PROGRAM

AMRITA AHEAD

Master of Computer Applications

(MCA-Online)

CURRICULUM AND SYLLABUS
2021

PROGRAMME OUTCOMES

PO1 **Basic Knowledge:** Ability to apply knowledge of mathematics, computing and management principles appropriately to design and develop software applications.

PO2 **Problem Analysis:** Ability to identify, formulate problem definition for real world problems, analyze the literature and develop solutions.

PO3 **Modern Tool Usage:** Ability to assimilate and use state of the art computing technologies, tools and techniques necessary for computing practices.

PO4 **Project Management and Ethics:** Ability to apply standards to manage projects and develop soft skills, and practice professional ethics in all environments.

PO5 **Communication:** Ability to communicate effectively in both verbal and written form.

PO6 **Team work:** Ability to function effectively as an individual, and as a member or leader in diverse teams, and in a multidisciplinary environment.

PO7 **Lifelong learning:** Ability to engage in self-learning for continual development as a computing professional and analyze the impact of computing on individuals, organizations, research community and the society at large.

CURRICULUM

SEMESTER I

Code	Title	L T P	Credit
21CSA512A	Foundations of Computer Systems	2 0 1	3
21MAT520A	Mathematical Foundations for Computer Applications	3 0 0	3
21CSA528A	Essentials of Cybersecurity	2 0 1	3
	Elective I	2 0 1	3
	Elective II	2 0 1	3
	Elective III	2 0 1	3
	TOTAL		18

SEMESTER II

Code	Title	L T P	Credit
21CSA508A	Data Structures and Algorithms	2 0 1	3
	Mathematics Elective	2 1 0	3
21CSA541A	Cloud Computing	2 0 1	3
	Elective IV	2 0 1	3
	Elective V	2 0 1	3
	Elective VI	2 0 1	3
	TOTAL		18

SEMESTER III

Code	Title	L T P	Credit
21CSA511A	Software Project Management	2 0 1	3
21CSA542A	Research Methodology	2 1 0	3
	Elective VII	2 0 1	3
	Elective VIII	2 0 1	3
	Elective IX	2 0 1	3
	Elective X	2 0 1	3
	TOTAL		18

SEMESTER IV

Code	Title	L T P	Credit
21CSA699A	Project		18
	TOTAL		18
	TOTAL CREDITS		72

ELECTIVES

Code	Title	L T P	Credit
21CSA501A	Object Oriented Programming Using Java	2 0 1	3
21CSA502A	Advanced Operating Systems	2 0 1	3
21CSA503A	Advanced Computer Networks	2 0 1	3
21CSA504A	Python Programming	2 0 1	3
21CSA505A	Advanced DBMS	2 0 1	3
21CSA509A	Advanced Web Technologies and Mean Stack	2 0 1	3
21CSA510A	Software Engineering and Design Patterns	2 0 1	3
21CSA518A	Design and Analysis of Algorithms	2 0 1	3
21CSA651A	Computer Graphics and Visualization	2 0 1	3
21CSA652A	Mobile Application Development	2 0 1	3
21CSA653A	Compiler Design	2 0 1	3
21CSA654A	Deep Learning	2 0 1	3
21CSA655A	Parallel and Distributed Computing	2 0 1	3
21CSA656A	Connected Internet of Things Devices	2 0 1	3
21CSA657A	Software Testing	2 0 1	3
21CSA658A	Network Management and System Administration	2 0 1	3
21CSA659A	Semantic Web Technologies	2 0 1	3
21CSA660A	Bioinformatics	2 0 1	3
21CSA661A	Digital Image Processing	2 0 1	3
21CSA662A	Information Retrieval	2 0 1	3
21CSA663A	Software Defined Networks	2 0 1	3
21CSA664A	Pattern Recognition	2 0 1	3
21CSA665A	Malware Analysis	2 0 1	3
21CSA666A	Network Security Essentials	2 0 1	3
21CSA667A	Block Chain Technologies	2 0 1	3
21CSA668A	Principles of Economics and Management	2 0 1	3
	AI & DS Stream		
21CSA513A	Foundations of Machine Learning	2 0 1	3
21CSA514A	Natural Language Processing	2 0 1	3
21CSA519A	Business Analytics and Visualization	2 0 1	3
21CSA520A	Deep Learning for AI	2 0 1	3
21CSA521A	Computer Vision	2 0 1	3
21CSA522A	Complex Network Analysis	2 0 1	3

21CSA523A	**Data Engineering for AI**	**2 0 1**	**3**
21CSA524A	**Reinforcement Learning**	**2 0 1**	**3**
21CSA525A	**IoT for AI**	**2 0 1**	**3**
21CSA731A	**Artificial Intelligence**	**2 0 1**	**3**
21CSA732A	**Artificial Intelligence for Robotics**	**2 0 1**	**3**
21CSA733A	**No-SQL Databases**	**2 0 1**	**3**
21CSA734A	**Applications of Machine Learning**	**2 0 1**	**3**
21CSA735A	**Web Analytics**	**2 0 1**	**3**
21CSA736A	**Computational Statistics**	**2 0 1**	**3**
21CSA737A	**AI for Drug Discovery and Target Validation**	**2 0 1**	**3**
21CSA738A	**Representation Learning**	**2 0 1**	**3**
21CSA739A	**Medical Signal Processing**	**2 0 1**	**3**
21CSA740A	**Applied Predictive Analytics**	**2 0 1**	**3**
21CSA741A	**Data Visualization**	**2 0 1**	**3**
Cyber Security Stream			
21CSA527A	**Network Security**	**2 0 1**	**3**
21CSA529A	**Python Scripting for Security**	**2 0 1**	**3**
21CSA530A	**Fundamentals of Cybersecurity Operations**	**2 0 1**	**3**
21CSA537A	**Cloud and Infrastructure Security**	**2 0 1**	**3**
21CSA538A	**Cybersecurity Governance, Risk and Compliance**	**2 0 1**	**3**
21CSA539A	**Cyber Security Law**	**2 0 1**	**3**
21CSA540A	**Web Application Security**	**2 0 1**	**3**
21CSA751A	**Machine Learning and Artificial Intelligence in Cybersecurity**	**2 0 1**	**3**
21CSA752A	**Mobile Security and Defence**	**2 0 1**	**3**
21CSA753A	**Cyber Forensics**	**2 0 1**	**3**
21CSA754A	**Blockchain and Decentralized Applications**	**2 0 1**	**3**
21CSA755A	**VAPT (Vulnerability and Penetration Testing)**	**2 0 1**	**3**
21CSA756A	**Security Architecture for Databases and Applications**	**2 0 1**	**3**
21CSA757A	**System Security**	**2 0 1**	**3**

* Any student completing 6 out of 10 of their electives from any particular stream will be given a certificate with that specialization name.

MATHEMATICS ELECTIVES

Code	Title	L T P	Credit
21MAT522A	**Computational Linear Algebra**	**2 1 0**	**3**
21MAT523A	**Probability and Statistics**	**2 1 0**	**3**
21MAT524A	**Mathematical Foundations for Cryptography**	**2 1 0**	**3**

SYLLABUS

SEMESTER I

21CSA512A	FOUNDATIONS OF COMPUTER SYSTEMS	L-T-P-C: 2-0-1-3

Course Objectives

- Introduce students to the basics of Computer Systems.
- To enable the student to identify the interrelationships between Computer hardware and software.
- To enable the student to identify the interrelationships of further courses in the MCA program.

Course Outcomes

COs	Description
CO1	Understand the basic components of computer systems and its functionality.
CO2	Demonstrate the functions of operating system and its role as a resource manager to execute any application.
CO3	Understand the need for database storage and learn to retrieve using SQL.
CO4	Implement the connection between operating systems, computer networks and database management through a case study

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	-	-	-	-	-	2
CO2	3	-	-	-	-	-	2
CO3	3	2	3	-	-	-	2
CO4	3	2	3	-	-	-	2
CAM	3	2	3	-	-	-	2

Syllabus

Unit I
Basics of Computers, Generations, and Classifications of Computers, Computer System hardware, Inside a compute cabinet, Input/ Output units, Computer Memory, Processor, Instruction format, Computer Architecture. Microcomputers: Digital Signal Processor, Microcontrollers, Smart Cards, Radio Frequency Identification.

Unit II
Data Representation, Binary Arithmetic, Binary coding schemes, Logic Circuits, and gates.

Unit III
Types of Softwares, Operating System, Different types and functions, Process management, memory management, File and device management, protection and security, UNIX Operating System, Utilities, Microkernel based OS.

Unit IV
Data, Information and Knowledge, Introduction to Database Management Systems, Data Models, Introduction to SQL: Datatypes, Classification of SQL-DDL with constraints, DML, DCL, TCL.

Unit V

Computer Networks, Data transmission media, network types and topologies, Network devices, ISO/OSI and TCP/IP models, Protocols, Voice and data communication, Wireless networking, Cellular communication, Bluetooth, Mobile communication.

Textbooks / References:

1. Fundamentals Computers, V Rajaraman, Neeharika Adabala, Phi Learning Pvt. Ltd.
2. Computer Fundamentals, Anita Goel, Pearson.
3. J. Glenn Brookshear," Computer Science: An Overview", Addison-Wesley, Twelfth Edition, 2014.

21MAT520A MATHEMATICAL FOUNDATIONS FOR COMPUTER APPLICATIONS L-T-P-C: 3-0-0-3

Course Objectives

This course provides mathematical background and sufficient experience on various topics like matrix algebra, logic and proofs, combinatorics, and algebraic structures. This knowledge improves student's Logical and Mathematical thinking and ability to deal with abstract concepts in computer science and to solve practical problems.

Course Outcomes

COs	Description
CO1	To construct mathematical arguments using logical connectives and quantifiers.
CO2	Understand the basic concepts of mathematical reasoning, set, and functions.
CO3	Acquires knowledge of matrix, set theory, functions, and relations concepts needed for designing and solving problems
CO4	Apply the concepts of generating functions to solve the recurrence relations.
CO5	To familiarize concepts like groups and rings.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	-	-	1	-	2
CO2	2	3	-	-	1	-	3
CO3	2	2	-	-	1	-	3
CO4	2	2	-	-	-	-	2
CO5	2	1	-	-	-	-	2
CAM	2	2	-	-	1	-	2

Syllabus

Unit I

Mathematical logic: Introduction, Statements and Notation, Connectives, Arguments, Normal Forms, Theory of Inference for the Statement Calculus, The Predicate Calculus, Inference Theory of the Predicate Calculus.

Unit II

Sets- Basic definitions - Laws of set theory - Principle of inclusion and exclusion – Partitions - Permutation and combination – Relations - Properties of relations – Equivalence relation-Matrices of relations - Closure operations on relations -n-ary relations- Functions.

Unit III

Groups – Axiom of a group – Examples and basic algebra in groups – Order of an element of a group – Isomorphism of groups – Cyclic groups – Subgroups – Cosets and Lagrange's theorem – Rings-Field

Unit IV

Matrices - Rank of a matrix - Solving system of equations – Echelon form of a matrix and row reduced echelon form of matrix.- Eigenvalues and Eigenvectors - Cayley - Hamilton theorem.

Unit V

COMBINATORICS -Review of Permutation and Combination - Mathematical Induction - Pigeon hole principle - Principle of Inclusion and Exclusion - generating function - Recurrence relations, Homogeneous and

nonhomogeneous recurrences, and their solutions - solving recurrences using generating functions.

Textbooks / References:

1. Rosen K. H., “Discrete Mathematics and its Applications”, Seventh Edition, Tata McGraw-Hill, New Delhi, 2007.
2. R. P. Grimaldi, “Discrete and Combinatorial Mathematics”, Pearson Education, Fifth Edition, 2007.
3. David Makinson, “Sets, Logic, and Maths for Computing”, Springer Indian Reprint, 2011.
4. Trembley, J.P., and Manohar, R, "Discrete Mathematical Structures with Applications to Computer Science", Tata McGraw Hill, New Delhi, 2007.

21CSA528A	ESSENTIALS OF CYBERSECURITY	L-T-P-C: 2-0-1-3

Course Objectives

The student will learn to navigate a Linux CLI and run basic bash commands. Comfort in understanding the common architecture and platforms. Students will practice basic cryptography with code, as well as analyzing malicious binaries.

Course Outcomes

COs	Description
CO1	Understanding the usage and fundamental principles behind the GNU/Linux operating system
CO2	Grasping the essential principles behind currently used cryptographic algorithms
CO3	Learning reverse engineering skills associated with the x86/x86-64 platform
CO4	Understanding how to perform analysis of malicious binaries
CO5	Understand stack and heap exploits on system calls

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	1	3	-	-	-	3
CO2	2	2	3	-	-	-	3
CO3	1	3	3	-	-	-	3
CO4	2	3	3	-	-	-	3
CO5	2	3	3	-	-	-	3
CAM	2	3	3	-	-	-	3

Syllabus

Unit I
Linux, Shell essential concepts, Shell I/O, Linux Paths and File Manipulation, Linux permissions,

Unit II
Cryptography, Kerkhoff's principle, Symmetric key encryption, MAC, Public key cryptography, Asymmetric key encryption, Digital signatures, TLS cryptography, Password hashing

Unit III
System security, System calls, Context switches, Malware Analysis, Static and dynamic analysis, Windows API, Malware identification, Malware disassembly

Textbooks / References:

1. Arpaci-Dusseau, R. H., & Arpaci-Dusseau, A. C. (2018). Operating systems: Three easy pieces. Arpaci-Dusseau Books LLC.
2. David Wong. (2021). Real-World Cryptography. Manning Publishing

SEMESTER II

21CSA508A	DATA STRUCTURES AND ALGORITHMS	L-T-P-C: 2-0-1-3

Course Objectives

- This course aims to provide the basic knowledge of different data structures and its usage. It also covers techniques used for analysing algorithms and notations for expressing time complexity.

Course Outcomes

COs	Description
CO1	Implement basic data structures such as Linked lists, Stack and Queue.
CO2	Analyse an algorithm, determine its time complexity and express it in asymptotic notation.
CO3	Implement different searching and sorting algorithms.
CO4	Use different data structures including tree and graph and solve computational problems using it.
CO5	Choose appropriate data structures and algorithms, understand the ADT/libraries, and use it to design algorithms for a specific problem.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	1	-	-	-	2
CO2	3	1	1	-	-	-	3
CO3	3	3	1	-	-	-	1
CO4	3	3	1	-	-	-	3
CO5	2	3	2	-	-	-	3
CAM	3	3	1	-	-	-	3

Syllabus

Linear Data Structures: Arrays (single and multi-dimensional), Stack ADT, Multi Stack ADT, Queue ADT, Circular Queue, Priority Queue, Singly Linked List, Doubly Linked List, Circular Linked List.

Nonlinear Data Structures: Trees - Array and List Representations: Binary Tree, Binary Search Tree, and Threaded Binary Tree. Balanced Trees: Weight Balanced Trees, Applications of WBTs, Height Balanced Trees -AVL Trees, Red-Black Trees. Binary Heaps: applications

Graphs: Matrix and List Representation of Graphs, Breadth-First Search, Depth First Search, Shortest Path Algorithms (with Analysis) – Dijkstra - Bellman Ford- Floyd Warshall's all Pair shortest path Algorithm- Minimum spanning Tree (with Analysis) – Kruskal– Prims - Applications of BFS and DFS.

The efficiency of algorithms - the notion of time and space complexity, Basic Complexity Analysis - Worst case, Average case, and Best cases, Asymptotic Analysis- notations, analyzing iterative programs – Simple examples; Recurrences, Recurrence Relation: Substitution method, Recursion Tree Methods, Master Method. Analysis of Divide and conquer algorithms – Quick Sort, Merge sort, Bucket Sort, Heap Sort, Greedy Algorithm: Fractional Knapsack Problem- Task Scheduling Problem.

Dynamic Programming: Longest common subsequence problem, Matrix Multiplication Problem- 0/1 Knap-sack Problem. Branch and Bound – backtracking

Textbooks / References:

1. Ellis Horowitz, Sartaj Sahni, and Susan Anderson-Freed, “Fundamentals of Data Structures in C”, Second Edition, Silicon Press, 2008.
2. Jean-Paul Tremblay and G. Sorenson, “An introduction to Data Structures with Applications”, Second Edition, Tata McGraw-Hill, 2008.
3. Robert L.Kruse, Bruce P. Leung, Clovis.L. Tondo and Shashi Mogalla, “Data Structure and Program Design in C”, Pearson Education, Second Edition, 1997.
4. CormenT.H, Leiserson C.E, Rivest R.L, and Stein C, “Introduction to Algorithms”, Third Edition, Prentice-Hall of India, 2009.
5. Baase.S and Gelder A.V., “Computer Algorithms- Introduction to Design and Analysis”, Third Edition, Pearson Education Asia, 2003.

21CSA541A	CLOUD COMPUTING	L-T-P-C: 2-0-1-3

Course Objectives

- The course is designed as an introductory guide to cloud computing and helps students to under-stand why it is a technological and business game-changer.
- This course provides an overview of compute options, structured and unstructured cloud storage models.
- This course also introduces a variety of managed services in the cloud.

Course Outcomes

COs	Description
CO1	Understand cloud compute options, and structured and unstructured storage models
CO2	Understand cloud API, cloud security – services that protect the data
CO3	Understand cloud networking options and guidelines for setting up the rules.
CO4	Understand the concepts of cloud automation, management tools, and AI services
CO5	Practical application of various modern cloud technologies

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	1	3	-	-	-	3
CO2	3	1	2	-	-	-	3
CO3	3	2	3	-	-	-	3
CO4	3	1	3	-	-	-	3
CO5	3	1	3	-	-	-	3
CAM	3	1	3	-	-	-	3

Syllabus

Unit I: Introduction to Cloud - Google Cloud Architecture - The cloud Console - Understanding projects - Billing - Install and configure Cloud SDK - Use Cloud Shell – APIs . Compute Services - Compute options in the cloud - Google Compute Engine virtual machine - zones, regions, and machine types- Exploring IaaS with Compute Engine - Exploring PaaS with App Engine. Structured and unstruc-tured storage - Storage options in the cloud.

Unit II: Cloud API - The purpose of APIs - Cloud Endpoints - Exploring Cloud SQL - Cloud Pub/Sub. Cloud Security - Introduction to security in the cloud, Cloud Identity and Access Management (IAM), Authentication and Authorization with Cloud. Networking - Introduction to networking in the cloud - Routes and firewall rules in the cloud.

Unit III: Cloud automation and management tools - Introduction to Infrastructure as Code - Cloud Deploy-ment Manager - Big data services - Introduction to big data managed services in the cloud - Ma-chine learning - Introduction to Machine Learning Models with AI Platform in the cloud - Pre-trained Machine Learning APIs - Natural Language and Google Cloud Speech APIs.

Textbooks / References:

1. Bahga, Arshdeep., Madisetti, Vijay. Cloud Computing: A Hands-on Approach. United Kingdom: Arsheep Bahga & Vijay Madisetti, 2014.
2. Google Cloud Computing Foundations, https://cloud.google.com/edu/curriculum

SEMESTER III

21CSA511A	SOFTWARE PROJECT MANAGEMENT	L-T-P-C: 2-0-1-3

Course Objectives

- This course is aimed at introducing the primary important concepts of project management related to managing software development projects. They will also get familiar with the different activities involved in Software Project Management. Further, they will also come to know how to successfully plan and implement a software project management activity, and to complete a specific project in time with the available budget.

Course Outcomes

COs	Description
CO1	Understand the basics of software project management activities for the success of a project.
CO2	Project Evaluation and program management techniques.
CO3	Understand the basic steps that need to be carried out by a Project Manager.
CO4	Learn the effort and duration estimation techniques.
CO5	Identify project activity planning based on estimations.
CO6	Study various risk management approaches and its simulations.
CO7	Identify the resource allocations and issues.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	2	-	-	1
CO2	3	2	-	2	-	-	1
CO3	3	2	-	3	-	-	1
CO4	3	2	-	3	-	-	1
CO5	2	2	-	3	-	-	1
CO6	3	2	-	2	-	-	-
CO7	2	2	-	3	-	1	1
CAM	3	2	-	3	-	1	1

Syllabus

Introduction to Software Project Management: Software Projects-Other Types of Projects -Problems with Software Projects. Project Evaluation and Program Management:

Evaluation of Individual Projects – Cost Benefit Evaluation Techniques – Risk Evaluation. Step Wise: An Overview of Project Planning. Selection of an Appropriate Project Approach: Build or Buy? - Waterfall Model – Spiral Model – Prototyping – Incremental Delivery–RAD – Agile Methods – XP - Scrum.

Software Effort Estimation: Bottom up Estimating – Top-down Estimating – FP Analysis –COCOMO II – Cost Estimation. Activity Planning: Project Schedules - Sequencing and Scheduling Projects - Network Planning Models – AOA – AON - CPM - Shortening Project Duration – Crashing - Identifying Critical Activities.

Risk Management: A Framework for Dealing with Risk – Risk Management – PERT. Resource Allocation: Identifying Resource Requirements – Scheduling Resources –Publishing Resource Schedule – Cost Schedule.

Monitoring and Control: Visualizing Progress - Earned Value Analysis. Managing People in SW Environments: Organizational Behavior – Motivation.

Working in Teams: Organizing Teams. Software Quality Management: Defining Software Quality – Metrics – Process Capability Models – Software Reliability. Case Study: PMBOK - MS Project.

Textbooks / References:

1. Mike Cotterell and Bob Hughes, “Software Project Management”, Fifth Edition, Tata McGraw-Hill, 2010.
2. Roger S. Pressman, “Software Engineering a Practitioner’s Approach”, Seventh Edition, Tata McGraw-Hill, 2010.
3. Jalote P, “Software Project Management in Practice”, Addison Wesley, 2002

21CSA542A	RESEARCH METHODOLOGY	L-T-P-C: 2-1-0-3

Course Objectives

- To inculcate research interest in students, help them to identify a research area and conduct literature review.

Course Outcomes

COs	Description
CO1	To develop the understanding of the basic framework of research process.
CO2	Identify various sources of information for literature review and data collection.
CO3	Gain a practical understanding of the various methodological tools used for conducting research.
CO4	Able to conduct a research study from its inception to its report and study on Ethical issues in research.
CO5	To formulate a problem based on a case study and design a proper research design with supporting literature survey.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	-	-	-	-	1
CO2	2	2	-	-	-	1	1
CO3	2	1	3	-	-	-	2
CO4	2	2	-	-	-	-	1
CO5	2	3	-	-	-	-	1
CAM	2	2	3	-	-	1	1

Syllabus

Research: Meaning, Purpose, Types of Research, Steps in Research, Identification, Selection and Formulation of Research Problem, Research Questions, Research Design, Review of Literature. Internet as a source in identifying gap areas from literature reviews and emerging trends. Research Report writing.

Ethical Issues, Copyright, Royalty, Intellectual Property Rights and Patent Law, Reproduction of Published Material, Citation and Acknowledgement.

Case study: conduct literature review on a chosen research topic, prepare a review report and present a seminar.

Textbooks / References:

1. CR Kothari: “Research Methodology-Methods and Techniques”, New Age International Publishers, 2004.
2. Jacques Barzun, Henry F. Graff: “The Modern Researcher” Edition 6, Wadsworth Inc Fulfillment, 2003.
3. Carlo Lastrucci, The Scientific Approach: Basic Principles of the Scientific Method (Cambridge, Mass.: Schenkman, 1967).
4. Robert P. Merges, Peter S. Menell, Mark A. Lemley, Intellectual Property in New TechnologicalAge, 2016.

ELECTIVES

21CSA501A OBJECT ORIENTED PROGRAMMING USING JAVA L-T-P-C: 2-0-1-3

Course Objectives

- The main objective of this course is to understand the basic concepts and techniques which form the object-oriented programming paradigm using Java Language.

Course Outcomes

COs	Description
CO1	Identify classes, objects, members of a class and relationships among them needed for a specific problem.
CO2	Implement Java application programs using OOP principles and proper program structuring.
CO3	Demonstrate the concepts of polymorphism, inheritance and thread and document a Java Program using Javadoc.
CO4	Use Java AWT and Swing classes to build GUIs and understand how collection interface is implemented.
CO5	Demonstrate the Conceptual model of UML, activity diagram and their modelling techniques.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	-	-	-	1
CO2	3	3	3	-	-	-	1
CO3	3	2	2	-	-	-	1
CO4	3	3	1	-	-	-	1
CO5	3	3	3	1	1	1	1
CAM	3	3	3	1	1	1	1

Syllabus

Unit I

Introduction to object oriented software design, Comparison of programming methodologies, Object Basics, Java Environment, Classes and Object, Data Members, Access Specifiers, Arrays within a Class, Array of Objects, Constructors, Default Constructors, Destructors, Static Members, Constant Members.

Unit II

Overview of Streams, Bytes vs. Characters, File Object, Binary Input and Output, Reading and Writing Objects, Method Overriding, Polymorphism, Super, Interfaces and Abstract Classes, Packages, Exception

Unit III

Introduction to Threads, Creating Threads, Thread States, Runnable Threads, Coordinating Threads, Interrupting Threads, Runnable Interface, Synchronization.

Unit IV

Collection framework, Collection interfaces and classes, AWT, Swing, Event Handling, Javadoc

Unit V

Object Oriented Design with UML, Class, object diagrams and sequence diagrams. Use case diagrams and activity diagrams

Textbooks / References:

1. Herbert Scheldt, “Java: The Complete Reference, Eleventh Edition”, Oracle 2018
2. Deitel PJ. Java how to program. Eleventh Edition, Pearson; 2018.
3. Nino J, Hosch FA. Introduction to Programming and Object-oriented Design using Java. Wiley India Private Limited; 2010.
4. Naughton P. and Schildt H. Java 2: The Complete Reference. Eighth Edition, Tata McGraw- Hill; 2011.
5. Bahrami A. Object Oriented Systems Development. Second Edition, McGraw-Hill; 2008.
6. Booch G, Maksimchuk RA. Object-oriented Analysis and Design with Applications. Third Edition, Pearson Education; 2009.

21CSA502A	ADVANCED OPERATING SYSTEMS	L-T-P-C: 2-0-1-3

Course Objectives

- The aim of this course is to study, learn, and understand the main concepts of basic and advanced operating systems.
- Distributed systems, open-source operating systems, and hardware and software features that support these systems are also covered here.

Course Outcomes

COs	Description
CO1	Able to illustrate the architecture and functionalities of modern OS and virtual machines
CO2	Able to apply the algorithms for resource management and scheduling.
CO3	Able to apply semaphores and monitors for classical and real world synchronization scenarios.
CO4	Illustrate how a distributed Operating System works.
CO5	Able to engage in independent learning as a team to study characteristic features of modern operating systems

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	-	-	-	-	2
CO2	3	3	1	-	-	-	2
CO3	3	3	2	-	-	-	2
CO4	3	3	-	-	-	-	2
CO5	3	3	-	-	-	-	2
CAM	3	3	2	-	-	-	2

Syllabus

Unit I

Introduction to Operating System and its functions: Types of Operating Systems; Computer hardware review – Instruction execution cycle, Interrupts; System calls – How to implement a new system call in Linux; Difference between system calls and library routines.

Process concept - Process Creation and termination, PCB, Process States, Inter-process Communication, Classic synchronization problems and their solutions; Deadlocks, Concept of Threads

Unit II

Memory Management & I/O: Address space abstraction, Address binding. Dynamic linking and shared libraries. Basic memory management, swapping, Paging, Segmentation, Virtual memory, Page replacement algorithms, DMA & Cache memory Creation of shared memory.Overview of I/O Hardware; Application I/O Interface; Kernel I/O Subsystem; Transforming I/O Requests to Hardware Operations; Performance.

Unit III

Unix Internals: Introduction and architecture of Unix OS – Basics & Commands- Architecture of Unix OS-Kernel Data structures, File subsystem, and process subsystem – Process states and transitions – sleep and wakeup – buffer cache. File system – Internal representation of files – system calls for the file system. Inter-process communication – System V IPC, Network Communications.

Unit IV

Memory management in Unix- swapping, demand paging, a hybrid system with swapping and demand paging. I/O subsystem- driver interfaces, disk drivers, terminal drivers, streams Protection and Security Domain of Protection, Access Matrix, Implementation of Access Matrix, Access Control, Revocation of Access Rights, Capability-Based Systems. User and group creation in Windows and Linux, directory, and file permissions for Linux.

Unit V

Distributed Operating Systems – Fundamentals of Distributed systems, Message Passing, RPC, Distributed Shared Memory, Synchronization; Distributed File System, Distributed Coordination – Mutual Exclusion; Time Stamping.

Textbooks / References:

1. Silberschatz, Galvin, Gagne, Operating System Concepts, Tenth Edition, John Wiley & Sons,Inc.
2. Distributed Operating Systems Concepts and Design – Pradeep K Sinha - Prentice-Hall India
3. The Design of the Unix Operating System - Maurice J Bach – Prentice-Hall India.
4. Godbole - Operating Systems - Tata McGraw Hill Publications
5. H.M Deitel - Operating Systems - Second Edition - Pearson Edition Asia
6. Modern Operating Systems – Andrew S Tanenbaum, Prentice-Hall, fourth Edition, 2015
7. Unix System Programming - Kay A Robbins, Steven Robbins – Pearson Education, Second Edition.

21CSA503A	ADVANCED COMPUTER NETWORKS	L-T-P-C: 2-0-1-3

Course Objectives

- The primary course objective is to provide the foundation of basics in computer networks in the digital era.
- Enable the student to understand the fundamental networking principles, standards, protocols and technologies.
- The course also provides insights into networking concepts in each layer of the protocol model.
- The course will enrich the students with hands on experience in configuring networking devices using Packet Tracer and analysing the protocols using Wireshark.

Course Outcomes

COs	Description
CO1	To master the network basics and examine the function of the layers in the Internet protocol stack.
CO2	Determine the IP addressing for hosts in subnets and configure the networking devices like routers and switch.
CO3	To design and build simple local area networks using simulator/emulator/real time devices.
CO4	To design or simulate network applications and study its performance
CO5	To examine the foundation of network security

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	-	-	-	-	2
CO2	2	1	-	-	-	-	2
CO3	3	3	2	-	-	-	2
CO4	3	3	2	-	-	-	2
CO5	3	3	1	-	-	-	2
CAM	3	3	2	-	-	-	2

Syllabus

Introduction: The Network Edge- The Network Core– Delay– Loss and Throughput in Packet Switched Networks. Network Types –LAN, WAN, PAN etc. Common network services in End devices, Wireshark and Packet Tracer Simulation tools, Characteristics of reliable networks.
Protocols: Open and Internet Standards, Network Protocol Interactions, Protocol suite, Layered Models - OSI, TCP/IP, Data Encapsulation, Logical and physical host address, Data Transfer in the network
Internetwork Operating Systems(IOS) basics, IOS Access and Navigation, The Command Structure, Basic Device Configurations.
Physical Layer - Physical Layer purpose and Characteristics, Copper and UTP cabling for wired LAN, Fibre-optic cabling and wireless media.
Network Access - Purpose of the Data Link Layer, Topologies, Frame, MAC address, Address Resolution protocol (ARP), Ethernet switch functionalities, Wireless LANs Basics. Configuring Wired and Wireless LAN
Network Layer – Layer Characteristics, IPv4 and IPv6 Packet, Host Routing Table, Functions of a router, Routing principles, Routing algorithm – Interior and Exterior routing, Routing decision process. Configure IP Addressing, Build a network in Packet Tracer simulator

Internet protocol – Internet Layer-Class full Addressing – Class less addressing – Private Addresses – Subnets – Subnet masks, Classless and Subnet Address Extensions (CIDR), Variable Length Subnet Masking(VLSM), Internet Multicasting. Familiarizing IPv4 and IPv6 addressing, Network Address Translation (NAT), ping and trace route utilities, ICMP.

Routing & Forwarding - Global Internet– RIP – OSPF – BGP – Broadcast & Multicast routing, Configuring Routing Protocols and application of subnetting in Packet Tracer,

Transport Layer –connection oriented and connection less service using sockets, Traffic Control and reliability strategies

Application Layer - Functionality, Web and Email Protocols, IP Addressing and File Sharing services

Internet of Things – Components like controllers, services, Fog and cloud computing, Applications.

Network Security – Security threats and vulnerabilities, network attacks, network attack mitigation, device security.

Textbooks / References:

1. James F. Kurose and Keith W. Ross, "Computer Networking: A Top-Down Approach", 6th Edition, Addison Wesley, 2008.
2. Andrew S.Tanenbaum, "Computer Networks", Fifth Edition, Prentice Hall of India, 2011.
3. Richard Stevens, Bill Fenner and Andrew M. Rudoff, "UNIX Network Programming", Volume 1: "The Sockets Networking API", Third Edition, Addison Wesley, 2004.
4. Cisco Certified Networking Associate Certification (CCNA) Part1 Introduction to Computer Networks, Cisco Networking Academy.
5. Cisco Netacad academy course regarding Introduction to Cybersecurity and Internet of Things Fundamentals

21CSA504A	PYTHON PROGRAMMING	L-T-P-C: 2-0-1-3

Course Objectives

- The main objective of this course is to familiarize the student with Python programming concepts, syntax, semantics, and the runtime environment, as well as with general coding techniques and object oriented programming.

Course Outcomes

COs	Description
CO1	Understandthe structure, syntax, and semantics of the Python language.
CO2	Solve realworld problems by applying the Python Data Structures, Objects, Functions andModules.
CO3	Apply the fundamental principles of ObjectOriented Programming.
CO4	Apply the basics of data science using advanced Python libraries.
CO5	Build practical applications in Python.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	-	-	-	3
CO2	2	3	3	-	-	-	3
CO3	3	1	-	-	-	-	3
CO4	3	2	3	-	-	-	3
CO5	2	3	3	-	-	-	3
CAM	3	2	3	-	-	-	3

Syllabus

Unit I

Basic concepts in Python: Python runtime environment, Python variables, Python basic Operators, Understanding python blocks. Python Data Types, Declaring and using Numeric data types and functions. Conditional statements and loop statements in Python.

Unit II

Python Complex data types: Strings and string functions, List and Tuple manipulation, Dictionary and Set operations.

Unit III

Functions and modules in Python: defining functions, scope, types of arguments, the anonymous function(lambda), map, filter, reduce and zip functions. Introduction to Python modules and creating own modules.

Unit IV

Exception handling in Python. Python File Operations: Reading files, Writing files in python. Python directories.

Object oriented programming in Python: Defining classes and instantiating objects. Python Constructors and destructors. Inheritance and polymorphism in Python.

Unit V

Fundamentals for data science: Introduction to Jupyter notebook, Programming using Numpy, Pandas and matplotlib libraries.

Textbooks / References:

1. Wesley J. Chun, “Core Python Applications Programming”, 3rd Edition , Pearson Education, 2016
2. Charles Dierbach, “Introduction to Computer Science using Python”, Wiley, 2015
3. Jeeva Jose & P. Sojan Lal, “Introduction to Computing and Problem Solving with PYTHON”, Khanna Publishers, New Delhi, 2016.
4. Downey, A. et al., "How to think like a Computer Scientist: Learning with Python", John Wiley, 2015.
5. Wes McKinney, “Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython”, 2nd edition, O’Reilly Publication, ISBN-13: 978-1491957660, ISBN-10: 1491957662
6. Mark Lutz, “Learning Python”, 5th edition, O’Reilly Publication, 2013, ISBN 978- 1449355739
7. John Zelle, “Python Programming: An Introduction to Computer Science”, Second edition, Course Technology Cengage Learning Publications, 2013, ISBN 978- 1590282410
8. Michel Dawson, “Python Programming for Absolute Beginners”, Third Edition, Course Technology Cengage Learning Publications, 2013, ISBN 978-1435455009
9. David Beazley, Brian Jones., “Python Cookbook”, Third Edition, O’Reilly Publication, 2013, ISBN 978-1449340377

21CSA505A	ADVANCED DBMS	L-T-P-C: 2-0-1-3

Course Objectives

- To provide students with theoretical knowledge and practical skills in advanced topics in database systems.
- To Design and implement object-relational database queries using Structured Query Language.
- To Understand and study parallel and distributed database principles.

Course Outcomes

COs	Description
CO1	Explain and evaluate the fundamental theories for advanced database architectures and query operators.
CO2	Examine the issues related to the database recovery process.
CO3	Analyze and Implement the concept of an object-relational database in the development of various real-time software.
CO4	Understand parallel database systems by evaluating different methods of storing, managing the parallel databases.
CO5	Analyze various terms related to transaction management in a distributed database.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	-	-	-	2
CO2	2	2	-	-	-	-	2
CO3	3	3	3	-	-	-	2
CO4	3	3	2	-	-	-	2
CO5	3	3	1	-	-	-	2
CAM	3	3	2	-	-	-	2

Syllabus

Introduction - Data Independence - The Three Levels Of Architecture - The External Level - Conceptual Level - Internal Level- System Structure, Instance and schema, Data Models, Types of DBMS , Keys, Structure Of Relational Databases, Introduction to relational algebra

Database Design using ER modeling.

SQL -DDL, DML, Order by, Group by, Join, Subquery

Transaction model and properties, Transaction structure, concurrency control -lock-based, timestamp-based, multi-version Schemas. Recovery System

Introduction to an object-relational database, Complex Data Types, Structured Types and Inheritance in SQL Table Inheritance, Array. Representing multivalued and composite attributes.

Introduction to Parallel database and I/O Parallelism, Interquery Parallelism, Intraquery Parallelism. Intraoperation Parallelism, Interoperation Parallelism.

Distributed Databases- Fragmentation, Replication, Distributed Transactions, Commit protocols

Indexing and hashing- Basic concepts, B+Tree index files, Hashing

Textbooks / References:

1. Database Systems Concepts; Silberschatz, Abraham, Henry F. Korth, and S.Sudarshan.
2. RamezElmasri and ShamkantNavathe, “Fundamentals of Database Systems”, Sixth Edition, Addison Wesley, 2010.
3. Hector Garcia-Molina, Jeffrey Ullman, and Jennifer Widom, “Database Systems: The Complete Book”, Second Edition, Prentice-Hall, 2008.
4. Carlo Zaniolo, Stefano Ceri, Christos Faloutsos, Richard T.Snodgrass, V.S.Subrahmanian, Roberto Zicari, ―Advanced Database Systems, Morgan Kaufmann Publishers,2006.

21CSA509A	ADVANCED WEB TECHNOLOGIES AND MEAN STACK	L-T-P-C: 2-0-1-3

Course Objectives

This course helps the students to proficient in Javascript and use HTML, CSS and Javascript to handle front-end operations and back-end server scripting. MEAN is a full-stack development toolkit used to develop a fast and robust web application.

Course Outcomes

COs	Description
CO1	Let the students acquainted with the latest web application development trends in the IT industry
CO2	Equip students with principles, knowledge, and skills for the design and construction of web-enabled internet applications.
CO3	Design, Implement and deploy an in-house project using MongoDB, Express.js, AngularJS, and Node.js.
CO4	Evaluate different web application development alternatives and choose the appropriate one for a specific scenario.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	3	-	-	-	2
CO2	2	3	3	-	-	-	2
CO3	2	3	3	-	-	-	2
CO4	2	3	3	-	-	-	2
CAM	2	3	3	-	-	-	2

Syllabus

Basics of HTML, CSS, and Javascript HTML, CSS, Bootstrap, Javascript basics – Variables, functions, and scopes, Logic flow and loops, Events, and Document object model, Handling JSON data, Understanding JSON callbacks.

Introduction to Node JS Installation, Callbacks, Installing dependencies with npm, Concurrency and event loop fundamentals, Node JS callbacks, Building HTTP server, Importing and exporting modules,

Building REST services using Node JS REST services, Installing Express JS, Express Node project structure, Building REST services with Express framework, Routes, filters, template engines - Jade, ejs.

MongoDB Basics and Communication with Node JS Installation, CRUD operations, Sorting, Projection, Aggregation framework, MongoDB indexes, Connecting to MongoDB with Node JS, Introduction to Mongoose, Connecting to MongoDB using mongoose, Defining mongoose schemas, CRUD operations using mongoose.

Building Single Page Applications with AngularJS Single Page Application – Introduction, Two-way data binding(Dependency Injection), MVC in Angular JS, Controllers, Getting user input, Loops, Client-side routing – Accessing URL data, Various ways to provide data in Angular JS – Services and Factories, Working with filters, Directives and Cookies, The digest loop and use of $apply.

Textbooks / References:

1. Simon Holmes, “Getting MEAN with Mongo, Express, Angular, and Node, Second Edition, Manning Publications; 1 edition (31 October 2015)
2. Jeff Dickey, “Write Modern Web Apps with Mean Stack, Peachpit press, 2015
3. Ken Williamson, “Learning Angular JS”, O'Reilly; 1 edition (24 March 2015)

4. MithunSatheesh, “Web development with MongoDB and Node JS”, Packt Publishing Limited; 2nd Revised edition (30 October 2015).

21CSA510A	SOFTWARE ENGINEERING AND DESIGN PATTERNS	L-T-P-C: 2-0-1-3

Course Objectives

This course presents a broad perspective on software systems engineering, concentrating on widely used techniques for developing large-scale software systems covering a wide spectrum of software processes from initial requirements elicitation through design and development to system evolution. The course also covers a wide range of software development abilities and skills from analyzing a problem to implement a solution, by discussing the design patterns in Smalltalk MVC architecture, Express representation invariants, understand their impact on efficiency and ease of implementation, and implement them as runtime assertions by differentiating between structural patterns and behavioral patterns involved in a software development process.

Course Outcomes

COs	Description
CO1	Deliver quality software products by possessing the leadership skills as an individual or contributing to the team development and demonstrating effective and modern working strategies by applying both communication and negotiation management skills.
CO2	Understands the concept of pattern-based analysis and design and the pattern-based design principle. Learn that design patterns are solutions, and they can solve many problems that can be encountered in the future.
CO3	Understands how to apply pattern-based analysis and design to the software to be developed. Understands the structure of design patterns and the logic of design patterns. Understands the importance of design patterns in software development.
CO4	Understands the details of object-oriented programming by comparing the object-oriented programming model with the standard structured programming.
CO5	Uses the basic design principles in solving real-life problems

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	-	-	-	2
CO2	3	2	-	-	-	-	2
CO3	3	2	-	-	-	-	2
CO4	3	2	-	-	-	-	2
CO5	3	2	1	-	-	-	2
CAM	3	2	1	-	-	-	2

Syllabus

Software Engineering – Introduction - Software Classification - Layered Technology – Software Process – Practice - Generic Process Model, Process Assessment and Improvement – CMMI framework - Perspective Models - Specialized Models - Agile Process Models Requirements Engineering – SRS - Requirement Analysis- Unified Modelling Language –Approaches - Scenario-based Modelling - UML Models that supplement Use Cases.

Activity and Swim lane Diagrams - Design Engineering - Architectural Design – Modelling Component level design - Performing User Interface Design.

Introduction: What Is a Design Pattern?, Design Patterns in Smalltalk MVC, Describing Design Patterns, The Catalog of Design Patterns, Organizing the Catalog, How Design Patterns Solve Design Problems, How to Select

a Design Pattern, How to Use a Design Pattern.

A Case Study: Designing a Document Editor: Design Problems, Document Structure, Formatting, Embellishing the User Interface.
Creational Patterns: Abstract Factory, Builder, Factory Method, Prototype, Singleton, Discussion of Creational Patterns. Structural Pattern Part-I: Adapter, Bridge, Composite. Structural Pattern Part-II: Decorator, açade, Flyweight, Proxy. Behavioral Patterns Part-I: Chain of Responsibility, Command, Interpreter, Iterator. Behavioral Patterns Part-II: Mediator, Memento, Observer, State, Strategy, Template Method, Visitor, Discussion of Behavioral Patterns.

Textbooks / References:

1. Roger S. Pressman, "Software Engineering-A Practitioner's Approach", Seventh Edition, Tata McGraw-Hill, 2010.
2. Ian Sommerville "Software Engineering", Ninth Edition, 2011
3. Richard Fairley, "Software Engineering concepts", Tata McGraw-Hill Publishing Company Pvt. Ltd., Ninth Edition
4. Pattern's in JAVA Vol-I By Mark Grand, Wiley DreamTech.
5. JAVA Enterprise Design Patterns Vol-III By Mark Grand, Wiley DreamTech.
6. Head First Design Patterns By Eric Freeman-Oreilly-spd

21CSA518A	DESIGN AND ANALYSIS OF ALGORITHMS	L-T-P-C: 2-0-1-3

Course Objectives

- To learn fundamental techniques for designing and analyzing algorithms.
- To understand various asymptotic analyses.
- To understand divide-and-conquer, greedy strategy, dynamic programming, using data structures

Course Outcomes

COs	Description
CO1	To develop an understanding of algorithm design techniques and apply them to real-life problems.
CO2	Map problems to the known classes of tractable or intractable problems.
CO3	To be able to analyze algorithms and compare their efficiency using empirical frameworks.
CO4	To be able to implement programs fluently using constructs of a programming language.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	1	-	-	-	-	2
CO2	2	3	-	-	-	-	1
CO3	2	3	-	-	-	-	1
CO4	2	3	2	-	-	-	1
CAM	2	3	2	-	-	-	1

Syllabus

Unit I

Programming fundamentals – Input, Output, Variables, Data types, Operators, Branching, Iterators, Functions, Lists, Strings, Recursion.

Notion of an Algorithm – Fundamentals of Algorithmic Problem Solving – Important Problem Types – Fundamentals of the Analysis of Algorithmic Efficiency – Asymptotic Notations and growth rate- Empirical analysis – Recursive and non-Recursive Templates.

Unit II

Divide and Conquer Methodology: Binary Search – Merge sort – Quick sort – Master's method. Principle of optimality: Optimal substructure – Greedy choice property – Overlapping subproblems. Dynamic programming: 0/1 Knapsack – Longest Increasing Subsequence - Longest Common Subsequence - Chain Matrix Multiplication.

Unit III

Greedy Technique: Currency exchange problem – Task Scheduling – Huffman Trees. Measuring Limitations: Lower – Bound Arguments – P, NP NP-Complete and NP-Hard Problems. Backtracking: N Queens problem - Branch and Bound: Travelling Salesman Problem

Textbooks / References:

1. 'Analysis of Algorithms', Jeffrey J McConnel, Jones and Bartlett Publishers, Inc; 2nd Revised edition, 2 November 2007
2. 'Introduction to the Design and Analysis of Algorithms, Anany Levitin, Third Edition, Pearson Education, 2012
3. 'Algorithms Design and Analysis', Harsh Bhasin, Oxford university press, 2016
4. CormenT.H, Leiserson C.E, Rivest R.L, and Stein C, "Introduction to Algorithms", Third Edition, Prentice-Hall of India, 2009.
5. Baase.S and Gelder A.V., "Computer Algorithms- Introduction to Design and Analysis", Third Edition, Pearson Education Asia, 2003.

21CSA651ACOMPUTER GRAPHICS AND VISUALIZATION L-T-P-C:2-0-1-3

Course Objectives

- To introduce the use of a graphics system and become familiar with building approach of graphics system components and algorithms related with them. Also covers the basic principles of 2D and 3D graphics. And an understanding of how to scan convert the basic geometrical primitives, how to transform the shapes to fit them as per the picture definition

Course Outcomes

COs	Description
CO1	Understand various types of video displays and colour models.
CO2	Understand and implement various drawing primitives using OPENGL
CO3	Understand fundamental concepts within computer graphics such as geometrical transformations.
CO4	Understand various 3D object representation techniques
CO5	Understand the concept of illumination models, removal of hidden surfaces and rendering.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	-	-	-	-	-	-
CO2	3	3	3	2	2	1	-
CO3	3	2	2	-	-	-	-
CO4	3	2	3	-	-	-	-
CO5	3	2	-	-	-	-	-
CAM	3	2	3	2	2	1	-

Syllabus

Computer Graphics Fundamentals: Overview of CG - Video Displays -Color Models- Output Primitives. Introduction to OPENGL- Points, Lines – Specifying a 2D World Coordinate Reference Frame in OpenGL-OpenGL Point Functions, Line Functions Polygon Fill Area Functions,Vertex Arrays - Line Drawing Algorithms - Circle Generation Algorithm Filled AreaPrimitives OpenGL fill Area Functions - Scan Line Polygon Filling Algorithms – BoundaryFill - Flood Fill Algorithms
Attributes of Output Primitives. Geometric Transformations: Basic 2Dtransformations-Other Transformations-Reflection and Shearing. OpenGL Geometric Transformation Functions.3D Object Representation: Fractals - Geometrical Transformation for - 3D Objects – Viewing and Clipping 2D Viewing Functions Clipping Operations. Three Dimensional Viewing:Viewing Pipeline, Viewing Coordinates. Projections: Parallel Projections, Perspective Projections. OpenGL Two-Dimensional and Three-Dimensional Viewing Functions-OpenGL Animation.Visible Surface Detection and Illumination Models: Visible SurfaceDetection Methods – Illumination Methods and Surface Rendering – Polygon. Rendering Methods: Constant Intensity Shading, Gouraud Shading, Phong Shading. OpenGL Illumination and Surface Rendering Functions, GUI – OpenGL Interactive Input Device Functions. The User Dialog –Interactive Picture Construction Techniques – Color Models - Computer Animation**.**

Textbooks/References:

1. Donald Hearn and Pauline Baker, “Computer Graphics with OpenGL ”, Third Edition, Prentice Hall of India, 2009.
2. Roy A. Plastock and Gordon Kalley, “Schaum's Outline Series - Theory and Problems ofComputer Graphics”, Second Edition, Tata McGraw-Hill, 2000.
3. Foley J.D, Van Dam A, Eiener S.K. and Hughes J.F., “Computer Graphics Principles andPractice”,

Second Edition, Pearson Education, 1996.
4. Rajiv Chopra , “Computer Graphics – A Practical Approach”

21CSA652AMOBILE APPLICATION DEVELOPMENT **L-T-P-C: 2-0-1-3**

Course Objectives

- This course is designed to quickly get a student up to speed with writing apps for Android devices. The student will learn the basics of Android platform and get to understand the application lifecycle.

Course Outcomes

COs	Description
CO1	Understand the different API levels and working of Dalvik Virtual Machine.
CO2	Understand the different views, layouts and resource files.
CO3	Understand different UI components.
CO4	Understand Android Notifications and Services.
CO5	Develop SQLite applications.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	2	-	-	-	1
CO2	2	2	2	-	1	1	1
CO3	2	3	2	-	1	1	2
CO4	2	3	2	1	1	1	2
CO5	2	2	3	1	1	1	2
CAM	2	3	2	1	1	1	2

Syllabus

Introduction: About Android, Pre-requisites to learn Android, Dalvik Virtual Machine & .apk file extension, Android API levels (versions & version names)
Android Java Basics: Getting started with Android development, project folder structure, simple programming, running project, generating build/APK of the app from Android Studio
First application: Creating Android Project, Android Virtual Device Creation, Set up debugging environment, Workspace set up for development, Launching emulator, debugging on mobile devices.
Basic UI design: Basics about Views, Layouts, Drawable Resources, Input controls, Input Events, Toasts.
More UI Components: Layouts - GridView and ListView, Action bar, Adapters, Menus: Option menu, context menu, sub menu, Pickers - Date and Time, Spinners.
Activity and Fragment: Activity, Fragment, Activity Lifecycle and Fragment Lifecycle.
Intents: Implicit Intents, Explicit intents, communicating data among Activities.
Navigation Drawer: Panel that displays the app's main navigation screens on the left edge of the screen
Android Notifications – Toast, Dialogs (TimePicker, DatePicker, Progress, Alert), Notification Manager and Push Notification
Introducing SQLite - SQLiteOpenHelper and creating a database - Opening and closing a database, Working with cursors Inserts, updates, and deletes
As a term project students should implement a mobile app with the following: Understand the app idea and design user interface/wireframes of mobile app. Set up the mobile app development environment

Textbooks / References:

1. Head first Android Development.
2. Android Programming: Pushing the Limits, Wiley By Erik Hellman
3. Android Application Development Black Book, Dreamtech Press, Pradeep Kothari, KLSI

21CSA653A	COMPILER DESIGN	L-T-P-C:2-0-1-3

Course Objectives

The main objective of this course is to introduce the major concept areas of language translation and compiler design and to develop an awareness of the function and complexity of modern compilers. This course is a study of the theory and practice required for the design and implementation of interpreters and compilers for programming languages

Course Outcomes

COs	Description
CO1	To understand the theory and practice of compiler implementation.
CO2	To learn finite state machines and lexical scanning.
CO3	To learn context-free grammars, compiler parsing techniques, construction of abstract syntax trees, symbol tables, intermediate machine representations, and actual code generation
CO4	Identify the similarities and differences among various parsing techniques and grammar transformation techniques.
CO5	To provide practical, hands-on experience in compiler design

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	2	-	-	-	-	2
CO2	2	2	-	-	-	-	2
CO3	3	3	-	-	-	-	2
CO4	3	3	2	-	-	-	2
CO5	3	3	2	-	-	-	2
CAM	3	3	2	-	-	-	2

Syllabus

Automata and Language: Chomsky hierarchy of languages, Introduction to Finite Automata –Non-Deterministic Finite Automata- equivalence of NFAs and DFAs- minimization of DFA-Regular Expressions. Context-free Grammar - Parse tree derivations (Top-down, Bottom-up), Context-free languages – Chomsky normal form, GNF.
Introduction to Compilers: Compiler structure – Overview of Translation. Lexical Analysis: From regular expression to Scanner. Implementation of scanner: Lex - Parsers: Expressing syntax – Top-down parsing: Recursive descent parsing, Non-recursive predictive parsing. Bottom-up parsing: LR(0), LR(1) and LALR(1) – Implementation of Parser - YACC
Context-Sensitive Analysis: Type Systems – Attribute – Grammar – Syntax Directed Translation. Intermediate Representations: Graphical and Linear Intermediate Representations – Symbol tables. Procedure Abstraction: Procedure calls – Name Spaces – Communicating Values between Procedures.
Iterative Data Flow Analysis – Instruction selection via Tree Pattern Matching – Register allocation: Local and Global – Introduction to Optimization.

Textbooks/References:

1. Peter Linz, “An Introduction to Formal Languages and Automata”, Fifth Edition, 2012.
2. Keith Cooper and Linda Torczon, “Engineering a Compiler”, Second Edition, Morgan Kauffmann, 2011.
3. Alfred V.Aho, Monica S. Lam, Ravi Sethi, and Jeffrey D. Ullman, “Compilers: Principles, Techniques, and Tools”, PrenticeHashing: hashilb Hall, Second Edition, 2006.

4. Andrew W. Appel and Jens Palsberg, "Modern Compiler Implementation in Java", Cambridge University Press, Second Edition, 2002

21CSA654A	DEEP LEARNING	L-T-P-C:2-0-1-3

Course Objectives

- This course gives an exposure to neural networks and deep learning architectures.
- This course focuses on implementing, training, and debugging deep feedforward neural networks.
- This course enables the application of Convolutional neural networks and RNN for Images and image sequences.

Course Outcomes

COs	Description
CO1	Understand the main architectures for deep learning algorithms
CO2	Design and implement deep neural network systems.
CO3	Identify new application requirements in the field of computer vision.
CO4	Apply Machine learning algorithms as deep learning models
CO5	Develop algorithms for resolving huge data processing problems

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	-	-	-	1
CO2	3	2	2	-	-	-	1
CO3	2	2	2	-	-	-	1
CO4	2	2	1	-	-	-	1
CO5	2	2	1	-	-	-	1
CAM	2	2	2	-	-	-	1

Syllabus

Unit I: Deep Feedforward Networks Gradient-Based Learning, Hidden Units, Architecture Design, Back-Propagation and Other Differentiation Algorithms Dataset Augmentation, Noise Robustness Semi-Supervised Learning, Multi-Task Learning, Early Stopping, Parameter Tying and Parameter Sharing, Sparse Representations, Bagging and Other Ensemble Methods, Dropout, Adversarial Training**.**

Unit II: Convolutional Networks the Convolution Operation, Pooling, Convolution and Pooling as an Infinitely Strong Prior, Variants of the Basic Convolution Function, Structured Outputs, Data Types, Efficient Convolution Algorithms, Random or Unsupervised Features**.**

Unit III: Sequence Modeling: Recurrent and Recursive Nets Recurrent Neural Networks, Bidirectional RNNs, Encoder- Decoder Sequence-to-Sequence Architectures, Deep Recurrent Networks, Recursive Neural Networks, The Challenge of Long-Term Dependencies, Echo State Networks, Leaky Units and Other Strategies for Multiple Time Scales, The Long Short-Term Memory and Other Gated RNNs, Optimization for Long-Term Dependencies, Explicit Memory

Textbooks/References:

1. Goodfellow I, Bengio Y, Courville A. Deep learning. MIT press; 2016.
2. Patterson J, Gibson A. Deep learning: A practitioner's approach. " O'Reilly Media, Inc."; 2017.

21CSA655A PARALLEL AND DISTRIBUTED COMPUTING L-T-P-C: 2-0-1-3

3. Chollet F. Deep Learning mit Python und Keras: Das Praxis-Handbuch vom Entwickler der Keras-Bibliothek. MITP-Verlags GmbH & Co. KG; 2018.

Course Objectives

- To introduce the fundamentals of parallel and distributed programming and application development in different parallel programming environments.
- To develop and execute basic parallel and distributed applications using basic programming models
- To learn tools such as CUDA for developing applications for multi-core processors.

Course Outcomes

COs	Description
CO1	Understand the requirements for programming parallel and distributed systems
CO2	Knowledge of parallel and distributed computing techniques and methodologies
CO3	Understand the architecture of Graphics Processing Units(GPU)
CO4	Understand the memory hierarchy and evaluate cost-performance tradeoffs.
CO5	Design, develop and analyze performance of parallel and distributed applications.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	-	-	-	2
CO2	3	2	-	-	-	-	2
CO3	3	2	-	-	-	-	2
CO4	3	2	-	-	-	-	2
CO5	3	3	2	-	-	-	2
CAM	3	2	2	-	-	-	2

Syllabus

Unit I: Introduction - Asynchronous and synchronous computation, Fault tolerance and recovery: basic concepts, fault models, agreement problems and its applications, commit protocols, voting protocols, check pointing and recovery, reliable communication, heterogeneity, interconnection topologies, load balancing, memory consistency model, memory hierarchies, Models of computation: shared memory and message passing systems

Unit II: GPU Programming Model, GPU Hardware and Parallel Communication, Fundamental Parallel Algorithms, Optimizing GPU Programs, Parallel Computing Patterns

Unit III: Multithreaded programming, parallel algorithms and architectures, parallel I/O, performance analysis, and tuning, power, programming models (data parallel, task parallel, process-centric, shared/ distributed memory), scalability and performance studies, scheduling, storage systems, synchronization.

Textbooks / References:

1. Kai Hwang, Jack Dongarra, and Geoffrey C. Fox, ”Distributed and Cloud Computing: Clusters, Grids, Clouds, and the Future Internet (DCC)”, 2012.

2. Andrew S. Tanenbaum and Maarten van Steen, ”Distributed Systems: Principles and Paradigms”, Prentice-Hall, 2017.
3. Ajay D Kshemkalyani and Mukesh Singhal, ”Distributed computing: principles algorithms and systems”, Cambridge University Press 2011.

21CSA656A CONNECTED INTERNET OF THINGS DEVICES L-T-P-C:2-0-1-3

4. David B. Kirk and Wen-mei W. Hwu, ”Programming Massively Parallel Processors: A Handson Approach”, Elsevier Science, 2016

Course Objectives

- To learn to specify, design and program modern connected electronic systems based on commodity smartphones and sensor networks.

Course Outcomes

COs	Description
CO1	Enables student to understand the basics of Internet of things and protocols.
CO2	Introduces some of the application areas where Internet of Things can be applied.
CO3	Students will learn about the middleware for Internet of Things.
CO4	Understand the concepts of Web of Things

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	2	-	-	-	1
CO2	2	3	2	-	-	-	1
CO3	3	1	2	-	-	-	1
CO4	2	1	-	-	-	-	1
CAM	3	1	2	-	-	-	1

Syllabus

Unit I: IOT - What is the IoT and why is it important? Elements of an IoT ecosystem, Technology drivers, Business drivers, Trends and implications, Overview of Governance, Privacy and Security Issues
Unit II: IOT PROTOCOLS - Protocol Standardization for IoT – Efforts – M2M and WSN Protocols – SCADA and RFID Protocols – Issues with IoT Standardization – Unified Data Standards – Protocols – IEEE802.15.4– BACNet Protocol– Mod bus – KNX – Zigbee– Network layer – APS layer – Security
Unit III: IOT ARCHITECTURE - IoT Open source architecture (OIC)- OIC Architecture & Design principles- IoT Devices and deployment models- IoTivity : An Open source IoT stack - Overview- IoTivity stack architecture- Resource model and Abstraction.
Unit IV: WEB OF THINGS - Web of Things versus Internet of Things – Two Pillars of the Web – Architecture Standardization for WoT– Platform Middleware for WoT – Unified Multitier WoT Architecture – WoT Portals and Business Intelligence.
Unit V: IOT APPLICATIONS - IoT applications for industry: Future Factory Concepts, Brownfield IoT, Smart Objects, Smart Applications. Study of existing IoT platforms /middleware, IoT- A, Hydra etc

Textbooks/References:

1. Honbo Zhou, “The Internet of Things in the Cloud: A Middleware Perspective”, CRC Press, 2012.
2. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), “Architecting the Internet of Things”, Springer, 2011.
3. David Easley and Jon Kleinberg, “Networks, Crowds, and Markets: Reasoning About a Highly Connected World”, Cambridge University Press, 2010.

4. Olivier Hersent, David Boswarthick, Omar Elloumi , "The Internet of Things – Key applications and Protocols", Wiley, 2012.
5. Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-on-Approach)",1st Edition, VPT, 2014
6. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to ConnectingEverything", 1st Edition, Apress Publications, 2013
7. CunoPfister, Getting Started with the Internet of Things, O"Reilly Media, 2011, ISBN: 978-1- 4493-9357-1

21CSA657A SOFTWARE TESTING L-T-P-C: 2-0-1-3

Course Objectives

- This course provides fundamental concepts in software testing, including software testing objectives, process, criteria, strategies, and methods.
- To discuss various software testing issues and solutions in software unit test; integration, regression, and system testing.
- This also expose the advanced software testing topics, such as object-oriented software testing methods, and component-based software testing issues, challenges, and solutions.

Course Outcomes

COs	Description
CO1	Introduce different software testing techniques, process and errors handled in software projects.
CO2	Distinguish black box and white box testing techniques for functional and structural testing and testcase designing.
CO3	To understand the different testing activities and levels of testing which aims to uncover the defects in all the stages of project.
CO4	Discuss about the non-functional testing and debugging methods.
CO5	Demonstrate various issues for object-oriented testing and tools for testing.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	-	-	-	-
CO2	3	2	-	-	-	-	-
CO3	3	2	2	-	1	1	-
CO4	3	3	-	-	1	1	-
CO5	2	3	2	-	1	1	-
CAM	3	2	2	-	1	1	-

Syllabus

Introduction: Introduction to software testing and analysis, Error, Fault, Failure, Incident, Test Cases, Testing Process, Limitations of Testing, No absolute proof of correctness.
Specification-based testing techniques, code-based testing techniques, Model-based testing,
Blackbox box testing- Functional Testing: Boundary Value Analysis, Equivalence Class Testing, Decision Table Based Testing, Cause Effect Graphing Technique.
Whitebox testing- Structural Testing: Path testing, DD-Paths, Cyclomatic Complexity, Graph Metrics, Data Flow Testing, Mutation testing, Static Analysis, Dynamic Analysis

Reducing the number of test cases: Prioritization guidelines, Priority category, Scheme, Risk Analysis, Regression Testing, Slice-based testing Testing Activities: Unit Testing, Levels of Testing, Integration Testing, System Testing, Debugging, Domain Testing, Regression Testing, Acceptance testing

Object Oriented Testing: Issues in Object Oriented Testing, Class Testing, GUI Testing, Object Oriented Integration and System Testing, Methods of test data generation and validation.
Program slicing and its application, Reliability analysis, Formal methods; verification methods; oracles. Testing Tools: Static Testing Tools, Dynamic Testing Tools, and Characteristics of Modern Tools

Textbooks / References:

1. William Perry, “Effective Methods for Software Testing”, John Wiley & Sons, New York, 2007.
2. CemKaner, Jack Falk, Nguyen Quoc, “Testing Computer Software”, Second Edition, Van Nostrand Reinhold, New York, 2000.
3. Boris Beizer, “Software Testing Techniques”, Second Volume, Second Edition, Van Nostrand Reinhold, New York, 1990.
4. Louise Tamres, “Software Testing”, Pearson Education Asia, 2002
5. "Software Testing: A Craftsman's Approach, Second Edition," by Paul C Jorgensen, CRC Press, June 26, 2002.

21CSA658A	NETWORK MANAGEMENT AND SYSTEM ADMINISTRATION	L-T-P-C: 2-0-1-3

Course Objectives

The main aim of this course is to provide basic ideas to manage and administer computer systems as well as networks.

Course Outcomes

COs	Description
CO1	Acquire knowledge about network fundamentals and network management standards (OSI and TCP/IP).
CO2	Acquire knowledge about network infrastructure and network security.
CO3	Acquire knowledge about windows server fundamentals and popular windows Network services and applications.
CO4	Understanding the concepts of Linux fundamentals and Linux installation and package management.
CO5	Understanding the concepts of User management and file management in Linux.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	-	-	-	2
CO2	3	2	-	-	-	-	2
CO3	3	2	2	-	-	-	2
CO4	3	2	2	-	-	-	2
CO5	3	2	2	-	-	-	2
CAM	3	2	2	-	-	-	2

Syllabus

Basic Hardware: Network Fundamentals: Local Area Networking - Defining Networks with the OSI Model - Wired and Wireless Networks - Internet Protocol - Implementing TCP/IP in the Command Line- Working with Networking Services - Understanding Wide Area Networks - Defining Network Infrastructures and Network Security.

Security Fundamentals: Security Layers – Authentication – Authorization - Accounting - Security Policies - Network Security - Server and Client Protection.

Windows Server Fundamentals: Server Overview - Managing Windows Server 2008 R2 - Managing Storage - Monitoring and Troubleshooting Servers - Essential Services - File and Print Services - Popular Windows Network Services and Applications.

Linux Fundamentals: System ArchitectureDetermine and Configure Hardware Settings- Boot the System - Change Run Levels and Shut Down or Reboot System -Linux Installation and Package Management - File Systems- Create Partitions and File systems - Maintain the Integrity of File Systems - Control Mounting and Unmounting of File Systems. Manage Disk Quotas - File Permissions and Ownership - Create and Change Hard and Symbolic Links. Network Management Lab: Windows Network Configurations and Linux Network Configurations.

Textbooks / References:

1. 98-366: “Networking Fundamentals, Microsoft Official Academic Course (MicrosoftCorporation)”, Wiley, 2011.

2. 98-367: “MTA Security Fundamentals, Microsoft Official Academic Course(MicrosoftCorporation)”, Wiley, 2011.
3. 98-365: “Windows Server Administration Fundamentals, Microsoft Official AcademicCourse (Microsoft Corporation)”, Wiley, 2011.
4. Adam Header, Stephen Addison Schneiter, James Stanger and Bruno Gomes Pessanha, LPI “Linux certification in Nutshell”, Third Edition, O’Reilly, 2010

21CSA659A	SEMANTIC WEB TECHNOLOGIES	L-T-P-C:2-0-1-3

Course Objectives

- This course will cover the core concepts of Semantic Web that promises to dramatically improve World Wide Web (WWW) and its use.
- This course covers key technologies include explicit metadata, ontologies, logic, inferencing, and intelligent agents.

Course Outcomes

COs	Description
CO1	Understand and discuss fundamental concepts, advantages and limits of the semantic web.
CO2	Understand and use ontologies in the context of Computer Science and the semantic web.
CO3	Understand the relationship between Semantic Web and Web 2.0.
CO4	Apply the RDF framework for Semantic Web.
CO5	Understand the concepts of metadata, semantics of knowledge and resource, ontology, and their descriptions in XML-based syntax and web ontology language (OWL).

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	-	-	-	-	-	2
CO2	2	1	-	-	-	-	1
CO3	2	2	2	-	-	-	3
CO4	2	1	3	-	-	-	2
CO5	3	3	3	-	-	-	1
CAM	2	1	3	-	-	-	2

Syllabus

Unit I: The World Wide Web - Limitations of Today's Web – The Next Generation Web – Semantic Web - Layers –Semantic Web technologies – Semantics in Semantic Web – XML: Basics – Well-formed and valid Documents – Namespaces- XML schema – Addressing – Querying - Document Object Model (DOM) – XML Applications – XML limitations.

Unit II:RDF Basic Ideas - RDF Specification – RDF Syntax: XML and Non- XML – RDF elements – RDF relationship:Reification, Container, and collaboration – RDF Schema – Editing, Parsing, and Browsing RDF/XML – DiscoveringInformation – Querying (RQL, SPARQL) – Web Ontology Language (OWL) - Classes, Instances and Properties inOWL - Complex Classes - Property Restrictions - Role Inclusion.

Unit III: Ontology - Ontology Types – Logic - Description Logics - Rules - Inference and Reasoning - Ontology Engineering: Introduction – Constructing ontologies – Tools used in building and storing ontologies (Sesame, Jena, Protégé,NeOn) – Reusing ontologies – ontology reasoning. The web of data - Data on the web -shallow and deep web – Linkedopen data - linked data principles - Linked data design - Publishing linked data - Consuming and aggregating linked data.

Textbooks/References:

1. Paul Groth, Frank van Harmelen, Rinke Hoekstra. A Semantic Web Primer, Third Edition, MIT press; 2012.
2. Gómez-Pérez, A. Fernández-López, M. Corcho, O. Ontological Engineering. Springer Verlag; 2003.
3. Michael C. Daconta, Leo J. Obrst, Kevin T. Smith. The Semantic Web: A Guide to the Future of XML, Web Services and Knowledge Management, Fourth Edition, Willey Publishing; 2003.
4. John Davies, Rudi Studer, Paul Warren. Semantic Web Technologies: Trends and Research in Ontology-based Systems, Wiley & Sons; 2006.

21CSA660A	BIOINFORMATICS	L-T-P-C: 2-0-1-3

Course Objectives

- The main objective of the course is to get introduced to the basic concepts of Bioinformatics and its significance in Biological data analysis. This course gives an overview about biological macromolecular structures and structure prediction methods along with basic understanding on computer aided drug design techniques.

Course Outcomes

COs	Description
CO1	Perform DNA sequence analysis using biological sequence data from online repositories.
CO2	Perform Protein structural analysis and do protein structure prediction.
CO3	Do computer aided drug design, docking, screening, QSAR.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	-	-	-	-
CO2	3	3	3	-	-	-	-
CO3	3	3	3	-	-	-	-
CAM	3	3	3	-	-	-	-

Syllabus

Unit I: Introduction to genes and proteins, organization of DNA, RNA and protein, Motifs, Restriction maps and Restriction enzymes, DNA sequence analysis, DNA Databases, Searching scientific information using search engines, Protein structure and function, protein sequence databases, sequence alignment, PAM matrix, Global and local alignment, BLAST: features and scores, Multiple sequence alignment, Conservation score, phylogenetic trees.

Unit II: Protein sequence analysis, hydrophobicity profiles, non-redundant datasets, Protein secondary structures, Ramachandran plot, propensity, secondary structure prediction, Protein tertiary structure, Protein Data Bank, visualization tools, structural classification, contact maps, Protein structural analysis, protein structure prediction.

Unit III: Protein stability, energetic contributions, database, stabilizing residues, stability upon mutations, Protein folding rates, proteins interactions, binding site residues, Computer aided drug design, docking, screening, QSAR..

Textbooks/References:

1. M. Michael Gromiha, Protein Bioinformatics: From Sequence to Function, Academic Press, 2010
2. D.E. Krane and M.L. Raymer, Fundamental concepts of bioinformatics, Pearson Education Inc. 2006

21CSA661A	DIGITAL IMAGE PROCESSING	L-T-P-C:2-0-1-3

Course Objectives

- This course introduces the basics of image processing and explores the algorithms in spatial and frequency domain relevant to image enhancement, restoration and segmentation applications.
- This course introduces binary, gray scale and color image processing.

Course Outcomes

COs	Description
CO1	Understand fundamental principles of image processing and perform basic operations on pixels.
CO2	Apply the image processing algorithms and filters in spatial domain for image enhancement and restoration.
CO3	Analyze images in the frequency domain and explore the frequency domain filters for image enhancement and restoration**.**
CO4	Apply segmentation algorithms on Images and analyze their performance.
CO5	Apply morphological processing on images for simple image processing applications.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	-	-	-	-	-	-
CO2	2	2	-	-	-	-	-
CO3	3	1	-	-	-	-	-
CO4	3	3	-	-	-	-	-
CO5	3	3	3	-	-	-	1
CAM	3	3	3	-	-	-	1

Syllabus

Unit I: Digital Image Fundamentals: Elements of Visual Perception- Image Sensing and Acquisition-Image Sampling and Quantization – Basic Relationships between Pixels - Image interpolation. Intensity Transformations and Spatial Filtering: Basic Intensity transformation Functions – Histogram Processing – Fundamentals of Spatial Filtering –Smoothing and Sharpening Spatial Filters.

Unit II: Filtering in Frequency Domain: 2D Discrete Fourier Transforms - Basics of filtering - Image Smoothing and Image Sharpening Using Frequency Domain Filters - Selective Filtering, Image Restoration: Noise Models – Restoration using Spatial Filters – Periodic Noise Reduction by Frequency Domain Filters.

Unit III: Morphological Image Processing: Erosion – Dilation – Opening – Closing – Hit-or-Miss Transform - Extraction ofConnected Components. Image Segmentation: Fundamentals – Point, Line and Edge Detection – Thresholding-Region Based Segmentation – Region Growing – Region Splitting and Merging. Color image processing.

Textbooks/References:

1. Gonzalez RC, Woods RE. Digital Image Processing. Third edition;2008**.**
2. Pratt W K.Digital Image Processing, Fourth Edition, John Wiley & Sons;2007.
3. Castleman K R. Digital Image Processing, Prentice Hall;1996.
4. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins. Digital Image Processing Using MATLAB®. Prentice Hall, 2004.
5. Russ JC, Introduction to Image Processing and Analysis. CRC press; 2007

21CSA662A	INFORMATION RETRIEVAL	L-T-P-C:2-0-1-3

Course Objectives

- The main objective of this course is to present the scientific support in the field of information search and retrieval.

Course Outcomes

COs	Description
CO1	Understand the concepts of indexing, vocabulary, normalization, and dictionary in Information Retrieval.
CO2	Define a Boolean model and a vector space model and explain the differences between them.
CO3	Evaluate information retrieval algorithms and give an account of the difficulties of evaluation.
CO4	Understand various methods of text classification.
CO5	Understand the basics of XML and Web search

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	1	1	-	-	-	1
CO2	2	1	1	-	-	-	1
CO3	1	1	2	-	-	-	1
CO4	2	2	2	-	-	-	1
CO5	2	2	2	-	-	-	1
CAM	2	1	2	-	-	-	1

Syllabus

Unit I: Introduction : Information Retrieval Early Developments, Information Retrieval in Libraries and Digital Libraries, Information Retrieval Problem, Information Retrieval System, Information Retrieval Web**.**

Unit II: Boolean Expression Based Retrieval: Vocabulary and Postings, Lists, Dictionaries and Tolerant Retrieval, Index Construction and Compression, Scoring and Vector Space Model, Score Computation, Evaluating Information**.**

Unit III: Retrieval Systems: Relevance Feedback and Query Expansion, XML Based Retrieval, Retrieval Metrics, Implicit Feedback through Global Analysis.

Unit IV: Probabilistic Models, Language Models, Text Classification, Vector Space Classification, SVM Based Document Classification.

Unit V: Latent Semantic Indexing, Web Search, Web Crawlers, Link Analysis, Unstructured Data Retrieval Semantic Web, Ontology, Implementations using Natural Language Toolkit**.**

Textbooks/References:

1. C. Manning, P. Raghavan and H. Schütze, “Introduction to Information Retrieval”,Cambridge University Press, 2008.
2. R. Baeza-Yates and B. Ribeiro Neto, “Modern Information Retrieval: The Conceptsand Technology Behind Search”, Second Edition, Addison Wesley, 2011.
3. David A. Grossman and Ophir Frieder “Information Retrieval: Algorithms andHeuristics”, Second Edition, Springer 2004.

21CSA663A	SOFTWARE DEFINED NETWORKS	L-T-P-C: 2-0-1-3

Course Objectives

- This course aims to develop knowledge in networking fundamentals, gain conceptual understanding of Software Defined Networks (SDN) and the study of industrial deployment use-cases of SDN.

Course Outcomes

COs	Description
CO1	Differentiate between traditional networks and software defined networks and learn the fundamentals of software defined networks.
CO2	Understand advanced and emerging networking technologies, separation of the data plane and control plane.
CO3	Improves the advanced networking research skills.
CO4	Study of the SDN Programming and analyze the performance of varying and complex networking tasks.
CO5	Expand the knowledge learned about SDN concepts and apply it to solve real time world problems

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	-	-	-	-	-	-
CO2	3	1	1	-	-	-	1
CO3	3	2	-	-	-	-	2
CO4	3	2	2	-	-	-	2
CO5	3	2	2	-	-	-	2
CAM	3	2	2	-	-	-	2

Syllabus

Unit I: Basic Packet Switching Terminology, Historical Background, The Modern Data Center, Traditional Switch Architecture, Autonomous and Dynamic Forwarding Tables, Open Source and Technological Shifts. Why SDN? Genesis of SDN

Unit II: Working of SDN- Fundamental Characteristics of SDN, SDN Operation, SDN Devices, SDN Controller, SDN Applications, Alternate SDN Methods. Introduction to OpenFlow Specification, Improving OpenFlow Interoperability, OpenFlow Limitations, Optical Transport Protocol Extensions

Unit III: Introduction to Open SDN and its limitations, SDN via APIs, SDN via Hypervisor Based Overlays, SDN via Opening up the Device, Introduction of SDN Controllers and its general concepts, Layer 3 Centric, Plexxi, Cisco OnePK. Introduction of Network Programmability, Management Interface, Application-Network Divide, Modern Programmatic Interfaces, I2RS, Modern Orchestration

Unit IV:SDN in the Data Center- Introduction of Data Center and its demands, Tunneling Technologies for the Data Center, Path Technologies in the Data Center, Ethernet Fabrics in the Data Center, SDN Use Cases in the Data Center, Comparison of Open SDN, Overlays and APIs, Real-World Data Center Implementations

Unit V: Introduction SDN application and its usages, SDN in the Data Center - SDN in Other Environments - SDN Applications - SDN Use Cases – The Open Network Operating System.

Textbooks / References:

1. Paul Goransson and Chuck Black, Software Defined Networks: A Comprehensive Approach, Second Edition, Morgan Kaufmann, 2014.
2. SDN: Software Defined Networks, An Authoritative Review of Network Programmability Technologies, By Thomas Nadeau, Ken Gray, Publisher: O'Reilly Media.
3. Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud 1st Edition, Kindle Edition, by William Stallings.
4. SDN and NFV Simplified: A Visual Guide to Understanding Software Defined Networks and Network Function Virtualization 1st Edition, Kindle Edition, by Jim Doherty.

21CSA664A	PATTERN RECOGNITION	L-T-P-C: 2-0-1-3

Course Objectives

- The primary objective of this course is to equip students with mathematical and statistical techniques used in pattern recognition and enable students to develop machine learning algorithms for real life problems.

Course Outcomes

COs	Description
CO1	Understand the concept of a pattern and the basic approach to the development of pattern recognition and machine intelligence algorithms and applications of PR system.
CO2	Understand the basic methods of feature extraction, feature evaluation, analyse and relate research in the pattern recognition area.
CO3	Understand and apply both supervised and unsupervised classification methods to develop PR system in real-world data.
CO4	Apply pattern recognition techniques to real-world problems such as object detection and recognition.
CO5	To implement simple pattern classifiers, classifier combinations, and structural pattern recognizers.
CO6	To summarize, analyse, and relate research in the pattern recognition area verbally and in writing.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	-	-	-	-	-	-
CO2	3	-	-	-	-	-	-
CO3	3	-	-	-	-	-	-
CO4	1	3	3	-	-	-	-
CO5	1	3	3	-	-	-	-
CO6	1	3	3	-	-	-	-
CAM	2	3	3	-	-	-	-

Syllabus

Introduction to Pattern Recognition- Tree Classifiers Getting our feet wet with real classifiers-Decision Trees: CART, C4.5, ID3- Random Forests-Bayesian Decision Theory Grounding our inquiry- Linear Discriminants Discriminative Classifiers: The Decision Boundary, Separability, Perceptrons, Support Vector Machines, Parametric Techniques Generative Methods grounded in Bayesian Decision Theory, Maximum Likelihood Estimation- Bayesian Parameter Estimation. Non-Parametric Techniques- Kernel Density Estimators- Nearest Neighbor Methods - Unsupervised Methods Exploring the Data for Latent Structure - Component Analysis and Dimension Reduction- The Curse of Dimensionality, Principal Component Analysis, Fisher Linear Discriminant, Locally Linear Embedding, Clustering, K-Means. Expectation Maximization, Mean Shift, Classifier Ensembles, Bagging, Boosting / AdaBoost.

Textbooks / References:

1. Duda, Hart and Stork, Pattern Classification, Second Edition, Wiley, 2001.
2. T.M. Mitchell, Machine learning, McGraw-Hill, New York, 1997.
3. S. Theodoridis, K. Koutroumbas, Pattern Recognition, Academic Press, 1999

21CSA665A	MALWARE ANALYSIS	L-T-P-C:2-0-1-3

Course Objectives

- This course aims to identify malware types based on static and behavioral analysis, determine malware capabilities and persistence vectors and evaluate potential threat from malware activity on the network.

Course Outcomes

COs	Description
CO1	Possess the skills necessary to carry out independent analysis of modern malware samples using both static and dynamic analysis techniques.
CO2	Understand executable formats, Windows internals and API, and analysis techniques.
CO3	Extract investigative leads from host and network based indicators associated with a malicious program
CO4	Apply techniques and concepts to unpack, extract, decrypt, or bypass new anti analysis techniques in future malware samples.
CO5	Achieve proficiency with industry standard tools including IDA Pro, OllyDbg, WinDBG, PE Explorer, ProcMon etc.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	1	1	-	-	-	1
CO2	3	1	1	-	-	-	1
CO3	3	1	-	-	-	-	1
CO4	3	1	1	-	-	-	1
CO5	3	2	3	-	-	-	2
CAM	3	1	1	-	-	-	1

Syllabus

Introduction to malware, Basic Static and Dynamic Analysis, Overview of Windows file format, PEView.exe, Patching Binaries , Disassembly(objdump, IDA Pro), Introduction to IDA, Introduction to Reverse Engineering, Extended Reverse Engineering using GDB and IDA, Advanced Dynamic Analysis - debugging tools and concepts, Malware Behavior - malicious activities and techniques, Analyzing Windows programs – Win API, Handles ,Networking , COM, Data Encoding, Malware Countermeasures , Covert Launching and Execution, Anti Analysis - Anti Disassembly, VM, Debugging -, Packers – packing and unpacking, Intro to Kernel – Kernel basics, Windows Kernel API, Windows Drivers, Kernel Debugging, Rootkit Techniques- Hooking, Patching, Kernel Object Manipulation , Rootkit Anti-forensics , Covert analysis

Textbooks/References:

1. Michael Sikorski and Andrew Honig, " Practical Malware Analysis", No Starch Press,2012
2. Jamie Butler and Greg Hoglund, "Rootkits: Subverting the Windows Kernel", Addison-Wesley, 2005
3. Dang, Gazet and Bachaalany, "Practical Reverse Engineering",Wiley,2014
4. Reverend Bill Blunden, "The Rootkit Arsenal: Escape and Evasion in the Dark Corners of the System" Second Edition, Jones& Bartlett, 2012.

21CSA666A	NETWORK SECURITY ESSENTIALS	L-T-P-C: 2-0-1-3

Course Objectives

To provide an understanding of the principle concepts and protocols used to provide authentication, email and web security. To be able to secure a message over insecure channel by various means and learn about how to maintain the Confidentiality, Integrity and Availability of data and to understand various protocols for network security to protect against the threats in the networks

Course Outcomes

COs	Description
CO1	Understand network security models and analyze authentication mechanisms for challenge response scenarios. Identify and classify particular examples of attacks. Define the terms vulnerability, threat and attack Able to apply cryptographic protocols in various applications to provide confidentiality, integrity and Availability (CIA).
CO2	Understand the working of authentication applications. Identify physical points of vulnerability in simple networks. . Identify some of the factors driving the need for network security. Compare and contrast symmetric and asymmetric encryption systems and their vulnerability to attack.
CO3	Understand e-mail architecture and standards for securing mail communication. Learn to protect the email services using PGP and SMIME.(Email security protocols).
CO4	Understand Internet Security Protocol and explore common solutions for security issues Gives knowledge about providing security in the network at packet level using IPsec.(IP security).
CO5	Apply and analyze Web security protocols for E-Commerce applications. Able to develop secure web applications and e-commerce sites using SSL/TLS and SET(web security).

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	-	1	1	1	1
CO2	3	2	1	1	1	1	1
CO3	3	2	2	-	-	-	2
CO4	3	2	2	-	-	-	2
CO5	3	2	2	2	2	2	2
CAM	3	2	2	1	1	1	2

Syllabus

Network vulnerability, attacks. Network Access Control-IDS/IPS,Key Management and Distribution(Symmetric/A Symmetric key).Digital Signature and Authentication Schemes: Digital signature-Digital Signature Schemes and their Variants- Digital Signature Standards-Authentication: Overview, Remote User-Authentication Principles, Authentication Requirements, Authentication Protocols -Applications - Kerberos -X.509 Directory Services. Electronic mail security: Email Architecture -PGP – Operational Descriptions- Key management- Trust Model- S/MIME.IP Security: Overview- Architecture - ESP, AH Protocols IPSec Modes – Security association - Key management. Web Security: Requirements- Secure Sockets Layer- Objectives-Layers -SSL secure communication-Protocols - Transport Level Security. Secure Electronic Transaction- Entities DS Verification-SET processing. Blockchains, Cloud Security and IoT security

Textbooks / References:

1. William Stallings-Cryptography and Network security PHI-3rd edition 2003
2. Dr.T.R Padmanabhan N Harini “Cryptography and Security paperback” Wiley India.
3. Behrouz A. Forouzan, “Cryptography and Network Security”, Tata McGraw-Hill Publishing.
4. Wenbo Mao, "Modern Cryptography, Theory & Practice", Pearson Education
5. Manuel Mogollon, “Cryptography and Security Services – Mechanisms and Applications”, Cybertech Publishing

6. Network Security: Private Communications in a Public World, M. Speciner, R. Perlman, C. Kaufman, Prentice-Hall, 2002.

Course Objectives

- This course examines the foundations of blockchain technology from multiple perspectives. It is designed to provide students with an understanding of key concepts and developments around cryptocurrencies anddistributed ledger systems.

Course Outcomes

COs	Description
CO1	Explain design principles of Bitcoin and Ethereum.
CO2	Explain Nakamoto consensus.
CO3	Explain the Simplified Payment Verification protocol.
CO4	List and describe differences between proof-of-work and proof-of-stake consensus.
CO5	Interact with a blockchain system by sending and reading transactions.
CO6	Design, build, and deploy a distributed application.
CO7	Evaluate security, privacy, and efficiency of a given blockchain system.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	-	1	1	1
CO2	2	1	2	-	2	1	1
CO3	1	3	2	-	1	-	1
CO4	3	3	1	-	-	-	1
CO5	2	2	3	1	1	-	1
CO6	2	-	3	-	-	-	1
CO7	2	2	3	-	-	-	1
CAM	2	2	3	1	1	1	1

Syllabus

Introduction: Need for Distributed Record Keeping, Modeling faults and adversaries, Byzantine Generals problem, Consensus algorithms and their scalability problems, Why Nakamoto Came up with Block chain based crypto currency? Technologies Borrowed in Block chain – hash pointers, consensus, byzantine fault-tolerant distributed computing, digital cash etc.

Basic Distributed Computing: Atomic Broadcast, Consensus, Byzantine Models of fault tolerance
Basic Crypto primitives: Hash functions, Puzzle friendly Hash, Collison resistant hash, digital signatures, public key crypto, verifiable random functions, Zero-knowledge systems

Blockchain 1.0 : Bitcoin blockchain, the challenges, and solutions, proof of work, Proof of stake, alternatives to Bitcoin consensus, Bitcoin scripting language and their use

Blockchain 2.0: Ethereum and Smart Contracts, The Turing Completeness of Smart Contract Languages and verification challenges, Using smart contracts to enforce legal contracts, comparing Bitcoin scripting vs.

Ethereum Smart Contracts

Blockchain 3.0: Hyperledger fabric, the plug and play platform and mechanisms in permissioned blockchain Privacy, Security issues in Blockchain: Pseudo-anonymity vs. anonymity, Zcash and Zk-SNARKS for anonymity preservation, attacks on Blockchains – such as Sybil attacks, selfish mining, 51% attacks - -advent of algorand, and Sharding based consensus algorithms to prevent these.

Textbooks/References:

1. Imran Bashir, Mastering Blockchain, Packt Publishing, 2018.
2. Drescher, Daniel. "Blockchain basics", Apress, 2017.
3. Josh Thompson, 'Blockchain: The Blockchain for Beginnings, Guild to Blockchain Technology and Blockchain Programming', Create Space Independent Publishing Platform, 2017.

21CSA668A	PRINCIPLES OF ECONOMICS AND MANAGEMENT	L-T-P-C: 2-0-1-3

Course Objectives

- The objective of this course is to develop the ability to apply the concepts, tools and techniques of economics in analysing and interpreting business decisions.

Course Outcomes

COs	Description
CO1	Define and explain how basic concepts of microeconomics (such as elasticity, scarcity or choice) can be used to explain the behavior of individuals, household or firms.
CO2	Represent supply and demand, in graphical form, including the downward/upward slope of the curves and what shifts/moves along the curves.
CO3	To understand the importance of market structures, on the question of the stability and failure of markets.
CO4	Describe and explain how basic macroeconomic policies (such as fiscal or monetary) can be used to analyse the economy as a whole
CO5	Explain basic management, business and marketing principles to be able to continue studies on a higher level.
CO6	To understand the role of PESTLE factors on the SWOT of corporations, in the domestic and the international business environment.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	1	-	-	-	-	1
CO2	1	-	-	-	1	1	1
CO3	1	2	-	1	1	2	2
CO4	1	2	1	-	1	-	1
CO5	1	1	1	1	1	-	3
CO6	1	-	-	1	-	-	1
CAM	1	2	1	1	1	2	2

Syllabus

Introduction to Management: Managers and Management - History Module - The Historical Roots of Contemporary Management Practices, The Management Environment.
Planning: Foundations of Planning - Foundations of Decision Making - Quantitative Module Quantitative Decision-Making Aids. Organizing:
Basic Organization Designs - Staffing and Human Resource Management - Career Module Building Your Career - Managing Change, Stress, and Innovation .Leading-Foundations of Individual and Group Behavior - Understanding Work Teams – Motivating and Rewarding Employees
- Leadership and Trust - Communication and Interpersonal Skills. Introduction to Economics: The Firm and Its Goals - Review of Mathematical Concepts usedin Managerial Economics, Supply and Demand -
The Mathematics of Supply and Demand,Demand Elasticity - Applications of Supply and Demand, Demand Estimation andForecasting, The Theory and Estimation of Production - The Multiple-Input Case -Expressing the Production Function with the Use of Calculus, The Theory and Estimation of cost - A Mathematical Restatement of the Short-Run Cost Function - The Estimation of Cost.
Pricing and Output Decisions: Perfect Competition and Monopoly - The Use of Calculus in Pricing and Output Decisions - Break-Even Analysis(Volume-Cost-Profit), MonopolisticCompetition and Oligopoly - Special Pricing Practices.

Textbooks / References:

1. Stephen P, Robbins David A. De Cenzo, “Fundamentals of Management”, Prentice Hall, Sixth Edition, 2008.

2. Philip K. Y. Young, Steve Erfle and Paul G. Keat, “Managerial Economics: Economic Tools for Today's Decision Makers”, Pearson, Seventh Edition, 2013.

21CSA513A	FOUNDATIONS OF MACHINE LEARNING	L-T-P-C: 2-0-1-3

Course Objectives

- Formulate a machine learning problem
- Preprocess and visualize data
- Develop models for classification/prediction using supervised learning algorithms
- Evaluate and fine-tune model performance
- Apply unsupervised learning algorithms for dimensionality reduction, association rules
- Use of Python packages for developing models

Course Outcomes

COs	Description
CO1	Identify and formulate a machine learning problem and select the subset of applicable techniques for model building.
CO2	Understand supervised learning problems, pre-process the data and train multiple models for testing using Python.
CO3	Understand unsupervised learning algorithms for building recommendation systems, clusters using Python.
CO4	Fine-tune and evaluate the performance of different models and select the best model for deployment using Python.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	1	-	1	2
CO2	3	2	2	1	-	1	2
CO3	2	2	2	-	-	-	2
CO4	1	1	3	-	-	-	2
CAM	3	2	3	1	-	1	2

Syllabus

Unit I

Introduction to Machine Learning, Supervised Learning vs Unsupervised Learning, Data Preparation, Pre-processing and Visualizing data, Performance metrics for Classification and Prediction.

Unit II

Supervised Learning Algorithms: Linear Regression, Logistic Regression, SVM, Decision Trees, Ensemble models – Bagging and Boosting, Model evaluation and improvement, Regularization, Bias Variance, Hyper-parameter Tuning.

Unit III

Unsupervised Learning Algorithms: Dimensionality Reduction - Principal Component Analysis (PCA), Nonnegative Matrix Factorization (NMF), Singular Value Decomposition (SVD), Association Rules, Clustering – Hierarchical, Non-hierarchical, eXplainable AI (XAI)

Textbooks / References:

1. Andreas Muller, "Introduction to Machine Learning with Python: A Guide for Data Scientists", Shroff/O'Reilly, 2016
2. Alexey Grigorev, Machine Learning Bookcamp, Manning, 2020
3. Tom Mitchell, Machine Learning, McGraw-Hill, India, 1990
4. Aurolien Geron, "Hands-On Machine Learning with Scikit-Learn and TensorFlow, Shroff/O'Reilly", 2017
5. https://developers.google.com/machine-learning/glossary

21CSA514A	NATURAL LANGUAGE PROCESSING	L-T-P-C: 2-0-1-3

Course Objectives

- Introduce the fundamental concepts and techniques of natural language processing
- To understand the computational properties of natural languages
- Introduce commonly used deep learning algorithms for processing linguistic information.
- Enable students to be capable to describe the application based on natural language processing and to show the points of syntactic, semantic, and pragmatic processing.

Course Outcomes

COs	Description
CO1	Understand the fundamentals of Natural Language Processing
CO2	Understand global vectors for word representations
CO3	Perform NLP tasks like NER, POS Tagging
CO4	Model languages and perform sentimental analysis.
CO5	Enable students to be capable to describe the application based on natural language processing and to show the points of syntactic, semantic, and pragmatic processing.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	-	-	-	-	-	-
CO2	2	-	3	-	-	-	1
CO3	1	3	3	-	-	-	1
CO4	1	3	3	-	-	-	1
CO5	1	3	3	-	-	-	1
CAM	1	3	3	-	-	-	1

Syllabus

Unit I: NLP Basics and Text Preprocessing:
NLP Introduction, NLP Applications Computational linguistics- Introduction, syntax, semantics, morphology, co-location, and other NLP problems.Text Preprocessing - tokenization, part-of-speech tagging, chunking, syntax parsing, and named entity recognition. Public NLP toolkits – NLTK, spacy.

Unit II: Text Representations and Embeddings:
One-hot encoding, Bag-of-Words (BoW) Dictionary: Term Frequency – Inverse Document Frequency (TF-IDF), N-gram. Word Embedding: Word2vec, Glove, and FastText. Text categorization: Basic supervised text categorization algorithms, including Naive Bayes, k Nearest Neighbor (kNN), and Logistic Regression. Sequences and sequential data

Unit III: NLP Applications:
Topic classification, Part-of-Speech tagging, Named Entity recognition, Morphological analysis, Sentiment analysis, Dependency parsing, Machine translation, Question answering, Text summarization. Introduction to Machine learning and deep learning for NLP, Sequence to sequence modeling (Encoder decoder). Topic modeling: Probabilistic Latent Semantic Indexing (pLSI) and Latent Dirichlet Allocation (LDA)

Textbooks / References:

1. Jurafsky and James H. Martin. Speech and Language Processing (3rd ed).
2. Hobson Lane, Cole Howard, Hannes Hapke Natural Language Processing in Action 2019
3. Jacob Eisenstein Introduction to Natural Language Processing 2019
4. Dipanjan Sarkar , Text Analytics with Python 2016

21CSA519A	BUSINESS ANALYTICS AND VISUALIZATION	L-T-P-C: 2-0-1-3

Course Objectives

- To promote the ability to critically analyze and solve data-oriented real-world decision problems.
- To utilize the theories of statistics and probabilities in business analytics.
- Familiarise the modeling techniques and best practices in visualization.

Course Outcomes

COs	Description
CO1	Apply best practices of data visualization in different stages of the data mining process.
CO2	Analyze and explore data to get useful insights for business.
CO3	Ability to choose an appropriate data analysis methodology suitable for a given business problem.
CO4	Achieve familiarity with using data analysis tools.
CO5	Apply time series analysis to real world problems.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	2	-	-	-	1
CO2	2	3	1	-	-	-	-
CO3	2	3	1	-	-	-	-
CO4	1	2	3	-	-	-	1
CO5	2	3	1	-	-	-	-
CAM	2	3	1	-	-	-	1

Syllabus

Unit I: Introduction to Business Analytics , Descriptive Statistics - Types of Data and its Measures, Data cleansing. Data Visualization-Design Techniques, Tables, Charts, Advanced data Visualization, Dashboards, Case Studies.

Unit II: Inferential Analysis - Statistical Inference, Descriptive Data Mining - Clustering and Association Rules. Performance Evaluation, Overview of key Classification and prediction techniques, Case studies.

Unit III: Introduction to Forecasting, Time Series – Level, Trend, and Seasonality, Smoothing Techniques – Moving Average and Exponential Smoothing, Determining the best forecasting model to use. Case Study.

Textbooks / References:

1. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, Dennis J. Sweeney, Thomas A. Williams 'Business Analytics',3/e, Cengage Learning,2019.
2. GalitShmueli, Kenneth C. Lichtendahl Jr., 'Practical Time Series Forecasting with R: A Hands-On Guide', 2/e, Axelrod Schnall Publishers, 2016.
3. Joel Grus, 'Data Science from Scratch: First Principles with Python', 2/e, O'Reilly Media, 2019.
4. Cole Nussbaumer Knaflic, 'Storytelling with Data: A Data Visualization Guide for Business Professionals', John Wiley& Sons, 2015.
5. Claus O. Wilke, "Fundamentals of Data Visualization: A primer for making informative and compelling

figures", O'Reilly, 2019.

Course Objectives

- Gain basic knowledge in Neural Networks, Training, and on Hyperparameter settings
- Learn to apply Neural Network Architectures for Object Detection, Localization Applications in Computer Vision (CNN)
- Learn to apply Neural Network Architectures for Sequence Modeling Applications like NLP, Action Recognition, Tracking (RNN)
- Applying Neural Network Architectures for Semi-Supervised Learning Settings (DBN)
- Applying Neural Network Architectures for Goal-Oriented Decision Making (DQN)

Course Outcomes

COs	Description
CO1	Understand the main architectures for deep learning algorithms.
CO2	Design and implement deep neural network systems.
CO3	Be able to design and train neural networks for solving real lifepractical problems
CO4	Have a good level of knowledge (Conceptual & Mathematical) on different neural network settings to pursue Research in this Field

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	-	-	-	2
CO2	3	3	2	-	-	-	2
CO3	3	3	2	-	-	-	2
CO4	3	2	-	-	-	-	2
CAM	3	3	2	-	-	-	2

Syllabus

Unit I

Single Layer Neural Networks – Multi-Layer Neural Networks – Back Propagation – Train – Development – Test Set – Bias-Variance Trade-off – Hyper Parameter Settings

Unit II

Convolutional Neural Networks – Basics and Evolution of Popular CNN architectures – Transfer Learning– Applications: Object Detection and Localization, Face Recognition, Neural Style Transfer

Recurrent Neural Networks – GRU – LSTM – NLP – Word Embeddings – Transfer Learning – Attention Models – Applications: Sentinel Classification, Speech Recognition, Action Recognition

Unit III

Restricted Boltzmann Machine – Deep Belief Network – Auto Encoders – Applications: Semi-Supervised classification, Noise Reduction, Non-linear Dimensionality Reduction

Goal-Oriented Decision Making – Policy and Target Networks – Deep Quality Network for Reinforcement Learning

Introduction to GAN – Encoder/Decoder, Generator/Discriminator architectures

Challenges in NN training – Data Augmentation – Hyper parameter Settings – Transfer Learning– Deploying ML Models with Tensor Flow

Textbooks / References:

1. Ian Goodfellow and Yoshua Bengio and Aaron Courville (2016) Deep Learning Book.

21CSA521A	COMPUTER VISION	L-T-P-C: 2-0-1-3

2. Research Papers on Relevant Topics and Internet Resources

Course Objectives

- To introduce students to the state of the art algorithms in the area of image analysis and object recognition
- Give exposure to video analysis techniques for object tracking and motion estimation
- To build a good understanding of the computer vision concepts and techniques to be applied for robotic vision applications
- Enable students to apply the vision algorithms and develop applications in the domain of image analysis, robotic navigation

Course Outcomes

COs	Description
CO1	To build an understanding of detailed models of image formation.
CO2	To expose the students to techniques of image analysis through image feature extraction and object recognition.
CO3	To introduce fundamental algorithms for video analysis such as object tracking, motion segmentation.
CO4	Become familiar with the major technical approaches involved in image registration, camera calibration, pose estimation, stereo vision, etc to be applied to develop vision algorithms for robotic applications.
CO5	Apply the algorithms and develop applications in the domain of image analysis and robotic vision.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	-	-	-	2
CO2	3	2	2	-	-	-	2
CO3	3	2	2	-	-	-	2
CO4	3	3	2	-	-	-	2
CO5	3	3	3	-	-	-	2
CAM	3	2	2	-	-	-	2

Syllabus

Unit I:
Introduction to Image Processing-Basic mathematical concepts: Image enhancement: Grey level transforms, Spatial filtering. Extraction of special features: edge and corner detection. Morphological processing, Image transforms, Discrete Fourier Transform, Fast Fourier Transform. Frequency domain enhancement.

Unit II:
Image Segmentation Algorithms: contextual, non-contextual segmentation, texture segmentation. Feature Detectors and Descriptors, Feature Matching-Object Recognition, Face detection (Viola-Jones), Face Recognition, Modern computer vision architectures based on deep convolutional neural networks, The Use of Motion in Segmentation Optical Flow & Tracking Algorithms, YOLO, DeepSORT: Deep Learning to Track Custom Objects in a Video, Action classification with convolutional neural networks, RNN, LSTM

Unit III:
Image registration, 2D and 3D feature-based alignment Pose estimation, Geometric intrinsic calibration, -

Camera Models and Calibration: Camera Projection Models – orthographic, affine, perspective, projective models. Projective Geometry, transformation of 2-d and 3-d, Internal Parameters, Lens Distortion Models, Calibration Methods – linear, direct, indirect, and multiplane methods. Geometry of Multiple views- Stereopsis, Camera and Epipolar Geometry, Fundamental matrix; Homography, Rectification, DLT, RANSAC, 3-D reconstruction framework; Auto-calibration., Introduction to SLAM (Simultaneous Localization and Mapping).

Textbooks / References:

1. Deep Learning (Adaptive Computation and Machine Learning series) Ian Goodfellow, Yoshua Bengio, Aaron Courville, Francis Bach, January 2017, MIT Press
2. Introduction to Computer Vision and its Application, Richard Szelinski,2010
3. E. Trucco and A. Verri, Prentice Hall, 1998.Introductory techniques for 3D Computer Vision.
4. Marco Treiber, "An Introduction to Object Recognition Selected Algorithms for a Wide Variety of Applications", Springer, 2010.
5. Forsyth and Ponce, "Computer Vision – A Modern Approach", Second Edition, Prentice-Hall, 2011.
6. R. C. Gonzalez, R. E. Woods, 'Digital Image Processing, 4th edition Addison-Wesley,2016

21CSA522A	COMPLEX NETWORK ANALYSIS	L-T-P-C: 2-0-1-3

Course Objectives

- Describe fundamental tools to study networks, mathematical models of network structure
- Learn computer algorithms for network data analysis and the theories of processes taking place on networks.
- Experience working with complex network data sets and implement computer algorithms to solve network problems, use modern network tools to analyze data
- Design algorithms to solve large real-world network problems, devise models of network structure to predict the behavior of networked systems.

Course Outcomes

COs	Description
CO1	Students will gain fundamental knowledge in complex networks.
CO2	The practical way of analyzing and visualizing network data using NetworkX/Gephi.
CO3	Apply network algorithms for partitioning and clustering and such applications using NetworkX.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	-	-	-	-	2
CO2	3	3	3	-	-	-	2
CO3	3	3	3	-	-	-	2
CAM	3	3	3	-	-	-	2

Syllabus

Unit I
Graphs and Networks- Review of basic graph theory, Mathematics of networks- Networks and their representation, Graph spectra, Graph Laplacian, The structure of complex networks, Clustering, Community structures, Social networks - the web graph, the internet graph, citation graphs. Introduction to Gephi/NetworkX

Unit II
Measures and metrics- Degree centrality, Eigenvector centrality, Katz centrality, PageRank, Hubs and authorities, Closeness centrality, Betweenness centrality, Transitivity, Reciprocity, Similarity, assortative mixing.

Unit III
Fundamental network algorithms- Graph partitioning, Spectral graph partitioning, Community detection, Girvan and Newmann Algorithm, Simple modularity maximization, Spectral modularity maximization, Fast methods based on the modularity.

Textbooks / References:

1. M.E.J. Newman, “Networks: An Introduction”, Oxford University Press, 2010.
2. Dougles West, “Introduction to Graph Theory”, Second Edition, PHI Learning Private Limited, 2011.
3. Guido Caldarelli, “Scale-Free Networks”, Oxford University Press, 2007.
4. Alain Barrat, Marc Barthelemy, and Alessandro Vespignani, “Dynamical processes on Complex Networks”, Cambridge University Press, 2008.

21CSA523A	DATA ENGINEERING FOR AI	L-T-P-C: 2-0-1-3

Course Objectives

- Familiarity with the concepts of data architecture, different data models, languages, and data storage for data manipulation
- Understand the different data retrieval methods by querying and combining big data sources
- Able to build a pipeline or interface for the flow and access of information
- Hands-on learning of SPARKSQL

Course Outcomes

COs	Description
CO1	Understand various architectures available for data modeling
CO2	Build a practical application using a real-time framework or tool
CO3	Analyze the performance of an application built by integrating different data handling frameworks
CO4	Should be able to wisely choose data engineering tools and techniques for building solutions to real life problems

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	-	-	-	2
CO2	3	2	3	-	-	-	2
CO3	3	3	3	-	-	-	2
CO4	3	3	3	-	-	-	2
CAM	3	3	3	-	-	-	2

Syllabus

Unit I

Data modeling, relational data models, ER models – Graph models - Normalization and de-normalization, OLTP and OLAP - Big data – Data Science – Processing big data – Languages – SQL, Cypher, Embedded SQL, Constraints – Data Consistency – Query optimization – Object-oriented databases - NoSQL data models – XML databases –schema migrations - PostgreSQL, Apache Cassandra, Presto

Unit II

Spark and data lakes: Python programming in Spark; Data wrangling – Sparkql, spark data frames - SparkSQL, ETL in Spark, SparkMlLib, Comparison of Pyspark with H2O, Dask, and Vaex

Unit III

Data Pipeline – Apache Airflow - Set up task dependencies- Create data connections using hooks - Track data lineage - Set up data pipeline schedules - Partition data to optimize pipelines - Write tests to ensure data quality - Backfill data - Build reusable and maintainable pipelines -Implement subDAGs - Set up task boundaries - Monitor data pipelines

Textbooks / References:

1. Database System Concepts, Abraham Silberschatz, Henry F. Korth, S. Sudarshan, McGraw-Hill Education, 2011
2. NoSQL Distilled: Pramod J. Sadalage, Martin Fowler, Addison-Wesley, 2012
3. Learning Spark: Lightning-Fast Big Data Analysis, Holden Karau, Andy Konwinski, Patrick Wendell, MateiZaharia, O'Reilly Media, Inc., 2015

4. Practical Machine Learning with H2O: Powerful, Scalable Techniques for Deep Learning and AI, Darren

21CSA524A	REINFORCEMENT LEARNING	L-T-P-C: 2-0-1-3

Cook, O'Reilly Media, Inc., 2016

Course Objectives

- Understand the relevance of Reinforcement Learning and how does it complement other ML techniques.
- Given a problem, how to formulate it as a Reinforcement Learning problem and solve it.
- Build a Reinforcement Learning system for sequential decision making.
- Understand various RL algorithms.
- Implement RL algorithms using Python.

Course Outcomes

COs	Description
CO1	Understand the relevance of Reinforcement Learning and how does it complement other ML techniques.
CO2	Understand various RL algorithms
CO3	Implement RL algorithms using Python
CO4	Formulate a real life problem as a Reinforcement Learning problem and find solution to it.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	-	-	-	2
CO2	3	2	-	-	-	-	2
CO3	2	3	3	-	-	-	2
CO4	2	3	3	-	-	-	2
CAM	3	3	3	-	-	-	2

Syllabus

Unit I

Introduction to Machine Learning and its various types, Motivation and Introduction to Reinforcement Learning, Multi arm Bandits; Markov Decision Process, Value functions; Dynamic programming: Policy evaluation and improvement, Value iteration and Policy iteration algorithms

Unit II

Value prediction problems: Temporal difference learning infinite state spaces Algorithms for large state spaces Control: Closed-loop interactive learning, online and active learning in bandits, Q learning infinite MDPs, Q learning with function approximation

Unit III

On policy approximation of action values: Value Prediction with Function Approximation, Gradient-Descent Methods, Policy approximation: Actor critic methods, Monte Carlo Methods: Monte Carlo prediction, estimation of action values, off policy prediction via importance sampling

Textbooks / References:

1. Richard S. Sutton, Andrew G. Barto, Reinforcement Learning: An Introduction", Second edition, MIT Press, 2018
2. Csaba Szepesvari, Algorithms for Reinforcement Learning, 2010, Morgan and Claypool

21CSA525A	IOT FOR AI	L-T-P-C: 2-0-1-3

Course Objectives

- Understand the general concepts in IoT and get familiar with the various hardware and software components of it
- Develop the basic skill set required to build real-life IoT based projects for different application domains
- Gain the necessary skills needed to evaluate the security issues associated with the IoT system designs

Course Outcomes

COs	Description
CO1	Understand the architecture, the design principles and elements of IoT.
CO2	Gain the necessary skills needed to build Machine learning models for edge devices.
CO3	Be able to design, deploy and evaluate scalable real-life IoT systems for different application domains
CO4	Understand and build scalable ML pipeline using Flask, Python, uWSGI, TensorFlow

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	-	-	-	2
CO2	3	2	3	-	-	-	2
CO3	3	3	3	-	-	-	2
CO4	3	3	3	-	-	-	2
CAM	3	3	3	-	-	-	2

Syllabus

Unit I
Introduction to IoT, Architectural Overview and Design Principles, Elements of IoT (Arduino, Raspberry Pi, NodeMCU, Sensors & Actuators), IoT Applications, Sensing, Actuation, Networking Basics, Embedded OS, IoT and Cloud, Security aspects in IoT.

Unit II
IoT Application Development, Introduction to Raspberry Pi, Integrating Sensors and Actuators with Raspberry Pi, Pushing and Managing Data in IoT Clouds, Programming APIs (Python/Node.js/Arduino) for communication protocols (MQTT, ZigBee, Bluetooth, UDP, TCP), Implementation of IoT with Raspberry Pi (lab - sensor, MQTT, visualization)

Unit III
Introduction to ML and Deep learning models for IoT (challenges, opportunities, solutions), Sensor data classification using ML in Raspberry Pi (lab), Introduction to TensorFlowLite, Image classification on Raspberry Pi (lab), object detection on Raspberry Pi (optional lab), building scalable ML pipeline using Flask, Python, uWSGI, TensorFlow (project)

Textbooks / References:

1. Vijay Madisetti, Arshdeep Bahga, Ïnternet of Things, “A Hands-on Approach”, University Press
2. Raj Kamal, “Internet of Things: Architecture and Design”, McGraw Hill
3. Elaine Rich and Kevin Knight, “Artificial Intelligence”, Tata McGraw Hill

4. https://www.tensorflow.org/lite/tutorials

Course Objectives

- The main objective of this course is to familiarize the students with how to represent knowledge, including incomplete and uncertain knowledge of the real world; how to reason logically with that knowledge using probabilities; how to use these reasoning models and methods to decide what to do, particularly by constructing plans; and how to reason and make decisions in the presence of uncertainty about the world. It includes some state-of-the-art topics, such as the logical representation of different types of knowledge, reasoning under uncertainty

Course Outcomes

COs	Description
CO1	Define the basics of artificial intelligence and the deep challenges it presents to the researcher.
CO2	Explain various AI search algorithms (uninformed, informed, heuristic, constraint satisfaction, genetic algorithms).
CO3	Define the fundamentals of knowledge representation (logic-based, frame-based, semantic nets), inference mechanisms, game playing and expert systems
CO4	Demonstrate working knowledge of reasoning in the presence of incomplete and/or uncertain information

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	-	-	-	-	-
CO2	3	3	-	-	-	-	-
CO3	2	3	-	-	-	-	-
CO4	2	2	-	-	-	-	1
CAM	2	3	-	-	-	-	1

Syllabus

Unit 1: What is Artificial Intelligence? – The AI Problems – The Underlying Assumption – What is an AI technique – Criteria for Success.Problems, Problem Spaces and Search – Defining Problem as a State Space Search – Production Systems – Problem Characteristics – Production System Characteristics – Issues in the design of Search Programs.

Unit 2: Heuristic Search Techniques - Generate – and – Test – Hill Climbing – Best-First Search – Problem Reduction – Constraint Satisfaction - Means - Ends Analysis. Knowledge Representation issues – Representations and Mapping - Approaches to knowledge Representation – Issues in knowledge Representation – The Frame Problem. Using Predicate Logic – Representing simple facts in Logic – Representing Instance and Isa Relationship – Computable Functions and Predicates – Resolution – Natural Deduction.

Unit 3: Representing Knowledge Using Rules – Procedural versus Declarative knowledge – Logic Programming – Forward versus Backward Reasoning – Matching – Control Knowledge.Symbolic Reasoning under Uncertainty – Introduction to Non-monotonic Reasoning – Augmenting a Problem Solver – Implementation: Depth - First Search.
Statistical Reasoning – Probability and Baye's Theorem – Bayesian Networks – Fuzzy Logic.

Unit 4: Game Playing - The Minimax Search Procedure – Adding Alpha-Beta Cutoffs.Understanding – What is Understanding? What makes Understanding hard?

Unit 5: Common Sense – Qualitative Physics – Common sense ontology – Memory Organization - Expert Systems – Representing and Using Domain knowledge – Expert System Shells – knowledge Acquisition - Components of an AI program.

Textbooks/References:

1. Artificial Intelligence (Second Edition) – Elaine Rich, Kevin knight (Tata McGraw-Hill)
2. A Guide to Expert Systems – Donald A. Waterman (Addison-Wesley)
3. Principles of Artificial Intelligence – Nils J. Nilsson (Narosa Publishing House)
4. Introduction to Artificial Intelligence – Eugene Charnaik, Drew McDermott (Pearson Education Asia)

21CSA732A	ARTIFICIAL INTELLIGENCE FOR ROBOTICS	L-T-P-C: 2-0-1-3

Course Objectives

- To understand the principles of reinforcement learning which is one of the key learning techniques for robots
- To understand uncertainty handling in robotics through probabilistic approaches
- To learn how measurements work for robots

Course Outcomes

COs	Description
CO1	Learn the foundations of reinforcement learning for robotics
CO2	Understand basic probabilistic principles behind Robotics intelligence
CO3	Learn different measurement techniques for robotics
CO4	Understand POMDP and its significance for robotics
CO5	Implement principles of robotics intelligence for solving real-world problems

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	1	-	-	-	-
CO2	3	3	2	-	-	-	1
CO3	3	3	2	-	-	-	1
CO4	2	3	2	-	-	-	1
CO5	3	1	-	-	-	-	3
CAM	3	3	2	-	-	-	1

Syllabus

Unit I

Overview: Robotics introduction, historical perspective on AI and Robotics, Uncertainty in Robotics Reinforcement Learning: Basic overview, examples, elements, Tabular Solution Methods - Multiarmed bandits, Finite Markov decision process, Dynamic programming (Policy Evaluation, Policy Iteration, Value Iteration), Monte Carlo Methods, Temporal-Difference Learning (Q-learning, SARSA).

Unit II

Approximate Solution Methods - On-policy Prediction with Approximation, Value function approximation, Non-linear function approximation, Reinforcement Learning in robotics, Recursive state estimation: Robot Environment Interaction, Bayes filters, Gaussian filters – The Kalman filter, The Extended Kalman Filter, The information filter, The particle filter Robot motion: Velocity Motion Model, Odometry Motion Model, Motion and maps**.**

Unit III

Measurement: Beam Models of Range Finders, Likelihood Fields for Range Finders, CorrelationBased Sensor Models, Feature-Based Sensor Models, Overview of POMDP.

Textbooks/References:

1. Sebastian Thrun, Wolfram Burgard, Dieter Fox, Probabilistic Robotics, MIT Press 2005
2. Richard S. Sutton, Andrew G. Barto, Reinforcement Learning: An Introduction", Second edition, MIT Press, 2018
3. Jens Kober, Jan Peters, Learning Motor Skills: From Algorithms to Robot Experiments, Springer, 2014
4. Francis X. Govers, Artificial Intelligence for Robotics, Packt, 2018

21CSA733A	NO-SQL DATABASES	L-T-P-C: 2-0-1-3

Course Objectives

- To understand the difference between SQL and NoSQL databases.
- To understand the advanced concepts and terminology related to NoSQL database.
- To develop advanced web application using MongoDB and python.

Course Outcomes

COs	Description
CO1	Will be able to comprehend and evaluate the role of NoSQL database management systems in various applications within organizations
CO2	Will be able to apply the operators CRUD to NoSQL
CO3	Able to connect NoSQL databases with high level languages like Python
CO4	Should be able to wisely choose between different databases for building solutions to real life problems

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	-	-	-	2
CO2	3	3	3	-	-	-	2
CO3	3	3	3	-	-	-	2
CO4	3	3	3	-	-	-	2
CAM	3	3	3	-	-	-	2

Syllabus

Unit I

Overview of DBMS SQL – Queries, Constraints, Normalization, Functional dependency and indexing. Introduction to NoSQL, CAP theorem. ACID vs BASE,

Types of No-SQL Databases-Key-Value and Document Data Models, Column-Family Stores, Aggregate-Oriented Databases. NoSQL Key/Value databases using MongoDB. Column-oriented NoSQL databases using Apache Cassandra. Comparison of relational databases to new NoSQL stores, MongoDB, Cassandra, HBase, Neo4j, - Data model and queries.

Unit II

NoSQL Key/Value databases using Riak. Key-Value Store Features, Consistency, Transactions, Query Features, Structure of Data, Scaling, Suitable Use Cases, Storing Session Information, User Profiles, Preferences, Shopping Cart Data, When Not to Use, Relationships among Data, Multi operation Transactions, Query by Data, Operations by Sets. Graph NoSQL databases using Neo4j - Query Features, Scaling, Suitable Use Cases, Connected Data, Routing, Dispatch, and Location-Based Services, Recommendation Engines

Unit III

Advanced Application Development – Connecting to MongoDB with Python, MongoDB query Language, Updating/Deleting documents in collection, MongoDB query operators. MongoDB and Python patterns – Using Indexes with MongoDB, GeoSpatial Indexing, Upserts in MongoDB. Document database with Web frameworks – Django and MongoDB, Flask and MongoDB.

Textbooks / References:

1. NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence, Author: Sadalage, P. and Fowler, Publication: Pearson Education, August 2012
2. Seven Databases in Seven Weeks: A Guide to Modern Databases and the NoSQL Movement, 2nd edition, Luc Perkins, Jim Wilson, Eric Redmond, 2018
3. Niall O'Higgins, "MongoDB and Python", O'Reilly, 2011.
4. Christof Strauch, "NoSQL Databases"

21CSA734A	APPLICATIONS OF MACHINE LEARNING	L-T-P-C: 2-0-1-3

Course Objectives

- Understand how Machine learning is applied to solve problems in various applications like game playing, recommendation systems, social graph mining, and targeted web advertising.
- Present and Implement ML algorithms to solve real-world problems

Course Outcomes

COs	Description
CO1	Understand how Machine learning is applied to solve problems in various applications like recommendation systems, high dimensional analysis, and targeted web advertising
CO2	Present and Implement ML algorithms to solve real world problems
CO3	Apply and compare different types of Machine learning approaches for a given application problem in the context of implementation and performance
CO4	Design a machine learning system by incorporating various components of ML and evaluate its performance

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	1	-	-	-	2
CO2	3	3	2	-	-	-	2
CO3	3	3	3	-	-	-	2
CO4	3	3	3	-	-	-	2
CAM	3	3	3	-	-	-	2

Syllabus

Unit I

Review of machine learning Concepts, Design of ML system – Model selection, bias, variance, learning curves, and error analysis.

Recommendation Systems – Model for Recommendation Systems, Utility Matrix, Content-Based Recommendations, Discovering Features of Documents, Collaborative Filtering, Usage of UV decomposition in Recommendation systems

Unit II

Customer segmentation – Subspace Clustering, Types of Subspace clustering, Top-down and bottom-up approach: PROCLUS and CLIQUE.

Advertising on the Web: Issues in Online Advertising, Online and offline algorithms, The matching Problem, The AdWords Problem, The Balance Algorithm, A Lower Bound on Competitive Ratio for Balance.

Application of dimensionality reduction, PCA, for Image Processing – compression and Visualization.

Unit III

Independent component Analysis(ICA) for speech processing

Mining Social network graphs – Clustering of Social Network Graphs, Partitioning of Graphs, and Finding Overlapping Communities.

Textbooks / References:

1. Anand Rajaraman, Jure Leskovec and J.D. Ullman, “Mining of Massive Data sets”, e-book, Publisher, 2014.
2. Kevin P. Murphey, “Machine Learning, a Probabilistic Perspective”, The MIT Press Cambridge,Massachusetts, 2012.
3. Selected papers.

21CSA735A	WEB ANALYTICS	L-T-P-C: 2-0-1-3

Course Objectives

- Learn the introductory theory and strategy behind web/digital marketing analytics
- Develop skills in various web and data analysis tools
- Understanding the concepts of knowledge discovery from the web for making intelligent decisions
- Learning social media analysis of popular applications

Course Outcomes

COs	Description
CO1	Students will gain fundamental knowledge in applying basic web analytics methods
CO2	Define and interpret commonly used web metrics, clickstream data collection techniques, their impact on metrics
CO3	Students will be able to do data collection from the web and its analysis and interpretation for decision making.
CO4	Should be able to wisely choose tools and techniques for web analytics in building solutions to real life problems

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	2	-	-	-	2
CO2	3	3	2	-	-	-	2
CO3	3	3	3	-	-	-	2
CO4	3	3	3	-	-	-	2
CAM	3	3	3	-	-	-	2

Syllabus

Unit I

Basics of Web Analytics: marketing analytics, marketing analytics tools, brand problems.
Framework for mapping business needs to web analytics tasks, Data collection architecture Introduction to OLAP, Web data exploration and reporting, Introduction to Splunk

Unit II

Computational advertisement: Display and search advertising, Ad Auctions, Conversion attribution, Knowledge discovery from web data. Analytics platforms: Adobe Analytics, ComScore and Google Analytics

Unit III

Web Analytics Case Studies: Social Media Analysis:- Facebook analysis, Twitter analysis, Youtube analytic, Social Ad analytic

Textbooks / References:

1. Jackson, Steve. Cult of Analytics: Driving online marketing strategies using web analytics. Routledge, 2009.
2. Clifton, B., 2012. Advanced web metrics with Google Analytics. John Wiley & Sons.
3. Kaushik, A., 2009. Web analytics 2.0: The art of online accountability and science of customer-centricity. John Wiley & Sons.
4. https://www.coursera.org/learn/marketing-analytics
5. https://www.coursera.org/learn/social-media-data-analytics

21CSA736A	COMPUTATIONAL STATISTICS	L-T-P-C: 2-0-1-3

Course Objectives

- Introduce students to the importance of computation in data analysis
- To familiarize students with computational methods and simulation techniques used in statistics.
- To enable the student to explore the features of high dimensional data sets
- To apply suitable computational methods to analyze real world data
- To apply computer algorithms and use Monte Carlo methods to solve statistical problems

Course Outcomes

COs	Description
CO1	Understand the need for computational methods in data analysis
CO2	Choose suitable computational methods to analyze real world high dimensional data sets
CO3	Identify statistical patterns in data using suitable algorithms
CO4	Use existing methods to develop new statistical tools

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	2	-	-	-	2
CO2	3	3	2	-	-	-	2
CO3	3	3	2	-	-	-	2
CO4	3	3	2	-	-	-	2
CAM	3	3	2	-	-	-	2

Syllabus

Unit I

Probability concepts, Probability simulations, Sampling concepts - random sampling, sampling distribution-, Parameter estimation methods – Maximum Likelihood Estimation, Method of Moments

Unit II

Random number generation - General techniques for generating Random Variables, Monte Carlo Algorithms- Buffon's needle experiment, Monte Carlo integrationMonte Carlo Methods for Inferential Statistics - Monte Carlo Hypothesis Testing, Bootstrap Methods

Unit III

Exploratory data analysis – Traditional statistics methods and computational statistics methods, Data Partitioning, Cross-Validation, Probability Density Estimation

Unit IV

Linear models and regression analysis - Maximum likelihood estimation, Linear Regression, Polynomial Regression, Stepwise Regression, Ridge Regression, Lasso, ElasticNet

Unit V

Statistical Pattern Recognition- Bayes Decision Theory Estimating Class-Conditional Probabilities Bayes Decision Rule Classification and Regression Trees, Clustering

Textbooks / References:

1. Wendy L. Martinez and Angel R, "Martinez Computational Statistics," Chapman & Hall/CRC, 2002.
2. Ian H. Witten, "Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations", Morgan Kaufmann, 2000.
3. Murphy, Kevin P. Machine learning: a probabilistic perspective. MIT Press, 2012.

4. Friedman, Jerome, Trevor Hastie, and Robert Tibshirani. The elements of statistical learning. Vol. 1. No. 10. New York: Springer series in statistics, 2001.

21CSA737A AI FOR DRUG DISCOVERY AND TARGET VALIDATION L-T-P-C:2-0-1-3

Course Objectives

- This course aims to provide knowledge on how artificial intelligence can be used for target identification, drug design and optimization.
- This also gives an introduction to protein modelling.

Course Outcomes

COs	Description
CO1	Understand the state-of-the art methods and techniques now a day's applied in CADD.
CO2	Choose the appropriate method (in terms of applicability, accuracy, and economy) for a given problem.
CO3	Solve problems like lead optimization, structure-based design, investigation of ligand receptor interaction.
CO4	Understand modelling ranging from molecular mechanics, molecular dynamics over computer graphics, data visualization.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	-	-	-	-
CO2	2	2	-	-	-	-	-
CO3	1	2	1	-	-	-	-
CO4	1	1	1	-	-	-	-
CAM	1	2	1	-	-	-	-

Syllabus

Unit I: **DRUG DESIGN and CADD:** What is a drug, The role of drugs in the practice of medicine, The role of Pharmaceutical Chemistry, The history of Pharmaceutical Chemistry, Natural substances as drugs. What is CADD, Explanation of some basic terms, Pharmacophore, Lock-Key principle and induced fit theory, Molecular Recognition and Molecular Docking, What makes a compound bioactive, The objects of CADD and Molecular Modeling.

Unit II: ARTIFICIAL NEURAL NETWORKS (ANN): Background and basics of ANN, Transfer functions in neurons, The Kohonen network, Special characteristics, Competitive learning, An example: mapping from dimensions, Counter propagation
AI and Drug Design: AI in drug screening, Prediction of the physicochemical properties, AI in designing drug molecules, Applications of ANNs in Drug design, ANN in Quantitive structure-activity relationships, ANN to determine the secondary structure of proteins.

Unit III: **PROTEIN MODELING:** The Protein Data Bank (PDB), Relationship between sequence and 3D structure of a protein. Alignment of protein sequences, Needleman-Wunsch alignment method, Multiple sequence alignments (MSA), Homology modeling of proteins, Construction of the core, Construction of loops and turns1, Construction of the Side chains, Refinement of the homology model, Prediction of protein structures by threading, Comparison of various strategies in homology modeling1, Protein folding, Thermodynamics of protein folding.

Textbooks/References:

1. Molecular Modelling: Principles and Applications (Paperback), by Andrew R. Leach, Pearson Higher Education, USA, 2001 (ISBN 0582382106).
2. Agrawal, P. (2018). Artificial intelligence in drug discovery and development. J Pharmacovigil, 6(2).

21CSA738A	REPRESENTATION LEARNING	L-T-P-C: 2-0-1-3

Course Objectives

- To understand the requirements for representation learning
- To understand various strategies for representation learning
- To understand and compare the mathematical aspects in each of the representation learning strategies

Course Outcomes

COs	Description
CO1	Understand why Representation Learning is required in various real-world domains
CO2	Present and implement Representation learning algorithms
CO3	Apply and compare different types of Representation learning approaches for data in a given domain
CO4	Design a representation learning algorithm by incorporating various processes involved in it for a specific domain dataset

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	-	-	-	-	2
CO2	3	3	-	-	-	-	2
CO3	3	3	2	-	-	-	2
CO4	3	3	3	-	-	-	2
CAM	3	3	3	-	-	-	2

Syllabus

Unit I: Introduction: Overview of Representation Learning and its motivation, Priors for Representation Learning in AI. Basic Representation Learning using Unsupervised strategies- Dimensionality reduction - Principal Component Analysis (PCA), Non-linear PCA, sparse PCA, Independent Component Analysis, Singular Value Decomposition. Clustering Strategies to extract features in high dimensional space - Subspace Learning: Top-down subspace clustering – PROCLUS, FINDIT, Bottom-up subspace clustering – CLIQUE, MAFIA.

Unit II: Manifold Learning: Kernel K-means, kernel PCA, similarity-based clustering. Deep Learning: Stochastic optimization, stochastic approximation algorithms. Restricted Boltzmann machines, autoencoders, deep belief networks, convolutional neural networks, Multi-view Learning: Partial least squares, canonical correlation analysis (CCA), Kernel CCA, Deep CCA. State of the art models in applications such as text classification, speech recognition and image classification

Unit III: Transfer Learning and Domain adaptation. Spectral Learning: Spectral methods, spectral clustering, co-training, spectral learning of Hidden Markov Models (HMMs), tensor factorization, latent variable PCFGs, multivariate latent tree structures.

Textbooks / References:

1. Jeremy Watt, Reza Borhani, Aggelos K. Katsaggelos, “Machine Learning Refined: Foundations,

Algorithms, and Applications". Cambridge University Press.
2. Shiliang Sun, Liang Mao, Ziang Dong, Lidan Vu, "Multiview Machine Learning". Springer.
3. Ian Goodfellow, YoshuaBengio and Aaron Courville, "Deep Learning", MIT Press.
4. Yoshua Bengio and Aaron Courville and Pascal Vincent, "Representation Learning: A Review and New Perspectives",arXiv:1206.5538, 2012.
5. https://www.deeplearningbook.org/contents/representation.html

21CSA739A MEDICAL SIGNAL PROCESSING L-T-P-C: 2-0-1-3

Course Objectives

- To understand various signals and the image modalities in the field of Biomedical
- To study origins and characteristics of some of the most commonly used biomedical signals like ECG.
- To explore the research domain in biomedical signal processing.
- To understand various reconstruction techniques for CT and MRI.

Course Outcomes

COs	Description
CO1	The student will be able to understand various methods of acquiring biosignals.
CO2	The student will be able to understand various sources of biosignal distortions and its remedial techniques.
CO3	The students will be able to analyse ECG and EEG signals with characteristic feature points.
CO4	The student will have a basic understanding of applying deep learning techniques for medical image segmentation, clustering and classification problems.
CO5	Understand various volume reconstruction and volume rendering techniques for Medical images

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	1	-	-	-	2
CO2	3	3	2	-	-	-	2
CO3	3	3	2	-	-	-	2
CO4	3	3	2	-	-	-	2
CO5	3	3	2	-	-	-	2
CAM	3	3	2	-	-	-	2

Syllabus

Unit I: Signals and systems: Review, Medical Imaging Modalities and the need for different modalities (MRI, CT, OCT for Retinal Images, PET, X-Ray, Ultra Sound, Microscopy, Flow Cytometry, Imaging Flow Cytometry, etc. Pre-processing – Image Enhancement – Focus Analysis - Noise reduction (Additive and Speckle Noise) – Image Quality Measures - Domain Transformation: Fourier Domain and Wavelet Domain- Thermal Imaging. Basic electrocardiography, ECG lead systems, ECG signal characteristics

Unit II: Medical Image Segmentation – Deep Learning-based Segmentation on 2D or 3D volume of Data Feature Extraction – Morphological Features – Textural Features –, Feature extraction for 1D Biomedical signals– Deep Features. Image Registration and Fusion — Key Point Matching - Geometric transformations. ECG data acquisition, ECG lead system, ECG signal characteristics (parameters and their estimation), Analog filters, ECG amplifier, and QRS detector, Power spectrum of the ECG, Bandpass filtering techniques, Differentiation techniques, Template matching techniques, A QRS detection algorithm

Unit III: Classification and Clustering– Examples of image classification for diagnostic/assistive technologies – Deep learning-based classifiers.3D volume reconstruction – Reconstruction techniques for CT, MRI- . Reconstruction of cell structure from focus stack of images - CT and MRI volume reconstruction – Wavelet-based Volume Rendering, Applications of EEG

Textbooks / References:

1. Klaus D. Toennies," Guide to Medical Image Analysis - Methods and Algorithms", Advances in Computer Vision and Pattern Recognition, 2nd Edition, Springer-Verlag London, DOI: 10.1007/978-1-4471-7320-5, ISBN 978-1-4471-7318-2
2. Geoff Dougherty, "Medical Image Processing Techniques and application", Springer New York 2011
3. MostafaAnaloui, Joseph D. Bronzino, Donald R. Peterson, "Medical Imaging: Principles and Practices", Taylor and Francis Group, 2012
4. Analysing Neural Time Series Data-Theory and Practice (MIT Press) 2014

21CSA740A	APPLIED PREDICTIVE ANALYTICS	L-T-P-C: 2-0-1-3

Course Objectives

- To familiarize students with the methods for exploration and visualization of data
- To develop machine learning models for predictive tasks
- To choose suitable performance measures for predictive models
- To apply predictive modelling techniques in real world data

Course Outcomes

COs	Description
CO1	Understand analytical methods used in predictive analytics
CO2	Evaluate the measures to access predictive performance of data mining tasks
CO3	Understand and design prediction, classification methods
CO4	Study approaches for forecasting time-series data
CO5	Apply suitable predictive methods in real-life problems

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	-	-	-	-	-	2
CO2	3	3	-	-	-	-	2
CO3	3	3	1	-	-	-	2
CO4	3	3	2	-	-	-	2
CO5	3	3	2	-	-	-	2
CAM	3	3	2	-	-	-	2

Syllabus

Unit I

Introduction and Overview of the Predictive Analytics – Building a Predictive Model - Predictive Power and Overfitting - Data Partitioning – Exploratory Data Analysis - Data Visualization - Dimension Reduction - Principal Components Analysis - Performance Evaluation - Evaluating Predictive Performance - Judging Classifier Performance – Lift and Decile Charts – Oversampling.

Unit II

Prediction and Classification Methods - Multiple Linear Regression - Explanatory vs. Predictive Modeling - Estimating the Regression Equation and Prediction - The k-NN Classifier (Categorical Outcome) - The Naive Bayes Classifier - Classification and Regression Trees - Logistic Regression - Neural Nets - Discriminant Analysis - Combining Methods: Ensembles - Uplift Modeling - Association Rules and Collaborative Filtering - Clustering.

Unit III

Forecasting Time Series – Components of a Time Series – Data Partitioning and Performance Evaluation for Time Series – Na¨ıve Forecasts - Smoothing Methods - Introduction - Moving Average - Simple Exponential Smoothing – Advanced Exponential Smoothing–Regression-Based Forecasting - Autocorrelation and ARIMA Models - Data Analytics - Social Network Analytics - - Text Mining -predictive analytics in business application - Other Case Studies.

Textbooks / References:

1. Max Kuhn and Kjell Johnson, “Applied Predictive Modeling”, Springer, 2018.
2. GalitShmueli, Peter C. Bruce, InbalYahav, Nitin R. Patel, Kenneth C. LichtendahlJr“Data Mining for Business Analytics: Concepts, Techniques, and Applications in Python”, Wiley, 2019.
3. Daniel T. Larose and Chantal D. Larose, “Data Mining and Predictive Analytics” (Wiley Series on Methods and Applications in Data Mining), Wiley, 2015.
4. Ratner Bruce, ”Statistical and Machine-Learning Data Mining:: Techniques for Better Predictive Modeling and Analysis of Big Data”, CRC Press, 2017.
5. Abbott Dean, ”Applied predictive analytics: Principles and techniques for the professional data analyst”, John Wiley & Sons, 2014.

21CSA741A	DATA VISUALIZATION	L-T-P-C: 2-0-1-3

Course Objectives

- To learn various types of visualization
- Develop skills to design and build visualizations
- Understand various components for data visualization
- Understand the various type of data that influences the type of visualization

Course Outcomes

COs	Description
CO1	Understand the key techniques and theory behind data visualization
CO2	Will be able to prepare data for good visualizations
CO3	Create multiple versions of digital visualizations using various software packages
CO4	Evaluate information visualization systems and other forms of visual presentation for their effectiveness
CO5	Design and build data visualization systems

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	-	-	-	-	2
CO2	3	3	3	-	-	-	2
CO3	3	3	2	-	-	-	2
CO4	3	3	2	-	-	-	2
CO5	3	3	2	-	-	-	2
CAM	3	3	2	-	-	-	2

Syllabus

Unit I:
Introduction to data visualization - Value of Visualization – What is Visualization and Why do it: External representation – Interactivity – Difficulty in Validation. Data Abstraction: Dataset types – Attribute types – Semantics. Task Abstraction – Analyze, Produce, Search, Query. Four levels of validation – Validation approaches – Validation examples. Marks and Channels
Design principles Categorical, time series, and statistical data graphics. Multivariate displays
Data for data graphics. Tableau introduction

Unit II:
Rules of thumb – Arrange tables: Geospatial displays- Visualization of Spatial Data, Networks, and Trees. Categorical regions – Spatial axis orientation – Spatial layout density. Arrange spatial data: Geometry – Scalar fields – Vector fields – Tensor fields. Arrange networks and trees: Connections, Matrix views – Containment. Map color: Color theory, Color maps and other channels.

Unit III:
Manipulate view: Change view over time – Select elements – Changing viewpoint – Reducing attributes. Facet into multiple views: Juxtapose and Coordinate views – Partition into views – Static and Dynamic layers – Reduce items and attributes: Filter – Aggregate. Focus and context: Elide – Superimpose - Distort – Case studies. Dashboards, interactive and animated displays

Textbooks / References:

1. Tamara Munzner, Visualization Analysis and Design, A K Peters Visualization Series, CRC Press, 2014.
2. Scott Murray, Interactive Data Visualization for the Web, O'Reilly, 2013.
3. Alberto Cairo, The Functional Art: An Introduction to Information Graphics and Visualization, New Riders, 2012
4. Nathan Yau, Visualize This: The FlowingData Guide to Design, Visualization and Statistics, John Wiley & Sons, 2011.
5. Sosulski, K. (2018). Data Visualization Made Simple: Insights Into Becoming Visual. New York: Routledge.
6. Beautiful Visualization, Looking at Data Through the Eyes of Experts by Julie Steele, Noah Iliinsky

21CSA527A	NETWORK SECURITY	L-T-P-C: 2-0-1-3

Course Objectives

Students will gain a fundamental understanding of network security. They will protect networks, both physical and wireless. Common protocols and data management techniques. They will be comfortable with all the layers of a network, Wifi, Bluetooth. The student will become comfortable with cryptography over networks, and IPv6 security, email security, and firewalls. Students will be familiar with IDS and IPS, common tools against network attacks

Course Outcomes

COs	Description
CO1	To understand the basics of Computer Networking and Network Security.
CO2	To learn about how to maintain the Confidentiality, Integrity, and Availability of aData over networks.
CO3	To understand various protocols for network security to protect against the threats in the networks.
CO4	To understand how to protect the data transferred over networks.
CO5	To use and practice practical python networking libraries.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	2	-	-	-	3
CO2	2	3	1	-	-	-	3
CO3	1	2	3	-	-	-	3
CO4	1	2	2	-	-	-	3
CO5	-	3	3	-	-	-	2
CAM	1	3	2	-	-	-	3

Syllabus

Unit I

Information Security Awareness: Bad Actors, Data Security Perspectives, Password Perspectives, Internet Threat Perspectives and Insider Threat Perspectives. Application Layer, Web and HTTP, Electronic mail protocols (SMTP,POP3,IMAP), DNS, Content Distribution Networks, Web Application Firewall
Transport Layer, Process to Process delivery, UDP, TCP, Flow Control and Error Control in TCP, Congestion Control in TCP, UDP Socket Programming, TCP Socket Programming, Practical

Unit II

Evolution of Network Security, Secure Access Service Edge, Cloud Security, SD-WAN, Endpoint Security, Data Link Layer, Relationship with other layers, Error detection and correction Techniques, ARP and RARP, Link-layer protocols, Switched Local Area Networks, Practical
WIFI Technologies: Introduction 1 (WiFi), NSE 2 Wi-Fi, WiFi Security, Practical - Traffic analysis, Practical - Demonstration of WIFI Exploitation

Unit III

Bluetooth and Zigbee, Bluetooth -Working, Zigbee – Working, Bluetooth and Zigbee security,
Symmetric Key Cryptography, Asymmetric Key Cryptography, Digital Signatures, Cryptographic, Hash Functions, Message Authentication Codes
IPv6 Security, Network Layer Security, Transport Layer Security
Email Security, Securing Email, Email Header Analysis, Secure Email Gateway
Firewalls, NSE 2 Firewall, Threat Intelligence Services

IDS and IPS, Types of IDS and IPS, IDS and IPS Designs
Network Risk and Vulnerability Management, Types of Vulnerability Assessment, Tools for Network Vulnerability Assessment
Network Attacks, Information Extraction using NMAP + Port scanning

Unit IV
Access Attacks, DNS Poisoning + ARP Poisoning,Replay attack and privilege Escalation
Malware & DDoS Attacks, DOS & DDOS, MAC Spoofing + switch port stealing

Textbooks / References:

1. J. F. Kurose and K. W. Ross, Computer Networking: A Top-Down Approach, Pearson Publication, 7th Edition, 2017.
2. L. Peterson and B. Davie, Computer Networks: A Systems Approach, 5th Edition, Elsevier Inc., 2011.
3. S.K.PARMAR, Cst, Computer, Internet, and Network Systems Security.
4. Scott Hogg and Eric Vyncke, IPv6 Security, Cisco, 2009

21CSA529A	PYTHON SCRIPTING FOR SECURITY	L-T-P-C: 2-0-1-3

Course Objectives

In this course students will learn to program in python, using an object-oriented approach. Students will learn and write short and long programs to use python to write programs that automate common security tasks.

Course Outcomes

COs	Description
CO1	Students will learn the fundamentals of computing with python
CO2	Students will be comfortable using python to automate simple tasks with OOP python scripts
CO3	Students will know how to debug their programs
CO4	Students will be familiarized with the simplicity of the Python ecosystem
CO5	Students will learn the central security of python libraries

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	3	-	-	-	2
CO2	2	2	3	-	-	-	2
CO3	1	3	3	-	-	-	2
CO4	2	1	3	-	-	-	3
CO5	2	2	3	-	-	-	3
CAM	2	2	3	-	-	-	2

Syllabus

Unit I: Fundamentals of Python, REPL, Variables, Datatypes, Control Flow, Functions, Recursion
Containers: List, Tuple, Dictionaries, Sets, Frozensets, Mutable vs Immutable, Generators: list comprehensions, dictionary creation routines.

Unit II: Object-Oriented Programming, Classes and Objects, Data attributes and methods, Serialization and deserialization using JSON, Pickle, Error handling and Debugging, Importing and using modules

Unit III: Scripting Files and folders, Os.path and pathlib, Process management and command execution, Os.system and subprocess module, Os.exec, os. fork, and os. kill

Unit IV: Networking, Socket Module and SSL modules, Socket Creation, Binding, Sending and receiving data, Cryptography, CSPRNG, secrets module, hashlib, fernet, MAC & HMAC

Unit V: Website Automation, Requests, Scraping, Beautiful Soup, Selenium, Data processing and Visualization with pandas, numpy , seaborn

Textbooks / References:

1. Wesley J. Chun, “Core Python Applications Programming”, 3rd Edition, Pearson Education, 2016.
2. https://automatetheboringstuff.com/ (free online version)
3. realpython.com (free articles only)
4. https://jakevdp.github.io/PythonDataScienceHandbook/ (free online version)

21CSA530A	FUNDAMENTALS OF CYBERSECURITY OPERATIONS	L-T-P-C: 2-0-1-3

Course Objectives

The course teaches students security concepts, common network and application operations and attacks, and the types of data needed to investigate security incidents. Students will learn how to monitor alerts and breaches and become a contributing members of a Cybersecurity Operations Center (SOC) including understanding the IT infrastructure, operations, and vulnerabilities

Course Outcomes

COs	Description
CO1	Students should be able to understand the functionalities of various SOC generations.
CO2	Understand different data collection, data analysis, and security analysis techniques as part of SOC technologies.
CO3	Understand the vulnerability management techniques and threat intelligence methodologies.
CO4	Assess the SOC capabilities using different SOC tools and techniques.
CO5	Learn how SOC helps in business continuity and disaster recovery plan.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	1	3	-	-	-	3
CO2	2	1	3	-	1	1	3
CO3	2	2	3	-	-	-	2
CO4	2	2	3	-	1	1	2
CO5	1	2	3	1	1	1	2
CAM	2	2	3	1	1	1	3

Syllabus

Information security incident management (Incident detection, triage and incident categories, Incident severity, resolution, Closure, Post-incident), Security Operations Center (SOC) Generations (First-generation, second, third and fourth generation SOC), SOC Maturity models (Introduction to maturity models, and applying maturity models in SOC), SOC Technologies-1 (Data collection and analysis, syslog protocol), SOC Technologies-2 (Telemetry Data, Security analysis, Data enrichment), Vulnerability Management (Broad introduction), Threat intelligence (Broad introduction), Assessment of SOC capabilities (Business and IT Goals, Assessing capabilities & IT processes), SOC - Business Continuity, Disaster recovery (Importance of BCP and DR processes, and its interface to SOC), Security event generation and collection (Cloud Security, IDPS, Breach Detection), SOC and SIEM – Introduction (Role of SIEM in SOC), SOC and Splunk (Splunk architecture & SOC, Splunk Rules, Splunk log management, Splunk correlation), SOC and Health Care - A Case study (SOC Considerations for a HealthCare situation), SOC and Application security (OWASP, Application security and SOC).

Textbooks / References:

1. Security Operations Center: Building, Operating, and Maintaining Your SOC, Book by Gary McIntyre, Joseph Muniz, and Nadhem AlFardan
2. Designing and Building Security Operations Center, 2015, Book by David Nathans
3. Security Operations Center - SIEM Use Cases and Cyber Threat Intelligence, 2018, Book by Arun E Thomas
4. The Modern Security Operations Center, 2021, Book by Joseph Muniz

5. Principles for Cyber Security Operations, 2020, Book by Hinne Hettema

Course Objectives

Familiarization of popular cloud platforms, VM creation, Container management, and Kubernetes, Storage management, Database creation, Network management, Access control mechanism in a computing environment, Virtual private cloud, Design and deployment of secure microservice applications, load balancing, Identity management, Homomorphic encryption, VPC Networking, and security.

Course Outcomes

COs	Description
CO1	Understand the architecture and infrastructure of cloud computing along with hands-on experience in various cloud computing platforms.
CO2	Identify the known threats, risks, vulnerabilities, and privacy issues in the various layers of cloud computing.
CO3	Compare modern security concepts as they are applied to cloud computing
CO4	Understand the concepts and various methods of secure data management in the cloud.
CO5	Practical application of various modern cloud technologies.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	1	3	-	-	-	3
CO2	1	1	2	-	-	-	3
CO3	2	1	3	-	-	-	3
CO4	2	1	3	-	-	-	3
CO5	2	1	3	-	-	-	3
CAM	2	1	3	-	-	-	3

Syllabus

Cloud computing essentials: - Characteristics, service models, deployment models, NIST reference architecture, virtualization, containers, Kubernetes, design of microservices, high availability, Load Balancing in the cloud, cloud storage, and databases, cloud networking and vpc, popular cloud platforms, open-source architectures.
Threats classification and countermeasures: - Infrastructure and host threats, service provider threats, generic threats, threats assessment, CSA Top threats, Virtualization system vulnerabilities, Authentication and authorization techniques for cloud solutions, Protection of application infrastructure, Protecting Data in the Cloud:- Tokenization, Cryptographic key management for data protection, Encryption techniques and applications for cloud computing, homomorphic encryption, Intrusion Detection and Prevention for cloud workloads, security breaches management for cloud computing, Cloud-centric regulatory compliance issues, and mechanisms.

Textbooks / References:

1. John R. Vacca(Editor), “Cloud Computing Security - Foundations and Challenges” CRC Press, 2017
2. Ronald L. Krutz and Russell Dean Vines, “Cloud Security- A Comprehensive Guide to Secure Cloud Computing”, Wiley, 2010
3. Chris Dotson “Practical Cloud Security “, O'Reilly,2019
4. Tim Mather, S. Kumaraswamy, and S. Latif, “Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance”, O’Reilly Media, 2009

21CSA538A	CYBERSECURITY GOVERNANCE, RISK AND COMPLIANCE	L-T-P-C: 2-0-1-3

Course Objectives

The students will learn the principles of cybersecurity governance, risk, and compliance. They will understand the tools methods, including vulnerability management, threat detection, metrics, and evaluations of organizations. Students will study the NIST framework and learn organizational roles within a company.

Course Outcomes

COs	Description
CO1	Understand the different methods to assess cybersecurity maturity.
CO2	Understand the vulnerability management techniques and threat management methodologies.
CO3	Understand the governance metrics (Application security, vulnerability, and network security).
CO4	Know the relation between security analytics and security governance.
CO5	Understand the NIST compliance for security mandate.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	-	3	-	2	1	1	3
CO2	1	3	-	2	-	-	3
CO3	1	2	-	2	-	-	3
CO4	-	2	-	-	1	-	3
CO5	-	2	-	-	-	-	3
CAM	1	2	-	2	1	1	3

Syllabus

Unit I

Basics of Cyber security governance, Principles of cyber-security governance, Assessment of cyber security maturity, Theories of governance – introduction, Governance – definitions and typologies

Unit II

Governance of security operations, Tools, methods, and processes, Vulnerability management, Threat management, Endpoint management, Intrusion detection and prevention (IDPS), Security incident management

Unit III

Security metrics and governance, Measurement of governance: Metrics – concepts, Application security metrics, Network security metrics, Security incident metrics, Vulnerability metrics, Service level objectives/agreement (SLO / SLA), NIST metrics

Unit IV

Security analytics and governance, Basics of security analytics, Threat intelligence and governance, Data-driven security governance, Impact of cognitive security on security governance

Unit V

Compliance and governance, Industry-specific security compliance, Cyber security governance – Republic of India, NIST mandates for compliance, Security reporting basics, CISO – role and organization structure, HIPAA, COBITZ compliance

Unit VI

Cyber Security Risk:, Information security risk management framework and methodologies, Risk Management Process, Framework, and Life Cycle, Identifying and modeling information security risks, Qualitative and quantitative risk assessment methods, Articulating information security risks as business consequences

Textbooks / References:

1. Information Security Governance: A Practical Development and Implementation Approach, Wiley publications 2009.
2. Information Security Governance, S.H. Solms, Rossouw Solms, Springer Science & Business Media.
3. Internet governance in an age of cyber insecurity,2010, Council on Foreign Relations Press.
4. Cyber justice: human rights and good governance for the internet, 2017, Springer.
5. Cyber Risk Management: Prioritize Threats, Identify Vulnerabilities and Apply Controls 1st Edition, Kogan Publishers, 2019.

21CSA539A	CYBER SECURITY LAW	L-T-P-C: 2-0-1-3

Course Objectives

Students will learn the cybersecurity laws in India and abroad. A clear introduction to the laws behind data security, breaches, cybercriminal combat, and much more.

Course Outcomes

COs	Description
CO1	Students will understand the history of cybercrime and the laws created.
CO2	Understand the different classes of cyber-crime.
CO3	Knowledge of the IT act.
CO4	Students will gain knowledge of procedures and authorities in India and abroad.
CO5	Gain familiarity with all laws regarding privacy.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	2	-	-	3	-	3
CO2	1	2	-	-	3	-	3
CO3	1	2	-	-	3	-	3
CO4	1	2	-	-	3	-	3
CO5	1	2	-	-	3	-	3
CAM	1	2	-	-	3	-	3

Syllabus

Jurisprudence of cyber law, Iinformation Technology Act, 2008, Cybercrimes, history and evolution of cybercrime, unauthorized access crimes, BEC, ATM frauds, online banking frauds, SIM swap frauds, email frauds, lottery frauds, Web defacement, Web Jacking, crimes relating to digital signature

Penalties under the IT Act, Relevant Offences under the IT Act

Exemption of liability of intermediaries, Information Technology (Intermediary Guidelines and Digital Media Ethics Code) Rules, 2021, due diligence, Procedures & Authorities

Authorities and their duties; The National Cyber Coordination Centre (NCCC), Cyber and Information Security (C&IS) Division, National Critical Information Infrastructure Protection Centre (NCIIPC), National Technical Research Organisation (NTRO)
Law of Privacy.

GDPR and the EU.

Textbooks / References:

1. Satish Chandra, “Cyberlaw in India”.
2. Nilakshi Jain, Ramesh Menon “Cybersecurity and Cyber laws” Wiley media

21CSA540A	WEB APPLICATION SECURITY	L-T-P-C: 2-0-1-3

Course Objectives

Students will learn an overview of web application architectures and the associated security vulnerabilities and defenses. By the end of the course, students will be confident to understand how to secure web applications.

Course Outcomes

COs	Description
CO1	Ability to find and exploit vulnerabilities in web applications
CO2	Ability to find CVEs in open source web application frameworks
CO3	Ability to participate and win in bug bounty programs
CO4	Ability to implement secure coding practices
CO5	Trained in responsible vulnerability disclosure

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	3	1	-	-	3
CO2	1	3	3	1	2	-	3
CO3	1	1	3	1	3	-	3
CO4	2	3	3	1	-	-	3
CO5	1	2	2	1	3	-	3
CAM	1	3	3	1	2	-	3

Syllabus

Introduction - Overview of web architecture, Protocols, Client-server architecture, P2P architecture, DNS, etc.
Understanding the browser: Same origin policy, Cookies, Cache, authentication.
Website development basics, understanding server-side languages like HTML, PHP and Database languages such as SQL. Understanding the frontend, backend, database paradigm of web application development.
Injection attacks: SQL injection, OS command injection.
File upload vulnerability: LFI, RFI, how to properly secure a file inclusion vulnerability.
Request forgery vulnerability: Server-side request forgery, Client-side request forgery.
Cross-site scripting attacks: Reflected XSS, Stored XSS, how to properly secure against XSS attacks.
DOS & DDOS attacks, Phishing attacks.
Automating vulnerabilities: SQLmap, Burp Suite.
OWASP Top 10: Broken Authentication, Sensitive Data Exposure, XML External Entities, Broken Access Control, Security Misconfiguration, Insecure Deserialization, Using Components with Known Vulnerabilities, Insufficient Logging & Monitoring.
Responsible vulnerability disclosure: CVE's, CVEmitre, Exploit-db, SearchSploit, bug bounty.
Secure coding practices: blacklisting, whitelisting, user input validation, automated testing, sanitizing HTML.

Textbooks / References:

1. Peter Yaworski, "Real-World Bug Hunting: A Field Guide to Web Hacking"
2. Michal Zalewski, "The Tangled Web: A Guide to Securing Modern Web Applications"
3. Dafydd Stuttard and Marcus Pinto, "The Web Application Hacker's Handbook" Second edition, 2011
4. OWASP, "Web Security Testing Guide", Fourth edition

21CSA751AMACHINE LEARNING AND ARTIFICIAL INTELLIGENCE IN CYBERSECURITYL-T-P-C: 2-0-1-3

Course Objectives

The students will be exposed to the fundamentals of machine learning: classification, regression, supervised and unsupervised learning. They will learn which algorithms to use in which context, including model validation and evaluation. They will be exposed to a thorough survey of the fundamental security applications that machine learning provides as well the current security limitations of machine learning.

Course Outcomes

COs	Description
CO1	Learn and understand what machine learning and artificial intelligence is
CO2	Gain proficiency in scikit-learn, using supervised and unsupervised learning
CO3	Learn the fundamentals of regression and classification
CO4	Make use of classification and anomaly detection systems in security – fraud and spam detection
CO5	Learn to threat model for machine learning, understanding adversarial attacks

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	2	-	-	-	3
CO2	1	2	3	-	-	-	3
CO3	3	3	2	-	-	-	3
CO4	2	3	3	-	-	-	3
CO5	2	2	3	-	-	-	3
CAM	2	3	3	-	-	-	3

Syllabus

Python, Jupyter Notebooks, Pandas, Numpy, Matplotlib, Seaborn, Scikit-Learn. Supervised learning: Linear regression, Decision Trees, Support Vector Machines, K-nearest neighbors, random forests, AdaBoost, gradient boosting, multi-layer perceptrons, logistic regression. Unsupervised learning: k-means clustering, dbscan, GMM, PCA, T-SNE. Bias-variance tradeoff. Learning and validation curves. Cross-validation, shuffle split, k-fold, time-series split. Random seeds. Baseline and benchmarking models. Gradient descent, regularization, feature scaling, one-hot encoding, label encoding. Train-test-split. Metrics: accuracy, f1-score, precision, recall, confusion matrices. Gini impurity, information gain ratio, feature ranking with multivariate and univariate methods. Hyper-parameter tuning with grid search and random search. Natural language processing, ngrams, bag of words, vectorizers. Data wrangling with feature preprocessing and EDA.
Artificial Intelligence (AI), Deep Learning (DL), and Machine learning (ML) in security. Understand the role AI plays in making decisions in large-scale settings. Algorithm bias and fraud.
Machine learning for security - anomaly detection, fraud detection, malware detection, spam detection, phishing detection, IDS, and NIDS.
Security of machine learning: adversarial attacks on machine learning. Data poisoning, model stealing, evasion attacks at inference time. Adversarial hardening.

Textbooks / References:

1. Tom M Mitchell, Machine Learning, McGraw Hill, 1997
2. Jake Vanderplas, Python Data Science Handbook, O'Reilly Media, 2016

3. Clarence Chio, David Freeman, Machine Learning and Security, O'Reilly Media, 2018

21CSA752A	MOBILE SECURITY AND DEFENCE	L-T-P-C: 2-0-1-3

Course Objectives

The students will learn the fundamental of mobile security and defense. Focus on android platform using android framework and APIs. Students will learn the structure of android applications, the exploits involved and common hardening techniques. Students will learn to perform static and dynamic analysis to identify malicious apps.

Course Outcomes

COs	Description
CO1	Understand internals of Android Operating System, security model of Android and iOS
CO2	Understand how to make use of relevant tools to inspect and understand the working of Android and iOS application
CO3	Learn how to identify vulnerable codebase and insecure configuration of application components
CO4	Learn how to reverse engineer and perform advanced static and dynamic analysis
CO5	Gain proficiency in identifying Android malware

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	2	3	-	-	-	2
CO2	2	3	3	-	-	-	2
CO3	2	3	3	1	-	-	3
CO4	2	3	3	1	-	-	3
CO5	1	2	3	-	-	-	3
CAM	2	3	3	1	-	-	3

Syllabus

History of Smartphones, Smartphone Applications and Development Ecosystem, Android Architecture, Syscalls, IPC mechanism in Android, Android Framework and APIs - APK, App Signing, Java/Dalvik Byte code, Android Run-Time, Reflection, Dynamic Code Loading, Serialization, Android Apps Overview - Java, Kotlin, Flutter and Android Studio, Activities and Intents - Life cycle, State and Architecture (Eg: MVVM), Broadcast Receiver, Content Provider, Services, Room Database and Shared Preference, Android emulator, AVD, ADB, SSL Pinning, Static Analysis - Assets and resources, Android Manifest, Native Code, Reverse engineering – apktool, jadx, Android App Bundles (AAB), Android System Security – Google Services, Android OS and Kernel, Device hardware, Android Malware – Stalkerware, Spyware, Adware. Vulnerabilities and Attack surfaces, Dynamic Analysis – Frida, Proxying Android traffic, Intercepting traffic using burp

Textbooks / References:

1. Joshua J. Drake, Pau Oliva Fora, Zach Lanier, Collin Mulliner, Stephen A. Ridley, Georg Wicherski - "Android™ Hacker's Handbook" 2014
2. Keith Makan - "Android Security Cookbook", ISBN - 978-1782167167, December 2013
3. Dominic Chell, Tyrone Erasmus, Shaun Colley, Ollie Whitehouse - "The Mobile Application Hacker's Handbook", ISBN: 978-1-118-95850-6, February 2015
4. Nikolay Elenkov - "Android Security Internals: An In-Depth Guide to Android's Security Architecture", ISBN - 978-1593275815, 2014

5. Jonathan Levin, “Android Internals - A Confectioner's Cookbook - Power User's View - 1st edition”,

21CSA753A	CYBER FORENSICS	L-T-P-C: 2-0-1-3

ISBN - 978-0991055524, January 2015

6. Mobile Systems and Smartphone Security course (MOBISEC), Fall 2020 at EUROCOM

Course Objectives

Students will learn an introduction to cyber forensics with investigation tools. They will be able to perform evidence collection, preservation, and data recovery. All platforms: Windows, Linux, iOS, Android will be covered. Cyber laws in India and case studies to illuminate.

Course Outcomes

COs	Description
CO1	Exploring Cyber Forensic Investigation, Investigation Tools, Digital Evidence Collection, Evidence Preservation, Data Recovery, Encryption and Decryption methods
CO2	Familiarizing with Hardware Forensics - Disk, SSD, Memory and Mobile Forensics
CO3	Exploring the Host/OS (MS Windows, Linux, Android and iOS) Forensics and related File System Forensics
CO4	Understanding Database Forensics, E-Mail Forensics, Browser Forensics, Dark Web Forensics and Anti-forensics
CO5	Exploring Network, Wireless, Cloud and IoT Forensics

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	3	2	-	2	3
CO2	2	2	3	1	-	2	3
CO3	1	3	3	2	-	2	3
CO4	1	3	3	1	-	2	3
CO5	2	2	3	2	-	1	3
CAM	2	3	3	2	-	2	3

Syllabus

Introduction to Cyber Forensic Investigation, Investigation Tools, Digital Evidence Collection, Evidence Preservation, Data Recovery, Encryption and Decryption methods, Search and Seizure of Computers and devices, Recovering deleted evidences, Password Cracking, Security Standards, Cyber Laws and Legal Frameworks, Cyber laws in India, Case studies and tools.
Hardware/SSD/Device Forensics, File System Forensics, OS Forensics (Windows, Linux, Android and iOS), Memory Forensics, Web/Browser Forensics, Dark Web/Tor Forensics, E-Mail Forensics, Mobile/Wireless Forensics, Network and Communication Forensics, Anti-forensics, Steganography, and Image File Forensics, IOT Forensics, Cloud Forensics, Overwriting/Forging/Wiping/Destruction, Obfuscation, Online Anonymity and Rootkits.
Assessing Threat Levels, Operating System Attacks, Malware Analysis, Financial Frauds, Espionage and Investigations, Investigating copiers, IVR, Video surveillance, RFID and Sim cards.

Textbooks / References:

1. File System Forensic Analysis by Brain Carrier ISBN: 978-0-32-126817-2
2. Incident Response and Computer Forensics, Third Edition by Jason T Luttgens, Mathew Pepe ISBN: 978-0-07-179869-3

3. Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software by Michael Sikorski, Andrew Honig ISBN: 978-1-59327-290-6
4. Android Forensics: Investigation, Analysis and Mobile Security for Google Android by Andrew Hoog, ISBN: 978-1-59749-651-3

21CSA754A BLOCKCHAIN AND DECENTRALIZED APPLICATIONS L-T-P-C: 2-0-1-3

5. iPhone and iOS Forensics: Investigation, Analysis and Mobile Security for Apple iPhone, iPad, and iOS Devices by Andrew Hoog, Katie Strzempka ISBN: 978-1-59749-659-9

Course Objectives

Students will be exposed to blockchains and decentralized applications. They will understand the fundamental algorithms supporting this modern technology and its place in the security setting of the modern technology era.

Course Outcomes

COs	Description
CO1	Exploring the fundamentals of Blockchain, Types & Generations of Blockchains, Enterprise Blockchains, Blockchain Mechanics & Optimizations and Blockchain Consensus Algorithms
CO2	Familiarizing with Blockchain IRL, Network Attacks, Scaling and Future of Blockchains
CO3	Understanding Bitcoin, Altcoins and Forking
CO4	Exploring Ethereum, dApps – Smart Contracts and related Languages & Tools, Forking, Stablecoins, NFTs, DeFi and DAO
CO5	Exploring Attack on Digital assets, Cryptocurrencies for the Masses, Funding Crypto development, How to destroy Cryptocurrencies? Digital Asset applications and Enterprise Real-World applications

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	2	-	-	2	3
CO2	2	3	3	-	-	2	3
CO3	3	3	3	-	-	2	3
CO4	2	3	3	-	-	1	3
CO5	2	3	3	-	-	1	3
CAM	2	3	3	-	-	2	3

Syllabus

Blockchain History. What is a Blockchain? Do you need a Blockchain? Permission-less vs Permissioned Blockchains, Public vs Private vs Hybrid vs Consortium Blockchains, Enterprise Blockchains (Hyperledger, R3 Corda), Generation of Blockchains – Bitcoin (First), Ethereum (Second with dApps), Cosmos (Third as IOB – Internet of Blockchains)
Introduction to Cryptography, Public Key Cryptography, Cryptographic primitives – Cryptographic hash functions and Digital signatures, Elliptic Curve Digital Signature Algorithm (ECDSA)
Blockchain Mechanics and Optimizations – Structure, Architecture, GHOST Protocol, Mining Process, Blockchain Demos
Blockchain Consensus Algorithms – Proof-of-Work (POW), Proof-of-Stake (POS), Delegated POS (DPOS), Byzantine Fault Tolerance (BFT), Practical BFT (PBFT), Ripple Protocol Consensus Algorithm (RPCA) and Unique Node Lists (UNL). BlockDAG & Blockless DAG Protocols
Blockchain IRL – Public & Private Keys, Hot and Cold Storages, Wallets, Lite Clients & Full nodes, Miners, Block & Transaction Incentives, Mining Infrastructure, Mining Pools & Organizations
Languages & Tools – Ethereum Smart Contracts using Solidity language with Tools (ethPM / npm, Node.js,

EVM, Truffle, Remix IDE, Ganache, MetaMask, web3.js, etc. …) and Hyperledger Fabric Chaincodes in GO language
Anonymity, Attacks on Blockchain Networks & Wallets, Scaling of Blockchains, Future of Blockchains

Decentralized Applications:
Cryptocurrencies (Internet of Money) – History, Bitcoin, Ethers & Gas (Ethereum) and Atom (Cosmos), Introduction to Altcoins & Stablecoins, DOT (Polkadot), Ripple, Stellar & IOTA, Forking of Cryptocurrencies, Attacks on Digital Assets, Cryptocurrencies for the Masses, Funding Crypto development (Crowd Funding, ICO & STO), How to destroy Cryptocurrencies?
Token Specifications, Non-Fungible Tokens (NFTs – Internet of Assets), Decentralized Finance (DeFi) and Decentralized Autonomous Organizations (DAO)
Digital Asset applications (Cryptokitties …) and Enterprise Real-World applications

Textbooks / References:

1. Blockchain Technology by Chandramouli Subramanian, Asha A George, Abhilash K A and Meena Karthikeyan
2. Blockchain Applications – A Hands-on Approach by Arshdeep Bahga and Vijay Madisetti
3. Bitcoin and Cryptocurrency Technologies by Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller and Steven Goldfeder
4. Mastering Bitcoin by Andreas Antonopoulos
5. Mastering Ethereum, Building Smart Contracts and dApps by Andreas Antonopoulos and Dr. Gavin Wood

21CSA755A	VAPT (VULNERABILITY AND PENETRATION TESTING)	L-T-P-C: 2-0-1-3

Course Objectives

The student will be confident to perform vulnerability and penetration testing for any organization of product team, generate a report and communicate remediation steps.

Course Outcomes

COs	Description
CO1	Ability to perform vulnerability assessment independently
CO2	Ability to perform penetration testing against a target and generate a report
CO3	Ability to find CVEs in open source CMS
CO4	Ability to perform bug bounties
CO5	Understand the difference between private vs public research

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	2	3	1	-	-	2
CO2	2	3	3	3	-	-	3
CO3	2	3	3	3	-	-	3
CO4	1	3	3	3	-	-	3
CO5	1	2	2	2	-	-	2
CAM	1	3	3	3	-	-	3

Syllabus

Unit I: Active information gathering , General vulnerability scanners, Port-based, Service-based, Banner grabbing, Web application scanners, General application flaw scanners, Directory listing/Brute forcing, Web server version/Vulnerability identification, Technology stacks and packages version detection, Network vulnerability scanners/Specific protocols, VPN, Manual direct connections

Unit II: Passive information gathering, Metadata analysis, Traffic monitoring, ARP/MAC cache overflow , Etherleak, Misconfigured clusters or load balancers
Public Research:, Vulnerability databases, Vendor advisories, Exploit databases and framework modules, Common/default passwords, Hardening guides/common misconfigurations, Private Research, Fuzzing

Unit III: WiFi password hacking, aircrack-ng, DNS Cache poisoning/Spoofing, Recon tools : NS enumeration tools, Nmap, Netcat, Tcpdump, Wireshark, Directory enumeration tools, Google hacking, Shodan

Unit IV: SQL injection Case study: SQLi , File upload vulnerabilities, Case study: SSRF , Reverse shell, Password brute-forcing using shadow file, Hashcat, John the ripper, Hydra, Medusa, Ncrack, Cross site scripting , XSS, Client-side request forgery, IDOR, Metasploit

Unit V:XML attacks , Case study: XXE, Vulnerability Exploitation and Generating PoC, Vulnerability assessment, Pen Test Report Generation

Textbooks / References:

1. OWASP Web Security Testing Guide V4
2. Bugcrowd, “The Ultimate Guide to Penetration Testing”, 2020 edition

3. HackerOne, "Web hacking 101"

Course Objectives

Students will learn introduction to threats, vulnerabilities and breaches in databases. They will be made familiar with the OWASP10 vulnerabilities and common hardening techniques. This is a database first course that focuses on securing them.

Course Outcomes

COs	Description
CO1	Understand database security concepts
CO2	Learn DB access control mechanisms
CO3	Understand web applications security concepts
CO4	Learn OWASP Top 10 Vulnerabilities
CO5	Learn application security and penetration testing

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	2	3	3	2	-	-	3
CO2	1	3	3	2	-	-	3
CO3	1	3	3	1	-	-	3
CO4	1	3	3	1	-	-	3
CO5	2	3	3	2	-	-	3
CAM	1	3	3	2	-	-	3

Syllabus

Unit I

Database security – Introduction includes threats, vulnerabilities and breaches, Basics of secure database design, DB security – concepts, approaches and challenges, types of access controls, Oracle VPD, Discretionary and Mandatory access control – Principles, applications and poly-instantiation, Database inference problem, types of inference attacks, distributed database, security levels. Role-based access control (RBAC). Application workflow and DB security;

Unit II

SQL-injection: types and advanced concepts. Security in relational data model, concurrency controls and locking, SQL extensions to security (oracle as an example), System R concepts, Context and control based access control, Hippocratic databases, Database intrusion, Secure data outsourcing; NIST considerations for secure DB design

Unit III

Web application security, Basic principles and concepts, Authentication, Authorization, Browser security principles; XSS and CSRF, same origin policies, File security principles, Secure development and deployment methodologies, Web DB principles, OWASP – Top 10 - Detailed treatment, IoT security – OWASP Top 10 – Detailed treatment, OWASP -WEB, SAST, DAST, RASP

Unit IV

Application security – Concepts, Architecture, CIA Triad, Hexad, types of cyberattacks, Introduction to software development vulnerabilities, code analyzers – Static and dynamic analyzers, Static application security testing

(SAST), Dynamic application security testing (DAST), Runtime Application Self-Protection (RASP) security, Architectural reviews

Unit V

Security testing / Penetration testing – Principles and concepts, PT workflows and examples, blind tests, SDLC phases and security mandates.

Unit VI

Cloud application security – concepts and architecture (AWS example); security consideration for cloud migrations. RDW Security and compliance.

Textbooks / References:

1. Michael Gertz and Sushil Jajodia, "*Handbook of Database Security— Applications and Trends*", Springer, 2008.
2. Bhavani Thuraisingham, "*Database and Applications Security*", Integrating Information Security and Data Management, Auerbach Publications, 2005.
3. Alfred Basta, Melissa Zgola, "*Database Security*", Course Technology, 2012.
4. Database and Application Security XV (IFIP International Federation For Information Processing) by Martin S. Olivier, 2001
5. Web application security – Exploitation and countermeasures for modern web applications, OReilly

21CSA757A	SYSTEM SECURITY	L-T-P-C: 2-0-1-3

Course Objectives

Students will learn the fundamentals of securing a computer system. They will understand and implement defenses against all common system attacks.

Course Outcomes

COs	Description
CO1	Describe security goals and principles which is used in designing a secure system
CO2	Demonstrate the exploitation of Access control vulnerabilities and develop its mitigation
CO3	Explain the basics of system organization, assembly language and Linux system calls.
CO4	Demonstrate buffer overflow attack, Format string attack and Return to libc attack withexamples
CO5	Understand the preventive mechanisms for different exploits

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	1	2	2	-	-	2	3
CO2	1	2	3	-	-	2	3
CO3	2	2	3	-	-	2	3
CO4	3	2	3	-	-	1	3
CO5	2	2	2	-	-	1	3
CAM	2	2	3	-	-	2	3

Syllabus

Security Goals, Secure Design Principles, Authentication, Linux Password scheme, Password Security, Authorization - Access control, MAC, DAC, ACL, Capabilities, Information flowcontrol, Privilege Escalation Attacks, constraining and sandboxing users and applications. Assembly Primer, Shell coding, ELF File Format. Memory Exploits – Buffer Overflow, Off byone overflow, Format String Attacks, Integer Overflow, Return to Libc, Heap Overflow, Exploitprevention mechanisms: stack canaries, Data Execution Prevention, Address Space LayoutRandomization, bypassing DEP & ASLR. Trusted Execution Environment - Case Study on IntelSGX. Fuzzing - Types of fuzzers, Bug detection, Case study - AFL fuzzer. Vulnerability and exploit analysis: spectre, meltdown, foreshadow, dirty COW.

Textbooks / References:

1. Neil Daswani, Christopher Kern, Anita Kesavan, “Foundations of Security, What Every Programmer Needs to Know”, Apress, 2007
2. Jon Ericson, “Hacking: The Art of Exploitation”, Second Edition, No Starch Press, 2008
3. Gary McGraw, John Viega, “Building Secure Software”, Addison-Wesley Professional, 2001.
4. Michael Sutton, Adam Greene, Pedram Amini, “Fuzzing Brute Force Vulnerability Discovery”

MATHEMATICS ELECTIVES

21MAT522A	COMPUTATIONAL LINEAR ALGEBRA	L-T-P-C: 2-1-0-3

Course Objectives

- Introduce students to the basics of linear algebra, and calculus concepts
- To enable the student to build mathematical background to perform data analysis tasks.
- To apply mathematical concepts in AI and data science applications.

Course Outcomes

COs	Description
CO1	Use computational techniques and algebraic skills essential for the study of systems of linear equations, matrix algebra, vector spaces, eigenvalues and Eigenvectors, orthogonalityand diagonalization.
CO2	Illustrate the basic concepts and techniques of linear algebra and calculus.
CO3	Integrate the application of these disciplines within the scientific field.
CO4	Should be able to wisely choose tools and techniques in Linear algebra for building and evaluating solutions to real life problems.

CO-PO Mapping

PO/PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	-	-	-	-	2
CO2	3	3	-	-	-	-	2
CO3	3	3	2	-	-	-	2
CO4	3	3	2	-	-	-	2
CAM	3	3	2	-	-	-	2

Syllabus

Unit I: Vector Spaces: Vector spaces, subspaces, linear independence, basis, dimension, inner products, orthogonality, orthogonal basis, Gram Schmidt Process, projection on subspace, least-square principle, QR decomposition.

Unit II: Eigen values and Eigen vectors, diagonalization and orthogonal diagonalization, iterative methods for the solution of linear systems, power method for Eigen values, and Eigen vectors.

Unit III: Numerical sets, functions, limits, derivatives: differentiability, chain rule, Mean Value Theorem, convexity, single variate functions extrema, and first derivative, extrema and second derivative, multivariate functions, partial derivatives, differentiability of a multivariate function

Textbooks/References:

1. Elementary Linear Algebra, Howard Anton and Chris Rorres, 11thEdition, Wiley, 2015.
2. Linear algebra: A modern introduction, D Poo, Cengage Learning, 4thEdition 2015.
3. Calculus, Monty J. Strauss, Gerald J. Bradley and Karl J. Smith, 3rdEdition, 2002.
4. Thomas Calculus, Pearson, 14thEdition, 2018

21MAT523A	PROBABILITY AND STATISTICS	L-T-P-C: 2-1-0-3

Course Objectives

- Introduce students to the basics of probability
- To enable the student to build statistical distribution-based models to perform data analysis tasks.
- To apply statistical concepts in data science problems

Course Outcomes

COs	Description
CO1	Understand the importance of probability distribution and statistical testing in data modeling and data analytics.
CO2	Illustrate the basic concepts and techniques of probability and statistical testing.
CO3	Apply the concepts of probability theory for building datasets for computational experiments in data science
CO4	Should be able to wisely choose tools and techniques in probability and statistics for building and evaluating solutions to real life problems

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	-	-	-	-	2
CO2	3	3	-	-	-	-	2
CO3	3	3	2	-	-	-	2
CO4	3	3	2	-	-	-	2
CAM	3	3	2	-	-	-	2

Syllabus

Unit I: Probability: Review of probability concepts, conditional probability and independence, Bayes' Theorem, Random Variables and Probability Distributions- mean and variance of a distribution, discrete and continuous distributions, Binomial, Poisson, Geometric, Uniform, Exponential, Normal distribution functions, Two-dimensional Random Variables, and distribution functions - conditional mean, variance, and covariance.

Unit II: Statistics: Linear correlation, correlation coefficient, properties of a correlation coefficient, sampling distributions, Chi-square, t and F distributions, Central Limit Theorem, theory of estimation-point estimation, unbiased estimator, maximum likelihood estimator - interval estimation.

Unit III: Testing of Hypothesis: Critical region, level of significance, errors in the testing of hypothesis, one-tailed and two-tailed tests, procedure for testing hypothesis, a test of significance of large and small samples, Student's t-distribution, Chi-Square Test for Goodness of fit and independence, F-test test for ratio of variances

Textbooks / References:

1. Douglas C. Montgomery and George C.Runger, Applied Statistics and Probability for Engineers, (2005) John Wiley and Sons Inc
2. Sheldon M Ross, Introduction to Probability and Statistical Inference, 6th Edition, Pearson.
3. Ravichandran J, Probability and Statistics for Engineers, (2010) First edition, Wiley India

21MAT524A	MATHEMATICAL FOUNDATIONS FOR CRYPTOGRAPHY	L-T-P-C: 2-1-0-3

Course Objectives

Students will be familiarized with the mathematics of cryptography. They will understand the fundamental algorithms behind all modern cryptographic primitives.

Course Outcomes

COs	Description
CO1	Understand Symmetric cryptography and the differences between symmetric and asymmetric cryptography.
CO2	Analyze, understand and evaluate the basic mathematical concepts used in cryptography
CO3	Learn and implement various Symmetric cryptographic algorithms.
CO4	Learn and implement various Asymmetric cryptographic algorithms.
CO5	Start to understand the use of protocols in cryptography such as Hash functions, digital signatures, and MACs.

CO-PO Mapping

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	1	-	-	-	3
CO2	3	2	1	-	-	-	3
CO3	3	2	1	-	-	-	2
CO4	3	2	1	-	-	-	2
CO5	3	2	1	-	-	-	3
CAM	3	2	1	-	-	-	3

Syllabus

Unit I: Introduction to Cryptography covering: Overview of cryptography, Symmetric Cryptography, Cryptanalysis logic and some basic attacks, Kercheoff's Principle and cover the discussion topic: Discussion: How many Key bits are enough

Unit II: The mathematics used in cryptography: Why mathematics is important, Set Theory, Integer Theory, Rings, Division, Congruence, Euclidean algorithm, extended Euclidean algorithm.

Unit III: Begin with symmetric cryptography and looked at Cease cipher, affine cipher and their corresponding attacks. Moving onto Stream ciphers, LFSR, RNGS, Trivium, DES, DES Weaknesses, AES, Finite Fields, Galois Fields, AES AND DES in software and hardware implementation. Modes of operation

Unit IV: Public Key Cryptography: Advantages and Disadvantages, different types of PKC:
RSA: Algorithm, drawbacks, Finding Large Primes, RSA Padding Diffie Hellman Algorithm, Groups, Order of Groups, Discrete Logarithm Problem, Generalised discrete logarithm Problem, Attacks on DLP El Gamal Protocol, Computational Aspects, Passive Attacks, Active Attacks

Unit V: Hash Functions:Properties of Hash Functions and security MD4 Family, SHA-1, SHA-2, SHA-3, Merkle Damgard Construction, Birthday Paradox

Unit VI: Digital Signatures and Message Authentication Codes, Digital Signature security services, RSA Digital Signature, DSA, Elgamal Digital Signature, Attacks on Digital Signatures, Message Authentication Codes MAC services, Prefix Mac, Suffix Mac

Unit VII: Key Establishment Protocols:
Man-in-the-middle attack, Kerberos, Certificates, Public Key Infrastructure, CA, Trusted third party

Textbooks / References:

1. Understanding Cryptography: A Textbook for Students and PractitionersTextbook by Christof Paar and Jan Pelzl
2. Handbook of Applied Cryptography1996 EditionPaul C. van Oorschot, Scott A. Vanstone A. J. Menezes
3. History of Cryptography and Cryptanalysis 2019 John F Dooley
4. Everyday Cryptography
5. Fundamental Principles and ApplicationsKeith M. Martin
6. Cryptography made simple by Nigel Smart