Shri Guru Gobind Singhji Institute of Engineering and Technology, Vishnupuri, Nanded

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

Curriculum Structure of B. Tech.

(With effective from 2021-2022)

Semester I						
Course Code	**Name of the course**	**L**	**T**	**P**	**Credits**	
					Th	**Pr**
PCC-CS401	Advanced Database Management Systems	03	--	02	03	01
PCC-CS402	TCP / IP Networking	03	--	02	03	01
PCC-CS403	Cryptography and Network Security	03	--	02	03	01
PCC-CS404	Distributed Computing	03	--	02	03	01
PEC-CS4**	Elective-III	03	--	02	03	01
PEC-CS4**	Elective-IV	03	--	02	03	01
	Total	**18**	**--**	**12**	**24**	
Semester II						
Course Code	**Name of the course**	**L**	**T**	**P**	**Credits**	
					Th	**Pr**
PRJ-CS421	Project	--	--	32	--	16
	Total	**--**	**--**	**32**	**16**	

L – No. of Lecture Hours/week, T – No. of Tutorial Hours/week, P – No. of Practical Hours/week

B.Tech.(CSE)	Contact Hours	Credits
TOTAL	62	40

Elective-III		Elective-IV	
PEC-CS405	Artificial Intelligence	PEC-CS413	Multimedia Systems
PEC-CS406	Computer Graphics	PEC-CS414	Mobile Computing
PEC-CS407	Human Computer Interaction	PEC-CS415	Big Data Analytics
PEC-CS408	Data Mining	PEC-CS416	Computer Vision
PEC-CS409	Cloud Computing	PEC-CS417	Real Time Systems
PEC-CS410	Information Security	PEC-CS418	High Performance Computing
PEC-CS411	Digital Image Processing	PEC-CS419	Embedded Systems
PEC-CS412	Deep Learning	PEC-CS420	Bandit Algorithm (Online Machine Learning)
PEC-CS405	Artificial Intelligence	PEC-CS413	Multimedia Systems

\PCC-CS401	Advanced Database Management Systems	3L:0T:2P	4 credits

COURSE OBJECTIVES:

- To understand the basic concepts and terminology related to DDBS and Parallel Database Design
- To the design and implement Distributed Databases.
- To understand advanced DBMS techniques to construct tables and write effective queries, forms, and reports.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Understanding the concepts of database techniques.
2. **CO2:** Learn the concepts of transaction processing, concurrency control and crash recovery.
3. **CO3:** Apply query processing in distributed databases.
4. **CO4:** Analyze long durations in advanced transaction processing.
5. **CO5:** Design and implement XML Applications.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	2	2	2	3	1	1	3	3	2	3
CO2	2	2	3	2	1	2	2	2	2	1	1	2	1	3	3
CO3	2	2	2	3	3		1	1	2	1	1	2	2	2	2
CO4	2	3		3	1		1	3	2	1	1	2	1	2	3
CO5	2	3	3	2	3	2	1	2	2	1	1	2	3	3	3

Distributed Databases: Introduction, promises of DDBSs, complicating factors, problem areas of DDBSs, architectural models for distributed DBMS, distributed DBMS architecture, distributed database design: alternative design strategies, distribution design issues.

Distributed Query Processing: Query processing problem, objectives of query processing, complexity of relational algebra operation, characterization of query processors, layers of query processing. Distributed transactions, commit protocols, concurrency control in distributed databases, failures, and fault tolerance in distributed databases.

Parallel Databases: Database servers, parallel architectures, parallel DBMS techniques, parallel execution problems, parallel execution for hierarchical architecture.

Application Development and Administration: Web interfaces to databases, performance tuning, performance benchmarks, standardization, e-commerce, and legacy systems

Advanced querying and information retrieval: Decision support systems, Information integration modes of information, wrappers in mediator-based systems, data analysis and OLAP, data mining, data warehousing, and information retrieval systems, and applications.

Advanced data types and new applications: Motivation, time in databases, spatial and geo- graphic data, multimedia databases, mobility, and personal databases.

Advanced transaction processing: Transaction processing monitors, transactional workflows, main memory databases, real time transaction systems, long duration transactions, transaction management in multidatabases.

Multidimensional indexes: Application needing multiple dimensions, hash like structures for multidimensional data, tree like structures for multidimensional data, bitmap indexes.

Xml: Background, structure of xml data, xml document schema, querying and trans-formation, API, storage of xml data, xml applications.

References:

1. Naveen Prakash, "Introduction to database management", TMH
2. Rob and Coronel, "Database Systems", Fifth Edition, Thomson
3. Molino, Ullman and Widom, "Database System Implementation", Pearson Education Asia
4. Ozsu and Valduriez, "Principles of Distributed Database Systems", Pearson Education Asia
5. Database management, Objectives, system functions and administration, Gordon Everest
6. Ramkrishnan and Gehrke, "Database Management Systems", MGH International Edition
7. Silberchatz, Korth and Sudarshan, "Database systems concepts", MGH, 4th edition

PCC-CS402	TCP/IP Networking	3L:0T:2P	4 credits

COURSE OBJECTIVES:

As a result of successfully completing this course, students will:

1. Become familiar with layered communication architecture with TCP/IP.
2. Understand the client/server model and key application layer protocols.
3. Understand the concepts of reliable data transfer and how TCP implements this.
4. Know the principles of congestion control and trade-offs in fairness and efficiency.
5. Learn the principles of routing and the semantics and syntax of IP.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Understanding the TCP/IP protocol suite.
2. **CO2:** Apply various routing protocols in data communication to select optimal path.
3. **CO3:** Learn IPv6 addressing.
4. **CO4:** Analyze TCP or UDP segments.
5. **CO5:** Implement and configure DNS, DHCP Server, FTP Server, SSH and Telnet.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	2	3					2		3	3	3	3
CO2	2	3	2	3	3			2	1	1	1	2	2	3	3
CO3	2	1	1	2	3					2		3	3	3	3
CO4	2	3	1	3	3			3	2	2	2	3	2	3	3
CO5	2	2	3	3	3			3	2	2	2	3	3	3	3

Introduction and Underlying Technologies: Introduction, The OSI Model and The TCP/IP Protocol Suite, Underlying Technologies.

Network Layer: Introduction to Network Layer, Ipv4 Addresses, Delivery and Forwarding of IP Packets, Internet Protocol Version 4 (Ipv4), Address Resolution Protocol (ARP), Internet Control Message Protocol Version 4 (ICMPV4), Unicast Routing Protocols (RIP, OSPF, and BGP), Multicasting and Multicast Routing Protocols.

Transport Layer: Introduction to the Transport Layer, User Datagram Protocol (Udp), Transmission Control Protocol (TCP), And Stream Control Transmission Protocol (SCTP).

Application Layer: Introduction to the Application Layer, Host Configuration: DHCP, Domain Name System (DNS), Remote Login: Telnet and SSH, File Transfer: FTP And TFTP, World Wide Web And HTTP, Electronic Mail: SMTP, POP, IMAP, and MIME, Network Management: SNMP, Multimedia.

IPv6 Addressing

References:

1. Internetworking with TCP/IP (5th Edition), Douglas E. Comer
2. TCP/IP Protocol Suite, 4/e, Forouzan
3. Computer Networks, 4/e, Andrew S. Tanenbaum

PCC-CS403	Cryptography and Network Security	3L:0T:2P	4 credits

COURSE OBJECTIVES:

As a result of successfully completing this course, students will:

- Understand Cryptography Theories, Algorithms and Systems.
- Understand necessary Approaches and Techniques to build protection mechanisms to secure computer networks.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Understand the number theory concepts.
2. **CO2:** Impart knowledge on symmetric and asymmetric encryption techniques.
3. **CO3:** Create Authentication functions as Message Authentication Codes and Hash Functions.
4. **CO4:** Examine the issues and structure of Authentication Service and Electronic Mail, web and IP security.
5. **CO5:** Provide familiarity in system security.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2		1	2	2				1	2		3	3	3	1
CO2	3	2	2	2	3				1	1	1	3	3	3	3
CO3	3	3	3	3	3			3	2	1	2	2	3	3	3
CO4	2	3	2	3	2			3	2	1	2	2	2	3	3
CO5	2	2	1	2	3			2	2	1	1	2	1	3	3

Introduction to cryptography: What is Cryptography, Encryption Schemes, Functions, Secret Key Cryptography, Public Key Cryptography, Hash Algorithms.

Mathematical Background for Cryptography: Modulo arithmetic, Euclid's algorithm, algebraic structures- groups, rings, fields-Polynomial fields, prime numbers, Fermat's theorem, Euler's totient function, Euler's theorem, testing for primality- Probabilistic Considerations, Chinese reminder theorem, Discrete Logarithms – the powers of an integer, Modulo n, Indices, calculation of Discrete Logarithms.

Conventional Encryption: Classical techniques, Modern Techniques, Algorithms, Confidentiality using conventional encryption.

Public Key encryption and Hash Function: Public Key Cryptography, Message authentication and hash function, Digital Signatures and authentication protocols.

System Security: Kerberos, Web security SSL, TSL, Firewalls.

References:

1. Bernard Menezes, "Network Security and Cryptography", Cengage Learning.
2. William Stalling, "Cryptography and Network and Network Security-Principals and practices", Pearson Education.
3. King, Dalton, and Osmanoglu, "Security Architecture", TMH edition Kaufman, Perlman, and Spenciner, "Network Security", PHI

PCC-CS404	Distributed Computing	3L:0T:2P	4 credits

COURSE OBJECTIVES:

- To expose students to both the abstraction and details of file systems.
- To provide students with contemporary knowledge in distributed computing.
- To focus on performance and flexibility issues related to systems design decisions.
- Introduce a variety of methodologies and approaches for reasoning about concurrent and distributed programs.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Understand distributed system and Computing.
2. **CO2:** Create distributed file systems.
3. **CO3:** Learn Naming, Synchronization, Consistency and Replication in distributed computing.
4. **CO4:** Analyze distributed application with various communication mechanisms.
5. **CO5:** Design Distributed applications for handling large data on clusters.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2		1	2	2				1	2		3	3	3	1
CO2	2	2	3	1	2			2	2	1	2	3	3	3	3
CO3	3	2	3	1	2				1	1	1	2	1	2	2
CO4	2	3	1	3	2				2	1	1	2	1	3	3
CO5	3	2	3	2	3		1	2	3	1	2	3	3	3	3

Introduction to Distributed Computing: Definition of a distributed system, goals, architecture.

Processes: Threads, virtualization, clients, servers, code migration Case study: Mobile Agents.

Communication: Remote procedure call, message-oriented communication, stream-oriented communication, Case, Study: RMI, MPI.

Naming: flat naming, structured naming, attribute-based naming Case study: LDAP.

Synchronization: clock synchronization, mutual exclusion, election algorithms.

Consistency and replication: Data-centric consistency models, client-centric consistency models, consistency protocols.

Distributed object-based systems: Distributed Objects, Object Servers, Binding a Client to an Object, Java RMI, Common Object Request, Broker Architecture (CORBA) Case Studies: Enterprise Java Beans.

Distributed file systems: architecture, NFS, synchronization, consistency and replication, Case Studies: Hadoop Distributed File System (HDFS).

Distributed web-based systems: Web-Based Systems, Web Services, Web Server /Client, Web Server Clusters, Web Proxy Caching, Case Study: Apache Web Server, Squid.

Programming Models for Distributed Systems: MapReduce: Simplified data processing on large clusters.

References:

1. Distributed Systems. Principles and Paradigms. (2nd Ed.) Prentice Hall, 2007. Andrew S. Tanenbaum, Vrije University, Amsterdam, The Netherlands, Maarten Van Steen
2. Distributed System Concepts and Design (5th Ed.), George Coulouris, Jean Dollimore, Tim Kindberg, Gordon Blair,
3. Hadoop, The Definitive Guide, Oreilly, 2010. Tom White

CS4 : Elective – III (CR-4, L-3,T-0,P-2)**

PEC-CS405	Artificial Intelligence	3L:0T:2P	4 credits

COURSE OBJECTIVES:

The primary objective of this course is to introduce the basic principles, techniques, and applications of Artificial Intelligence.

- Gain a historical perspective of AI and its foundations.
- Become familiar with basic principles of AI toward problem solving, inference, perception, knowledge representation, and learning.
- Investigate applications of AI techniques in intelligent agents, expert systems.
- Experience AI development tools such as an 'AI language', expert system shell, and/or data mining tool.
- Explore the current scope, potential, limitations, and implications of intelligent systems.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Demonstrate fundamental understanding of the history of artificial intelligence (AI) and its foundations.
2. **CO2:** Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation, and learning.
3. **CO3:** Demonstrate awareness and a fundamental understanding of various applications of AI techniques in intelligent agents, expert systems
4. **CO4:** Develop applications in an 'AI language' and expert system shell.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	1	2	1		1	2			2	3	3	2
CO2	2	3	3	3	3	2		1	2			3	3	3	3
CO3	2	2	2	2	2	1		2	2			2	3	3	3
CO4	2	3	3	2	3	1		1	2			3	3	3	3

Introduction: General, Developments in Artificial Intelligence, Developments in Expert Systems, Role of AI and Expert Systems in Engineering.

Search Techniques: Problem Definition and Solution Process, Production Systems, Search Techniques, Problem Decomposition and AND-OR Graphs.

Knowledge-Based Expert System: What is KBES? Architecture of KBES.

Engineering Design Synthesis: Synthesis, Decomposition Model for Synthesis, Role of Synthesizer in KBES Environment, An Architecture for a Synthesizer a Generic Tool Generic Synthesis Tool-GENSYNT

Criticism and Evaluation: Methodologies Used in Knowledge Based Environment, a Framework for Critiquing and Evaluation, Generic Critiquing Tool GENCRIT.

Case-Based Reasoning: Applications of Case-Based Reasoning, Case Based Reasoning Process, A Framework for CBR in Engineering Design (CASETOOL), Architecture of CASETOOL Application Example.

Process Models and Knowledge-Based System: Expert Systems for Diagnosis, Blackboard Model of Problem Solving, ODESSY an Integrated System for Preliminary Design of Reinforced Concrete Multistory Office Buildings, Conceptual Design of a Car Body Shape, SETHU-An Integrated KBES for Concrete Road Bridge Design.

References:

1. C.S. Krishnamoorthy, S. Rajeev: Artificial Intelligence and Expert Systems for Engineers
2. Stuart E. Savory, Artificial Intelligence & Expert Systems, Ellis Horwood Ltd

PEC-CS406	Computer Graphics	3L:0T:2P	4 credits

COURSE OBJECTIVES:

The main objective of this course is to introduce to the students the concepts of computer graphics.

- To introduce the use of the components of a graphics system and become familiar with building approach of graphics system components and algorithms related with them.
- To learn the basic principles of 3- dimensional computer graphics.
- Provide an understanding of how to scan convert the basic geometrical primitives, how to transform the shapes to fit them as per the picture definition.
- Provide an understanding of mapping from a world coordinates to device coordinates, clipping, and projections.
- To be able to discuss the application of computer graphics concepts in the development of computer games, information visualization, and business applications.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Understand the basics of computer graphics, different graphics systems and applications of computer graphics.
2. **CO2:** Learn various algorithms for scan conversion and filling of basic objects.
3. **CO3:** Use geometric transformations on graphics objects and apply in composite form.
4. **CO4:** Extract scene with different clipping methods and transform to graphics display device.
5. **CO5:** Use illumination models to Render projected objects to naturalize the scene in 2D view.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	1	1	2				2			2	2	2	2
CO2	2	3	3	2	2				2			2	3	2	2
CO3	2	3	2	2	2				2			2	3	3	3
CO4	2	3	3	3	2				2			2	3	3	3
CO5	2	2	3	2	2				2			2	2	2	3

Introduction to Computer Graphics: Overview of Computer Graphics, Graphics Displays, Output Devices and Physical Interactive Devices, Graphical User Interfaces, Graphics Image File Formats.

Raster Scan Graphics: Line Drawing Algorithms, DDA, Bresenham's Algorithm, Circle Generations, Scan Conversion Generation of Displays, Image Compression, Displaying Lines, Characters and Polygons, Polygon Filling Algorithms, Fundamentals of Antialiasing, Halftoning.

Geometrical Transformations: 2-D Transformations, Linear Transformations, other transformations, combined Transformation, Coordinate Systems, 3-D Transformations, Rotation, Scaling and Translation, Reflection about any Arbitrary Axis.

Windowing and Clipping: Viewing Transformations, Parallel Projections, Perspective Projection, Perspective Transform, Two-Dimensional Clipping, Simple Visibility Algorithm, Polygon Clipping, 3-Dimensional Clipping.

Hidden surface elimination: Floating Horizon, Back Face Removal Algorithms, Z-Buffer Algorithm, Painter's Algorithm, Warnock Algorithm, BSP Tree Methods.

Rendering: Introduction, Illumination Models, Transparency, Shadows, Phongs and Gouraud Shading.

Curve Design: Properties of curves, Bezier and B-Splines.

References:

1. David f. Rogers, “Procedural elements of computer graphics”, TMH.
2. Foley, Van dam, Feiner Hughes, “Computer graphics principles and practice”, Addison Wesley Indian Edition.
3. Newman Sproull, “Principles of Interactive computer graphics”, McGraw Hill Company.

PEC-CS407	Human Computer Interaction	3L:0T:2P	4 credits

COURSE OBJECTIVES:

For end-users, the interface is the system. So, design in this domain must be interaction-focused and human-centered. Students need a different repertoire of techniques to address this objective. Thus, the main objectives of the course are:

- Provide an overview of the concepts relating to the design of human-computer interfaces in ways making computer-based systems comprehensive, friendly, and usable.
- Understand the theoretical dimensions of human factors involved in the acceptance of computer interfaces.
- Understand the important aspects of implementation of human-computer interfaces.
- Identify the various tools and techniques for interface analysis, design, and evaluation.
- Identify the impact of usable interfaces in the acceptance and performance utilization of information systems.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Understand the Computer and Human-Computer Interaction (HCI).
2. **CO2:** Understand core cognitive aspects of interaction design.
3. **CO3:** Be aware of different styles of interaction with a software system.
4. **CO4:** Define usability attributes.
5. **CO5:** Evaluate an interactive product using suitable techniques.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1			2					2			2	2	3	2
CO2	2	2	2	2					2			2	3	3	3
CO3	2	2	2	2					2			2	2	3	2
CO4	2	2	2	2					2			2	1	2	2
CO5	3	3	2	2					2			2	2	2	2

The Scope and Challenges of HCI and Interaction Design.

Visual Representation. Segmentation and Variables of The Display Plane. Modes of Correspondence.

Text and Gesture Interaction. Evolution of Interaction Hardware. Measurement and Assessment of Novel Methods.

Inference Based Approaches. Bayesian Strategies for Data Entry, and Programming by Example.

Augmented Reality and Tangible User Interfaces. Machine Vision, Fiducial Markers, Paper Interfaces, Mixed Reality

Usability of Programming Languages. End User Programming, Programming for Children, Cognitive Dimensions of Notations.

User Centered Design Research. Contextual Observation, Prototyping, Think-Aloud Protocols, Qualitative Data in The Design Cycle.

Usability Evaluation Methods. Formative and Summative Methods. Empirical Measures. Evaluation of Part II Projects.

References:

1. Sharp, H., Rogers, Y. & Preece, J. (2007), Interaction design: beyond human-computer interaction, Wiley (2nd ed.).
2. Carroll, J.M. (ed.) (2003). HCI models, theories and frameworks: toward a multi-disciplinary science. Morgan Kaufmann.
3. Cairns, P. & Cox, A. (eds.) (2008). Research methods for human-computer interaction. Cambridge University Press.

PEC-CS408	Data Mining	3L:0T:2P	4 credits

COURSE OBJECTIVES:

Students will try to learn:

- To introduce the concept of data Mining as an important tool for enterprise data management and as a cutting-edge technology for building competitive advantage.
- To enable students to effectively identify sources of data and process it for data mining
- To make students well versed in all data mining algorithms, methods of evaluation.
- To impart knowledge of tools used for data mining
- To provide knowledge on how to gather and analyze large sets of data to gain useful business understanding.
- To impart skills that can enable students to approach business problems analytically by identifying opportunities to derive business value from data.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Demonstrate an understanding of the importance of data mining and the principles of business intelligence.
2. **CO2:** Organize and Prepare the data needed for data mining using pre preprocessing techniques.
3. **CO3:** Perform exploratory analysis of the data to be used for mining.
4. **CO4:** Implement the appropriate data mining methods like classification, clustering, or Frequent Pattern mining on large data sets.
5. **CO5:** Define and apply metrics to measure the performance of various data mining algorithms.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1	1					2			2		3	2
CO2	3	2	3	3	3				2			3	2	3	3
CO3	2	2	3	3	3				2			3	3	3	3
CO4	2	2	3	3	3				2			3	3	3	3
CO5	2	3		3	3				2			2	2		

Introduction to Data Mining: What is data mining?, Related technologies - Machine Learning, DBMS, OLAP, Statistics, Data Mining Goals, Stages of the Data Mining Process, Data Mining Techniques, Knowledge Representation Methods, Applications , Example: weather data.

Data Warehouse and OLAP: Data Warehouse and OLAP Technology for Data Mining: Data Warehouse, Multidimensional Data Model, Data Warehouse Architecture, Data Warehouse Implementation, Further Development of Data Cube Technology, From Data Warehousing to Data

Mining Data Cube Computation and Data Generalization: Efficient Methods for Data Cube Computation, Further Development of Data Cube and OLAP Technology, Attribute-Oriented Induction.

Data preprocessing: Data cleaning, Data transformation, Data reduction, Discretization and generating concept hierarchies, Installing Weka3 Data Mining System.

Mining Frequent Patterns, Associations and Correlations: Basic Concepts, Efficient and Scalable Frequent Itemset Mining Methods, Mining various kinds of Association Rules, From Association Mining to Correlation Analysis, Constraint-Based Association Mining

Classification and Prediction: Issues Regarding Classification and Prediction, Classification by Decision Tree Induction, Bayesian Classification, Rule-Based Classification, Classification by Backpropagation, Support Vector Machines, Associative Classification, Lazy Learners, Other Classification Methods, Prediction, Accuracy and Error measures, Evaluating the accuracy of a Classifier or a Predictor, Ensemble Methods.

Cluster Analysis Introduction: Types of Data in Cluster Analysis, A Categorization of Major Clustering Methods, Partitioning Methods, Hierarchical Methods, Density-Based Methods, Grid-Based Methods, Model-Based Clustering Methods, Clustering High-Dimensional Data, Constraint-Based Cluster Analysis, Outlier Analysis.

Mining Streams, Time Series and Sequence Data: Mining Data Streams, Mining Time-Series Data, Mining Sequence Patterns in Transactional Databases, Mining Sequence Patterns in Biological Data, Graph Mining.

Social Network Analysis and Multi relational Data Mining: Mining Object, Spatial, Multimedia, Text and Web Data: Multidimensional Analysis and Descriptive Mining of Complex Data Objects, Spatial Data Mining, Multimedia Data Mining, Text Mining, Mining the World Wide Web.

References:

1. Data Mining Concepts and Techniques - Jiawei Han & Micheline Kamber, Morgan Kaufmann Publishers, Elsevier,2nd Edition, 2006.
2. Introduction to Data Mining – Pang-Ning Tan, Michael Steinbach and Vipin Kumar, Pearson education.
3. Data Mining Techniques – Arun K Pujari,2nd edition, Universities Press.
4. Data Warehousing in the Real World – Sam Aanhory & Dennis Murray Pearson Edn Asia.

PEC-CS409	Cloud Computing	3L:0T:2P	4 credits

COURSE OBJECTIVES:

Students will try to learn:

- Basics of cloud computing.
- Key concepts of virtualization.
- Different Cloud Computing services
- Cloud Implementation, Programming and Mobile cloud computing
- Key components of Amazon Web Services
- Cloud Backup and solutions

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Define Cloud Computing and memorize the different Cloud service and deployment models.
2. **CO2:** Describe importance of virtualization along with their technologies.
3. **CO3:** Use and Examine different cloud computing services.
4. **CO4:** Design & develop backup strategies for cloud data based on features.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	1	2	3				2			3	1	3	3
CO2	2	2	2	2	3				2			3	1	3	3
CO3	2	3	3	3	3				2			3	1	3	3
CO4	3	3	3	3	3				2			3	1	3	3

Overview of Distributed Computing: Trends Of Computing, Introduction To Distributed Computing, Next Big Thing: Cloud Computing.

Introduction to Cloud Computing: What's Cloud Computing, Properties & Characteristics, Service Models, Deployment Models.

Infrastructure As A Service (Iaas): Introduction to IAAS, Resource Virtualization, Server, Storage, Network, Case Studies.

Platform As A Service (Paas): Introduction To Paas, Cloud Platform & Management, Computation, Storage, Case Studies.

Software As A Service (Saas): Introduction To Saas, Web Services, Web 2.0, Web OS, Case Studies Cloud Issues and Challenges: Cloud Provider Lock In, Security

References:

1. Executive's Guide to Cloud Computing by Eric A. Marks.
2. Cloud Computing by Anthony T. Velte.

PEC-CS410	Information Security	3L:0T:2P	4 credits

COURSE OBJECTIVES:

Students will try to learn

- Exhibit knowledge to secure corrupted systems, protect personal data, and secure computer networks in an organization.
- Practice with an expertise in academics to design and implement security solutions.
- Understand key terms and concepts in Cryptography, Governance and Compliance.
- Develop Information security strategies and policies

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Analyze and evaluate the security needs of an organization.
2. **CO2:** Investigate vulnerabilities in system.
3. **CO3:** Measure the performance and troubleshoot security systems.
4. **CO4:** Design and develop a security architecture for an organization.
5. **CO5:** Design operational and strategic security strategies and policies.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	3	1	2	3				2			3	3	3	3
CO2	2	3	1	3	3				2			3	3	3	3
CO3	2	3	2	3	3				2			3	3	3	3
CO4	2	2	3	2	3				2			3	3	3	3
CO5	2	2	3	2	3				2			3	3	3	3

Introduction: History, what is Information Security, Critical Characteristics of Information, NSTISSC Security Model, Components of an Information System, Securing the Components, Balancing Security and Access, The SDLC, The Security SDLC.

Security Investigation: Risk Management: Identifying and Assessing Risk, Assessing and Controlling Risk

Logical Design: Blueprint for Security, Information Security Policy, Standards and Practices, ISO 17799 / BS 7799, NIST Models, VISA International Security Model, Design of Security Architecture, Planning for Continuity

Physical Design: Security Technology, IDS, Scanning and Analysis Tools, Cryptography, Access Control Devices, Physical Security, Security and Personnel.

Security and Attacks: Firewalls, Security on the Internet and the World Wide Web, Attack Techniques, IDS, Security in Windows, Linux, Social & Ethical issues of Information Security, Information Security management, Case studies, topics on security in OS, databases, and current trends.

References:

1. Michael E Whitman and Herbert J Mattord, “Principles of Information Security”, Vikas Publishing House, New Delhi, 2003
2. Micki Krause, Harold F. Tipton, “Handbook of Information Security Management”, Vol 1-3 CRC Press LLC, 2004.
3. Matt Bishop, “Computer Security Art and Science”, Pearson/PHI, 2002.

PEC-CS411	Digital Image Processing	3L:0T:2P	4 credits

COURSE OBJECTIVES:

Students will try to learn:

- Fundamental concepts of a digital image processing system.
- Concepts of image enhancement techniques.
- Various Image Transforms.
- Compression techniques and Morphological concepts
- Various segmentation techniques, and object descriptors.
- Color models and various applications of image processing.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Remember the fundamental concepts of image processing.
2. **CO2:** Explain different Image enhancement techniques.
3. **CO3:** Understand and review image transforms.
4. **CO4:** Analyze the basic algorithms used for image processing & compression.
5. **CO5:** Contrast Image Segmentation and Representation
6. **CO6:** Design solutions for image compressions.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	1						1			2	2	3	3
CO2	2	2	2	2	2				2			3	3	3	3
CO3	2	2		2	2				2			3	3	3	3
CO4	2	2	3	3	3				2			2	3	3	3
CO5	3	2		2					2			3	3	3	3
CO6	3	2	3	3	3				2			3	3	3	3

Digital Image Fundamentals: Elements of digital image processing systems, Digital Camera working principles, Elements of visual perception, brightness, contrast, hue, saturation, mach band effect, Color image fundamentals - RGB, HSI models, Image sampling, Quantization, dither, Two-dimensional mathematical preliminaries, 2D transforms - DFT, DCT.

Image Enhancement: Histogram equalization and specification techniques, Noise distributions, Spatial averaging, Directional Smoothing, Median, Geometric mean, Harmonic mean, Homomorphic filtering, Color image enhancement.

Image Restoration: Image Restoration, degradation model, Unconstrained restoration, Lagrange multiplier and Constrained restoration, Inverse filtering-removal of blur caused by uniform linear motion, Wiener filtering, Geometric transformations-spatial transformations.

Image Segmentation: Edge detection, Edge linking via Hough Transform, Thresholding Region based segmentation, Region growing, Region splitting and Merging, Segmentation by morphological watersheds.

Image Compression: Need for data compression, Huffman, Run Length Encoding, Shift codes, Arithmetic coding, Vector Quantization, Transform coding, JPEG standard, MPEG.

References:

1. Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing', Pearson, Second Edition, 2004.

2. Anil K. Jain, Fundamentals of Digital Image Processing', Pearson 2002.

3. Gonzalez, Richard E. Woods, Steven Eddins,' Digital Image Processing using MATLAB', Pearson Education, Inc., 2004

PCC-CS412	Deep Learning	3L:0T:2P	4 credits

COURSE OBJECTIVES:

At the end of the course, the students will be expected to:

- Learn deep learning methods for working with sequential data,
- Learn deep recurrent and memory networks,
- Learn deep Turing machines,
- Apply such deep learning mechanisms to various learning problems.
- Know the open issues in deep learning and have a grasp of the current research directions.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Understand the fundamentals of deep learning.
2. **CO2:** Design and implement deep neural network systems.
3. **CO3:** Understand the data needs of deep learning.
4. **CO4:** Explore the parameters for neural networks.
5. **CO5:** Implement deep learning algorithms and solve real-world problems.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3				2				2			3	3	3	3
CO2	2	2	3	2	3				2			3	3	3	3
CO3	3	3		3					2			3	3	3	3
CO4	3	3		3					2			3	3	3	3
CO5	3	3	3	3	3				3			3	3	3	3

Unit 1: History of Deep Learning, Deep Learning Success Stories, McCulloch Pitts Neuron, Thresholding Logic, Perceptrons, Perceptron Learning Algorithm, Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent, Feedforward Neural Networks, Representation Power of Feedforward Neural Networks.

Unit 2: Feed Forward Neural Networks, Backpropagation, Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam, Eigenvalues and eigenvectors, Eigenvalue Decomposition, Basis.

Unit 3: Principal Component Analysis and its interpretations, Singular Value Decomposition, Autoencoders and relation to PCA, Regularization in autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive autoencoders.

Unit 4: Regularization: Bias Variance Trade off, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout, Greedy Layer wise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization, Learning Vectorial Representations of Words.

Unit 5: Convolutional Neural Networks, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet, Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks.

Unit 6: Recurrent Neural Networks, Backpropagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, GRU, LSTMs, Encoder Decoder Models, Attention Mechanism, Attention over images.

Unit 7: A brief introduction to Directed Graphical Models**,** A brief introduction to Markov Networks, Using joint distributions for classification and sampling, Latent variables.

Unit 8: Restricted Boltzmann Machines, Unsupervised Learning, Motivation for Sampling, Markov Chains, Gibbs Sampling for training RBMs, Contrastive Divergence for training RBMs**,** Variational Autoencoders, Autoregressive models, GANs.

References:

1. Deep Learning, An MIT Press book, Ian Goodfellow and Yoshua Bengio and Aaron Courville http://www.deeplearningbook.org
2. Bishop, Christopher. Neural Networks for Pattern Recognition. New York, NY: Oxford University Press, 1995. ISBN: 9780198538646.
3. Bishop, Christopher M. Pattern Recognition and Machine Learning. Springer, 2006. ISBN 978-0-387-31073-2
4. Duda, Richard, Peter Hart, and David Stork. Pattern Classification. 2nd ed. New York, NY: Wiley-Interscience, 2000. ISBN: 9780471056690.
5. Michael Nielsen, Neural Networks and Deep Learning, 2016
6. Yoshua Bengio, Learning Deep Architectures for AI, 2009
7. Study Material provided by instructor during the semester

PEC-CS4: Elective – IV (CR-4, L-3, T-0, P-2)**

PEC-CS413	Multimedia Systems	3L:0T:2P	4 credits

COURSE OBJECTIVES:

Students will try to learn:

- Basics of Multimedia Systems.
- Standards available for different audio, video, and text applications.
- Various multimedia authoring systems.
- Various networking aspects used for multimedia applications.
- To develop multimedia application and analyze the performance of the same.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Understand technical aspects of Multimedia Systems.
2. **CO2:** Understand various file formats for audio, video, and text media.
3. **CO3:** Develop various Multimedia Systems applicable in real time.
4. **CO4:** Design storage system for multimedia.
5. **CO5:** Apply various networking protocols for multimedia applications.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2		1					2			2		3	3
CO2	3	3		3					2			3	2	3	3
CO3	2	2	3	2	3				2			3	3	3	3
CO4	2	2	3	3	3				2			3	3	3	3
CO5	2	2	3	2	3				2			3	3	3	3

Introduction: Multimedia Elements and Applications, Architecture, Evolving Technologies, Defining Objects, Data Interface Standards, Multimedia Databases.

Compression and Decompression: Types of Compression, Binary Image Compression Schemes, Color, Gray Scale and Still Video Image Compression, Video Image And Audio Compression.

Data and File Format Standards: RTF, TIFF, BMP, RIFF, MIDI, JPEG DIB, AVI and MPEG

Multimedia Input / Output Technologies: Issues, Pen Input, Video and Image Display Systems, Print Output Technologies, Image Scanners, Digital Voice and Audio, Digital Camera, Video Images and Animation, and Full Motion Video

Storage and Retrieval Technologies: Magnetic Media Technologies, Optical Media, Hierarchical Storage and Cache Management.

Architectural and Telecommunications Considerations: Specialized Computational Processors, Memory Systems, Multimedia Board Solutions, LAN/WAN Connectivity, Distributed Object Model.

Multimedia Application Design: Application Classes, Types of Multimedia Systems, Virtual Reality Design, Components Of Multimedia Systems, Organizing Multimedia Databases, Application Workflow and Distributed Application Design Issues.

Multimedia Authoring and User Interface: Multimedia Authoring Systems, Hyper-Media Application Design Considerations, User Interface Design, Information Access, and Object Display/ Playback Issues

Multimedia Messaging: Mobile Messaging, Hypermedia Message Components, Hypermedia Linking and Embedding, Creating Hypermedia Messages, Integrated Multimedia Message Standards and Document Management.

Distributed Multimedia Systems: Components, Distributed Client-Server Operation, Multimedia Object Severs, Multi-Server Network Topologies, Distributed Multimedia Databases and Managing Distributed Objects.

Multimedia Database Systems: Multimedia Database Management System, Characteristics Of an MDBMS, Data Analysis, Data Structure, Operations on Data, Integration In a Database Model, Relational Database Model, Object-Oriented Database Model.

References:

1. Prabhat K. Andleigh and Kiran Thakrarar, "Multimedia systems design", PHI, 2002
2. John F. Koegel Buford, "Multimedia systems", Pearson Education, 2002
3. Steinmetz and Nahrstedt, "Multimedia: Computing, Communications and Applications".
4. Tay Vaughan, "Multimedia Making it work", Fifth Edition, TMH
5. Chapman," Digital Multimedia" Wiley India.
6. Ranajan Parekh, "Principles of Multimedia", Tata McGraw Hill
7. Buford – "Multimedia Systems", Pearson.

PEC-CS414	Mobile Computing	3L:0T:2P	4 credits

COURSE OBJECTIVES:

To impart the knowledge to the students so that they will be able to

- To learn about the concepts and principles of mobile computing.
- To explore both theoretical and practical issues of mobile computing.
- To develop skills of finding solutions and building software for mobile computing applications.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Understand and identify the GSM, GPRS and Bluetooth software model for mobile computing.
2. **CO2:** Develop applications that are mobile-device specific and demonstrate current practice in mobile computing contexts.
3. **CO3:** Understanding of the characteristics and limitations of mobile hardware devices including their user-interface modalities.
4. **CO4:** Analyze QoS over wireless channels.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2		2	2				2			3		3	3
CO2	2	2	3	2	3				2			3	3	3	3
CO3	2	2		2					2			3		3	3
CO4	2	3		3	3				2			3		3	3

Wireless Transmission: Signals, propagation, signal encoding, multiplexing, modulation and spread spectrum

Wireless LANS: IEEE 802.11, Bluetooth and Hiperlan

Mobile Network Layer: IP packet delivery, agent discovery, registration, tunneling and encapsulation, optimization, reverse tunneling, mobile ad-hoc networks

Mobile Transport Layer: Indirect TCP, snooping TCP, mobile TCP, Transaction Oriented TCP, TCP over 3G wireless networks

Wireless WANS: Cellular network, GSM, GPRS, UMTS, CDPD and CDMA

Other Topics: Operating Systems for mobile devices, wireless application protocol, WML and WML Scripts

References:

1. Mobile Communications, Jochen Schiller
2. Wireless Communications and Networks, William Stallings

3. Mobile Computing, Talukder and Yavagal
4. The Wireless Appilcation Protocol, Singhal, Bridgman,
5. Mauney, Alvinen, Bevis, Chan and Hild

PEC-CS415	Big Data Analytics	3L:0T:2P	4 credits

COURSE OBJECTIVES:

- To provide students with the fundamentals and essentials of Big Data and Hadoop.
- Demonstrate various challenges in processing Big Data.
- Demonstrate various concepts of Big Data and Hadoop.
- Understand Hadoop MapReduce Framework.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Understand the concepts of Big data and challenges in processing Big Data.
2. **CO2:** Understand Hadoop architecture and eco-system.
3. **CO3:** Gain conceptual understanding of Hadoop Distributed File System.
4. **CO4:** Understand the concepts of map and reduce and functional programming.
5. **CO5:** Identify appropriate techniques and tools to solve actual Big Data problems.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2		2	2				2			2	1	3	3
CO2	3	2		2	2				2			2	2	3	3
CO3	3	3	2	2	3				2			2	2	3	3
CO4	3	3	2	2	3				2			2	3	3	3
CO5	3	3	3	3	3				2			2	2	3	3

Overview of Big Data, Stages of analytical evolution, State of the Practice in Analytics, The Data Scientist, Big Data Analytics in Industry Verticals, Data Analytics Lifecycle, Operationalizing Basic Data Analytic Methods, Using R, Advanced Analytics - Analytics for Unstructured Data - Map Reduce and Hadoop, The Hadoop, Ecosystem, In-database Analytics, Data Visualization Techniques, Stream Computing Challenges, Systems architecture, Main memory data management techniques, energy-efficient data processing, Benchmarking, Security and Privacy, Failover and reliability.

References:

1. Bill Franks, Taming The Big Data Tidal Wave, 1st Edition, Wiley, 2012.
2. Frank J. Ohlhorst, Big Data Analytics,1st Edition, Wiley, 2012.

PEC-CS416	Computer Vision	3L:0T:2P	4 credits

COURSE OBJECTIVES:

- To review image processing techniques for computer vision
- To illustrate shape and region analysis
- To describe Hough Transform and its applications to detect lines, circles, ellipses
- To discuss three-dimensional image analysis techniques
- To discuss motion analysis
- To explore some applications of computer vision algorithms

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Describe different image representation, their mathematical representation and data structures used.
2. **CO2:** Classify different Boundary Detection algorithm.
3. **CO3:** Create a 3D object from given set of images.
4. **CO4:** Detect a moving object in video using the concept of motion analysis.
5. **CO5:** Recognize the object using the concept of computer vision.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2		2	2				2			3	2	3	3
CO2	3	2		3	3				2			3	3	3	3
CO3	3	3	3	3	3				2			3	3	3	3
CO4	3	3	3	3	3				2			3	3	3	3
CO5	3	3	3	3	3				2			3	3	3	3

Introduction: Image Formation-Image Model, Imaging Devices

Early Processing: Recovering Intrinsic Structure, Filtering Image, Finding Local Edges, Range Information from Geometry, Surface Orientation, Optical Flow, Resolution Pyramids.

Boundary Detection: Searching Near and Approximate Location, Hough Method for Curve Detection, Edge Following As Graph Searching, Edge Following As Dynamic Programming, Contour Following.

Region Growing: Regions, Local Technique, Blob Coloring, Global Techniques, Splitting And Merging.

Texture: Structural Models, Texture As A Pattern Recognition Problem, Texture Gradients.

Motion: Motion Understanding, Optical Flow, Image Sequences.

Representation Of 2-D Geometrical Structure: Boundary Representation, Region Representation, Simple Shape Properties, Representation Of 3-D Structures, Solids And Their Representation, Surface

Representation, Generalized Cylinder Representation, Volumetric Representation, Understanding Line Drawings.

Knowledge Representation And Use: Knowledge Base Models And Processes, Se-Mantic Nets, Control Issues in Vision Systems.

Matching: Aspects, Graph Theoretic Algorithms, Implementation, Matching In Practice

Inference: First Order Predicate Calculus, Computer Reasoning, Production Systems, Scene Labeling, Active Knowledge.

References:

1. Ballard And Brown, "Computer Vision", Prentice Hall Publication
2. Jain, Kasturi And Schunck, "Machine Vision", Mcgraw-Hill International EditionsCS441F : Real Time Systems

PEC-CS417	Real Time Systems	3L:0T:2P	4 credits

COURSE OBJECTIVES:

- Develop an understanding of various Real Time systems Application.
- Obtain a broad understanding of the technologies and applications for the emerging and exciting domain of real-time systems.
- Get in-depth hands-on experience in designing and developing a real operational system.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** understand concepts of Real-Time systems and modeling.
2. **CO2:** recognize the characteristics of a real-time system.
3. **CO3:** understand and develop document on an architectural design of a real-time system.
4. **CO4:** develop and document Task scheduling, resource management, real-time operating systems, databases and communication, and fault tolerant applications of Real-Time Systems.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2		1	2				2			3		2	2
CO2	3	2		2	2				2			3		3	3
CO3	3	2	2	2	2				2			2	2	3	3
CO4	3	3	3	3	3				2			3	3	3	3

Introduction: Example of real-time applications, Hard and Soft timing constraints, Task and computational model, Performance metrics.

Scheduling Real-Time Tasks: types of schedulers, table-driven scheduling, cyclic schedulers, EDF, RMA. Handling resource sharing among real-time tasks, scheduling real time tasks in multiprocessor and distributed systems.

Commercial Real-time operating systems: General concepts, Unix and Windows as RTOS, Survey of Commercial RTOS

Real-time Databases (time permitting): Transaction Priority and Concurrency Control Issues, Disk Scheduling.

Real-Time Communication: Real-Time Networks, Communication Protocols.

References:

1. Rajib Mall, "Real-Time Systems: Theory and Practice", Pearson, 2008
2. Jane W. Liu, "Real-Time Systems", Pearson Education, 2001
3. Krishna and Shin, "Real-Time Systems", Tata McGraw Hill, 1999

PEC-CS418	High Performance Computing	3L:0T:2P	4 credits

COURSE OBJECTIVES:

- Provide systematic and comprehensive treatment of the hardware and the software high performance techniques involved in current day computing.
- Introduce the fundamentals of high-performance computing with the graphics processing units and many integrated cores using their architectures and corresponding programming environments.
- Introduce the learner to fundamental and advanced parallel algorithms through the GPU and MIC programming environments.
- Provide systematic and comprehensive treatment of the components in the pipeline that extract instruction level parallelism.
- Provide a strong foundation on memory hierarchy design and tradeoffs in both uniprocessor and multiprocessors.
- Illustrate the cache coherence and consistency problems in multiprocessors, and their existing solutions.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** design, formulate, solve, and implement high performance versions of standard single threaded algorithms.
2. **CO2:** demonstrate the architectural features in the GPU and MIC hardware accelerators.
3. **CO3:** design programs to extract maximum performance in a multicore, shared memory execution environment processor.
4. **CO4:** design and deploy large scale parallel programs on tightly coupled parallel systems using the message passing paradigm.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3				2			3		3	3
CO2	3	3		3	3				2			3		3	3
CO3	3	3	3	3	3				2			3	2	3	3
CO4	3	3	3	3	3				2			3	3	3	3

Introduction to parallel computing: Motivating Parallelism, Scope of Parallel Computing, Parallel Programming Platforms.

Principles of parallel algorithm design: Preliminaries, Decomposition Techniques, Mapping Techniques and Load Balancing, Parallel Algorithms Models.

Parallel programming: message passing: Introduction To MPI, Using Clusters of Computers, Evaluating Parallel Programs, Debugging.

Parallel programming: shared memory: Thread basics, programming with Pthreads, Java Threads, OpenMp.

Load balancing and termination detection: Dynamic Load Balancing, Distributed Termination Detection Algorithms.

References:

1. An Introduction to Parallel Computing: Design and Analysis of Algorithms, Second Edition - A.Grama, A. Gupta, G. Karypis and V. Kumar, Pearson.

2. Parallel Programming: Techniques and Applications using Networked Work-stations and Parallel Computers" (2nd ed.) by B. Wilkinson and M. Allen, Prentice Hall.

3. Parallel Programming: for Multicore and Cluster Systems, Thomas Rauber, Gudula Rünger, Springer.

PEC-CS419	Embedded Systems	3L:0T:2P	4 credits

COURSE OBJECTIVES:

- Develop an understanding of the technologies behind the embedded computing systems.
- To introduce students to the design issues of embedded systems.
- Enable students to analyze and develop software programs for embedded systems.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Understand hardware and software design requirements of embedded systems.
2. **CO2:** Analyze the embedded systems specification and develop software programs.
3. **CO3:** Evaluate the requirements of programming Embedded Systems, related software architectures and tool chain for Embedded Systems.
4. **CO4:** Design real time embedded systems using the concepts of RTOS.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3		3					2			3		3	2
CO2	2	3		3	3				2			3		3	3
CO3	3	3		3	3				2			3		3	3
CO4	3	3	3	3	3				2			3		3	3

Introduction to Embedded Systems: Definition of Embedded System, Embedded Systems Vs General Computing Systems, History of Embedded Systems, Classification, Major Application Areas, Purpose of Embedded Systems, Characteristics and Quality Attributes of Embedded Systems.

Typical Embedded System: Core of the Embedded System: General Purpose and Domain Specific Processors, ASICs, PLDs, Commercial Off-The-Shelf Components (COTS), Memory: ROM, RAM, Memory according to the type of Interface, Memory Shadowing, Memory selection for Embedded Systems, Sensors and Actuators, Communication Interface: Onboard and External Communication Interfaces.

Embedded Firmware: Reset Circuit, Brown-out Protection Circuit, Oscillator Unit, Real Time Clock, Watchdog Timer, Embedded Firmware Design Approaches and Development Languages.

RTOS Based Embedded System Design: Operating System Basics, Types of Operating Systems, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling.

Task Communication: Shared Memory, Message Passing, Remote Procedure Call and Sockets, Task Synchronization: Task Communication/ Synchronization Issues, Task Synchronization Techniques, Device Drivers, How to Choose an RTOS.

References:

1. Embedded Systems - Raj Kamal, TMH.
2. Embedded System Design - Frank Vahid, Tony Givargis, John Wiley.
3. Embedded Systems – Lyla, Pearson, 2013
4. An Embedded Software Primer - David E. Simon, Pearson Education.

PEC-CS420	Bandit Algorithm (Online Machine Learning)	3L:0T:2P	4 credits

COURSE OBJECTIVES:

This elective course is aimed

- To expose students to techniques for online or sequential learning/decision making under uncertainty.
- To explore several frameworks and algorithms for online prediction, along with rigorous analyses of their performance.

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** understand bandit algorithms
2. **CO2:** Analyze Multi-Armed Bandits
3. **CO3:** Learn Stochastic Bandit Algorithms
4. **CO4:** Design solutions based on bandit algorithms

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	2	2	2				1			3	3	3	3
CO2	2	3	2	3	3				2			3	3	3	3
CO3	2	2	2	2	3				2			3	3	3	3
CO4	3	3	3	3	3				3			3	3	3	3

Unit 1: Introduction to Bandit Algorithms. From Batch to Online Setting**,** Adversarial Setting with Full information (Halving, WM Algorithm)

Unit 2: Adversarial Setting with Bandit Information, Regret lower bounds for adversarial Setting.

Unit 3: Introduction to Stochastic Setting and various regret notions**,** A primer on Concentration inequalities.

Unit 4: Stochastic Bandit Algorithms UCB, KL-UCB**,** Lower bounds for stochastic Bandits.

Unit 5: Introductions to contextual bandits**,** Overview of contextual bandit algorithms.

Unit 6: Introduction to pure exploration setups (fixed confidence vs budget)**,** Algorithms for pure explorations (LUCB, KL-LUCB, lil'UCB).

References:

1. Bandit Algorithms by Tor Lattimore and Csaba Szepesvari
2. Regret Analysis of Stochastic and non-stochastic multi-armed bandit problems by Nicolo Cesaianchi and Sebastien Bubeck
3. Study Material provided by instructor during the semester.

Semester – II

PRJ-CS421	Project	3L:0T:2P	4 credits

COURSE OBJECTIVES:

COURSE OUTCOMES:

After successful completion of this course, student will be able to

1. **CO1:** Review the literature and develop solutions for framed problem statement.
2. **CO2:** Implement hardware and/or software techniques for identified problems.
3. **CO3:** Test and analyze the modules of planned project.
4. **CO4:** Write technical report and deliver presentation.
5. **CO5:** Apply engineering and management principles to achieve project goal.

Articulation Matrix (as below):

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3		3	3				3			3	3	3	3
CO4	3	3		3					3	3		3	3	3	3
CO5	3	3	3	3	3	3	3		3		3	3	3	3	3

Student may complete the said project work in the industry or within the department / institute or any reputed academic / research organization. Performance of the student will be evaluated in the midterm and at the end of the semester. Students are required to prepare a complete project report duly signed by the appropriate authorities at the time of examination, where the work done by the student will be evaluated by the examiners.