techniques and its cost estimation
CO3	Students gain the knowledge of UML and its tools.
CO4	Students will be able to understand the concepts of scheduling and staffing.
CO5	Students gain the knowledge of risk management and software maintenance.

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction	in class	The software engineering discipline-evaluation and impact, Computer system engineering, Life Cycle Models, SDLC phases, Feasibility study, Requirements gathering and analysis, Software requirement specification (SRS). Software Design, Cohesion and coupling, Object oriented vs. function-oriented design, user interface design, Characteristics of a good user interface, Basics concepts, Types of user interfaces. Coding, Code review, testing, types of testing, test cases design.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Software project management	in class	Responsibilities of project manager, Project planning, Metrics for project size estimation, Project estimation techniques, Scheduling, Organization and team structure, Staffing, Risk management, Software configuration management. Software reliability, Statistical testing, Software quality management system, ISO 9000, SEI capability maturity model, Personal software process (PSP), Six sigma.	[8]

		Characteristics of software maintenance, Software reverse engineering, Basics issues in any reuse program	
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Object Oriented Paradigm	in class	Objects, Functional method and Object-Oriented method, the key concepts of OOP, Relationship among objects. Fundamentals of Object-Oriented approach, various concepts, Object Oriented Analysis & Object-Oriented Design, Rum Baugh et. al.'s object model, Booch Model, Jacobson et. al. methodology, Coad and Yourdon Object Oriented analysis model, Pattern& frameworks.	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: UML	in class	UML Background, its evolution and various variants, UML building blocks and modelling views, requirements engineering using various UML tools such as Use Case Modelling, Conceptual modelling, Behavioural modelling.	[10]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Architecture	in class	System Architecture using various UML tools such as collaboration diagrams, Component diagrams, Design of class diagrams, Activity diagrams, Sequence diagrams, State chart diagrams, Design patterns.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Rajib Mall, Fundamentals of Software Engineering, PHI.
2. Grady Booch, James Rum Baugh, Ivar Jacobson, The Unified Modelling Language User Guide, Addison- Wesley.

Reference Books:

1. Jalote Pankaj, An integrated approach to Software Engineering, Narosa.
2. Pressman R, Software Engineering- Practioner Approach, Tata McGraw Hill.
3. Budgen, Software Design, Pearson.
4. Ali Bahrami, Object Oriented Systems Development, Tata McGraw Hill.

CA*A3** **(2L + 1T Hrs./week)**

ELECTIVE - III

No. of questions to be set: 05 (All Compulsory)

Objectives and Pre-requisites are given under Elective course details

To be chosen/offered from the list of electives for second semester.

CA*A3** **(2L + 1T Hrs./week)**

ELECTIVE - IV

No. of questions to be set: 05 (All Compulsory)

Objectives and Pre-requisites are given under Elective course details

To be chosen/offered from the list of electives for second semester.

CA607A1 **(2L + 1T Hrs./week)**

FORMAL LANGUAGES AND AUTOMATA THEORY

Questions to be set: 05 (All Compulsory)

Objectives: The central objective of the course is to provide learners with a detailed understanding of the mathematical models of the machines and their evolution through requirement generation and advancement in languages.

Pre-requisites: Computer Programming concepts and Discrete Structures for Computer Science.

Course Outcomes (CO):

CO1	Understand the fundamentals and significance of language, grammar, and automata.
CO2	Learn finiteness, DFA, and NFA concepts in automata.
CO3	Study regular expressions, their properties, and relation to automata.
CO4	Explore grammars, ambiguity, normal forms, CFG, and pushdown automata.
CO5	Understand Chomsky hierarchy, halting problem, Turing machines, and learning models

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction & Finite automata	in class	Mathematical preliminaries: Sets, Logic, Functions, Relations, Languages. Definitions: Language, Grammar, Automata, Relation between language, Grammar and automata, Importance of automata theory. Informal introduction: Drawing examples from everyday life to bring out the essence of finite automata, Finiteness and its importance in automata theory. Deterministic finite automata: Definition, Processing strings, Transition functions, Language of a DFA, Nondeterministic finite automata: Non-determinism, Definition, Extended transition functions, Language of a NFA, Equivalence of DFA and NFA, Kleene's theorem, Epsilon transitions, Applications of Finite automata in text search.	[8]
	Assignment Topics	To be provided by the concern faculty members.	
Module 2: Regular expressions and regular languages & Properties of regular languages	in class	Memory required to recognize a language, Regular expressions, Regular expression to finite automata, Finite automata to regular expression, Algebraic laws for regular expressions, Applications of regular expressions, Criterion for regularity, Regular languages. Pigeonhole principle, pumping lemma for regular languages, Closure properties, Testing membership of regular languages, Equivalence of automata.	[8]

	Assignment Topics	To be provided by the concern faculty members.	
Module 3: Context Free Grammars and Languages & Pushdown automata and context free languages	in class	Definition, Leftmost and rightmost grammars, Parse trees, Ambiguity: Ambiguous grammar, Removing ambiguity. Normal forms, Applications of context free grammars: Parsers. Definition of pushdown automata, representing pushdown automata, Acceptance by pushdown automata: By final state, by empty stack, Deterministic pushdown automata, Equivalence of pushdown automata and context free grammars, pumping lemma for context free languages, Closure properties of context free languages, Testing membership of context free, Decision problems for context free languages.	[6]
	Assignment Topics	To be provided by the concern faculty members.	
Module 4: Turing machines & Recursively enumerable languages	in class	Definition, Language of a Turing machine, Programming Turing machines, The Church-Turing thesis, A simple programming language, Extensions of the basic Turing machine. Definition, Enumeration, Chomsky hierarchy.	[10]
	Assignment Topics	To be provided by the concern faculty members.	
Module 5: Undecidability & Language learning	in class	The halting problem, The post correspondence problem, Time and space complexity of Turing machines, Complexity classes. Learning framework, Inductive inference, Grammar induction.	[8]
	Assignment Topics	To be provided by the concern faculty members.	

Textbooks:

1. John. E. Hopcroft, Rajeev Motwani, Jeffry. Ullman, Introduction to Automata Theory, Languages and Computation, Pearson Education.
2. John Martin, Introduction to Languages and the Theory of Computation, Tata McGraw Hill.

Reference Books:

1. Peter Linz, An Introduction to Formal Languages and Automata, Narosa.
2. James. L. Hein, Discrete Structures, Logic and Computability, Narosa.
3. Partha Niyogi, The Computational Nature of Language Learning and Evolution, PHI.
4. Zvi Kohavi and Niraj K. Jha, Switching and Finite Automata theory, Tata McGraw Hill.

CA603A4 **(2 Hrs./week)**

SOFTWARE ENGINEERING AND UML LAB

Objective: At least 10 experiments covering the entire syllabus of the corresponding theory paper to be carried out using the theory studied /programming skill of the subject concerned to get insight into the practical applications of the theoretical studies. The outcome of the lab classes must lead to a skilled and self-sustained program developer.

Pre-requisites: Corresponding theory paper CA20105A - Software Engineering and Unified Modelling Language and associated prerequisites.

Course Outcomes (CO):

CO1	Students will able to understand the concepts of software engineering and its paradigms.
CO2	Students will be able to learn about the proficiency in software development techniques and its cost estimation
CO3	Students gain the knowledge of UML and its tools.
CO4	Students will able to understand the concepts of scheduling and staffing.
CO5	Students gain the knowledge of risk management and software maintenance.

CA604A4 **(2 Hrs./week)**

DESIGN & ANALYSIS OF ALGORITHMS LAB

Objective: At least 10 experiments covering the entire syllabus of the corresponding theory paper to be carried out using the theory studied /programming skill of the subject concerned to get insight into the practical applications of the theoretical studies. The outcome of the lab classes must lead to a skilled and self-sustained program developer.

Pre-requisites: Basic knowledge in searching and sorting algorithms.

Course Outcomes (CO):

CO1	Students will be able to understand the concepts of software engineering and its paradigms.
CO2	Students will be able to learn about the proficiency in software development techniques and its cost estimation
CO3	Students gain the knowledge of UML and its tools.
CO4	Students will be able to understand the concepts of scheduling and staffing.
CO5	Students gain the knowledge of risk management and software maintenance.

CA605A5

MINOR PROJECT

SN	Subject	Objectives	Total Credits
1.	Minor Project	The students are required to undertake innovative and research-oriented project or application development project under the direct supervision of a faculty member of the department. The minor project should not only to reflect their knowledge gained in the previous Semesters but also to acquire additional knowledge and skill of their own effort. The minor projects are assigned at the end of II semester and the final evaluation and grades are awarded at the end of III semester.	
2.	Minor Project Reviews	The progress is being evaluated in phases through interim seminars/ presentations to make the department aware of his/her project.	1
3.	Awarded by Project Guide	The faculty-guide assesses the work of the group(s) working under his/ her guidance on day-to-day basis and evaluate.	1
		Total Credits	2

Course Outcomes (CO):

CO1	Students will be able to identify, understand, analyze and solving real world problem.
CO2	Students will be able to apply the concept of database management system and software engineering
CO3	Students will be able to apply the modern tools to develop software or carry out research
CO4	Students will be able to understand and apply the different aspects of project documentation and report generation
CO5	Students will be able to understand social and ethical issues and develop presentation skills

CA606A9

INDUSTRIAL TRAINING/COURSEWORK

SN	Subject	Objectives	Total Credits
1	Industrial training/ Coursework	The students are required either to undergo 4 weeks training in Industries or to attend summer training course on courses / skill-based course beyond the scope of normal curriculum organized by the Department by calling experts from outside of provided by any reputed EdTech company recognized by Sikkim Manipal University.	**1**
Total Credit			**1**

Course Outcomes (CO):

CO1	Students will be able to identify, understand, analyze and solving real world problem.
CO2	Students will be able to apply the concept of database management system and software engineering
CO3	Students will be able to apply the modern tools to develop software or carry out research
CO4	Students will be able to understand and apply the different aspects of project documentation and report generation
CO5	Students will be able to understand social and ethical issues and develop presentation skills

CA607A6

MAJOR PROJECT

SN	Subject	Objectives	Total Credits
1.	Major Project	The students are required to undertake industry-oriented application development projects or innovative and research-oriented project. The projects will be carried out in any industry with or without stipend or under the direct supervision of a faculty member of the department. The project should not only to reflect their knowledge gained in the previous Semesters but also to acquire additional knowledge and skill of their own effort. The minor projects are assigned at the end of III semester and the final evaluation and grades are awarded at the end of IV semester.	
2.	Major Project Reviews	The progress is being evaluated in phases through interim seminars/ presentations to make the department aware of his/her project.	8
3.	Awarded by Project Guide	An average of marks assigned by the internal and external project guides for the outstation candidates and marks assigned by faculty-guides working under his/ her guidance on day-to-day basis and evaluate.	8
		Total Credits	16

Course Outcomes (CO):

CO1	Students will develop the ability to identify, comprehend, analyze, and resolve real-world challenges.
CO2	Students will gain proficiency in applying database management system concepts and software engineering principles.
CO3	Students will effectively use modern tools for software development and academic research.
CO4	Students will acquire knowledge and skills to create project documentation and generate comprehensive reports.
CO5	Students will understand ethical and social considerations while refining their presentation abilities.

MCA PROGRAM ELECTIVES

(COURSE CURRICULUM)

CA551A3 **(2L + 1T Hrs./week)**

BIOINFORMATICS

Questions to be set: 05 (All Compulsory)

Objective: The course is designed to introduce the basic concepts, methods, and tools used in Bioinformatics. The objective is to help the students to reach rapidly the frontier of bioinformatics and working knowledge of a variety of publicly available data and the bioinformatics tools in handling flood of biological data and to solve the problems on their own research. The course also highlights the programming paradigm of Bioinformatics.

Pre-requisites: Concept of Algorithms, Probability and Statistics and Knowledge of Biology.

Course Outcomes (CO):

CO1	Students will be able to develop a solid background in bioinformatics.
CO2	Students will be able to develop computer programs for bioinformatics data analysis
CO3	Students will be able to pursue research in bioinformatics area.
CO4	Students will be able to implement projects on solving current open problems in the area of bio informatics.
CO5	Students will be able to understand the scope of career in bioinformatics in India and abroad.

Module	Topics to be covered	Topics	Hrs
Module 1: Bioinformatics an Overview	in class	Definition and history, Information networks, Internet in bioinformatics, EMBnet , Commercial databases and software, Intranet and internet packages, Bioinformatics glossary.	[3]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Bioinformatics Programming using Perl	in class	Basics of programming PERL, Basics, String handling, subroutines.HTML basics, Tags, Text handling, Image handling, Links, Frames and tables. XML, Basics, Data binding and record sets.	[2]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Protein Information Resources	in class	Biological databases, Primary sequence databases, Composite protein sequence databases, - Secondary databases, Prosite, Prints, Blocks profiles and identity.	[9]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Genome Information Resources	in class	DNA sequence databases, EMBL DDBJ, Genbank GSDB (Genome, Sequence database), UniGene.	[12]
	Assignment Topics	To be provided by the concern faculty members	

Module 5: Evolution of Bioinformatics	in class	Scope, Potentials of bioinformatics, Human genome project, Bioinformatics in India, Future of bioinformatics.	[14]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Arthur M. Lesk, Introduction to Bioinformatics, Oxford University Press.
2. T.K. Attwood and D.J. Parry-Smith, Introduction to Bioinformatics, Pearson Education.

Reference Books:

1. D. Higgins and W. Taylor, Bioinformatics- Sequence, structure and databanks, Oxford University Press.
2. Baxevanis and B.F. Ouellette. Bioinformatics: A practical Guide to the Analysis of Genes and Proteins, Wiley.
3. S. R. Swindell, R.R.Miller and G.S.A.Myers (Eds.), Internet for the Molecular Biologist, Horizon Scientific Press.
4. Andrea Cabibbo, Richard Grant and Manuela Helmer-Citterich (Eds.), The Internet for Cell and Molecular Biologists, Horizon scientific Press.

CA552A3 **(2L + 1T Hrs./week)**

DIGITAL IMAGE PROCESSING

Questions to be set: 05 (All Compulsory)

Objective: The objective of this course is to provide the students a general understanding of the fundamentals of digital image processing. It also introduces analytical tools which are currently used in digital image processing. By the end of the course student will be able to develop any software/programs that uses image restoration, enhancement and compression etc.

Pre-requisites: Computer Graphics, Set theory and Probability.

Course Outcomes (CO):

CO1	Students will be able to understand the real-life Image processing problems.
CO2	Students will be able to understand the concepts of transformations and Fourier theory.
CO3	Students will able to develop their own software in Digital Image processing area.
CO4	Students will be able to research and implement projects on current open problems in image processing.
CO5	Students will be able to understand and implement Machine Learning algorithms to design solutions for problems in image processing.

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction	in class	Digital image representation, Fundamental steps in Image Processing, Elements of DIP systems. Elements of Visual Perception, Sampling and Quantization, Relationships between pixels, Linear and Nonlinear operations.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Image Enhancement	in class	Enhancement by Point Processing, Histogram Processing, Spatial Filtering. Introduction to the Fourier Transform, The discrete Fourier Transform, Properties of the two-dimensional Fourier Transform, Smoothing Frequency-domain filters, Sharpening Frequency domain filters.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Image Compression and segmentation	in class	Fundamentals, Image Compression Models, Error Free Compression, Lossy Compression. Threshold Techniques: Global, Adaptive and Optimum thresholding, Edge detection, Region Growing.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Module 4: Representation and Description	in class	Representation Schemes, Boundary Descriptors, Regional Descriptors.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Object Recognition	in class	Patterns and Pattern Classes, Recognition based on Decision-theoretic methods, structural methods.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Rafael C Gonzalez, Richard E Woods, Digital Image Processing, Pearson Education.
2. Rajjan Shinghal, Pattern Recognition, Oxford.

Reference Books:

1. Chanda and Majumder, Digital Image Processing and Analysis, Prentice Hall.
2. Rafael C Gonzalez, Richard E Woods, Digital Image Processing with Matlab, Pearson Education.
3. S. Sridhar, Digital Image Processing, Oxford University Press.
4. Jayaraman, Digital Image Processing, Tata McGraw Hill.

CA553A3 **(2L + 1T Hrs./week)**

MANAGEMENT INFORMATION SYSTEM

Questions to be set: 05 (All Compulsory)

Objective: The main objective of this course is to describe the use and function of Management Information Systems, describe and evaluate Information Systems Development processes and techniques. It also identifies and evaluates hardware and software requirements for Information Systems; Data Management technologies and the security risks associated with Management Information Systems.

Pre-requisites: DBMS, Programming skills with any programming language.

Course Outcomes (CO):

CO1	Students will be able to apply fundamental business analysis methods to understand the organizational and economic characteristics of organizations.
CO2	Students will be able to Model real-world situations for information systems support.
CO3	Students will be able to develop software and can use fundamental concepts of information systems and technology.
CO4	Students will be able to understand the role of MIS in modern business organizations.
CO5	Students will be able to understand the security polices in MIS.

Module	Topics to be covered	Topics	Hrs
Module 1: Organization and Information Systems	in class	Changing Environment and its impact on Business - The IT/IS and its influence - The Organization: Structure, Managers and activities - Data, information and its attributes - The level of people and their information needs - Types of Decisions and information - Information System, categorization of information on the basis of nature and characteristics. Transaction Processing System (TPS) - Office Automation System (OAS) - Management Information System (MIS) - Decision Support System (DSS) and Group Decision Support System (GDSS) - Expert System (ES) - Executive Support System (EIS or ESS).	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: System Analysis and Development and Models	in class	Need for System Analysis - Stages in System Analysis - Structured SAD and tools like DFD, Context Diagram Decision Table and Structured Diagram. System Development Models: Water Flow, Prototype, Spiral– Roles and responsibilities of System Analyst, Database Administrator and Database Designer.	[8]

	Assignment Topics	To be provided by the concern faculty members	
Module 3: Enterprise System	in class	Enterprise Resources Planning (ERP): Features, selection criteria, merits, issues and challenges in Implementation- Supply Chain Management (SCM): Features, Modules in SCM - Customer Relationship Management (CRM)and its Phases.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Knowledge Management and E-Governance	in class	Choice of IT Nature of IT decision - Strategic decision - configuration design and evaluation Information technology implementation plan.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Security and Ethical Challenges	in class	Ethical responsibilities of Business Professionals – Business, technology. Computer crime – Hacking, cyber theft, unauthorized use at work. Piracy – software and intellectual property. Privacy – Issues and the Internet Privacy. Challenges – working condition, individuals. Health and Social Issues	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Kenneth J Laudon, Jane P. Laudon, Management Information Systems, Pearson.
2. W. S. Jawadekar, Management Information Systems, Tata McGraw Hill.

Reference Books:

1. James A O' Brien, Introduction to Information System, Tata McGraw Hill.
2. S. Sadagopan, Management Information Systems, PHI.
3. Effy Oz, Management Information Systems, Thomson Course Technology.
4. Lynda M Apple Gate, Robert D Austin Corporate Information Strategy and Management, Tata McGraw Hill.

CA554A3 **(2L + 1T Hrs./week)**

OPTIMIZATION TECHNIQUE

Questions to be set: 05 (All Compulsory)

Objective: The objective of this course is to understand the need and origin of the optimization methods and to get a broad picture of the various applications of optimization methods used in engineering. This course is indent for designing and controlling complex systems, solving hard problems of efficiently allocating scarce resources using in complete information, and developing sustainable strategies to master situations of conflict and co-operation using scientific methods and information technology.

Pre-requisites: Quantitative Analysis using C/C++, Design and Analysis of Algorithms and Probability & Statistics.

Course Outcomes (CO):

CO1	Students will be able to demonstrate knowledge and understanding of the basic ideas underlying optimization techniques.
CO2	Students will be able to use decomposition techniques to solve hard optimization problems.
CO3	Student can use mathematical approach to optimization problems relevant to computer application.
CO4	Students will be able to implement optimization techniques to existing problems an evaluate their implications.
CO5	Students will be able to understand and implement solutions for open problems in this area.

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction to Operations Research	in class	Introduction to OR modelling approach and various real life situations, Linear programming problems and applications, Solving Linear Programming problem using simultaneous equations and Graphical Method, Simplex Method and extensions, Sensitivity analysis - Duality theory. Transportation model, Transhipment problems and Assignment problems.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Dynamic Programming and Network Analysis	in class	Bellman's principle of optimality, Examples on the application on routing problem, Inventory problem, Simplex problem, Marketing problem. PERT and CPM, Probability of achieving completion data, Cost analysis, Graph reduction theory, Updating, Resource allocation, Resource smoothing.	[8]

	Assignment Topics	To be provided by the concern faculty members	
Module 3: Inventory Method	in class	Inventory problem, Variables in an inventory problem, Inventory models with penalty, Storage and Quantity discount, Safety stock, Inventory models with probability Demand, Multi-item deterministic model. Simulation, Types of simulation models, Applications of simulation for Inventory problems.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Queuing Theory	in class	Poison arrivals and Exponential service times, Waiting time and Idle time cost, Single channel and Multi-channel problem. Applications of simulation for Queuing problems. Monte Carlo technique applied to queuing problems, Poisson arrivals and service time.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Theory of Games	in class	Introduction – Minimax (maximin) – Criterion and optimal strategy – Solution of games with saddle points –Rectangular games without saddle points – 2X2 games, Examples on the application of theory of games. –Dominance principle – mX2 & 2Xn games - Graphical method and Linear programming method for different problems, Decision trees.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Hamdy A. Taha, Operations Research, Macmillan.
2. Kumar Gupta, Prem and Hira, D.S., Operations Research, S Chand.
3. Swarup, Kanti, Gupta, P.K. and Manmohan, Operations Research, Sultan Chand & Sons.

Reference Books:

1. Richard Bronson, Operations Research – Schaum outline series, Tata McGraw Hill.
2. V.K. Kapoor-- Operations Research, S Chand & Sons.
3. Hiller F. and Leibermann G. J., Operation Research, Tata McGraw Hill.
4. Srinath L.S., PERT & CPM Principles and Applications, Affiliate East West Press(P).

CA555A3 **(2L + 1T Hrs./week)**

MOBILE APPLICATION DEVELOPMENT

Questions to be set: 05 (All Compulsory)

Objective: The Java Programming Language course provides students with a solid foundation for programming with JAVA. It also highlights the creation of graphical user interfaces (GUIs), exceptions, file input/output (I/O), and threads, and network programming.

Pre-requisites: Basic Programming Concept, Object Oriented Programming.

Course Outcomes (CO):

CO1	Students will be able to develop and design mobile applications for specific requirements.
CO2	Student will be able to implement the design using Android SDK.
CO3	Student will be able to implement the design using Objective C and iOS.
CO4	Students will be able to understand and implement cross platform applications techniques.
CO5	Students will be able to understand and exercise security policies in mobile applications.

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction	in class	Introduction to mobile applications, Embedded systems, Market and business drivers for mobile applications, Publishing and delivery of mobile applications, Requirements gathering and validation for mobile applications.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Basic design	in class	Introduction to basics of embedded systems design, Embedded OS, Design constraints for mobile applications, Architecting mobile applications, User interfaces for mobile applications, touch events and gestures, Achieving quality constraints, performance, usability, security, availability and modifiability.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Advanced Design	in class	Designing applications with multimedia and web access capabilities, Integration with GPS and social media networking applications, Accessing applications hosted in a cloud computing environment, Design patterns for mobile applications.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Module 4: Android Development Environment	in class	Introduction to Android Environment, Establishing the development environment, Android architecture, Activities and views, Interacting with UI, persisting data using SQLite, Packaging and deployment, Interaction with server-side applications, Using Google Maps, GPS and Wifi – Integration with social media applications.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: IOS Development environment	in class	Introduction to Objective C, iOS features, UI implementation, Touch frameworks, Data persistence using Core Data and SQLite, Location aware applications using Core Location and Map Kit, integrating calendar and address book with social media application, Using Wifi - iPhone marketplace.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Jeff McWherter and Scott Gowell, Professional Mobile Application Development, Wrox Publishers.
2. Charlie Collins, Michael Galpin and Matthias Kappler, Android in Practice, DreamTech,

Reference Books:

1. James Dovey and Ash Furrow, Beginning Objective C, Apress.
2. David Mark, Jack Nutting, Jeff LaMarche and Frederic Olsson, Beginning iOS 6 Development: Exploring the iOS SDK, Apress.
3. DT Editorial Services, Mobile Application Development Black Book, Dreamtech Press.
4. Carmen Delessio, Lauren Darcey, Shane Conder, Sams Teach Yourself Android Application Development in 24 Hours, Sams Publishing.

CA556A3 **(2L + 1T Hrs./week)**

ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS

Questions to be set: 05 (All Compulsory)

Objective: The objective of the course is to learn various areas of Artificial Intelligence, such as symbolic representation, knowledge representation, cognitive models, goal-based systems, heuristic search, games as environments, deductive systems and expert systems, vision; audition, language understanding etc. Rather than present AI as a loose collection of ideas and techniques, this course will strive to emphasize important unifying themes that occur throughout many areas of AI research.

Pre-requisites: Data Structures, Analysis and Design of Algorithms and Statistics.

Course Outcomes (CO):

CO1	Students will be able to develop an understanding of artificial intelligence and problem-solving techniques.
CO2	Students will be able to draw inferences using the concepts of knowledge and reasoning.
CO3	Students will be able to understand and apply the concepts of expert system.
CO4	Students will be able to understand and implement solutions to current open research problems in AI.
CO5	Students will be able to understand and apply AI solutions to various areas including finance, medical, IoT and others.

Module	Topics to be covered	Topics	Hrs
Module 1: Artificial Intelligence	in class	Introduction, Intelligent agents: Agents and environments, the concept of rationality, Nature of environments, Structure of environments. Solving Problems by Searching: Problem solving agents, Uninformed Search strategies, Avoiding repeated states, Informed Searches and exploration, Informed search strategies, Heuristic functions, Local search algorithms and optimization problems.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Adversarial searches	in class	Games, Optimal decision in games, Alpha beta pruning, Imperfect real-time decisions	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Knowledge and Reasoning	in class	Logical Agents: Knowledge based agents, Propositional logic, Resolution, Effective propositional inference, Agents based on propositional logic. Syntax and semantics of First order logic, Using FOPL.	[8]

	Assignment Topics	To be provided by the concern faculty members	
Module 4: Inference in First-Order Logic	in class	Unification, Forward chaining, Backward chaining, Resolution. Learning from Observations: Form of learning, Inductive learning, Learning decision tree, Ensemble learning, Computational learning theory.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Expert Systems	in class	Introduction (characteristic features of expert systems, Background History, Applications, importance of expert systems); Rule based system architectures (the knowledge base, the inference process, explaining how or why, building a knowledge base, the I/O interface).	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. S. Russel, & P Norvig, Artificial Intelligence A Modern Approach, Pearson Education.
2. Nills J Nillson, Artificial Intelligence A New Synthesis, Morgan Kauffman

Reference Books:

1. Luger, Artificial Intelligence, Pearson education.
2. Charnials Engine, Introduction to artificial intelligence, Wesley.
3. Petterson, Introduction to artificial intelligence and expert systems, PHI.
4. Padhy, N.P., Artificial intelligence and intelligence system, Oxford University Press.

CA557A3 **(2L + 1T Hrs./week)**

IT LAW AND PRACTICES

Questions to be set: 05 (All Compulsory)

Objective: The main objectives of this course are to develop an understanding of the IT security and its related ethical issues. This course will cover about security threats and their actions. This course will provide an awareness of computer network vulnerabilities.

Pre-requisites: Fundamentals of IT and E-commerce.

Course Outcomes (CO):

CO1	Students will have the knowledge of IT security and its related issues/act.
CO2	Student will be aware of the IT Act 2000, various sections and corresponding penalties of various IT related offences.
CO3	Students will have the knowledge in various security threats on internet and their counter measures.
CO4	Students will be able to understand and follow security best practices in their professional career.
CO5	Students will have the understanding of various security policies and technologies.

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction to Information Security	in class	History of Information Security, Characteristics of Information, NSTISSC Security model, Components of Information System, Security Systems Development life cycle, Security professional. The Information Technology Act, 2000 (No. 21 of 2000). Intellectual Property, Understand how copyrights, patents, trademarks and other forms of IP differ. Cognizable and non-cognizable offence. Necessity of Arrest without Warrant under IT Act 2000.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Need for Security	in class	Business needs, Threats, Attacks. Information Security Risk Management: An Overview of Risk Management, Risk Identification Identifying assets, Threats and vulnerabilities Risk Analysis and Assessment Understanding risk analysis, planning for risk analysis, Performing risk analysis and assessment, Risk Control Strategies and selection.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Module 3: Cyber Security and practices	in class	Security problem in computing: definition of secure, Attacks, the meaning of computer security, computer criminals, methods of defence. Information security policy, Standards and practices, the information security blueprint, security education, and Training and awareness program. Implementing Information Security: Project Management for Information Security, Technical topics, Nontechnical aspects. Disaster Recovery and Risk Monitoring: Disaster recovery planning, Disaster recovery plan , Risk monitoring Application-Level Risks the Fundamental hacking concept,	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Network Vulnerability	in class	Network service vulnerabilities and attacks memory manipulation attacks, Mitigation process manipulation risks. Introduction, Access control, Firewall, protecting Remote connections- Remote Access and Virtual Private Networks (VPNs) Intrusion Detection and prevention system: IDPS Terminology, need of IDPS. Types of intrusion detection system.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Network Security Assessment and Tools Required	in class	The business benefits, Classifying internet-based attackers, Assessment service definitions, Network security methodology, The cyclic assessment approach, Free and commercial network scanning tools.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Michael E. Whitman and Herbert J. Mattord, Principles of information security, Cengage Learning.
2. Chris McNab Network Security Assessment, O'Reilly.

Reference Books:

1. John W. Rittinghouse and William N. Hancock, Cyber Security Operations handbook, Digital Press.
2. The Information Technology 2000(No. 21 of 2000) -Bare Act
3. Lech J. Andrew M. Colarik, Cyber Warfare and Cyber Terrorism, IGI Global.

CA558A3 **(2L + 1T Hrs./week)**

COMPUTER ORGANIZATION AND ARCHITECTURE

Questions to be set: 05 (All Compulsory)

Objective: The main objectives of this course are to develop an understanding of the functional blocks of a computer and the inter-relation between them. Covered in-sync with the course on Microprocessors, these two courses enable the learner to co-relate and build a complete picture of the machine and its working under microprocessor and multiprocessor systems.

Pre-requisites: Digital Circuits & Logic Design, PC hardware & peripherals.

Course Outcomes (CO):

CO1	Students will have the understanding of computer organization and architecture.
CO2	Students will be able to interpret data expressed in binary, decimal, and hexadecimal.
CO3	Students will have the knowledge to use assembly language procedures and macros.
CO4	Students will be able to understand the various components and steps followed for execution of computer programs and design and implement better code.
CO5	Students will be able to understand and evaluate different system architectures.

Module	Topics to be covered	Topics	Hrs.
Module 1: Basic structure of computers	in class	Functional units, Basic operational concepts, Bus structures, Memory locations, Encoding of information, Main memory operations, Addressing modes, Program sequencing, Basic Input-Output operations, Memory reference, Register reference, Input-Output reference instructions, Register stack, Memory stack, Subroutines.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: The Processing Unit	in class	Fetching a word from memory, Storing a word in memory, Register transfers, Performing an arithmetic or logic operation, Instruction format–Three, Two, One and Zero address instruction, Execution of a complete instruction, Control Unit-hardwired control, Micro programmed control.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Arithmetic	in class	Number representation, Fixed point addition and subtraction, Design of fast adders, Multiplication of fixed point numbers, Booth's multiplication, Integer division, Floating point numbers and operations.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Module 4: Memory organization	in class	A review of random and serial access memories, Basic concept of main memory-static and dynamic memory, Memory hierarchies-cache memory, Virtual memory, Logical to physical memory mapping.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Input and output organization	in class	Accessing I/O devices interrupt, Enabling and disabling interrupts, Handling multiple devices, Controlling device requests, Direct memory access, I/O hardware- processor bus, Interface circuits, Standard I/O interfaces.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. V. C. Hamacher, Zaky, Vranesic, Computer Organization, Tata McGraw Hill.
2. Morris Mano, Computer System Architecture, PHI.

Reference Books:

1. J. P. Hayes, Computer Architecture & Organization, Tata McGraw Hill.
2. P .Pal Choudhury, Computer Designing & Architecture, PHI.
3. William Stallings, Computer organization & Architecture – Designing for Performance, Pearson Education.
4. D. A. Patterson and J. L. Hennessy, Computer Organization and Design-The Hardware/ Software Interface, Morgan Kaufmann.

CA559A3 **(2L + 1T Hrs./week)**

PYTHON PROGRAMMING

Questions to be set: 05 (All Compulsory)

Objective: Python is a powerful, versatile cross-platform programming language that has a strong presence in diverse software engineering disciplines including web development, information security, network scripting, data science, and embedded systems. This course will provide a pragmatic and hands-on introduction to the Python programming language, with a focus on practical applications and projects, rather than theoretical topics.

Pre-requisites: Programming skill.

Course Outcomes (CO):

CO1	Students will have the understanding of computer organization and architecture.
CO2	Students will be able to interpret data expressed in binary, decimal, and hexadecimal.
CO3	Students will have the knowledge to use assembly language procedures and macros.
CO4	Students will be able to understand the various components and steps followed for execution of computer programs and design and implement better code.
CO5	Students will be able to understand and evaluate different system architectures.

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction and Basics	in class	Introduction, Features, Lexical Structure, Data Type, Variables, Numbers, Strings, Expression and Operators, Numeric Operations, Conditional Statements, Looping, Control flow Statements, Introduction to List and Tuple, Accessing List and Tuple, Operations, working with List and Tuple Build-in Function and Methods, Working with dictionaries, properties and Methods.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Functions and Objects	in class	Defining a function, calling a function, Types of functions, Function Arguments, Anonymous functions, Defining Your Own Functions, Scope, Passing Functions to a Function, Defining Class, Creating Object, Inheritance, Overloading and Overriding, Data Hiding, Polymorphism. File Objects, File Built-in Function, File Built-in Methods, File Built-in Attributes, Standard Files, Command-line Arguments, File System, File Execution, Persistent Storage Modules.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Module 3: Files, Error and Exceptions	in class	File Objects, File Built-in Function, File Built-in Methods, File Built-in Attributes, Standard Files, Command-line Arguments, File System, File Execution, Persistent Storage Modules. Exceptions in Python, Exceptions as Strings, Raising Exceptions, Assertions, Standard Exceptions, Run Time Errors, The Exception Model, Exception Hierarchy, Handling Multiple Exceptions.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Data Wrangling and Data Aggregation	in class	Combining and Merging DataSets, Reshaping and Pivoting, Data Transformation, String Manipulation, Regular Expressions, Data Aggregation, Group wise Operations and Transformations, Pivot, Tables and Cross Tabulations	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Web Scraping	in class	Data Acquisition by Scraping web applications – Submitting a form - Fetching web pages, Downloading web pages through form submission, CSS Selectors.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Mark Lutz, “Programming Python”, O'Reilly Media, 4th edition, 2010.
2. Mark Lutz, “Learning Python”, O'Reilly Media, 5th Edition, 2013.

Reference Books:

1. Tim Hall and J-P Stacey, “Python 3 for Absolute Beginners”, Apress, 1st edition, 2009.
2. Magnus Lie Hetland, “Beginning Python: From Novice to Professional”, Apress, Second Edition, 2005.
3. Shai Vaingast, “Beginning Python Visualization Crafting Visual Transformation Scripts”, Apress, 2nd edition, 2014.
4. Wes Mc Kinney, “Python for Data Analysis”, O'Reilly Media, 2012.

CA560A3 **(2L + 1T Hrs./week)**

ANGULAR JS, REACT JS AND VUE JS

Questions to be set: 05 (All Compulsory)

Objective: To make the students familiar with the frameworks of JavaScript that are popular in the market today. The course intends to provide students a thorough insight into developing applications using different JavaScript frameworks so that they become industry ready upon completion of the course.

Pre-requisites: HTML basics, Programming concepts.

Course Outcomes (CO):

CO1	Students will have the understanding of basic concepts of Angular, Architecture of angular, Structure of Angular projects, Creating Components & Directives
CO2	Students will be able to understand the fundamentals of TypeScript, Assertions, Access Modifiers, Properties and Modules.
CO3	Students will have the knowledge of React JS Fundamental I, Setting Up the environment, Components, Embedding expression, Conditional Rendering and Handling Events.
CO4	Students will understand the React JS advanced version of Fundamental II, composing components, Props vs State, Mounting & Unmounting phase.
CO5	Students will understand the Vue JS Fundamental I & II, Data & Methods, Data Binding, Computed Properties, Conditionals, Component CSS, HTTP requests and Routing

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction to Angular JS	in class	Introduction to Angular, Architecture of Angular Apps, Setting Up the Development Environment, Structure of Angular Projects, Webpack, Angular Version History, Building Blocks of Angular Apps, Creating Components, Generating Components Using Angular CLI, Templates, Directives, Services, Dependency Injection, Generating Services Using Angular CLI	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Introduction to TypeScript and ReactJS	in class	TypeScript Fundamentals, Declaring Variables, Types, Type Assertions, Arrow Functions, Interfaces, Classes, Objects, Constructors, Access Modifiers, Access Modifiers in Constructor, Parameters, Properties, Modules. What is React, Setting Up the Development Environment, Your First React App, Components, Setting Up the Project, Your First React Component, Specifying Children, Embedding Expressions, Setting Attributes, Rendering Classes Dynamically, Rendering Lists, Conditional Rendering, Handling Events, Binding	[8]

		Event Handlers, Updating the State, What Happens When State Changes, Passing Event Arguments	
	Assignment Topics	To be provided by the concern faculty members	
Module 3: React JS Fundamentals	in class	Composing Components, Passing Data to Components, Passing Children, Debugging React Apps, Props vs State, Raising and Handling Events, Updating the State, Single Source of Truth, Removing the Local State, Multiple Components in Sync, Lifting the State Up, Stateless Functional Components, Destructuring Arguments, Lifecycle Hooks, Mounting Phase, Updating Phase, Unmounting Phase	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Vue JS Fundamentals I	in class	Introduction, The Vue Instance, Data & Methods, Data Binding, Events, Event Modifiers, Keyboard Events, Two-Way Data Binding, Computed Properties, Dynamic CSS Classes, Conditionals, Looping with v-for, Multiple Vue Instances, Intro to Components, Refs, The Vue CLI, Vue Files & The Root Component, Nesting Components, Component CSS, Nesting Components Examples	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Vue JS Fundamentals II	in class	Props, Primitive vs Reference Types, Events, The Event Bus, Life-cycle Hooks, Slots, Dynamic Components, Input Binding, Checkbox Binding, Select Box Binding, HTTP Requests, GET Requests, Custom Directives, Filters, Custom Search Filter, Registering Things Locally, Mixins, Setting up Routing, Hash vs History (Routing), Adding Router Links, Route Parameters, Posting to Firebase, Retrieving Posts from Firebase	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. AngularJS: Up and Running: Enhanced Productivity with Structured Web Apps, Brad Green and Shyam Seshadri
2. Learning React: Functional Web Development with React and Redux, Alex Banks and Eve Porcello
3. Vue.js: Up and Running: Building Accessible and Performant Web Apps, Callum Macrae

Reference Books:

1. AngularJS Web Application Development Cookbook, Matt Frisbie
2. Learning React: A Hands-On Guide to Building Web Applications Using React and Redux, Kirupa Chinnathambi
3. Fullstack Vue: The Complete Guide to Vue.js, Ari Lerner, Hassan Djirdeh, and Nate Murray.

GROUP ELECTIVE SPECIALIZATION
DATA SCIENCE

(COURSE CURRICULUM)

CA561A3 **(2L + 1T Hrs./week)**

DATA SCIENCE

Questions to be set: 05 (All Compulsory)

Objective: The objective of this course is to introduce students to the foundational concepts and practical techniques of data science, focusing on data analysis, preprocessing, transformation, and visualization. Students will gain knowledge of statistical methods, data mining, and data representation using Python libraries to derive meaningful insights and develop effective data-driven solutions.

Prerequisites: Basic knowledge of programming, preferably in Python, Fundamental understanding of mathematics and statistics, Familiarity with computer operations and data structures

Course Outcomes:

CO1	Understand fundamental concepts, benefits, and processes of data science.
CO2	Apply statistical techniques to describe and analyze various data types.
CO3	Perform data preprocessing including missing value handling, PCA, and clustering.
CO4	Evaluate and apply data transformation and discretization methods for analysis.
CO5	Create effective data visualizations using Python libraries like Matplotlib, Pandas, and Seaborn

Modules	Topics to be covered	Topics	Hrs.
Module 1: Introduction	in class	Data Science: Benefits and uses – facets of data - Data Science Process: Overview – Defining research goals – Retrieving data – Data preparation - Exploratory Data analysis – build the model– presenting findings and building applications - Data Mining - Data Warehousing – Basic Statistical descriptions of Data	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Describing Data	in class	Attributes and its types, Discrete versus Continuous Attributes, Describing Data with Tables and Graphs – Describing Data with Averages - Describing Variability - Normal Distributions and Standard (z) Scores. Data Matrix versus Dissimilarity Matrix, Proximity Measures for Nominal Attributes, Proximity Measures for Binary Attributes, Dissimilarity of Numeric Data: Minkowski Distance, Proximity Measures for Ordinal Attributes, Dissimilarity for Attributes of Mixed Types, Cosine Similarity	[8]

	Assignment Topics	To be provided by the concern faculty members	
Module 3: Data Preprocessing	in class	Missing Values, Noisy Data, Data Cleaning, Entity Identification Problem, Redundancy and Correlation Analysis, Data Reduction Strategies, Wavelet Transforms, Principal Components Analysis, Attribute Subset Selection, Regression and Log-Linear Models: Parametric Data Reduction, Histograms, Clustering, Sampling strategies.	[9]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Data Transformation & Discretization	in class	Data Transformation Strategies Overview, Data Transformation by Normalization, Discretization by Binning, Discretization by Histogram Analysis, Discretization by Cluster, Decision Tree, and Correlation Analyses, Concept Hierarchy Generation for Nominal Data	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Data Representation through Python Libraries	in class	Basics of Numpy arrays –aggregations –computations on arrays –comparisons, masks, Boolean logic – fancy indexing – structured arrays – Data manipulation with Pandas – data indexing and selection , Importing Matplotlib – Line plots – Scatter plots – visualizing errors – density and contour plots – Histograms – legends – colors – subplots – text and annotation – customization – three dimensional plotting - Geographic Data with Basemap - Visualization with Seaborn.	[9]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Jiawei Han, Micheline Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann.
2. Cathy O Neil, Rachel Schutt, 2014, “Doing Data Science-Straight Talk from the Frontline”, Orielly

Reference Books:

1. Peter Bruce, Andre Bruce, Practical Statistics for Data Scientists, Orielly Series
2. Kelleher John D. and Tierney Brendan, Data Science, MIT Press
3. Monika Bansal, Munish Jindal, Harmandeep Kaur, Vishal Goyal, Data Science using Python, D.P.S. Publishing House
4. Vijay Kotu, Bala Deshpande, Bala Deshpande, Vijay Kotu, Data Science: Concepts and Practice, Morgan Kaufmann Publishers

CA651A3 **(2L + 1T Hrs./week)**

STATISTICAL FOUNDATIONS OF DATA SCIENCE

Questions to be set: 05 (All Compulsory)

Objectives: The course aims to build a strong foundation in probability, statistical inference, and data analysis techniques. Students will learn to summarize data, model uncertainty, perform hypothesis testing, and apply regression and computational methods, enabling them to make informed, data-driven decisions in real-world applications.

Pre-requisites: Mathematical concepts.

Course Outcomes (CO):

CO1	To understand fundamental concepts of probability and statistics.
CO2	To analyze and visualize data using descriptive techniques.
CO3	To apply statistical inference methods like estimation and hypothesis testing.
CO4	To use regression and ANOVA for data modeling.
CO5	To implement computational techniques such as bootstraps and cross-validation.

Module	Topics to be covered	Topics	Hrs
Module 1: Descriptive Statistics	in class	Elements of descriptive statistics, averages, dispersion, skewness, quantiles; graphical displays, pie charts, bar charts, histograms, scatter plots, box plots, steam and leaf plots.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Probability & Random variables	in class	Probability spaces, conditional probability, independence; Random variables, distribution functions, probability mass and density functions, functions of random variables, standard univariate discrete and continuous distributions; Mathematical expectations, moments, moment generating functions, inequalities; Multidimensional random variables, joint, marginal and conditional distributions, conditional expectations, independence, covariance, correlation, standard multivariate distributions, functions of multidimensional random variables; Forms of convergence, law of large numbers, central limit theorem.	[12]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Estimation & Inference	in class	Sampling distributions; Point estimation - estimators, minimum variance unbiased estimation, maximum likelihood estimation, method of moments estimation, Cramer -Rao inequality, consistency;	[12]

		Interval estimation; Testing of hypotheses – tests and critical regions, Neymann-Pearson lemma, uniformly most powerful tests, likelihood ratio tests.	
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Statistical Modeling	in class	Linear regression, ANOVA, discriminant analysis.	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Statistical Computing	in class	Computing techniques, cross-validation, bootstrap re-sampling.	[6]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Fundamentals of Mathematical Statistics by S.C. Gupta and V.K. Kapoor, published by Sultan Chand & Sons, 12th Revised Edition, 2020
2. Introduction to Probability Theory and Statistical Inference by B.R. Bhat, published by New Age International Publishers, 3rd Edition, 2014.

Reference Books:

1. Statistical Methods by S.P. Gupta, published by Sultan Chand & Sons, 44th Revised Edition, 2019
2. Applied Statistics by R.S.N. Pillai and Bagavathi, published by S. Chand Publishing, 3rd Edition, 2010

CA652A3 **(2L + 1T Hrs./week)**

DATA WAREHOUSING AND DATA MINING

Questions to be set: 05 (All Compulsory)

Objective: This course is indent for understanding the techniques behind the recent development in data warehousing and data mining. The data warehousing part of the module aims to give students a good overview of the ideas and the techniques, which are behind recent developments in the data warehousing and On Line Analytical Processing (OLAP) fields, in terms of data models, query languages, conceptual design methodologies, and storage techniques. The data mining part discusses various tools and techniques used to find out the interesting patterns from data.

Pre-requisites: Data structures, Concepts of Algorithms, Fundamentals of probability & statistics and programming skills

Course Outcomes (CO):

CO1	Students will understand basic concepts of Angular, Architecture of angular, Structure of Angular projects, Creating Components & Directives
CO2	Students will be able to understand the fundamentals of TypeScript, Assertions, Access Modifiers, Properties and Modules.
CO3	Students will have knowledge of React JS Fundamental I, Setting Up the environment, Components, Embedding expression, Conditional Rendering and Handling Events.
CO4	Students will understand the React JS advanced version of Fundamental II, composing components, Props vs State, Mounting & Unmounting phase.
CO5	Students will understand the Vue JS Fundamental I & II, Data & Methods, Data Binding, Computed Properties, Conditionals, Component CSS, HTTP requests and Routing

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction of Data Warehousing and Data Mining	in class	Introduction, Definition, Multidimensional data transformation, OLAP operations, Warehouse schema, Warehouse Server, Meta data, OLAP engine. KDD vs. DM, DBMS vs. DM, DM techniques, Issues and challenges in DM, DM applications.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Data Pre-processing	in class	Data objects and attribute types, basic statistical descriptions of data, data visualization mechanisms, measuring data similarity and dissimilarity. Data Quality, Major tasks of data pre-processing, Data Cleaning, Data Integration, Data Reduction, Data transformation and discretization.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Module 3: Supervised and unsupervised Learning	in class	Basic Concepts, Decision tree induction, Tree pruning, Extracting classification rules from decision trees, Decision tree construction algorithms, Decision tree construction with pre-sorting. Clustering analysis, Types of data in cluster analysis, Partitioning algorithms, Hierarchical, Density based, Grid based, Model based algorithms, High dimensional & Categorical data clustering.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Outlier Detection	in class	Outliers and Outliers analysis, Outlier detection methods, statistical approaches, proximity-based approaches, clustering and classification-based approaches, Outlier detection in high dimensional data.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Unstructured Data Mining	in class	Text mining, Web mining, spatial data mining, Multimedia data mining.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Jiawei Han, Micheline Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann.
2. A K Pujari, Data Mining Concepts, University Press.

Reference Books:

1. Ian H. Witten, Eibe Frank, Data Mining Practical Machine Learning Tools and Techniques with Java Implementations, Morgan Kaufmann Publishers.
2. Alex Berson, Stephen J. Smith, Data Warehousing, Data Mining and OLAP, Tata McGrawHill.
3. Richard O. Duda, Peter E. Hart, Pattern Recognition and Scene Analysis, Wiley.
4. VikramPudi, P. Radha Krishna, Data Mining, Oxford University Press.

CA653A3 **(2L + 1T Hrs./week)**

DATA ANALYTICS USING PYTHON

Questions to be set: 05 (All Compulsory)

Objectives: Data, which is available in abundance and in accessible forms, if analysed in an efficient manner unfolds many patterns and promising solutions. Data has to be pre-processed, converted to required format and fed to appropriately chosen algorithm to yield better results. This course aims at applying such techniques to raw data, using Python, to arrive at meaningful results.

Pre-requisites: Programming knowledge, Data structures, Design and analysis of algorithms

Course Outcomes (CO):

CO1	To understand basic programming concepts, statements, and functions.
CO2	To work with numeric types, strings, tuples, lists, and classes in Python.
CO3	To read, write, and process text and binary files.
CO4	To perform data manipulation, aggregation, and time series analysis.
CO5	To create data visualizations and scrape data from web pages using Python.

Module	Topics to be covered	Topics	Hrs.
Module 1: Python Concepts, Data Structures, Classes	in class	Interpreter, Program Execution, Statements, Expressions, Flow Controls, Functions -Numeric Types, Sequences - Strings, Tuples, Lists and - Class Definition, Constructors, Inheritance, Overloading, Text & Binary Files - Reading and Writing.	[10]
	Assignment Topics	To be provided by the concerned faculty members	
Module 2: Data Wrangling	in class	Combining and Merging DataSets, Reshaping and Pivoting, Data Transformation, String Manipulation, Regular Expressions.	[7]
	Assignment Topics	To be provided by the concerned faculty members	
Module 3: Data Aggregation, Group Operations & Time Series	in class	Data Aggregation, Group Operations: GoupBy Mechanics, Data Aggregation, Group wise Operations and Transformations, Pivot, Tables and Cross Tabulations. Time Series: Date and Time Date Type tools, Time Series Basics, Data, Ranges, Frequencies and Shifting.	[7]
	Assignment Topics	To be provided by the concerned faculty members	

Module 4: Web Scraping	in class	Web Scraping: Data Acquisition by Scraping web applications –Submitting a form - Fetching web pages, Downloading web pages through form submission, CSS Selectors.	[8]
	Assignment Topics	To be provided by the concerned faculty members	
Module 5: Visualization in Python	in class	Visualization in Python: Matplotlib package, Plotting Graphs, Controlling Graph, Adding Text, More Graph Types, Getting and setting values, Patches.	[8]
	Assignment Topics	To be provided by the concerned faculty members	

Textbooks

1. Mark Lutz, “Programming Python”, O'Reilly Media, 4th edition, 2010.
2. Mark Lutz, “Learning Python”, O'Reilly Media, 5th Edition, 2013.

Reference Books

1. Tim Hall and J-P Stacey, “Python 3 for Absolute Beginners”, Apress, 1st edition, 2009.
2. Magnus Lie Hetland, “Beginning Python: From Novice to Professional”, Apress, Second Edition, 2005.
3. Shai Vaingast, “Beginning Python Visualization Crafting Visual Transformation Scripts”, Apress, 2nd edition, 2014.
4. Wes Mc Kinney, “Python for Data Analysis”, O'Reilly Media, 2012.

CA654A3 **(2L + 1T Hrs./week)**

MACHINE LEARNING

Questions to be set: 05 (All Compulsory)

Objectives: This course is indent for understanding the core techniques behind the recent development in machine learning and pattern recognition. The machine learning part of the module aims to give students a good overview of the supervised classification mechanisms, which is the heart of pattern recognition. Further the machine learning is helpful for pattern recognition.

Pre-requisites: Fundamentals of probability & statistics and programming skills, data mining concepts.

Course Outcomes (CO):

CO1	Students will be able to understand the techniques behind the recent development in supervised classification
CO2	Students will be able to implement classification and outlier analysis program.
CO3	Students will be able to design small projects in related field.
CO4	Students will be able to learn the concepts in Bayesian analysis from probability models and methods
CO5	Students will be able to characterize the machine learning algorithms as supervised learning and unsupervised learning and apply and analyse the various algorithms of supervised and unsupervised learning

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction & Decision Tree Learning	in class	Machine learning and its applications, Analysing Supervised and unsupervised learning, Designing a learning system, Issues of machine learning. Decision tree representation, Characteristics of decision trees, Basic decision tree algorithm, Inductive bias in decision tree, Issues in decision tree: Avoiding Overfitting the Data, Reduced error pruning, Rule post pruning, Incorporating Continuous-Valued Attributes, Alternative Measures for Selecting Attributes, Handling Training Examples with Missing Attribute Values, Handling Attributes with Differing Costs	[8]
	Assignment Topics	To be provided by the concern faculty members.	
Module 2: Artificial Neural Networks & Bayesian Learning	in class	Biological motivation, Neural network representations, Appropriate problems for neural network learning, Perceptron, Multilayer networks and the backpropagation, Hidden Layer Representation Bayes Theorem, Concept learning, Maximum likelihood and least-squared error hypotheses, Maximum likelihood hypotheses for predicting probabilities, Minimum description length	[8]

		principle, Bayes optimal classifier, Gibbs algorithm, Naïve Bayes Classifier, Bayesian belief network, The EM algorithm	
	Assignment Topics	To be provided by the concern faculty members.	
Module 3: Instance based learning	in class	*k*-Nearest neighbour learning, Distance weighted nearest neighbour algorithm, Locally Weighted Regression, Radial Basis Function, Case based reasoning, Lazy vs Eager Learning.	[6]
	Assignment Topics	To be provided by the concern faculty members.	
Module 4: Genetic Algorithm & Learning sets of rules	in class	Basic Concepts and the algorithm, Genetic operators, Fitness function and selection, Hypothesis space search, Lamarckian Evolution, Baldwin Effect. Sequential covering algorithms, Learn one rule algorithm, Evaluation functions of learn one rule algorithm, Learning first order rules, learning sets of first-order rules: FOIL, Guiding the Search in FOIL, PROGOL,	[10]
	Assignment Topics	To be provided by the concern faculty members.	
Module 5: Analytical Learning	in class	Basic concepts, Inductive and Analytical Learning Problems, Learning with perfect domain theories: PROLOG-EB, Properties of explanation-based learning, Explanation-based learning of search control knowledge.	[8]
	Assignment Topics	To be provided by the concern faculty members.	

Textbooks:

1. Tom M. Mitchell, Machine Learning, McGraw-Hill Publishers
2. Ethem Alpaydın, Introduction to Machine Learning, The MIT Press Cambridge, Massachusetts, London, England

Reference Books:

1. Ian H. Witten, Eibe Frank, Data Mining Practical Machine Learning Tools and Techniques with Java Implementations, Morgan Kaufmann Publishers.
2. Sunila Gollapudi, Practical Machine Learning, Packt publication.
3. Richard O. Duda, Peter E. Hart, Pattern Recognition and Scene Analysis, Wiley.
4. Kevin P. Murphy, Machine Learning: A Probabilistic Perspective (Adaptive Computation and Machine Learning series), MIT Press.

CA655A3 **(2L + 1T Hrs./week)**

SECURITY AND PRIVACY FOR DATA SCIENCE

Questions to be set: 05 (All Compulsory)

Objectives: This course introduces foundational data science concepts with a focus on privacy. It explores privacy-preserving techniques such as tabular anonymization and differential privacy, along with advanced matrix and wavelet-based methods. Students will also study privacy risks and mitigation strategies in collaborative, distributed, and social network environments.

Pre-requisites: Basic programming knowledge; Fundamental understanding of data mining concepts

Course Outcomes (CO):

CO1	Demonstrate understanding of key data mining tasks and the importance of privacy in data science.
CO2	Apply privacy-preserving data mining techniques such as k-anonymity and differential privacy.
CO3	Analyze matrix decomposition and wavelet-based methods for secure data representation.
CO4	Evaluate various privacy attacks and develop strategies for defense.
CO5	Examine privacy-preserving techniques in social network data analysis and collaborative systems.

Modules	Topics to be covered	Topics	Hrs.
Module 1: Fundamentals of Data Science and Data Mining	in class	Introduction to Data Science: Definition, Scope, and Applications, The Data Science Process: Collection, Cleaning, Exploration, Modeling, and Interpretation, Introduction to Data Mining: Key Concepts and Techniques, Types of Data and Data Attributes, Data Preprocessing: Cleaning, Integration, Reduction, and Transformation, Overview of Classification, Clustering, and Association Rule Mining, Tools and Technologies in Data Science and Mining (e.g., Python, R, WEKA)	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Privacy-Preserving Concepts in Data Science and Data Mining	In class	Importance of Data Privacy in Data Mining, Data Privacy Threats and Risks, Privacy-Preserving Data Mining (PPDM): Introduction and Goals, Tabular Data Anonymization Techniques: k-Anonymity, l-Diversity, t-Closeness, Introduction to Differential Privacy: Concept and Mechanisms (Laplace, Exponential), Cryptographic Approaches to PPDM (e.g., Secure Multiparty Computation), Federated	[8]

		Learning and Privacy in Distributed Environments, Regulatory and Ethical Considerations (GDPR, HIPAA)	
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Tabular Privacy-Preserving Techniques	in class	▪ k-Anonymity: Concepts and models ▪ Microdata release and identity protection ▪ Incognito: Efficient Full-Domain K-Anonymity ▪ Mondrian Multidimensional K-Anonymity ▪ Anatomy-based privacy preservation ▪ Differential Privacy: Principles and application	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Advanced Techniques in Privacy-Preserving	in class	Matrix Decomposition Techniques: Need and benefits, Singular Value Decomposition (SVD), Nonnegative Matrix Factorization (NMF), Applications in PPDM, Wavelet Analysis Techniques: Introduction and benefits, Privacy in collaborative data analysis, Statistical and experimental analysis using wavelets	[10]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Privacy Attacks and Social Network Privacy	in class	Background and types of privacy attacks, General data perturbation model, Data privacy attack models, Privacy challenges in social network analysis, Clustering-based and heuristic algorithms, Data privacy vs data utility in social networks	[10]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Rajendra Akerkar, Priti Srinivas Sajja, Intelligent Techniques for Data Science, Springer
2. Yaniv Altshuler et al., Security and Privacy in Social Networks, Springer

Reference Books:

1. David Salomon, Data Privacy and Security, Springer
2. Bhavani Thuraisingham et al., Big Data Analytics with Applications in Insider Threat Detection, CRC Press

CA656A3 **(2L + 1T Hrs./week)**

IMAGE ANALYTICS AND VISUALIZATION

Questions to be set: 05 (All Compulsory)

Objectives: To provide a comprehensive foundation in the principles and applications of digital image processing. The curriculum is designed to develop both theoretical knowledge and practical skills essential for applications in fields such as computer vision, medical imaging, remote sensing, and multimedia systems.

Pre-requisites: Familiarity with algorithms, data structures, and digital imaging fundamentals will also help in comprehending advanced image processing techniques

Course Outcomes (CO):

CO1	Explain the essentials of digital image processing.
CO2	Describe various segmentation techniques for image analysis.
CO3	Outline the various feature extraction techniques for image analysis.
CO4	Discuss the concepts of image registration and fusion
CO5	Illustrate 3D image visualization.

Module	Topics to be covered	Topics	Hrs.
Module 1: Image Processing Fundamentals	in class	Introduction – Elements of visual perception, Steps in Image Processing Systems – Digital Imaging System - Image Acquisition – Sampling and Quantization – Pixel Relationships – File Formats – colour images and models - Image Operations – Arithmetic, logical, statistical and spatial operations. Elements of visual perception- brightness adaptation, Mach band effect. Image enhancement in spatial and frequency domain, Histogram equalization.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Segmentation	in class	Edge detection, Thresholding, Region growing, Fuzzy clustering, Watershed algorithm, Active contour models, Texture feature-based segmentation, Graph based segmentation, Wavelet based Segmentation - Applications of image segmentation.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Module 3: Feature Extraction	in class	First and second order edge detection operators, Phase congruency, Localized feature extraction -detecting image curvature, shape features, Hough transform, shape skeletonization, Boundary descriptors, Moments, Texture descriptors- Autocorrelation, Co-occurrence features, Run length features, Fractal model-based features, Gabor filter, wavelet features.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Registration And Image Fusion	in class	Registration - Preprocessing, Feature selection - points, lines, regions and templates Feature correspondence - Point pattern matching, Line matching, Region matching, Template matching. Transformation functions - Similarity transformation and Affine Transformation. Resampling – Nearest Neighbor and Cubic Splines. Image Fusion - Overview of image fusion, pixel fusion, wavelet-based fusion -region based fusion.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: 3D Image Visualization	in class	Sources of 3D Data sets, Slicing the Data set, Arbitrary section planes, The use of color, Volumetric display, Stereo Viewing, Ray tracing, Reflection, Surfaces, Multiple connected surfaces, Image processing in 3D, Measurements on 3D images	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing', Pearson, Education, Inc., Second Edition, 2004.
2. Mark Nixon, Alberto Aguado, "Feature Extraction and Image Processing", Academic Press,2008.

Reference Books:

1. Ardeshir Goshtasby, "2D and 3D Image registration for Medical, Remote Sensing and Industrial Applications", John Wiley and Sons,2005.
2. John C. Russ, "The Image Processing Handbook", CRC Press,2007.
3. Anil K. Jain, Fundamentals of Digital Image Processing', Pearson Education, Inc., 2002

CA657A3 **(2L + 1T Hrs./week)**

DEEP LEARNING

Questions to be set: 05 (All Compulsory)

Objectives: To make the students familiar understand the foundations of Deep Learning, understand how to build neural networks. The students will learn about Convolutional networks, RNNs, Deep unsupervised learning and more.

Pre-requisites: Machine Learning, Programming concepts.

Course Outcomes (CO):

CO1	Students will be able to understand the concepts of deep learning.
CO2	Students will be able to understand to build Deep Learning projects.
CO3	Students will be able to apply the concepts of Deep Learning on case studies in the field of healthcare, autonomous driving and many more.
CO4	Students will be able to understand and distinguish between different algorithms, choose appropriate one as per the requirement and evaluate their performance.
CO5	Students will be able to analyse problems and implement Deep Learning solutions.

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction & Neural Networks	in class	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 Feedforward Neural Networks, Backpropagation.	[8]
	Assignment Topics	To be provided by the concern faculty members.	
Module 2 Gradient Descent & Convolutional Neural Networks (CNN)	in class	Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam, Eigenvalues and eigenvectors, Eigenvalue Decomposition. Convolutional Neural Networks, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet, Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks.	[8]
	Assignment Topics	To be provided by the concern faculty members.	
Module 3: Recurrent	in class	Recurrent Neural Networks, Backpropagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, GRU, LSTMs	[6]

Neural Networks	Assignment Topics	To be provided by the concern faculty members.	
Module 4: Object detection & Applications of Deep Learning to Computer Vision	in class	Object Localization, Landmark Detection, Object Detection, Convolutional Implementation of Sliding Windows, Bounding Box Predictions, Intersection Over Union, Non-max Suppression, Anchor Boxes, YOLO Algorithm Image segmentation, object detection, automatic image captioning, Image generation with Generative adversarial networks, video to text with LSTM models. Attention models for computer vision tasks.	[10]
	Assignment Topics	To be provided by the concern faculty members.	
Module 5: Applications of Deep Learning to NLP	in class	Introduction to NLP and Vector Space Model of Semantics, Word Vector Representations: Continuous Skip-Gram Model, Continuous Bag-of-Words model (CBOW), Glove, Evaluations and Applications in word similarity, analogy reasoning.	[8]
	Assignment Topics	To be provided by the concern faculty members.	

Textbooks:

1. Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms, Nicholas Locascio and Nikhil Buduma
2. Deep Learning, Aaron Courville, Ian Goodfellow, and Yoshua Bengio

Reference Books:

1. Deep Learning: A Practitioner's Approach, Adam Gibson and Josh Patterson
2. Deep Learning with Python, François Chollet

CA658A3 **(2L + 1T Hrs./week)**

NATURAL LANGUAGE PROCESSING

Questions to be set: 05 (All Compulsory)

Objectives: his course aims to provide a comprehensive understanding of human language processing techniques. Students will explore text representation, encoding schemes, statistical models, syntactic and semantic analysis, and machine learning approaches. The course also covers NLP applications like machine translation, named entity recognition, and part-of-speech tagging.

Pre-requisites: Basic computing, Algorithm basics

Course Outcomes (CO):

CO1	To understand the fundamental concepts of human language processing.
CO2	To learn text representation techniques and encoding schemes.
CO3	To apply statistical models like HMM, SVM, and CRF for NLP tasks.
CO4	To master part-of-speech tagging and handling linguistic data.
CO5	To explore NLP applications, including machine translation and semantic analysis.

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction	in class	Human languages, models, ambiguity, processing paradigms; Phases in natural language processing, applications. Text representation in computers, encoding schemes	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Linguistics Resources	in class	Introduction to corpus, elements in balanced corpus, TreeBank, PropBank, WordNet, VerbNet etc. Resource management with XML, Management of linguistic data with the help of GATE, NLTK. Regular expressions, Finite State Automata, word recognition, lexicon. Morphology, acquisition models, Finite State Transducer. N-grams, smoothing, entropy, HMM, ME, SVM, CRF.	[10]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Part of Speech Tagging	in class	Stochastic POS tagging, HMM, Transformation based tagging (TBL), Handling of unknown words, named entities, multi word expressions. A survey on natural language grammars, lexeme, phonemes, phrases and idioms, word order, agreement, tense, aspect and mood and agreement, Context Free Grammar, spoken language syntax.	[10]
	Assignment Topics	To be provided by the concern faculty members	

Module 4: Parsing and Semantics	in class	Unification, probabilistic parsing, TreeBank. Meaning representation, semantic analysis, lexical semantics, WordNet	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Word Sense Disambiguation	in class	Selectional restrictions, machine learning approaches, dictionary-based approaches. Overview of Machine Translation	[10]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. T V Geetha, Understanding Natural Language Processing (Machine Learning and Deep Learning Perspectives), Pearson Education, 2024
2. Daniel Jurafsky and James H Martin. Speech and Language Processing, 2e, Pearson Education, 2009

Reference Books:

1. James A., Natural language Understanding 2e, Pearson Education, 1994
2. Siddiqui T., Tiwary U. S., Natural language processing and Information retrieval, OUP, 2008

CA659A3 **(2L + 1T Hrs./week)**

BIG DATA ANALYTICS

Questions to be set: 05 (All Compulsory)

Objectives: This course provides an overview of approaches facilitating data analytics on huge datasets. Different strategies are presented including sampling to make classical analytics tools amenable for big datasets, analytics tools that can be applied in the batch or the speed layer of a lambda architecture, stream analytics, and commercial attempts to make big data manageable in massively distributed or in-memory databases. Learners will be able to realistically assess the application of big data analytics technologies for different usage scenarios and start with their own experiments.

Pre-requisites: Fundamentals of data mining concepts

Course Outcomes (CO):

CO1	Students will be able to understand the concepts of Big data.
CO2	Students will be able to understand categorization and modelling.
CO3	Students will be able to practice on incremental learning.
CO4	Students will be able to design an algorithm to solve data intensive problems
CO5	Students will be able to analyze the big data framework like Hadoop and NOSQL to efficiently store and process Big Data to generate analytics

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction to Big Data & Data Mining and modelling	in class	Big data, Challenges of mining unstructured data, Challenges of big data mining, Advanced machine learning and text data mining, Context, Context Building through multi-level data mining, Big data and learning, Analytics and big data, Text analytics and big data, Business intelligence products to handle big data, Big data and machine learning tools. Data models, stages of data mining, Aspect of data mining, Data mining approaches, Crawling the web and information retrieval, current trends.	[8]
	Assignment Topics	To be provided by the concern faculty members.	
Module 2: Big data mining application perspectives & Context of big data	in class	Basic concepts, Data cleaning, Sorting and categorizing data, Protection and security to the data, Data storage technologies, Data mining using pattern analysis with big data, Data mining using classification analysis with big data, Data mining using cluster analysis with big data. Context basics, Importance of context in unstructured big data, Using contextually enabled data, Context types, Identification of context region in Short and	[8]

		large texts, Closeness, Contextual Analytics, Advantages of Contextual Analytics	
	Assignment Topics	To be provided by the concern faculty members.	
Module 3: Big data Text categorization and topic modelling	in class	Text Mining and categorization, Context learning, Corpus representation, Exploiting hyperlink and Linguistic context, GATE JAPE rules, Topic modelling, Situation modelling, Big data and Text classification.	[6]
	Assignment Topics	To be provided by the concern faculty members.	
Module 4: Multilevel Big data Mining & Distributed High Dimensional Data Clustering for Big data	in class	Phases in multilevel unstructured text mining, Graph based model, Graph representation, Text operations using graph model. Distributed subspace clustering, High dimensional data clustering, Dimensionality reduction, Subspace clustering, Distributed systems, Types of distributed databases, Types of transmission of data, Advantages of distributed database systems, Distributed clustering, Text data clustering, Data representations for clustering text data, Text clustering system, Subspace clustering in text data, Big data clustering.	[10]
	Assignment Topics	To be provided by the concern faculty members.	
Module 5: Machine Learning and Incremental Learning with Big data	in class	Machine learning concepts, Big data and machine learning, Incremental learning, Incremental learning for knowledge building, Incremental technique to handle big data, Applications	[8]
	Assignment Topics	To be provided by the concern faculty members.	

Textbooks:

1. Parag Kulkarni, Sarang Joshi, Meta S. Brown, Big data Analytics, PHI Learning
2. Y. Lakshmi Prasad, Big Data Analytics Made Easy, Notion Press

Reference Books:

1. Venkat Ankam, Big data Analytics, Packt Publishing Ltd.
2. Kim H. Pries, Robert Dunnigan, Big Data Analytics: A Practical Guide for Managers, CRC Press.
3. V. B. Aggarwal, Vasudha Bhatnagar, Durgesh Kumar Mishra, Big Data Analytics: Proceedings of CSI 2015, Springer.

CA660A3 **(2L + 1T Hrs./week)**

BUSINESS INTELLIGENCE AND ANALYTICS

Questions to be set: 05 (All Compulsory)

Objectives: This course introduces foundational principles of Business Intelligence, analytics, and decision support systems. It covers decision-making processes, sentiment analysis, and predictive modelling using AI. Students will gain insights into model-based and automated decision systems, including expert systems, enhancing their ability to support data-driven business decisions.

Pre-requisites: Basic understanding of information systems; Familiarity with data handling and spreadsheet tools; Introductory knowledge of Artificial Intelligence and Machine Learning is beneficial

Course Outcomes (CO):

CO1	Explain the role of Business Intelligence and analytics in modern decision-making environments.
CO2	Describe the phases and structure of decision support systems and their implementation.
CO3	Apply neural networks and sentiment analysis techniques to extract actionable insights from data.
CO4	Construct model-based solutions for decision problems using decision trees, tables, and optimization tools.
CO5	Evaluate and implement automated decision systems and expert systems in practical scenarios.

Modules	Topics to be covered	Topics	Hrs.
Module 1: Overview of Business Intelligence, Analytics, and Decision Support	in class	▪ Introduction to information systems support for decision making ▪ Frameworks for computerized decision support ▪ Decision Support Systems (DSS) concepts ▪ Business Intelligence framework ▪ Business Analytics overview ▪ Introduction to Big Data Analytics	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Decision Making Processes and DSS	In class	▪ Introduction and definitions of decision-making ▪ Phases of the decision-making process: Intelligence, Design, Choice, Implementation ▪ Capabilities and classification of Decision Support Systems ▪ Components of DSS	[8]
	Assignment Topics	To be provided by the concern faculty members	

Module 3: Neural Networks and Sentiment Analysis	in class	▪ Neural networks: concepts and development ▪ Black-box explanation through sensitivity analysis ▪ Support Vector Machines and Nearest Neighbor methods ▪ Sentiment analysis: Overview, applications, process ▪ Introduction to speech analytics	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Model-Based Decision Making	in class	▪ DSS modeling concepts and mathematical model structure ▪ Decision-making under certainty, uncertainty, and risk ▪ Spreadsheet-based modeling ▪ Optimization using mathematical programming ▪ Decision tables and decision trees ▪ Multi-criteria decision-making using pairwise comparisons	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Automated Decision Systems and Expert Systems	in class	▪ Introduction to automated decision systems ▪ Artificial Intelligence and expert system fundamentals ▪ Expert system components and development ▪ Applications and knowledge engineering in expert systems	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Sharda, R., Delen, D., & Turban, E. (2014). Business intelligence and analytics: Systems for decision support (10th ed.). Pearson Education.
2. Turban, E., Sharda, R., & Delen, D. (2010). Decision support and business intelligence systems (9th ed.). Pearson Education.
3.

Reference Books:

3. Provost, F., & Fawcett, T. (2013). Data science for business: What you need to know about data mining and data-analytic thinking (1st ed.). O'Reilly Media.
4. Glass, R., & Callahan, S. (2014). The big data-driven business: How to use big data to win customers, beat competitors, and boost profits (1st ed.). Wiley.

GROUP ELECTIVE SPECIALIZATION
CLOUD TECHNOLOGY

(COURSE CURRICULUM)

CA562A3 **(2L + 1T Hrs./week)**

CLOUD COMPUTING

Questions to be set: 05 (All Compulsory)

Objective: This course aims to introduce the fundamental concepts of cloud computing, including its architecture, services, and deployment models. It explores virtualization, scalability, and resource management in cloud environments. Students will also learn about cloud security, service models (IaaS, PaaS, SaaS), and current trends to build practical cloud-based solutions.

Pre-requisites: Operating Systems and Computer Network.

Course Outcomes (CO):

CO1	Understand the foundation of cloud computing and related technologies.
CO2	Understand Cloud platforms and technologies.
CO3	Understand Service Oriented Architecture
CO4	Understand the concept of Virtualization
CO5	Understand the cloud development Services

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction to Cloud Computing	in class	Introduction- Definition, Characteristics, Components, Applications, Pros and cons, Limitations. Need for cloud computing. History/ Evolution of cloud and related technologies- Multi-processing, Distributed computing, Parallel computing to ubiquitous computing. What cloud computing really is and what really isn't? Importance of cloud computing in current era- why cloud computing matters? Who should use cloud computing and who shouldn't use it? Types of cloud computing. Major players in cloud computing.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Cloud Computing Platforms and Technologies	in class	Migrating into the cloud platform- Issues and deployment considerations. Cloud Reference Model, NIST Cloud model, Exploring cloud service models- IaaS, PaaS, SaaS, IDaaS, STaaS, CaaS, and other service models. Deployment models- Private, Public, Community and Hybrid clouds, Cloud-cube model. Cloud computing platforms- Microsoft Azure, Hadoop, Map-reduce, Amazone Web services (AWS)	[8]
	Assignment Topics	To be provided by the concern faculty members	

Module 3: Cloud Computing Architecture	in class	Service Level Agreement (SLA), Understanding cloud architecture, Service Oriented Architecture (SOA), Cloud abstraction and virtualization, Cloud federation, Cloud life cycle.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Virtualization	in class	Virtualization- definition, Implementation levels of virtualization, Virtualization architecture and software. Virtual clustering, Virtual Infrastructure, Virtualization of CPU, Memory, I/O Devices, Application virtualization, Virtualization for data-centre automation. Virtualization and cloud computing, Migrating virtual machines, Pros and cons of virtualization. Para-virtualization, Full-virtualization. Examples- Xen, Microsoft Hyper-V, VMware.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Developing Cloud Services	in class	Web-based application, Pros and cons of cloud service development, Types of cloud service development, cloud development life cycle. Discovering cloud services, Development services and tools, Amazon EC2, Amazon Web services (AWS), Google app engine, IBM blue cloud, Microsoft Azure, Hadoop, Map-reduce, Force.com.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Barrie Sosinsky, Cloud Computing Bible, Wiley.
2. Rajkumar Buyya, James Broberg, Andrzej Goscinski, Cloud Computing– Principles and paradigms, Wiley.
3. Anthony T. Velte, Toby J. Velte, Robert Elsenpeter, Cloud Computing: A Practical Approach, Tata McGraw Hill.
4. Kai Hwang, Geoffrey C Fox, Jack J. Dongarra, Distributed and Cloud Computing: From parallel processing to the Internet of Things, Elsevier.

Reference Books:

1. George Reese, Cloud Application Architectures, O'Reilly.
2. Michael Miller, Cloud computing: Web based applications that change the way you work and collaborate online, Pearson.
3. Lee Gillam, Cloud Computing: Principles, Systems and Applications, Springer.
4. Brian J. S. Chee, Curtis Franklin, Jr., Cloud Computing: Technologies and Strategies of the Ubiquitous Data Center, CRC Press.

CA563A3 **(2L + 1T Hrs./week)**

PRINCIPLES OF CYBER SECURITY

Questions to be set: 05 (All Compulsory)

Course Objectives: This course introduces an overview of the concept of cyber security. The course covers various aspects of cyber security for modern days cyber space. It also covers security risks and measures in social media, e-commerce and digital payments. Various cyber security tools and technologies are also covered in brief. The syllabus has been prepared with an aim to create more aware, responsive and responsible digital citizens, thereby contributing effectively to an overall healthy cyber security posture and ecosystem.

Pre-requisites: Computer Network, Internet.

Course Outcomes (COs):

CO1	Understand basic cyber security terms and threat landscape.
CO2	Explain types of cybercrimes and related legal frameworks.
CO3	Understand personal data privacy and protection measures.
CO4	Identify components of a cyber security plan and compliance needs.
CO5	Use basic security tools to safeguard digital devices.

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction to Cyber security	in class	Defining Cyberspace. Concept of cyber security, Issues and challenges of cyber security. Evolving cyber threat landscape, Cyber security terminologies- Cyberspace, attack, attack vector, attack surface, threat, risk, vulnerability, exploit, exploitation, hacker, non-state actors, Cyber terrorism, Protection of end user machine, Critical IT and National Critical Infrastructure, Cyberwarfare.	[7]
	Assignment Topics	To be provided by the concerned faculty members	
Module 2: Cybercrimes and Cyber Laws	in class	Classification of cybercrimes, Common cybercrimes- cybercrime targeting computers and mobiles, cybercrime against women and children, financial frauds, social engineering attacks, malware and ransomware attacks, zero day and zero click attacks, Cybercriminals modus-operandi, Reporting of cybercrimes, Remedial and mitigation measures, Cybercrime and legal landscape around the world, IT Act 2000 and its amendments. Cybercrime and punishments, Cyber Laws and Legal and ethical aspects related to new technologies- AI/ML, IoT, Blockchain, Darknet and social media, Cyber Laws of other countries	[8]

	Assignment Topics	To be provided by the concerned faculty members	
Module 3: Data Privacy and Data Security	in class	Defining data, meta-data, big data, non-personal data. Data protection, Data privacy and data security, Personal Data Protection Bill and its compliance, Data protection principles, big data security issues and challenges, Data protection regulations of other countries- General Data Protection Regulations (GDPR), 2016 Personal Information Protection and Electronic Documents Act (PIPEDA), social media-data privacy and security issues.	[5]
	Assignment Topics	To be provided by the concerned faculty members	
Module 4: Cyber security Management, Compliance and Governance	in class	Cyber security plan- cyber security policy, cyber crises management plan, Business continuity, Risk assessment, Types of security controls and their goals, Cyber security audit and compliance, National cyber security policy and strategy.	[5]
	Assignment Topics	To be provided by the concerned faculty members	
Module 5: Digital Devices Security, Tools and Technologies for Cyber Security	in class	End Point device and Mobile phone security, Password policy, Security patch management, Data backup, Downloading and management of third-party software, Device security policy, Cyber Security best practices, Significance of host firewall and Anti-virus, Management of host firewall and Anti-virus, Wi-Fi security, Configuration of basic security policy and permissions.	[5]
	Assignment Topics	To be provided by the concerned faculty members	

Textbooks:

1. Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives by Sumit Belapure and Nina Godbole, Wiley India Pvt. Ltd.
2. Security in the Digital Age: Social Media Security Threats and Vulnerabilities by Henry A. Oliver, Create Space Independent Publishing Platform.

Reference Books:

1. Information Warfare and Security by Dorothy F. Denning, Addison Wesley.
2. Data Privacy Principles and Practice by Natraj Venkataramanan and Ashwin Shriram, CRC Press.
3. Information Security Governance, Guidance for Information Security Managers by W. Krag Brothy, 1st Edition, Wiley Publication.
4. Auditing IT Infrastructures for Compliance by Martin Weiss, Michael G. Solomon, 2nd Edition, Jones Bartlett Learning.

CA661A3 **(2L + 1T Hrs./week)**

SCHEDULING IN CLOUD COMPUTING

Questions to be set: 05 (All Compulsory)

Course Objectives: This course introduces the fundamental concepts of scheduling in cloud computing, explores various scheduling algorithms and their practical uses, analyzes key performance metrics and optimization techniques, and examines real-world case studies and emerging trends to provide students with a comprehensive understanding of efficient resource management in cloud environments.

Pre-requisites: Operating System, Algorithms, Basics of Cloud Computing.

Course Outcomes (COs):

CO1	Understand the role and types of scheduling in cloud computing environments.
CO2	Analyze different scheduling algorithms including static and dynamic scheduling algorithms
CO3	Explain advanced scheduling algorithms based on metaheuristic, Machine learning and Energy efficiency.
CO4	Explore workflow scheduling techniques and VM scheduling and resource management.
CO5	Explore recent trends such as AI-based scheduling, serverless computing and container scheduling in cloud and edge computing.

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction to Cloud Computing and Scheduling	in class	Overview of Cloud Computing: Definition, Characteristics, Service Models, Deployment Models. Need for Scheduling in Cloud Computing: Challenges in Cloud Resource Management, Role of Scheduling in Cloud performance. Types of Scheduling: Task Scheduling, Workflow Scheduling, Resource Scheduling. Performance Metrics: Makespan, Response Time, Cost Efficiency, Load Balancing, Energy Consumption.	[7]
	Assignment Topics	To be provided by the concerned faculty members	
Module 2: Static and Dynamic Scheduling Algorithms	in class	Static Scheduling: FCFS, SJF, Round Robin, Min-Min Scheduling, Max-Min Scheduling. Dynamic Scheduling: Priority-Based Scheduling, Deadline-Constrained Scheduling, QoS-Aware Scheduling. Comparative Analysis of Scheduling Algorithms: Strengths and Weaknesses. Suitability for Different Cloud Workloads	[8]
	Assignment Topics	To be provided by the concerned faculty members	

Module 3: Advanced Scheduling Techniques	in class	Metaheuristic-Based Scheduling: Genetic Algorithm (GA), Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO). Machine Learning-Based Scheduling: Reinforcement Learning Reinforcement Learning for Dynamic Workloads, Neural Networks for Predictive Scheduling. Energy-Efficient Scheduling: DVFS (Dynamic Voltage and Frequency Scaling), Thermal-Aware Scheduling.	[5]
	Assignment Topics	To be provided by the concerned faculty members	
Module 4: Workflow Scheduling, VM Scheduling and Resource Allocation	in class	Workflow Scheduling: Directed Acyclic Graph (DAG) Based Models, Critical Path Method (CPM). VM placement Scheduling and Challenges. Load Balancing Strategies: Static, Dynamic and Randomized. Resource overbooking and under-provisioning. SLA-aware and energy-efficient scheduling models. Performance metrics.	[5]
	Assignment Topics	To be provided by the concerned faculty members	
Module 5: Advanced Trends and Research in Scheduling	in class	Serverless Computing and Scheduling: Function-as-a-Service (FaaS) Scheduling Cold Start Problem, Container and serverless computing (e.g., Kubernetes). Edge and fog computing scheduling: Decentralized Scheduling Approaches, Latency-Sensitive Task Allocation. Open research challenges: AI/ML in scheduling, AI-Driven Autonomous Scheduling, Blockchain-Based Scheduling for Trust and Fairness.	[5]
	Assignment Topics	To be provided by the concerned faculty members	

Textbooks:

1. Rajkumar Buyya et al., Cloud Computing: Principles and Paradigms, Wiley.
2. Thomas Erl, Cloud Computing: Concepts, Technology & Architecture, Pearson.

Reference Books:

1. Oliver Sinnen, Task Scheduling for Parallel Systems
2. Albert Zomaya & Young Choon Lee, Energy-Efficient Distributed Computing Systems.

CA662A3 **(2L + 1T Hrs./week)**

CLOUD ARCHITECTURE AND TECHNOLOGY

Questions to be set: 05 (All Compulsory)

Course Objectives: This course introduces the architectural foundations of cloud computing. It explores cloud service and deployment models, virtualization, containers, and orchestration technologies. Students will understand the design and deployment of cloud-native applications, while analyzing performance, integration, and interoperability aspects essential to enterprise-level cloud architectures and infrastructure.

Pre-requisites: Operating System, Algorithms, Basics of Cloud Computing.

Course Outcomes (COs):

CO1	Understand architectural principles for cloud computing.
CO2	Analyze the importance of virtualization in cloud architecture.
CO3	Analyze the role of containerization technologies in cloud environments.
CO4	Explore cloud-native application architecture and cloud design principles.
CO5	Evaluate the performance, availability and interoperability issues in the cloud.

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction to Cloud Architecture	in class	Definition and Characteristics of Cloud Computing. Cloud Service Models: IaaS, PaaS, SaaS, Cloud Deployment Models: Public, Private, Hybrid, Community. NIST Cloud Reference Architecture. Benefits, Challenges, and Limitations of Cloud Architecture. Overview of Service-Oriented Architecture (SOA) and Service Level Agreement (SLA).	[8]
	Assignment Topics	To be provided by the concerned faculty members	
Module 2: Virtualization Technologies in the Cloud	in class	Basics of Virtualization and Resource Abstraction. Hypervisors: Type 1 and Type 2. Hypervisors, Dockers and Kubernetes. Storage and Network Virtualization. Role of Virtual Appliances. Comparison of Virtualization vs Traditional Computing.	[7]
	Assignment Topics	To be provided by the concerned faculty members	

Module 3: Containers and Cloud Orchestration	in class	Concept of Containerization: Need and Advantages. Docker Ecosystem: Images, Containers, Volumes, Registries. Comparison between Containers and VMs. Kubernetes Basics: Architecture, Nodes, Pods, Deployments, Services. Cloud-native Management and Orchestration Tools.	[5]
	Assignment Topics	To be provided by the concerned faculty members	
Module 4: Cloud-native Application Design	in class	Principles of Cloud-native Applications. Microservices Architecture and the 12-Factor App Methodology. Statelessness, API Gateway, and Service Mesh Concepts. Cloud Design Patterns: Scalability, Availability, Loose Coupling	[5]
	Assignment Topics	To be provided by the concerned faculty members	
Module 5: Performance, Integration, and Interoperability	in class	Performance Optimization: Load Balancing, Caching, Auto-scaling. High Availability and Disaster Recovery Techniques. Interoperability and Vendor Lock-in Issues. Multi-cloud and Hybrid Cloud Strategy. Compliance, Security, and Governance Considerations in Cloud Architecture.	[5]
	Assignment Topics	To be provided by the concerned faculty members	

Textbooks:

1. Michael J. Kavis "Architecting the Cloud" Wiley.
2. Thomas Erl, “Cloud Computing: Concepts, Technology & Architecture”, Pearson.

Reference Books:

1. John Arundel and Justin Domingus, “Cloud Native DevOps with Kubernetes”, O'Reilly Media
2. Kelsey Hightower et al., “Kubernetes: Up and Running”, O'Reilly
3. Rajkumar Buyya et al., Cloud Computing: Principles and Paradigms, Wiley.

CA663A3 **(2L + 1T Hrs./week)**

BIG DATA AND ITS APPLICATIONS IN CLOUD

Questions to be set: 05 (All Compulsory)

Objectives: This course provides an overview of the concept of Big Data, Machine Learning and Cloud Computing. It provides different aspect of knowledge discovery for Big data and various data mining process for climate data and multilevel text mining. It also presents the Hadoop framework for distributed computing and MapReduce for parallel processing and stream processing with Spark for data management.

Pre-requisites: Fundamentals of data mining concepts.

Course Outcomes (CO):

CO1	Understand the concepts knowledge discovery from big data.
CO2	Understand the concept of machine learning.
CO3	Handle the programming language for distributed computing.
CO4	Understand and work with cloud applications to support scalable online services.
CO5	Understand and work with big data processing applications to efficiently process high volume and velocity data

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction to Big Data & Machine Learning and Incremental Learning with Big data	in class	Understanding Big Data, capturing Big Data: Volume of Data, Velocity of Data, variety of Data, Veracity of Data. Benefitting from Big Data, Management of Big Data, Organising and Analysing Big Data. Machine learning concepts, Big data and machine learning, Incremental learning, Incremental learning for knowledge building, Incremental technique to handle big data, Applications.	[8]
	Assignment Topics	To be provided by the concern faculty members.	
Module 2 Knowledge discovery for big data & Introduction to cloud computing	in class	Opinion Mining: Aspect and entity extraction, Data Mining for climate data, Multilevel Text Mining. Need for cloud computing, Business and IT perspectives, Benefits and challenges of cloud computing, cloud module: Public, private, Hybrid, community cloud. Cloud application architecture: Grid computing, transaction computing. Cloud computing architecture, cloud services: Database as a service, infrastructure as a service, platform as a service.	[8]
	Assignment Topics	To be provided by the concern faculty members.	

Module 3: Distributed computing using Hadoop	in class	Hadoop Framework, HDFS Design goals, Master-slave architecture, Block system, sequence files, YARN	[6]
	Assignment Topics	To be provided by the concern faculty members.	
Module 4: Parallel processing with Map Reduce	in class	MapReduce overview, Sample Map Reduce Application: WordCount. MapReduce Programming: Data Types and Format, Writing MapReduce programming, Testing MapReduce programs. MapReduce Jobs Execution: Managing Failures, process & status updates. Hive Language and Pig language.	[10]
	Assignment Topics	To be provided by the concern faculty members.	
Module 5: Stream processing with Spark	in class	Spark Architecture, Resilient Distributed Datasetrs (RDDs), Directed Acylic GraPH(dag), Spark Ecosystem. Spark for Big Data processing: MLlib, Spark GraphX, Spark R, Spark SQL, Spark Streaming. Spark vs Hadoop.	[8]
	Assignment Topics	To be provided by the concern faculty members.	

Textbooks:

1. Anil Maheshwari, Big Data, McGraw-Hill Education
2. M.N Rao, Cloud Computing, PHI learning Pvt. Ltd.

Reference Books:

1. Wesley W. Chu Data Mining & Knowledge Discovery for Big Data: Methodologies, challenges and opportunities, Springer Science and Business Media.
2. VenkatAnkam, Big data Analytics, Packt Publishing Ltd.
3. Kim H. Pries, Robert Dunnigan, Big Data Analytics: A Practical Guide for Managers, CRC Press.

CA664A3 **(2L + 1T Hrs./week)**

DISTRIBUTED SYSTEM

Questions to be set: 05 (All Compulsory)

Objectives: This course covers general introductory concepts in the design and implementation of distributed systems, covering all the major branches such as Cloud Computing, Grid Computing, Cluster Computing and Many-core Computing.

Pre-requisites: Networking, Operating systems, Distributed system.

Course Outcomes (CO):

CO1	Understand the concepts and design of distributed system.
CO2	Understand how to build large scale distributed systems.
CO3	Understand applications that require data-intensive computing.
CO4	Understand the significance of distributed systems and their implications in the modern IT infrastructure.
CO5	Understand the issues associated with distributed systems and the implementation of potential solutions.

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction to the Distributed Systems	in class	Introduction – Examples of Distributed Systems– Trends in Distributed Systems – Focus on resource sharing – Challenges. Case study: World Wide Web.	[8]
	Assignment Topics	To be provided by the concern faculty members.	
Module 2 Communication in Distributed System	in class	System Model – Inter process Communication, The API for internet protocols, External data representation and Multicast communication. Network virtualization: Overlay networks. Case study: MPI Remote Method Invocation and Objects: Remote Invocation – Introduction - Request-reply protocols - Remote procedure call - Remote method invocation. Case study: Java RMI - Group communication - Publish-subscribe systems - Message queues - Shared memory approaches - Distributed objects - Case study: Enterprise Java Beans -from objects to components	[8]
	Assignment Topics	To be provided by the concern faculty members.	
Module 3: Peer to Peer services and File system	in class	Introduction to P2P systems, Overlays, Unstructured P2P systems (Gnutella, Freenet), Structured P2P systems (Distributed, Hash Tables - Chord, Pastry), Integrating unstructured and structured , P2P system	[6]
	Assignment Topics	To be provided by the concern faculty members.	

Module 4: Synchronization and Replication & Introduction to Grid Computing	in class	Introduction - Clocks, events and process states - Synchronizing physical clocks- Logical time and logical clocks, Global states, Coordination and Agreement, Introduction, Distributed mutual exclusion, Elections, Transactions and Concurrency Control, Transactions ,Nested transactions, Locks, Optimistic concurrency control, Timestamp ordering , Atomic Commit protocols, Distributed deadlocks, Replication, Case study :Coda. Introduction to Grid Computing, Classification of Grids, Introduction to Service Oriented Computing.	[10]
	Assignment Topics	To be provided by the concern faculty members.	
Module 5: Grid Computing Middleware	in class	Functions/Challenges of a Grid computing middleware Globus: Open source software toolkit used for building Grid systems and applications Vishwa: A reconfigurable P2P middleware for Grid computations.	[8]
	Assignment Topics	To be provided by the concern faculty members.	

Textbook:

1. George Coulouris, Jean Dollimore, and Tim Kindberg," Distributed Systems: Concepts and Design", Fifth Edition, Pearson Education, 2012.
2. D. Janakiram, "Grid Computing", Tata Mcgrahill, 2005.

Reference Book:

1. Pradeep K. Sinha, "Distributed Operating Systems Concepts and Design, EEE, 2014
2. Kai Hwang, Jack Dongarra & Geoffrey C. Fox, "Distributed and Cloud Computing", Morgan Kaufmann, Elsevier, 2011.

CA665A3 **(2L + 1T Hrs./week)**

CLOUD COMPUTING AND SECURITY

Questions to be set: 05 (All Compulsory)

Objectives: This course aims to provide a solid understanding of cloud computing concepts, architectures, and security principles. It covers IAM practices, cloud migration security, data protection techniques, and secure application development. Emphasis is placed on legal compliance, encryption, auditing, and integrating security throughout the Software Development Lifecycle (SDLC) with DevSecOps.

Pre-requisites: Basic Understanding of Networking and Security Basics

Course Outcomes (CO):

CO1	Understand cloud computing concepts, architectures, and service models.
CO2	Learn cloud security principles and legal compliance requirements.
CO3	Gain proficiency in Identity and Access Management (IAM) practices.
CO4	Explore data protection techniques such as encryption and key management.
CO5	Integrate security into the Software Development Lifecycle (SDLC) using DevSecOps.

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction	in class	Introduction of Cloud and Cloud Concepts. Cloud Architecture, Service Models and Design, Cloud Security Concepts, Legal, Compliance & Industry Standards, Security Challenges	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Identity and Access Management	in class	Introduction to Identity and Access Management, Introduction to Federated Identity Management (SAML, OAuth), Identify security holes in their cloud account's IAM service, Principle of least privilege access, Discover and protect various secrets related to cloud service authentication, Case Study - AWS IAM pitfalls, Cloud vendor provided IAM analysis tools, Cloud IAM Audit (Intro, Audit, Best Practice)	[10]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Cloud Infrastructure Security	in class	On-prem to Cloud Migration security considerations (Hybrid cloud), During Migration, During integration, Cloud Configuration & Patch Management, Cloud Change management, Securing Compute and Storage, Cloud Infrastructure Audit (Intro, Audit, Best Practice)	[8]

	Assignment Topics	To be provided by the concern faculty members	
Module 4: Cloud Data Security	in class	Data Protection (rest, at transit, in use), Data Information lifecycle, Cloud Data Security Foundational Strategies, Encryption, Egress monitoring, Masking, Obfuscation, Anonymization & tokenization, Key management, Near-time data, Real time data, Batch processing, Cloud Data Audit (Intro, Audit, Best Practice), Cloud Key management Audit (Intro, Audit, Best Practice),	[10]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Cloud Application Security	in class	Cloud Application Challenges & Development Basics, Cloud applications access to resource, Common Pitfalls & Vulnerabilities, Cloud Software Assurance and Validation, Secure Software Development Lifecycle (SDLC), OWSAP Top 10, DevSecOps	[10]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Cloud Computing: Concepts, Technology & Architecture by Thomas Erl, Prentice Hall, 2013
2. Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance by Tim Mather, Subra Kumaraswamy, and Shahed Latif, O'Reilly Media, 2009

Reference Books:

1. Cloud Computing: A Practical Approach by Anthony T. Velte, Toby J. Velte, and Robert Elsenpeter, McGraw-Hill Education, 2010
2. Cloud Security and Compliance: A Practical Guide by Ben Potter and Scott Ward, Wiley, 2017

CA666A3 **(2L + 1T Hrs./week)**

EDGE/FOG COMPUTING

Questions to be set: 05 (All Compulsory)

Objectives: This course explores edge computing frameworks, beginning with cloud computing limitations. It covers edge-cloud integration, context-aware computing, enabling technologies, and distributed data analytics. Drawing from research and documentation, students will gain practical insights and develop a project utilizing edge and cloud computing for real-world applications.

Pre-requisites: Data Structures, Operating Systems and Programming language concepts, Computer Networking, Distributed Systems and Algorithms.

Course Outcomes (CO):

CO1	Understand the evolution of networking technology in view of IoT and BigData.
CO2	Learn the tools to implement Edge/Fog Computing.
CO3	Understand the open-source edge computing application development concept.
CO4	Understand the benefits, advantages and challenges of edge/fog computing.
CO5	Implement/simulate an IoT ecosystem and implement the concepts of edge/fog computing.

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction to Cloud Computing and its Limitations	in class	Evolution of UNIX Operating System, Introduction to Multi-user System, Features and benefits of UNIX, Versions of UNIX, Standards and flavours of UNIX, User perspective services, Operating System perspective services, Assumptions about hardware, Kernel architecture of UNIX Operating System.	[8]
	Assignment Topics	To be provided by the concern faculty members.	
Module 2 Introduction to Fog Computing	in class	Introduction to Edge/FOG Computing, Different types of distributed computing paradigms, Cloud computing, Emergence of fog computing, Issues and Challenges, Edge vs Fog Computing, Bringing intelligence down from the cloud close to the ground. E.g Cellular base stations, network routers, WiFi Gateways- capable of running applications.	[8]
	Assignment Topics	To be provided by the concern faculty members.	
Module 3: USE cases of FOG Computing	in class	Emergency Evacuation Systems: Real-time information about currently affected areas of building and exit route planning. Natural Disaster Management: Real-time notification about landslides, flash floods to potentially affected areas. Large sensor deployments generate a lot of data, which can be pre processed, summarized and then sent to the cloud to	[6]

		reduce congestion in network. Internet of Things (IoT) based big-data applications: Connected Vehicle, Smart Cities, Wireless Sensors and Actuators Networks (WSANs) etc.	
	Assignment Topics	To be provided by the concern faculty members.	
Module 4: Fog Computing Enablers	in class	Virtualization: use of virtual machines as an edge device. Containers: Reduces the overhead of resource management by using lightweight virtualizations. Example: Docker containers. Service Oriented Architecture: Service-oriented architecture (SOA) a style of software design where services are provided to the other components by application components, through a communication protocol over a network. Software Defined Networking: Software defined networking (SDN) - an approach to using open protocols, such as OpenFlow, to apply globally aware software control at the edges of the network to access network switches and routers that typically would use closed and proprietary firmware.	[10]
	Assignment Topics	To be provided by the concern faculty members.	
Module 5: Edge Architecture & Hands on Experiment on Edge Computing	in class	CloudPath: A Multi-Tier Cloud Computing Framework, Cloud4Home -- Enhancing Data Services with @Home Clouds. Installing Docker in Ubuntu, Creating/building a container, Run containers, REST APIs of docker.	[8]
	Assignment Topics	To be provided by the concern faculty members.	

Textbooks:

1. Rajkumar Buyya, Satish Narayana, “Fog and Edge Computing: Principles and Paradigms”, Wiley, 2019.
2. Jie Cao, Quan Zhang, Weisong Shi, “Edge Computing”, Springer, 2018.

Reference Books:

1. Assad Abbas, Samee U. Khan, Albert Y. Zomaya, “Fog Computing: Theory and Practice” Wiley, 2020.
2. Kannan, Sudarsun, Ada Gavrilovska, and Karsten Schwan. "Cloud4Home--Enhancing Data Services with@ Home Clouds." In 2011 31st International Conference on Distributed Computing Systems, IEEE, 2011.

CA667A3 **(2L + 1T Hrs./week)**

VIRTUALIZATION AND CLOUD SECURITY

Questions to be set: 05 (All Compulsory)

Objectives: This course aims to introduce core concepts of virtualization and its role in cloud computing. It focuses on security challenges, risk mitigation techniques, and compliance in virtualized environments. Students will learn about secure cloud architecture, hypervisor vulnerabilities, data protection strategies, and best practices to ensure robust cloud security and governance.

Pre-requisites: Operating Systems and Computer Network.

Course Outcomes (CO):

CO1	Understand the importance and role of virtualization in cloud.
CO2	Understand the concept of security related threats in virtual environment for cloud computing.
CO3	Understand the technology and platform for cloud security.
CO4	Understand the concept of storage network Design
CO5	Understand apply concept of privacy in cloud computing

Module	Topics to be covered	Topics	Hrs.
Module 1: Virtualized Data Centre Architecture	in class	Cloud infrastructures; public, private, hybrid. Service provider interfaces; SaaS, PaaS, IaaS. VDC environments; concept, planning and design, business continuity and disaster recovery principles. Managing VDC and cloud environments and infrastructures.	[8]
	Assignment Topics	To be provided by the concern faculty members.	
Module 2 Information Storage Security and Design	in class	Storage strategy and governance; security and regulations. Designing secure solutions; the considerations and implementations involved. Securing storage in virtualized and cloud environments. Monitoring and management; security auditing and SIEM.	[8]
	Assignment Topics	To be provided by the concern faculty members.	
Module 3: Storage Network Design	in class	Architecture of storage, analysis and planning. Storage network design considerations; NAS and FC SANs, hybrid storage networking technologies (iSCSI, FCIP, FCoE), design for storage virtualization in cloud computing, host system design considerations.	[6]
	Assignment Topics	To be provided by the concern faculty members.	

Module 4: Security Concepts & Secure Virtual Networking	in class	Confidentiality, privacy, integrity, authentication, non-repudiation, availability, access control, defence in depth, least privilege, how these concepts apply in the cloud, what these concepts mean and their importance in PaaS, IaaS and SaaS. e.g. User authentication in the cloud; Cryptographic Systems- Symmetric cryptography, stream ciphers, block ciphers, modes of operation, public-key cryptography, hashing, digital signatures, public-key infrastructures, key management, X.509 certificates, OpenSSL. Configuration and change management goals and guidelines, tools and technologies in virtualized environments; Virtual network security architecture, network segmentation and traffic isolation to secure a virtual network configuration.	[10]
	Assignment Topics	To be provided by the concern faculty members.	
Module 5: Cloud Security and Privacy	in class	Infrastructure security, Data security, Security management in cloud, Privacy, Security in the cloud, Cloud Information security, Cloud security services, Design principles, Secure Cloud Software Requirements, Cloud Computing Security Challenges. Future of cloud computing.	[8]
	Assignment Topics	To be provided by the concern faculty members.	

Textbook:

1. Greg Schulz, "Cloud and Virtual Data Storage Networking", Auerbach Publications, 2011.
2. Tim Mather, Subra Kumaraswamy, Shahed Latif, "Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance" O'Reilly Media; 1st edition, 2009

Reference Books:

1. Marty Poniatowski, "Foundations of Green IT" Prentice Hall; 1 edition, 2009.
2. EMC, "Information Storage and Management" Wiley; 2nd Edition, 2012.
3. Volker Herminghaus, Albrecht Scriba, "Storage Management in Data Centres" Springer, 2009.

CA668A3 **(2L + 1T Hrs./week)**

CLOUD APPLICATION DEVELOPMENT

Questions to be set: 05 (All Compulsory)

Objectives: This course enables students to understand core cloud computing concepts, explore major cloud platforms, and develop basic cloud-native applications. Learners will apply tools for automation and resource management, and analyze key aspects such as security, scalability, and performance in cloud-based application development.

Pre-requisites: Basic knowledge of programming, web development, computer networks, and databases is required. Familiarity with operating system concepts and cloud fundamentals is an added advantage.

Course Outcomes (CO):

CO1	Understand and explain the basic concepts of cloud computing, including its service and deployment models.
CO2	Gain knowledge of the architecture and core services offered by popular cloud platforms such as AWS, Azure, and Google Cloud.
CO3	Build and deploy simple cloud-based applications using tools provided by cloud service providers.
CO4	Apply cloud storage, databases, and APIs effectively in real-time application development.
CO5	Address security, performance, and scalability issues while developing and managing cloud applications.

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction to Cloud Computing	in class	Definition, history, and evolution of cloud computing, Characteristics and benefits of cloud computing, Cloud service models: IaaS, PaaS, SaaS, Cloud deployment models: Public, Private, Hybrid, Community, Challenges and risks associated with cloud adoption	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Virtualization in Cloud Computing	in class	Concepts of virtualization and its importance in cloud computing, Types of virtualizations: Server, Storage, Network, Application. Hypervisors: Type 1 and Type 2, Virtual machine provisioning and management, Benefits and challenges of virtualization.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Cloud Infrastructure and Services	in class	Cloud architecture and components, Infrastructure as a Service (IaaS): Compute, Storage, Networking. Platform as a Service (PaaS): Development platforms and tools, Software as a Service (SaaS):	[6]

		Applications and delivery models. Case studies: AWS, Microsoft Azure, Google Cloud Platform.	
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Developing Applications for the Cloud	in class	Cloud-native application development principles, Microservices architecture and containerization, Deployment and orchestration using tools like Docker and Kubernetes, Continuous Integration and Continuous Deployment (CI/CD) pipelines, Monitoring and logging in cloud environments.	[10]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Security, Privacy, and Compliance in the Cloud\	in class	Security challenges in cloud computing, Data protection strategies: Encryption, Identity and Access Management (IAM), Compliance standards: GDPR, HIPAA, ISO/IEC 27001, Disaster recovery and business continuity planning, Best practices for securing cloud applications and data.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Rajkumar Buyya, James Broberg, Andrzej M. Goscinsk (2011), Cloud Computing: Principles and Paradigms, ISBN: 978-0470887998, Vol.1, Wiley.
2. Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi (2013), Mastering Cloud Computing, ISBN: 978-0070702087, Vol.1, McGraw Hill.
3. Anthony T. Velte, Toby J. Velte, Robert Elsenpeter (2010), Cloud Computing: A Practical Approach, ISBN: 978-0071626987, Vol.1, McGraw Hill.

Reference Books:

1. Barrie Sosinsky (2011), Cloud Computing Bible**,** ISBN: 978-0470878507, Vol.1, Wiley.
2. Ronald L. Krutz, Russell Dean Vines (2011), Cloud Security: A Comprehensive Guide to Secure Cloud Computing", Vol.1,Wiley.

CA669A3 **(2L + 1T Hrs./week)**

CLOUD ANALYTICS

Questions to be set: 05 (All Compulsory)

Objectives: This course introduces the fundamentals of cloud computing for analytics, explores tools and technologies used in cloud-based analytics, and addresses deployment strategies. It covers big data challenges in cloud environments and provides practical experience using popular cloud platforms for analytics solutions.

Pre-requisites: Basic knowledge of cloud computing, data analytics, and SQL; familiarity with programming (Python/R) and databases (relational or NoSQL).

Course Outcomes (CO):

CO1	Demonstrate an understanding of cloud computing concepts and their relevance to data analytics.
CO2	Implement analytics solutions on popular cloud platforms like AWS, Azure, or Google Cloud.
CO3	Analyze large datasets using cloud tools and services.
CO4	Use machine learning models in the cloud for data analysis.
CO5	Evaluate the benefits and challenges of cloud analytics solutions.

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction to Cloud Computing and Cloud Analytics	in class	Overview of Cloud Computing: Definition, Characteristics, and Models (IaaS, PaaS, SaaS), Deployment Models (Public, Private, Hybrid Clouds). Introduction to Cloud Analytics: Importance of cloud in data analytics, Comparison between traditional and cloud analytics, Cloud data storage and processing.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Cloud Computing Platforms and Services	in class	Overview of major cloud providers: AWS, Google Cloud, Microsoft Azure. Cloud Storage Services: AWS S3, Google Cloud Storage, Azure Blob Storage. Cloud Data Processing Services: AWS Redshift, Google BigQuery, Azure Synapse Analytics. Introduction to Cloud Machine Learning Services: AWS SageMaker, Azure Machine Learning, Google AI Platform	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Big Data and	in class	Big Data Concepts and Challenges: Data lakes, Data Warehouses, and NoSQL Databases. Big Data Processing using Hadoop, Spark on the Cloud. Cloud	[8]

Analytics in the Cloud		Data Pipelines: ETL (Extract, Transform, Load) in the cloud.	
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Cloud-based Analytics Tools and Techniques	in class	Data Analytics Tools for Cloud Platforms: Amazon QuickSight, Google Data Studio, Power BI (Azure). Using Machine Learning in Cloud Analytics: Introduction to ML models and algorithms on cloud platforms. Hands-on with cloud machine learning tools (AWS SageMaker, Google AI Platform). Data Visualization on Cloud Platforms: Creating dashboards and reports using cloud tools.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Practical Applications and Case Studies	in class	Real-world Use Cases of Cloud Analytics: Cloud Analytics in Healthcare, Finance, E-commerce, and more. Case Study: Implementing an Analytics Solution on the Cloud. Project work using cloud analytics tools and techniques. Best Practices and Security in Cloud Analytics: Ensuring data security, privacy, and compliance in cloud-based analytics.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Ritesh Modi (2017), Cloud Analytics with Microsoft Azure, ISBN: 978-1786460106, Packt Publishing.
2. Soumendra Mohanty, Madhu Jagadeesh, Harsha Srivatsa (2013), Big Data Imperatives: Enterprise 'Big Data' Warehouse, 'BI' Implementations and Analytics, ISBN: 978-1430248715, Apress.

Reference Books:

1. Pradeep Menon (2021), Data Science and Machine Learning in the Cloud with Azure ML and Azure Databricks, ISBN: 978-1484267987, Apress.
2. K Chandrasekaran (2015), Essentials of Cloud Computing, ISBN: 978-1466588961, CRC Press.

CA670A3 **(2L + 1T Hrs./week)**

PRIVATE CLOUD DEPLOYMENT AND MANAGEMENT

Questions to be set: 05 (All Compulsory)

Objectives: This course aims to provide an to provide an understanding of private cloud architecture and components covering deployment, configuration and management. It covers popular platforms like OpenStack or VMware vSphere and explores automation, orchestration, and monitoring tools.

Pre-requisites: Operating system, computer networks fundamentals

Course Outcomes (CO):

CO1	Explain the principles and architecture of private cloud computing, including service models, deployment models, and enabling technologies.
CO2	Demonstrate an understanding of the configuration and deployment of core components of a private cloud platform for providing services.
CO3	Demonstrate the use of virtualization technologies and orchestration tools to automate resource provisioning in a private cloud environment.
CO4	Analyze performance, scalability, and security issues in private cloud deployments, and recommend suitable optimization strategies.
CO5	Apply monitoring, backup, and disaster recovery techniques to ensure high availability and reliability in private cloud infrastructure.

Module	Topics to be covered	Topics	Hrs.
Module 1: Overview of Cloud Models	in class	Overview of Cloud Models: Public, Private, Hybrid; Characteristics and Benefits of Private Cloud; Service Models: IaaS, PaaS, SaaS; Key Technologies: Virtualization, Containers; Security and Compliance Considerations in Private Cloud	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Core Components	in class	Core Components: Compute, Storage, Networking; Hypervisors: Type 1 vs Type 2 (KVM, VMware ESXi); Virtual Networking Concepts: Bridges, VLANs, SDN; Storage Solutions: NAS, SAN, Object Storage; Identity and Access Management (IAM)	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Introduction to OpenStack Architecture	in class	Introduction to OpenStack Architecture - Nova, Neutron, Keystone, Glance, Cinder, Horizon, Swift; Installing and Configuring OpenStack (PackStack or DevStack); Introduction to VMware vSphere and vCenter; Comparison of Private Cloud Platforms: OpenStack vs VMware vs Proxmox	[6]

	Assignment Topics	To be provided by the concern faculty members	
Module 4: Cloud Resource Provisioning and Orchestration	in class	Cloud Resource Provisioning and Orchestration; Configuration Management: Ansible, Puppet, or Chef; Monitoring and Logging: Zabbix, Nagios, Prometheus, ELK Stack; Backup and Disaster Recovery; Scaling and Load Balancing	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Role-Based Access Control (RBAC)	in class	Role-Based Access Control (RBAC); Network Security: Firewalls, VPNs, IDS/IPS; Performance Tuning and Capacity Planning; Patch Management and Software Updates; Auditing and Compliance (e.g., ISO 27001, GDPR basics)	[6]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Cloud Computing Concepts, Technology & Architecture, Thomas Erl, Zaigham Mahmood, and Ricardo Puttini, Prentice Hall
2. Barrie Sosinsky, Cloud Computing Bible, Wiley.
3. Rajkumar Buyya, James Broberg, Andrzej Goscinski, Cloud Computing– Principles and paradigms, Wiley.

Reference Books:

1. George Reese, Cloud Application Architectures, O'Reilly.
2. Anthony T. Velte, Toby J. Velte, Robert Elsenpeter, Cloud Computing: A Practical Approach, Tata McGraw Hill.

GROUP ELECTIVE SPECIALIZATION
CYBER SECURITY

(COURSE CURRICULUM)

CA563A3 **(2L + 1 T hrs./week)**

PRINCIPLES OF CYBER SECURITY

Questions to be set: 05 (All Compulsory)

Course Objectives: This course introduces an overview of the concept of cyber security. The course covers various aspects of cyber security for modern days cyber space. It also covers security risks and measures in social media, e-commerce and digital payments. Various cyber security tools and technologies are also covered in brief. The syllabus has been prepared with an aim to create more aware, responsive and responsible digital citizens, thereby contributing effectively to an overall healthy cyber security posture and ecosystem.

Pre-requisites: Computer Network, Internet.

Course Outcomes (COs):

CO1	Understand the basic terminologies related to cyber security and current cyber security threat landscape.
CO2	Understand the cybercrimes, their nature, legal remedies and framework that exist in India and elsewhere for cybercrimes and penalties and punishments for such crimes.
CO3	Understand the aspects related to personal data privacy and security.
CO4	Understand the components of cyber security plan, risk-based assessment, requirement of security controls and need for cyber security audit and compliance.
CO5	Understand and apply the basic security tools and technologies to protect their devices.

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction to Cyber security	in class	Defining Cyberspace. Concept of cyber security, Issues and challenges of cyber security. Evolving cyber threat landscape, Cyber security terminologies- Cyberspace, attack, attack vector, attack surface, threat, risk, vulnerability, exploit, exploitation, hacker, non-state actors, Cyber terrorism, Protection of end user machine, Critical IT and National Critical Infrastructure, Cyberwarfare.	[7]
	Assignment Topics	To be provided by the concerned faculty members	
Module 2: Cybercrimes and Cyber Laws	in class	Classification of cybercrimes, Common cybercrimes- cybercrime targeting computers and mobiles, cybercrime against women and children, financial frauds, social engineering attacks, malware and ransomware attacks, zero day and zero click attacks, Cybercriminals modus-operandi, Reporting of cybercrimes, Remedial and mitigation measures, Cybercrime and legal landscape around the world, IT Act 2000 and its amendments. Cybercrime and punishments, Cyber Laws and Legal and ethical aspects related to new technologies- AI/ML, IoT, Blockchain, Darknet and social media, Cyber Laws of other countries	[8]

	Assignment Topics	To be provided by the concerned faculty members	
Module 3: Data Privacy and Data Security	in class	Defining data, meta-data, big data, non-personal data. Data protection, Data privacy and data security, Personal Data Protection Bill and its compliance, Data protection principles, big data security issues and challenges, Data protection regulations of other countries- General Data Protection Regulations (GDPR), 2016 Personal Information Protection and Electronic Documents Act (PIPEDA), social media- data privacy and security issues.	[5]
	Assignment Topics	To be provided by the concerned faculty members	
Module 4: Cyber security Management, Compliance and Governance	in class	Cyber security plan- cyber security policy, cyber crises management plan, Business continuity, Risk assessment, Types of security controls and their goals, Cyber security audit and compliance, National cyber security policy and strategy.	[5]
	Assignment Topics	To be provided by the concerned faculty members	
Module 5: Digital Devices Security, Tools and Technologies for Cyber Security	in class	End Point device and Mobile phone security, Password policy, Security patch management, Data backup, Downloading and management of third-party software, Device security policy, Cyber Security best practices, Significance of host firewall and Anti-virus, Management of host firewall and Anti-virus, Wi-Fi security, Configuration of basic security and permissions.	[5]
	Assignment Topics	To be provided by the concerned faculty members	

Textbooks:

1. Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives by Sumit Belapure and Nina Godbole, Wiley India Pvt. Ltd.
2. Security in the Digital Age: Social Media Security Threats and Vulnerabilities by Henry A. Oliver, Create Space Independent Publishing Platform.

Reference Books:

1. Information Warfare and Security by Dorothy F. Denning, Addison Wesley.
2. Data Privacy Principles and Practice by Natraj Venkataramanan and Ashwin Shriram, CRC Press.
3. Information Security Governance, Guidance for Information Security Managers by W. Krag Brothy, 1st Edition, Wiley Publication.
4. Auditing IT Infrastructures for Compliance by Martin Weiss, Michael G. Solomon, 2nd Edition, Jones Bartlett Learning.

CA671A3 **(2L + 1T Hrs./week)**

CRYPTOGRAPHY

Questions to be set: 05 (All Compulsory)

Objective: This course provides an overview of computer security principles using cryptography. The course will help to learn the principles of cyber information security in various computing environments. The goal of the course is to provide students with the necessary foundations to understand cryptograph and its applications.

Pre-requisites: Computer Networks.

Course Outcomes (CO):

CO1	Understand the role of cryptography for network and information security.
CO2	Implement asymmetric cryptography
CO3	Understand the role of authentication, hash function and also digital signatures.
CO4	Understand and implement the suitable cryptography techniques as per the requirement.
CO5	Evaluate the security provided by various cryptography techniques.

Module	Topics to be covered	Topics	Hrs.
Module 1: Foundations and Principles of Cryptography	in class	Introduction- History, Terminology, Confidentiality, Authentication, Integrity, Non-repudiation, OSI Security Architecture: Attacks, Services and Mechanisms, A model of internetwork conventional encryption model. Cryptanalysis, types of attack in encrypted message.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Basic Number Theory for Cryptography	in class	Principles of prime and relatively prime numbers, Greatest Common Devisor, Modular arithmetic, Fermat's and Euler's theorems, Random number and pseudo random number.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Classical Encryption Technique	in class	Substitution techniques and Transposition techniques. Stream Ciphers: Caesar Cipher, Mono-alphabetic cipher, Playfair cipher, Hill Cipher, Poly-alphabetic cipher, One-time pad. Block Cipher: Principles and motivations	[8]
	Assignment Topics	To be provided by the concern faculty members	

Module 4: Symmetric and asymmetric Key Cryptography	in class	Symmetric key encryption model, Feistal Cipher structure, Block cipher principles, The data encryption standard, The strength of DES, Differential and linear cryptanalysis algorithms, Confusion and Diffusion, Triple DES, Confidentiality using conventional encryption, Placement of encryption function, Traffic confidentiality, Key distribution. Asymmetric key encryption model. Principles of Public key cryptography, The RSA algorithm, Public Key management, Diffie-Hellman key exchange protocol. Confidentiality and authentication using public key cryptography.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Message Authentication and Hash Functions	in class	Authentication Requirements, Authentication Functions, Message Authentication Codes (MAC), MD5 Message Digest Algorithm, Hash Function, Secure Hash Algorithm (SHA). Digital Signature and Authentication Protocols: Digital Signatures, Authentication protocols, Digital Signature Standard (DSS).	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. William Stallings, “Cryptography and Network Security”, Pearson.
2. Behrouz A Frouzan, “Cryptography and Network Security”, Tata McGraw Hill.

Reference Books:

1. Richard E. Smith, “Internet Cryptography”, Pearson.
2. D. Chapman and E. Zwicky, “Bulding Internet Firewalls”, O’Reilly.
3. Derek Atkins et al., “Internet Security, Professional Reference”, Techmedia.
4. Atul Kahate, “Cryptography and Network Security”, McGraw Hill.

CA672A3 **(2L + 1T Hrs./week)**

PRIVACY AND SECURITY IN WEB APPLICATION

Questions to be set: 05 (All Compulsory)

Objective: The primary objective of this course is to study and practice fundamental techniques in developing secure web-based applications, including vulnerability of web-based applications and how to protect those applications from attacks.

Pre-requisites: Web Applications Development and Computer Security.

Course Outcomes (CO):

CO1	understand the concepts of attack to browser.
CO2	learn Cookie flaws.
CO3	understand and can deal with the concepts of web security.
CO4	understand the various security techniques available for web security.
CO5	Students will be study security incidents and investigate the potential reasons.

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction	in class	Web Basics: HTML, CSS, JS, URLs, DOM, Frames, HTTP, Navigation, X-Domain communication, Network Attacks & HTTPS, Limitations of HTTPS, Browser – general concepts, configuration (HTTP-cookies, contents, scripting), attack to browsers and users tracking/profiling, browser security (add-ons, plugins, same-origin policy) and secure browsing	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Web Security-I	in class	Same Origin Policy and Web Attacker Model, Injection Flaws, Cross-site Scripting (XSS), Injection Flaws, SQL Injection, OS Command Injection, HTTP Header Injection, Authentication Flaws, Request Authorization Flaws, Insecure Web Logic: Logic Flaws, HTTP Pollution, HTTP Parameter Tampering, Cookie Flaws and Server Misconfiguration	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Web Security-II	in class	Attacks on User Interfaces, Browser Design & Flaws, User Privacy: Browser & Device Fingerprinting, User Tracking, Browser Caching Flaws. Security Issues in TCP/IP, Network Defence tools – Firewalls, Intrusion Detection, Filtering, DNSSec, NSec3, Distributed Firewalls, Intrusion Detection tools Threat Models, Denial of Service Attacks	[8]
	Assignment Topics	To be provided by the concern faculty members	

Module 4: Web Security-III	in class	DOS-proof network architecture, Security architecture of World Wide Web, Security Architecture of Web Servers, and Web Clients, Web Application Security – Cross Site Scripting Attacks, Cross Site Request Forgery, SQL Injection Attacks, Content Security Policies (CSP) in web, Session Management and User Authentication, Session Integrity	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Applications	in class	What is Online Social Networks, data collection from social networks, challenges, opportunities, and pitfalls in online social networks, APIs, Trust, credibility, and reputations in social systems, information privacy disclosure, revelation and its effects in online social networks, Phishing and identifying fraudulent entities in online social networks.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. O: Oppliger, Rolf. “Security Technologies for the World Wide Web”, Second Edition. Artech House Publishers. 2003.
2. Dafydd Stuttard, Marcus Pinto, “The Web Application Hacker's Handbook: Finding and Exploiting security Flaws”, Wiley, 2011.

Reference Books:

1. Wade Alcorn, Christian Frichot, Michele Orru, “The Browser Hacker's Handbook”, Wiley 2014
2. Gavin Bell, “Building Social Web Applications”, O'Reilly Media, 2009

CA673A3 **(2L + 1T Hrs./week)**

NETWORK AND INFORMATION SECURITY

Questions to be set: 05 (All Compulsory)

Objectives: This course provides an insight into the real-world scenario of network and information security risks and their solutions. The course will help to learn the implementation of cryptographic algorithms for network and information security. The goal of the course is to provide students with the necessary understanding of information security and network security risks and its solutions.

Pre-requisites: Computer Networks, Cryptography and Number Theory.

Course Outcomes (CO):

CO1	Understand the various security principles.
CO2	Learn the concepts of Cryptography.
CO3	Understand the concepts of Intrusion detection system.
CO4	Study cases of security incidents and analyse the lapses and identify potential solutions.
CO5	Understand different types of attacks and their countermeasures.

Module	Topics to be covered	Topics	Hrs
Module 1: Network Security fundamentals & Introduction to information theory	in class	Introduction to computer security, information security and network security. Security models. Security goals. Security principles Cryptology and steganography. OSI Security Architecture. Entropy and Uncertainty, Rate of a language and redundancy, Security of a cryptosystem, Unicity distance, confusion and diffusion.	[8]
	Assignment Topics	To be provided by the concern faculty members.	
Module 2: Authentication and Digital Signature & Electronic mail security	in class	Authentication, Types of authentications, Authentication applications, Kerberos, X.509 directory authentication service, Digital Signature, requirements for digital signatures, types of digital signature, dual signature, Digital Signature Algorithm (DSA) Pretty Good Privacy (PGP), S/MIME.	[8]
	Assignment Topics	To be provided by the concern faculty members.	
Module 3: IP security	in class	IP security overview, IP security architecture, Authentication header, Encapsulation security, Payload, Combining security associations, Key management.	[6]
	Assignment Topics	To be provided by the concern faculty members.	

Module 4: Web security & Intrusion Detection System and Firewalls	in class	Web security requirements, secure socket and transport layer security, secure electronic transaction. Intruders, Intrusion and Intrusion Detection System (IDS), Types of IDS, Firewalls, Characteristics of firewalls, types of firewalls.	[10]
	Assignment Topics	To be provided by the concern faculty members.	
Module 5: Malicious Software and Countermeasures	in class	Viruses, worms, trojans, spyware, malware, botnet, and related threats, types of virus, Anti-virus software, Anti-malware, Anti-phising and anti-spyware software.	[8]
	Assignment Topics	To be provided by the concern faculty members.	

Textbooks:

1. William Stallings, “Cryptography and Network Security”, Pearson.
2. Behrouz A Frouzan, “Cryptography and Network Security”, Tata McGraw Hill.

Reference Books:

1. Richard E. Smith, “Internet Cryptography”, Pearson.
2. D. Chapman and E. Zwicky, “Bulding Internet Firewalls”, O’Reilly.
3. Derek Atkins et al., “Internet Security, Professional Reference”, Techmedia.
4. AtulKahate, “Cryptography and Network Security”, McGraw Hill.

CA674A3 **(2L + 1T Hrs./week)**

COMPUTATIONAL NUMBER THEORY & CRYPTOGRAPHY

Questions to be set: 05 (All Compulsory)

Objectives: This course aims to provide an understanding of the concepts of number theory and cryptography fundamentals. It explores the application of number theory in cryptography. It also covers the different types of cryptographic algorithms, their strengths, limitations and their applications.

Pre-requisites: Computer Networks

Course Outcomes (CO):

CO1	Understand and analyze the implementation and application of number theory concepts in cryptography.
CO2	Demonstrate an understanding of cryptography fundamentals and analyze the various implementations for achieving the security goals.
CO3	Analyze the various symmetric and asymmetric ciphers and determine the appropriate solution based on the application.
CO4	Analyze the various key exchange algorithms and determine the appropriate one for a given scenario.
CO5	Make an assessment of the attacks on different ciphers and determine their effectiveness in modern applications.

Module	Topics to be covered	Topics	Hrs.
Module 1: Divisibility and Euclidean Algorithm	in class	Divisibility and Euclidean Algorithm, Prime numbers and Fundamental Theorem of Arithmetic, Congruences and Modular arithmetic, Chinese Remainder Theorem, Linear Diophantine Equations	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Euler's Theorem	in class	Euler's Theorem and Fermat's Little Theorem, Euler's phi-function and its properties, Modular inverses, Primitive roots and discrete logarithms, Quadratic residues and Legendre symbol	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Various Ciphers	in class	Caesar Cipher, Monoalphabetic and Polyalphabetic ciphers, Hill Cipher, Playfair Cipher, Substitution and Transposition techniques, Cryptanalysis basics	[6]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Principles of	in class	Principles of public key cryptography, RSA algorithm: key generation, encryption, decryption, ElGamal encryption, Diffie-Hellman key exchange,	[6]

Public Key Cryptography		Attacks on RSA and related number-theoretic assumptions	
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Cryptographic Hash Functions	in class	Cryptographic hash functions (SHA, MD5 basics), Digital signatures: DSS and RSA-based, Message authentication codes (MAC), Integrity and authenticity in cryptography, Applications in cybersecurity and blockchain	[6]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. William Stallings, "Cryptography and Network Security", Pearson.
2. Behrouz A Frouzan, "Cryptography and Network Security", Tata McGraw Hill.

Reference Books:

1. Richard E. Smith, "Internet Cryptography", Pearson.
2. D. Chapman and E. Zwicky, "Bulding Internet Firewalls", O'Reilly.
3. Derek Atkins et al., "Internet Security, Professional Reference", Techmedia.
4. Atul Kahate, "Cryptography and Network Security", McGraw Hill.

CA675A3 **(2L + 1T Hrs./week)**

INTERNET SECURITY AND PRIVACY

Questions to be set: 05 (All Compulsory)

Objectives: Provide an in-depth understanding of security challenges and solutions in Internet-based environments. Introduce cryptographic foundations and techniques for secure communication. Examine network security mechanisms, protocols, and countermeasures. Explore privacy concerns, technologies, and legal frameworks in digital systems. Equip learners with practical knowledge on ethical hacking, malware analysis, and security risk management.

Pre-requisites: Computer Networks, Operating Systems, Basic understanding of cryptographic principles

Course Outcomes (CO):

CO1	Analyze and interpret the fundamental threats, vulnerabilities, and attack surfaces in Internet systems.
CO2	Apply cryptographic techniques for securing data and communications.
CO3	Evaluate the effectiveness of network and transport-level security mechanisms.
CO4	Assess privacy-enhancing technologies and understand the socio-legal implications of digital privacy.
CO5	Demonstrate knowledge of incident response, ethical hacking techniques, and digital forensics.

Modules	Topics to be covered	Topics	Hrs
Module 1: Fundamentals of Internet Security	in class	Internet threats and vulnerabilities, Attack types: Denial of Service (DoS), Man-in-the-Middle (MITM), SQL injection, Cross-site scripting (XSS) Security objectives: Confidentiality, Integrity, Availability (CIA triad), Security policies and controls, Basics of risk management and security models	[5]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Cryptography and Secure Communication	In class	Classical and modern cryptography: Symmetric and Asymmetric encryption, Algorithms: DES, AES, RSA, ECC, Key management and Public Key Infrastructure (PKI), Hashing algorithms: MD5, SHA-1, SHA-256, Digital signatures and certificates, Secure Sockets Layer (SSL), Transport Layer Security (TLS)	[8]
	Assignment Topics	To be provided by the concern faculty members	

Module 3: Network Security and Protocols	in class	Firewalls, Intrusion Detection Systems (IDS), and Intrusion Prevention Systems (IPS), Virtual Private Network (VPN) technologies, IP security (IPSec) Secure routing and DNS security, Email security: PGP, S/MIME, Security in wireless and mobile environments	[7]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Web and Application Security	in class	Web vulnerabilities and exploits: OWASP Top 10 Secure software development lifecycle (SSDLC), Input validation, authentication, and session management, Security testing tools: Burp Suite, OWASP ZAP, Application-layer defenses and secure coding principles	[10]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Privacy, Legal, and Ethical Issues	in class	Definitions and principles of privacy, Data privacy techniques: anonymization, differential privacy, Privacy in web tracking and social media, Regulatory frameworks: GDPR, HIPAA, Indian IT Act, Ethical hacking and penetration testing, Digital forensics and incident response, Case studies: Real-world breaches and lessons learned	[10]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Stallings, W. (2017). Cryptography and network security: Principles and practice (7th ed.). Pearson.
2. Kaufman, C., Perlman, R., & Speciner, M. (2016). Network security: Private communication in a public world (3rd ed.). Pearson.
3. Bishop, M. (2004). Computer security: Art and science (1st ed.). Addison-Wesley.
4. Garfinkel, S., & Lipford, H. R. (2014). Usable security: History, themes, and challenges (1st ed.). Morgan & Claypool.

Reference Books:

1. Shostack, A. (2014). Threat modeling: Designing for security (1st ed.). Wiley.
2. Grimes, R. A. (2017). Hacking the hacker: Learn from the experts who take down hackers (1st ed.). Wiley.
3. Zwicky, E. D., Cooper, S., & Chapman, D. B. (2000). Building Internet firewalls (2nd ed.). O'Reilly Media.

CA676A3 **(2L + 1T Hrs./week)**

IOT SECURITY AND PRIVACY

Questions to be set: 05 (All Compulsory)

Objectives: This course introduces key concepts of security and privacy in the Internet of Things (IoT). It focuses on IoT architecture, threat models, and security requirements. Students will explore cryptographic solutions, authentication protocols, data privacy techniques, and secure communication frameworks tailored to IoT environments. Practical case studies and current challenges are also discussed.

Pre-requisites: Basic knowledge of Networking, Cryptography, and Embedded Systems.

Course Outcomes (CO):

CO1	Analyze the security architecture of various IoT platforms.
CO2	Identify potential threats and vulnerabilities in IoT systems.
CO3	Apply cryptographic and privacy-preserving techniques in IoT scenarios.
CO4	Evaluate legal and ethical implications of IoT data privacy.
CO5	Design and implement secure IoT systems.

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction to IoT and Security Challenges	in class	Overview of IoT Ecosystem: Devices, Gateways, Cloud, and Applications, IoT Protocols (MQTT, CoAP, XMPP, etc.), Security and Privacy Challenges in IoT, Attack Surfaces in IoT	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Cryptography and Access Control in IoT	in class	Lightweight Cryptography for IoT, Symmetric and Asymmetric Encryption Techniques, Key Management in Constrained Devices, Authentication and Access Control Models (OAuth, RBAC, ABAC)	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Network Security in IoT	in class	IoT-Specific Attacks (e.g., Routing Attacks, DoS, Node Replication), Secure Routing and Communication Protocols, Intrusion Detection and Prevention in IoT, IPv4 or IPv6	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Privacy Issues and Mechanisms	in class	Security in IPv6 and 6LoWPAN, Privacy Threats in IoT: Data Leakage, Tracking, Profiling, Anonymization and Pseudonymization Techniques, Privacy-by-Design in IoT Architectures, GDPR and Legal Frameworks for IoT Privacy	[10]

	Assignment Topics	To be provided by the concern faculty members	
Module 5: Secure IoT Architectures and its associated Frameworks	in class	Secure Boot and Firmware Update Mechanisms, Role of Blockchain in IoT Security, Fog and Edge Computing Security Models, Case Studies: Smart Home, Healthcare, Industrial IoT, Zero Trust Architectures of IoT	[10]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Security and Privacy in Internet of Things (IoTs) by Fei Hu, CRC Press
2. Int Internet of Things: Architecture and Security" by Ramjee Prasad, Sudhir Dixit

Reference Books:

1. Internet of Things (IoT): Architecture and Security by Bokare, U. M., & Verma, R., BPB Publications, 2020.
2. The Internet of Things: Insights into the Building Blocks, Component Interactions, and Architecture Layers by Kumar, R. & Mallick, P. K., CRC Press, 2019.

CA677A3 **(2L + 1T Hrs./week)**

BLOCKCHAIN TECHNOLOGY

Questions to be set: 05 (All Compulsory)

Objective: The syllabus is aimed at giving a basic understanding of block chain technology, its architecture and its use cases in present and future context. It is focused on defining the technological backbone of Bitcoin fundamentals and expands the concepts to building the block chain technology. It helps students to understand the history of digital currency, the polices involving laws and organizations, the latest trends, and the communities involved, which facilitates us to construct, visualize and understand the ecosystem of block chain technology and its environment on which it is deployed.

Pre-requisites: Distributed System, Cloud computing, Programming concepts.

Course Outcomes (CO):

CO1	Learn basic of blockchain technology, its working, distributed consensus, bit coin and crypto currencies.
CO2	Learn the pros and cons of using blockchain in industrial, academic and governmental use cases.
CO3	Learn future research aspects in the blockchain technology.
CO4	Apply blockchain concepts to different use cases.
CO5	Understand the issues related to blockchain technology and identify potential solutions

Module	Topics to be covered	Topics	Hrs.
Module 1: Introduction to Blockchain	in class	Basics- What is a Blockchain? Public Ledgers, Blockchain as public ledgers, History and Evolution- Blockchain, Bitcoin, Blockchain 2.0, Smart Contracts, Architecture- Block in a Blockchain, Transactions, Distributed Consensus, Conceptualization- The Chain and the Longest Chain, Cryptocurrency to Blockchain 2.0, Permissioned and permission-less Model of Blockchain. Cryptographic Hash Function, Properties of a hash function, Hash pointer and Merkle tree, Digital Signature, Public Key Cryptography, A basic cryptocurrency.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Bitcoin	in class	Basics – Creation of coins, Payments and double spending, Bitcoin scripting, Bitcoin Scripts, Bitcoin P2P Network, Transaction in Bitcoin Network, Bitcoin mining, Block propagation and block relay	[8]
	Assignment Topics	To be provided by the concern faculty members	

Module 3: Distributed Consensus	in class	Why Consensus, Distributed consensus in open environments, Consensus in a Bitcoin network, Proof of Work (PoW) – basic introduction, Hashcash PoW, Bitcoin PoW, Attacks on PoW and the monopoly problem. Basics- Permissioned model and use cases, Design issues for Permissioned blockchains, Execute contracts, State machine replication, Consensus models for permissioned blockchain- Distributed consensus in closed environment, Paxos.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Blockchain Use Cases	in class	Blockchain applications across industries including finance, trade, supply chain, and container management. Use cases in food traceability, healthcare, energy, and media. Government adoption through e-Estonia, digital identity, and land registry. Highlights on business problems, stakeholders, and fraud prevention, with emphasis on blockchain communities and digital compliance.	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Research Aspects	in class	Explores consensus scalability in blockchain systems, comparing PoW and BFT, and techniques like Bitcoin-NG, Byzcoin, and Algorand. Covers topics such as finality, fairness, synchrony, cross-fault tolerance (XFT), and collective signing. Includes secured multi-party computation (MPC) and the role of blockchain in big data and scientific applications.	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Andreas Antonopoulos, “Mastering Bitcoin: Unlocking Digital Cryptocurrencies”
2. Melanie Swa, “Blockchain”, O’Reilly

Reference Books:

1. Arvind Narayanan, Joseph Bonneau, Edward Felten, “Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction”, ISBN-10: 0691171696.
2. Andreas M. Antonopoulo, “Mastering Bitcoin: Programming the Open Blockchain”, 2ndEdition. ISBN-10: 1491954388

CA678A3 **(2L + 1T Hrs./week)**

EMBEDDED AND CYBER PHYSICAL SYSTEMS SECURITY

Questions to be set: 05 (All Compulsory)

Objectives: To understand and apply security principles, techniques, and technologies in the design, development, and protection of embedded and cyber-physical systems, with a focus on mitigating risks, ensuring data integrity, and enhancing system resilience in critical real-world applications.

Pre-requisites: Basics of computer architecture and embedded systems, Computer Networks and cybersecurity fundamentals, Programming skills, Understanding of cryptography and communication protocols

Course Outcomes (CO):

CO1	Analyze security threats and vulnerabilities specific to embedded and cyber-physical systems.
CO2	Apply cryptographic and security techniques suitable for resource-constrained devices.
CO3	Design secure architectures for embedded and IoT-based cyber-physical applications.
CO4	Evaluate the effectiveness of AI based methods in enhancing system security.
CO5	Demonstrate the ability to implement and test security mechanisms in embedded system environments.

Module	Topics to be covered	Topics	Hrs.
Module 1: Security engineering for Embedded and Cyber-Physical Systems: Challenges and Applications.	in class	Introduction to Embedded and Cyber-Physical Systems, Security Challenges in Embedded Systems, Applications of Cyber-Physical Systems in Various Domains, Case Studies Highlighting Security Breaches, Future Trends and Research Directions	[08]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Algorithms and Techniques for Security in Embedded Systems	in class	Cryptographic Algorithms Suitable for Embedded Devices, Access Control Mechanisms, Intrusion Detection Systems for Embedded Platforms, Secure Boot and Firmware Integrity, Resource-Constrained Security Protocols.	[08]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Security Engineering for Embedded and	in class	Design Principles for Secure Embedded Systems, Risk Assessment and Threat Modeling, Integration of Security in the Development Lifecycle, Emerging Use Cases	[08]

Cyber-Physical Systems and Potential Future-Use Cases.		in Healthcare, Automotive, and Industrial Automation.	
	Assignment Topics	To be provided by the concern faculty members	
Module 4: Artificial Intelligence Techniques for Cybersecurity and Privacy	in class	Machine Learning Approaches for Threat Detection, Anomaly Detection in Cyber-Physical Systems, Privacy-Preserving AI Models, AI-Driven Security Automation, Challenges in Implementing AI for Security.	[08]
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Security Engineering for Internet of Things	in class	IoT Architecture and Security Challenges, Authentication and Authorization in IoT, Secure Communication Protocols, IoT Device Management and Update Mechanisms, Case Studies on IoT Security Implementations.	[08]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Security Engineering for Embedded and Cyber-Physical Systems, Editors: Saad Motahhir and Yassine Maleh, Publisher: CRC Press (2023), ISBN: 9781032576497
2. Embedded Systems Security: Practical Methods for Safe and Secure Software and Systems Design", Authors: David J. Wheeler, et al., Publisher: Elsevier.

Reference Books:

1. Security and Privacy in Cyber-Physical Systems: Techniques, Applications, and Future Directions", Editors: Bhavani Thuraisingham, et al., Publisher: Springer.
2. Foundations of Cyber-Physical Systems and Networking: A Complete Guide to Embedded Systems and Networking", Authors: R. D. H. Warnecke, et al., Publisher: CRC Press.

CA679A3 **(2L + 1T Hrs./week)**

GAME THEORY

Questions to be set: 05 (All Compulsory)

Objectives: Knowledge of game theory would help students to understand and analyse real life situations such as market behaviour or voting in elections, apart from equipping them with analytical concepts which might be useful should they decide to pursue social sciences, engineering, sciences or managerial higher studies

Pre-requisites: Students should have a basic understanding of mathematics, logical reasoning, and introductory economics to effectively learn game theory concepts.

Course Outcomes (CO):

CO1	Demonstrate a clear understanding of foundational game theory concepts.
CO2	Analyse strategic interactions using dominance, best responses, and iterated elimination of dominated strategies.
CO3	Evaluate Equilibria in Various Game Structure.
CO4	Identify and compute equilibrium in different game forms including mixed strategies.
CO5	Apply concepts such as subgame perfect equilibrium, Folk theorems, and the one-shot deviation.

Module	Topics to be covered	Topics	Hrs
Module 1: Introduction to Game Theory	in class	What is game theory? Theory of rational choice Interacting decision maker, Strategic-form games, Dominance, Nash equilibrium, Existence: convex strategy set, mixed extension, computation, Two player zero-sum games, Correlated rationalizability, iterated elimination of dominated strategies, Correlated equilibrium.	[10]
	Assignment Topics	To be provided by the concern faculty members	
Module 2: Bayesian Games	in class	Types and Bayes-Nash equilibrium, First-price auction, Bilateral trading	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 3: Repeated Games	in class	Infinitely repeated games, Nash Folk theorem, Subgame perfect equilibrium and perfect Folk theorem (reversion to Nash), One-shot deviation principle, Tacit collusion	[8]
	Assignment Topics	To be provided by the concern faculty members	
Module 4:	in class	Game trees and extensive forms, Reduced form and Nash equilibrium, Backward induction and subgame	[8]

Extensive form games: Perfect information		perfect equilibrium, Mixed and behaviour strategies, Alternating offers bargaining	
	Assignment Topics	To be provided by the concern faculty members	
Module 5: Extensive form games: incomplete information	in class	Perfect Bayesian equilibrium, Sequential equilibrium	[8]
	Assignment Topics	To be provided by the concern faculty members	

Textbooks:

1. Osborne, M.J. An Introduction to Game Theory, Oxford University Press, 2004
2. Mas-Colell, A., M.D. Whinston and J.R. Green Microeconomic Theory, Oxford University Press, 1995

Reference Books:

1. Mark Nixon, Alberto Aguado, “Feature Extraction and Image Processing”, Academic Press,2008.
2. Martin J. Osborne, An Introduction to Game Theory, Oxford University Press