COURSE STRUCTURE & SYLLABUS

FOR

2-YEAR M.TECH
IN
COMPUTER SCIENCE AND ENGINEERING

Effective from Academic Session 2019-2020

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY
(INDIAN SCHOOL OF MINES)

DHANBAD- 826 004, JHARKHAND

TEMPLATE FOR PG PROGRAMMES

2-Year M. Tech.(CSE) Programme

SEMESTER - 1					
Course No.	**Course Name**	**L**	**T**	**P**	**C**
CSC 501	Advanced Data Structures & Algorithms	3	0	0	9
CSC 502	Advanced DBMS	3	0	0	9
CSC 504	Computing Techniques and Mathematical Tools	3	0	0	9
CSC 505	High Performance Computer Architecture	3	0	0	9
CSC 503	Algorithmic Graph Theory	3	0	0	9
CSC 506	Lab. On Advanced Data Structures & Algorithms	0	0	3	3
CSC 507	Lab. On Computing Techniques and Mathematical Tools	0	0	3	3
	Total	**15**	**0**	**6**	**51**

SEMESTER -2					
Course No.	**Course Name**	**L**	**T**	**P**	**C**
DE xxx	D Elective 1	3	0	0	9
DE xxx	D Elective 2	3	0	0	9
DE xxx	D Elective 3	3	0	0	9

OE xxx	Open Elective 1	3	0	0	9
OE xxx	Open Elective 2	3	0	0	9
CSC 508	Lab. on Computing1*	0	0	3	3
CSC 509	Lab. on Computing2*	0	0	3	3
	Total	**12**	**0**	**6**	**51**

*depending on offered elective courses in Semester 2/departmental core courses in Semester 1.

SEMESTER - 3

Course No.	Course Name	L	T	P	C
CSC 597	Thesis Unit	0	0	0	36

SEMESTER - 4

Course No.	Course Name	L	T	P	C
DE xxx / OE xxx	D Elective 4 / Open Elective 3	3	0	0	9
DE xxx / OE xxx	D Elective 5 / Open Elective 4	3	0	0	9
CSC 598	Thesis Unit	0	0	0	18
	Total	**0**	**0**	**0**	**36**

List of Subjects for Department Electives

Course No.	Course Name	L	T	P	C
CSD 520	VLSI Design & Testing	3	0	0	9

CSD 505	Cryptography and Network Security	3	0	0	9
CSD 517	Parallel Computing	3	0	0	9
CSD 512	Interactive Computer Graphics	3	0	0	9
CSD 509	Image and Video Processing	3	0	0	9
CSD 507	Data Compression	3	0	0	9
CSD 521	Wireless Networks	3	0	0	9
CSD 504	Computer Vision	3	0	0	9
CSD 514	Mobile and Wireless Network Security	3	0	0	9
CSD 513	Internet of Things	3	0	0	9
CSD 516	Optimization Techniques	3	0	0	9
CSD 506	Cryptology	3	0	0	9
CSD 519	Software Testing	3	0	0	9
CSD 508	Distributed Systems	3	0	0	9
CSD 502	Cloud Computing	3	0	0	9
CSD 518	Pattern Recognition	3	0	0	9
CSD 516	Multimedia Systems & Security	3	0	0	9
CSD 501	Algorithms for Bioinformatics	3	0	0	9
CSD 510	Information Retrieval	3	0	0	9
CSD 503	Computational Number Theory	3	0	0	9
CSD 511	Information Theory and Coding	3	0	0	9

List of Subjects for Open Electives

Course No.	Course Name	L	T	P	C
CSO 503	Data Mining	3	0	0	9
CSO 505	Soft Computing	3	0	0	9
CSO 504	Machine Learning	3	0	0	9
CSO 502	Data Analytics	3	0	0	9
CSO 501	Principles of Artificial Intelligence	3	0	0	9
CSO 506	Principles of Blockchain Technologies	3	0	0	9

COURSE DETAILS OF M. TECH (CSE)

List of Subjects for Departmental Core

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	CSC501	**ADVANCED DATA STRUCTURES AND ALGORITHMS**	3	0	0	9

Course Objective
To provide knowledge of advanced level computer algorithms with considerable depth, analysis and their applications. This course will also provide a strong foundation for research in many areas of computer science.
Learning Outcomes
● To impart knowledge of advanced algorithms ● To familiar with some advanced data structures ● To know the application areas of such algorithms and data structures

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Amortized Analysis: Aggregate Analysis, Accounting Method And Potential Method.	3	To understand how to analyse algorithms using advanced techniques with some examples.
2	Dynamic Programming: Assembly Line Scheduling, Matrix Chain Multiplication.	3	To understand how to design algorithms using dynamic Programming for specific applications.
3	Graph Algorithms: Topological Sorting, Strongly Connected Components, Single Source Shortest Paths In DAG, Johnson's Algorithm.	7	To familiar with advanced level graph algorithms with their applications.
4	Computational Geometric Algorithms: Geometric Searching Algorithms, Segment Intersection Problems.	3	To familiar with some geometric algorithms and their real applications.
5	Polynomials And FFT: Representation, DFT, FFT(Recursive & Iterative).	3	To impart knowledge about DFT computation and FFT
6	String Matching Algorithms: Naïve Approach, Finite Automata Approach, Rabin-Karp And Knuth-Morris-Pratt Algorithm.	5	To understand of designing various string matching algorithms.
7	Matrix Algorithms: LU Decomposition, LUP Decomposition, Linear System of Equations Solver, Matrix Inversion.	4	To learn how to use matrix methods to solve linear system of equations and how to obtain inverse of a high dimensional matrix.
8	Approximation Algorithms: Vertex Cover Problem, Travelling Salesman Problem, Set Cover .	2	To understand how to develop approximation algorithms for some NP complete/NP hard problems.
9	Randomized Algorithms: Randomized Quicksort, Minimum Cost Spanning Tree, Parallel Algorithms: Mesh Algorithms, Hypercube Algorithms.	5	To familiar with design of some specific randomized and parallel algorithms.
10	Advanced Data Structures: kd-Tree, Binomial and Fibonacci Heaps.	5	To learn how to represent and design algorithms for various operations on these advanced level data structures.

Text Books:

1. Cormen, Leiserson, Rivest and Stein, *Introduction to Algorithms*, Prentice Hall of India, 3rd Edition, 2010.

Reference Books:

1. Mark De Berg et al., *Computational geometry: Algorithms and Application*, 3rd edition, Springer, 2008.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	CSC502	Advanced DBMS	3	0	0	9

Course Objective
This course is intended to provide the students with an understanding of the current theory and practice of database management systems. To help the students more fully appreciate their nature, the course provides a solid technical overview of database management systems, using a current database product as a case study.
Learning Outcomes
Students will be learning advanced database management strategies which will help them in campus placement and research work.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Relational Databases: Integrity Constraints, Functional Dependency, Multi-valued Dependency	3	Understanding of the fundamentals of Relational databases
2	Query Processing and Optimization: Evaluation of Relational Operations, Transformation of Relational Expressions, Indexing and Query Optimization, Data access from disk, Index based access, Sort and Join Processing, Physical plan selection, Limitations of Relational Data Model;	8	To understand query processing enhancement techniques using indexing on relational models.
3	Parallel and Distributed Databases: Distributed Data Storage, Fragmentation & Replication, Location and Fragment Transparency	4	To understand fundamental knowledge about fragmentation and replication on various locations.
4	Distributed Query Processing and Optimization, Distributed Transaction Modeling and Concurrency Control, Distributed Deadlock, Commit Protocols, Design of Parallel Databases, Parallel Query Evaluation.	6	Understanding the concept of distributed query processing and concurrency models
5	Advanced Transaction Processing: Nested and Multilevel Transactions, Compensating Transactions and Saga, Long Duration Transactions, Weak Levels of Consistency, Transaction Work Flows, Transaction Processing Monitors	6	To understand basic and advanced level of transaction processing mechanisms with various workflows.
6	Objected Oriented and Object Relational Databases: Modeling Complex Data Semantics, Specialization, Generalization, Aggregation and Association, Objects, Object Identity, Equality and Object Reference, Architecture of Object Oriented and Object Relational Databases;	5	Understanding different type of relational databases and their need with required modalities.
7	NoSQL databases: Cassandra, MongoDB, etc.,	4	To understand the advanced level of cloud databases for practical importance

Text Books:

1. Avi Silberschatz, Henry F. Korth & S. Sudarshan, “Database System Concepts”, Tata Mc-Graw-Hill.

Reference Books:

1. W. Kim, “Modern Database Systems”, Addison Wesley.
2. W. Kim, “Introduction to Object Oriented Databases”, MIT Press.
3. J. D. Ullman, “Principles of Database and Knowledge Base Systems”, Computer Science Press.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	CSC504	Computing Techniques and Mathematical Tools (CTMT)	3	0	0	9

Course Objective

- Enhancement of mathematical, statistical and programming skills of the students with an objective to enable them to deal with other subjects with higher level of comfort, understanding and confidence.

Learning Outcomes

- The knowledge and concepts in these topics are likely to help the students do better in future in job as well as in higher studies.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Sets, Fuzzy sets, Rough Sets	3	The students will ;learn important concepts and applications of crisp sets, fuzzy sets and rough sets,.
2	Number theory	4	The students will learn important techniques of number theory with applications in cryptography and security for related research works
3	Random number and random process, Queuing theory, Hidden Markov Model, Linear and nonlinear regression, multiple regression, partial regression,	6	The students will learn about important statistical techniques which are widely used in machine learning and AI
4	Linear programming, optimization (golden section search, simulated annealing)	4	The students will learn some important optimization and searching techniques
5	Solution of linear algebraic equations (Gaussian elimination, LU decomposition, SVD, sparse systems) Eigen systems.	4	The students will learn important techniques in matrix algebra in connection to computing
6	Special functions (beta function, error function, hypergeometric function, Bessel, Legendre),	5	The students will learn important mathematical tools which will assist them computer analysis of multi-dimensional data and signals
7	FFT, other integral transforms, Differential equation and partial difference equation based systems(like diffusion etc)	5	The students will learn how to handle dynamic ssyetems in real and transformed domain
8	Numerical Techniques: Transcendental and polynomial equations, convergence and computational issues, System of linear algebraic equations, Interpolation and approximation, numerical differentiation/integration/differential equation/partial differential equations	6	The students will learn important numerical techniques
9	Programming: Introduction to Python and R, shell programming, Xwindow programming. Solving problems using numerical methods and programming anguages like C/C++ /MATLAB/Python.	5	The students will learn about programming.

Text Books:

1. An Introduction to Numerical Methods and Optimization Techniques by Richard W Daniels, Elsevier

2. Probability, Statistics, and Queuing Theory with Computer Science Applications, Arnold O Allen, Academic Press
3. Special Functions for Scientists and Engineers, W.W.Bell, Courier Corporation
4. X Window Applications Programming, Eric Foster-Johnson, Kevin Reichard,Johnson, MIS Press, USA
5. Any text book on Python programming

Reference Books: Numerical recipes in C: the art of scientific computing, Press W.H.,
Teukolsky S.A., Vetterling W.T., Flannery B.P., Cambridge University Press

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	CSC505	High Performance Computer Architecture	3	0	0	9

Course Objective

This course deals with two interrelated issues in high-performance computing: (i) fundamental concepts and techniques in parallel computation structuring and design, including parallelization methodologies and paradigms, parallel programming models, their implementation, and related cost models; (ii) architectures of high-performance computing systems, including shared memory multiprocessors, distributed memory multicomputer, clusters, and others.

Learning Outcomes

Technical competence in computer architecture and high-performance computing. Ability to describe the operation of modern and high-performance computers. Ability to undertake performance comparisons of modern and high-performance computers. Ability to improve the performance of applications on modern and high-performance computers.

Unit No.	Topics to be Covered	Lec. Hours	Learning Outcome
1	Introduction: Fundamental of Quantitative Design, Benchmark Programs, Review of Basic Organization and Architectural Techniques: RISC processors: Characteristics of RISC processors; RISC Vs CISC; Classification of Instruction Set Architectures; Review of performance measurements;	6	Study of fundamental of quantitative design in computer architecture. Comparison of RISC vs. CISC.
2	Basic parallel processing techniques: instruction level,thread level and process level; Classification of parallel architectures,	3	Understanding of instruction level parallelism and its merits and demerits.
3	Instruction Level Parallelism (ILP): Pipelining, Pipeline Hazards,	3	Learning pipeline concepts and various hazards in pipelining.
4	Advanced ILP: Advanced Compiler and Hardware Techniques for ILP, Branch Prediction Techniques, Loop Unrolling, Score boarding, Tomasula's Algorithm, Hardware-Based Speculation,	6	Study of advanced ILP concepts like Tomasulo's algorithm, hardware-based speculation.
5	Multi-Issue Processors: VLIW, Global Code Scheduling, Compiler Speculation, Classifying ILP Machines, Superscalar and Super-pipelined Architectures, and Limits on ILP.	5	Learning software based advanced ILP concepts line, VLIW, super pipelined and other concepts.
6	Data Level Parallelism: SIMD Vector Architecture, Graphics Processing Units, Systolic Arrays. Interconnection networks,	5	Understanding the basics of data level parallelism concepts like vector and systolic architectures.
7	Thread Level Parallelism: Multiprocessors: Introduction Symmetric and Distributed Shared Memory Architectures, Cache Coherence Issues, Performance Issues, Synchronization Issues, Models of Memory Consistency,	6	Study of MIMD based architectures like SMP, MPP and DSM.
	Memory Hierarchy Design: Advanced Optimizations of Cache Performance, Memory Technology and Optimizations, Protection: Virtual Memory and Virtual Machines, Design of Memory Hierarchies, Case Studies.	6	Study of role of memory hierarchy in computer architecture, cache optimization techniques to improve the cache performance.

Text Book:

1. J. L. Hennessy, D. A. Patterson "Computer Architecture: A Quantitative Approach," 3rd edition

Reference Book:

1. "Modern Processor Design: Fundamentals of Superscalar Processors" by John Paul Shen and Mikko H Lipasti
2. "Computer Architecture: Pipelined and Parallel Processor Design" by M J Flynn
3. "High Performance Embedded Architectures And Compilers" by Soft Cover and J Emer

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	CSC503	**Algorithmic Graph Theory**	3	0	0	9

Course Objective
• Development of concepts of algorithms related to graphs
Learning Outcomes
• Students are expected to be able to handle the combinatorial and graph problems with greater ease. • Students will learn how to formulate and analyze problems under the framework of graph theory

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Graphs and algorithmic complexity, graph representation, graph traversals;	3	The students will learn the basics of graphs, their representation in data structures and traversals
2	Spanning trees, branching, connectivity, circuits, cut-sets;	4	The students will pick up concepts of trees and related applications
3	Planar graphs: genus, crossing numbers, thickness, characterization of planarity, planarity testing	5	The students will learn about the important aspects of planar graphs
4	Networks and flows: Menger's theorem, maximizing flow in graph networks, minimum cost flow	6	The graph cut techniques have wide applications - the students will learn salient aspects of that
5	Matching: maximum cardinality matching, maximum weight matching, perfect matching;	6	Matching is another very important part of graph algorithms and the students will learn them
6	Euler tours and Hamiltonian cycles: counting Eulerian tours, finding all Hamiltonian cycles using matricial products, 2-factors	6	The students will learn about Euler and Hamiltonian graphs
7	Graph coloring: dominating set, edge coloring, vertex coloring, chromatic polynomial, face coloring, 4-color theorem, 5-color theorem;	5	Students will learn how to solve problems under the framework of graph coloring
8	Graph problems and intractability: Cook's theorem, vertex covering, independent sets and cliques	5	Students will learn about vertext and edge independent sets, covering sets

Text Books:

1. Algorithmic Graph Theory by Alan Gibbons, Cambrige University Press

Reference Books:

1. Algorithmic Graph Theory and Perfect Graphs by Martin Charles Golumbic, North Holland
2. Graph Theoretic Algorithms, Therese Biedl, U of Waterloo
3. Advanced Topics in Graph Algorithms, Ron Shamir, Tel Aviv U.

List of Subjects for Departmental Core Lab

Course Type

Course Type	Course Code	Name of Course	L	T	P	Credit
DP	CSC506	**Lab on ADVANCED DATA STRUCTURES AND ALGORITHMS**	3	0	0	9

Course Objective
To make the students learn implementation of the algorithms discussed in the theory class of Advanced Algorithms.
Learning Outcomes
Coding skill, helpful for research work.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Lab. based on Dynamic Programming	2	To learn how to design and implement various algorithms based on dynamic Programming.
2	Lab. based on Graph Algorithms	4	To impart knowledge of implementing various advanced level graph algorithms.
3	Lab. based on Polynomials And FFT	2	To understand how to implement DFT computation and FFT
4	Lab. based on String Matching Algorithms	4	To learn how to implement various string matching algorithms
5	Lab. based on Matrix Algorithms	2	To learn how to implement various matrix algorithms

Text Books:

1. Cormen, Leiserson, Rivest and Stein, *Introduction to Algorithms*, Prentice Hall of India, 3rd Edition, 2010.

Reference Books:

Sartaj Sahni and Sanguthevar Rajasekaran Ellis Horowitz, *Fundamentals of Computer Algorithms*, Universities Press

Course Type	Course Code	Name of Course	L	T	P	Credit
DP	CSC507	Lab on Computing Techniques and Matheatical Tools(CTMT)	3	0	0	9

Course Objective

- Enhancement of mathematical, statistical and programming skills of the students with an objective to enable them to deal with other subjects with higher level of comfort, understanding and confidence.
- A better comprehension and command over the concepts taught in the theoretical classes

Learning Outcomes

- The knowledge and concepts in these topics are likely to help the students do better in future in job as well as in higher studies.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Lab. on number theory .	1	The students will learn important techniques of number theory
2	Lab. on Statistics: Random number and random process, Queuing theory, Hidden Markov Model, Linear and nonlinear regression, multiple regression, partial regression,	2	The students will learn about important statistical techniques
3	Lab. on Linear programming, optimization(golden section search, simulated annealing)	1	The students will learn about important optimization techniques
4	Lab. on Solution of linear algebraic equations (Gaussian elimination, LU decomposition, SVD, sparse systems) Eigen systems	1	The students will learn about matrix and matrix related operations
5	Lab. on Special functions (beta function, error function, hypergeometric function, Bessel, Legendre),	1	The students will learn about some special functions and their applications
6	Lab. on FFT, other integral transforms, Differential equation and partial difference equation based systems(like diffusion etc)	2	The students will ;learn about important integral transforms and differential equation based systems
7	Lab. on Numerical Techniques: Transcendental and polynomial equations, convergence and computational issues, System of linear algebraic equations, Interpolation and approximation, numerical differentiation/integration/differential equation/partial differential equations	2	The students will learn about important numerical techniques
8	Lab. on Python and R, shell programming, X-window programming. Matlab.	4	The students will learn about programming

Text Books:

1. An Introduction to Numerical Methods and Optimization Techniques by Richard W Daniels, Elsevier
2. Probability, Statistics, and Queuing Theory with Computer Science Applications, Arnold O Allen, Academic Press
3. Special Functions for Scientists and Engineers, W.W.Bell, Courier Corporation
4. X Window Applications Programming, Eric Foster-Johnson, Kevin Reichard,Johnson, MIS Press, USA

5. Any text book on Python programming

Reference Books: Numerical recipes in C: the art of scientific computing, Press W.H., Teukolsky S.A., Vetterling W.T., Flannery B.P., Cambridge University Press

Course No.	Course Name	L	T	P	C
CSC508	**LAB ON COMPUTING 1**	0	0	3	3
This Lab. will be conducted based on the offered elective courses in Semester 2/departmental core courses in Semester 1.					

Course No.	Course Name	L	T	P	C
CSC 509	**LAB ON COMPUTING 2**	0	0	3	3
This Lab. will be conducted based on the offered elective courses in Semester 2/departmental core courses in Semester 1.					

List of Subjects for Department Electives

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD520	VLSI DESIGN & TESTING	3	0	0	9

Course Objective
Understanding of basic topics required for VLSI designs as well as for testing of VLSI circuits.
Learning Outcomes
Ability for the following. ● The basics about nMOS, pMOS, CMOS transistors and design of VLSI circuits ● MOS theory, Fabrication and different design aspects ● Design of combinational, sequential circuits and memory design ● Testing of VLSI circuits: DFT, BIST, Scan designs etc.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	MOS Technology: Transistor basics, Fabrication, Transistor theory, Design process,	4	The basics about nMOS, pMOS, CMOS transistors and design of VLSI circuits
2	VLSI circuit concepts, MOS inverters and characteristics;	5	Understanding of MOS inverters and characteristics as basic steps
3	Combinational MOS logic circuits: nMOS logic designs, CMOS logic circuits;	5	Learning of design of combinational circuits using different approaches
4	Sequential MOS logic circuits: SR, JK, D flip-flops; Semiconductor memories: Static random access memory (SRAM), Dynamic access memory (DRAM);	8	Understanding of design of different flip-flops, and semiconductor memories SRAM and DRAM
5	Test and testability: Different abstraction levels in Circuits and fault models,	4	Learning of fault models for testing of VLSI circuits
6	Testing methods for combinational and sequential circuits	4	Learning about testing approaches for combinational and sequential circuits
7	DFT guidelines and testing, Scan design technique,	5	Understanding of DFT and Scan design approaches for testing of VLSI circuits
8	BIST technique using LFSR and Cellular Automata	5	Learning of BIST approach for testable design of VLSI circuits

Text Books:

1. D.A. Pucknell and K. Eshraghian, ‘Basic VLSI Design’ Prentice-Hall of India.

Reference Books:

1. N.H.E. Weste, ‘Principles of CMOS VLSI Design’Pearson Education,
2. S. Kang and Y. Leblebici, ‘CMOS Digital Integrated Circuits’ Tata McGraw-Hill

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD505	**CRYPTOGRAPHY AND NETWORK SECURITY**	3	0	0	9

Course Objective
To understand basics of Cryptography and Network Security and to learn how to maintain the Confidentiality, Integrity, and Availability (CIA) of the data. To be able to secure a message over insecure channel by various the cryptographic techniques and understanding the various protocols for network security to protect the data against the threats in the networks.
Learning Outcomes
To understand the both theoretical and practical knowledges in information security aspects and provide the security of the data over the public network. To do research in the new emerging areas of cryptography and network security and implement the various networking protocols To protect any network from the threats in the real scenario.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Cryptography: Introduction, Security requirements, Attacks, Security techniques.	3	Learning the basics of cryptography and security
2	Cryptographic mathematics: Modular Arithmetic, Group, Ring, Field, Prime numbers and primality tests.	4	Understanding the basics of mathematics used in cryptography
3	Classical encryption techniques, Block ciphers, Public-key ciphers.	4	Learning about the classical as well as public ciphers techniques
4	Elliptic curve cryptography.	3	Understanding the elliptic curve cryptography
5	Message authentication, Cryptographic hash algorithms.	3	learning about message authentication and hash algorithms
6	Digital Signatures.	4	Understanding the digital signatures
7	Key management.	3	Understanding the key management in cryptography
8	Network Security: Network layer security (IPSec)-Authentication header (AH), Encapsulated security payload (ESP), Security association (SA), Internet security protocol (IKE).	5	Understanding the network layer security and the protocols
9	Transport layer security: Secure socket layer (SSL)-SSL architecture, Four protocols, SSL message formats, TLS.	4	Understanding the transport layer security and the protocols
10	E-mail security: Introduction to E-mail architecture, PGP (Pretty Good Privacy), S/MIME.	4	Understanding the application layer security and the protocols
11	Secure Electronic transaction (SET), Digicash	3	Understanding the applications how cryptographic protocols are used

Text Books:

1. William Stallings, 'Cryptography and Network Security-Principles and Applications' Pearson Education.
2. B.A. Forouzan, 'Cryptography and Network Security' Tata McGraw-Hill

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD 517	**PARALLEL COMPUTING**	3	0	0	9

Course Objective

This course is intended to cover a comprehensive introduction to parallel architecture and parallel computing techniques followed by in depth coverage of parallel algorithms. This is also supplemented by moden parallel programming paradigms through GPU and CUDA

Learning Outcomes

- To provide a strong foundation of parallel architecture and parallel algorithms.
- To impart knowledge of interconnection networks and mapping parallel algorithms on them.
- To familiar with parallel programming through CUDA

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction to Parallel Computing, Applications; Parallel Computing Models: SIMD, MIMD, PRAMS, Multiprocessors; Shared Memory Architectures, Message Passing Architectures, Multi-Cores.	5	To understand basic models of parallel computers
2	Interconnection Networks: Linear Array, Meshes, Trees, Mesh of Trees, Hypercubes, Butterfly Networks.	4	To learn about various interconnection networks which are popular in the domain of parallel computing.
3	Parallel Computing Techniques: Pointer Jumping, Divide and Conquer, Partitioning, Pipelining, Systolic Computation; Parallel Performance Analysis, Scalability, High Level Parallel Programming Models and Framework.	8	To familiar with various parallel computing techniques and performance analysis.
4	Parallel Algorithms: Prefix Computation, List Ranking, Euler Tour, Sorting, Searching, Merging; Matrix Operations; Multiprocessor Algorithms.	12	To understand how to design parallel algorithms for various important computations.
5	Message passing programming: Distributed memory model; Introduction to message passing interface (MPI).	4	To impart knowledge about distributed memory model and message passing interface.
6	Synchronization as Send/Receive pair; Introduction to GPU Programming: GPU Architecture; Introduction to CUDA Programming.	5	To impart knowledge about GPU architecture and programming and to be familiar with CUDA.

Text Books:

1. Michael J. Quinn, Parallel Computing : Theory and Practice, Singapore : McGraw-Hill, 1994.

Reference Books:

1. Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar, Introduction to Parallel Computing, Second Edition, Addison Wesley, 2003.
2. Michael J. Quinn, Designing efficient algorithms for parallel computers, McGraw-Hill Ryerson, Limited, 1987.
3. Selim G. Akl , The Design and Analysis of Parallel Algorithms, Prentice Hall, Englewood Cliffs, New Jersey, 1989.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD512	**Interactive Computer Graphics**	3	0	0	9

Course Objective
• To train the students to develop the concepts and skill of graphics programming in interactive fashion.
Learning Outcomes
• The students will become in graphics programming, multimedia processing and other rela time applications etc

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction: graphics systems and models, images, imaging systems, camera models, graphics architecture, programmable pipelines	3	The students will learn the basics of interactive graphics and its applications
2	Graphics programming: Sierpinski gasket, primitives and attributes, color, viewing, control functions, gasket programs, adding interaction, menus	3	Programming is the most important part of interactive computer graphics and the students will be taught about these
3	Geometric objects and transformation	3	Object representation and transformation involve underlying mathematics and the students will acquire knowledge in those
4	Viewing	3	Viewing transformations are important part of computer graphics and the students will pick up how to handle that - they will also learn details of various projections.
5	Lighting and shading	5	The students will learn about the details of illumination and shading - for realistic applications.
6	Vertices to fragments	3	The students will get knowledge about rasterization
7	Discrete techniques	3	The students will pick up concepts in surface mapping, compositing, anti-aliasing and will learn how to deal with surface properties like transparency
8	Modelling and hierarchy ;	3	The students will learn how to deal with objects and models from the perspective of graphics programming
9	Procedural methods	3	The students will learn about generating objects via procedure or programming
10	Curves and surfaces	7	The students will learn about important curve and surface interpolation techniques
11	Advanced rendering	4	The students will learn about photo-realistic and non-photorealistic object and scene generation

Test book

1. Interactive Computer Graphics, A top-down approach with OpenGL by Edward Angel, Dave Shreiner Addison Wesley

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD509	Image and Video Processing	3	0	0	9

Course Objective

To provide basic and fundamental knowledge on different phases of digital image processing. Describe in brief the fundamental knowledge on video processing. The proposed syllabus is designed in such manner to provide better practical and research understanding for students in the field of image and video processing.

Learning Outcomes

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

- Explain and apply the basic and fundamental methods on digital image processing and video processing.
- Use these methods in subsequent courses like pattern recognition and computer vision.
- Apply the knowledge primarily obtained by studying examples and cases in the field of engineering disciplines.
- Prepare for research interest using recent techniques for solving real life problems.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Digital Image Fundamentals: Image Model, Sampling and Quantization, Image Geometry, Digital Geometry.	3	Understanding of the fundamentals of digital image processing and pixel geometry.
2	Image Enhancement: Contrast Enhancement, Histogram Processing, Point Processing, Spatial Domain Filtering, Frequency Domain Filtering.	6	To understand different mathematical principles and current techniques used in image enhancement in spatial and frequency domain.
3	Noise Models, Image Restoration Filtering, Motion Blur Removal, Geometric Corrections.	3	To understand fundamental knowledge about image restoration techniques used in digital image processing.
4	Image Compression: Redundancy and Compression Models, Lossless and Lossy Compression Schemes– Run Length, Huffman, Arithmetic Coding, Block Truncation, Vector Quantization, JPEG Standard.	5	To understand efficient storage and compression techniques (lossy and lossless) to analyze the constraints in image processing when dealing with larger data sets.
5	Wavelets and Multiresolution Processing: Pyramidal Coding; Subband Coding; Application of Wavelets.	3	Understanding the effect of multiresolution analysis and its different techniques used in digital image processing.
6	Image Morphology: Fundamental Operations, Morphological Algorithms.	3	Understanding of different operations used in image morphology and corresponding mathematical examples.
7	Image Segmentation: Pixel-based Segmentation, Multilevel and Adaptive Thresholding, Optimal Thresholding, Region-based Segmentation, First and Second Order Edge Operators, Canny Edge Detector, Hough Transform, Edge Linking.	6	To understand the basic principle of image segmentation, different types of segmentation methods and their used in real applications..
8	Representation and Description: Chain Codes, Polygonal Approximation, Boundary Segments, Skeletons; Boundary, Regional and Relational Descriptors.	3	Understanding of different techniques used for image representation as well as description.

9	Video Processing: Introduction, Video Formats, Motion Detection and Estimation, Video Enhancement and Restoration, Video Segmentation.	7	Understanding of different phases of video processing in brief.

Text Books:

1. Digital Image Processing, R. C. Gonzalez and R. E. woods, Pearson Education.
2. Fundamentals of Digital Image Processing, A. K. Jain, Pearson India Education.

Reference Books:

1. Handbook of Image and Video Processing, AL Bovik, Academic Press.
2. Digital Image Processing and Analysis, B. Chanda and D. Dutta Mazumdar, PHI.
3. Digital Image Processing, W. K. Pratt, Wiley-Interscience.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD 507	Data Compression	3	0	0	9

Course Objective
To provide fundamental knowledge about how to represent the digital data in concise way.
Learning Outcomes
Upon successful completion of this course, students will: ● understand different Data Compression techniques ● able to apply them in real life applications. ● capable to develop new schemes for data compression

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction to information theory, entropy, information value, data redundancy; probability and random processes, statistical methods,	5	• To provide the course outline. • To give some brief idea about information theory
2	Shannon-Fano algorithm, Huffman algorithm, adaptive Huffman coding, arithmetic coding, context based compression, dictionary methods: LZ77, LZ78, LZW algorithms,	8	• To learn the need of source coding and to get an overview of different categories of source codes. • To understand the compression based on dictionary based concepts
3	differential encoding, transforms, sub bands, transform coding, sub band coding,	7	• To know the coding mechanism in the context of differential encoding
4	image compression, scalar quantization, vector quantization, discrete cosine transform, jpeg compression, wavelet methods, discrete wavelet transform, JPEG 2000,	10	• To learn the different image compression approaches and their standards
5	video compression: motion compensation, temporal and spatial prediction. MPEG and H.264, audio coding, analysis by synthesis schemes MPEG-1/2 audio layers.	10	• To learn the different video compression approaches and their standards

Text Books:

2. A concise introduction to data compression, David Salomon, Springer

Reference Books:

3. Introduction to Data Compression, Khalid Sayood, Morgan Kaufman
4. Data compression: The Complete Reference , David Salomon, G. Motta, D. Bryant, Springer

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD 521	WIRELESS NETWORKS	3	0	0	9

Course Objective

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

- To study the evolving wireless technologies and standards
- To understand the protocols, architectures and applications of various wireless networks.
- To gain expertise in some specific areas of wireless networking.

Learning Outcomes

On successful completion of this unit students will be able to:

- Identify the basic concept and understand the state-of-the-art in protocols, architectures and applications of wireless networks.
- Compare, contrast and analyze wireless networks;
- Classify and also develop new protocols in ad-hoc networks.
- Understand how wireless networking research is done.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction to Wireless Networks: Issues and Challenges.	2	Comprehensive introduction about the course content will be delivered and basics of Wireless Networks
2	Radio wave propagation: Data and Signals; Analog and Digital Transmission; Antennas; Propagation Modes; LOS Transmission; Fading in the wireless Environment; Energy consumption and Delay.	6	To understand the working procedure of Physical layer and Radio wave propagation
3	MAC Layer: Noisy channels and its protocols; Multiple Access Techniques; Control Access Mechanisms; Channelization methods - TDMA, FDMA, Spread Spectrum, CDMA, OFDMA.	6	To understand the MAC layer for Wireless networks.
4	Mobility Management and GSM: Cellular Architecture, Cell splitting and sectoring concept; Frequency allocation and interference issues; Handoff techniques; Hierarchical Scheme; Mobile IP; Mobile TCP.	6	This unit will help students to understand GSM architecture and working principle of Cell phones.
5	Wireless LANs: Wireless LAN technologies, Wireless standards (IEEE 802.11, 802.15, 802.16 etc.), WiFi, Bluetooth and WiMAX.	4	Students learn the different types of wireless LANs.
6	Ad-hoc Networks and Sensor Networks: Introduction, Challenges and Issues, AODV, DSR, DSDV Routing protocols; Architecture and factors influencing the sensor network design; Concept of MANET and VANET.	7	To understand basic properties of Ad-hoc Networks and to get an overview of different routing techniques.
7	Satellite Networks: Orbits; Footprint; Categories of Satellites; GPS.	2	To understand the basic concepts of Satellite Networks.
8	Advanced and selected topics in wireless networks, e.g., LTE, Software Defined Radio, Cognitive Radio Networks, Delay Tolerant Networks etc.	6	Students will learn about the advanced research topics in wireless networks.

Text Books:

1. Wireless Communications and Networks by William Stallings, PHI
2. Wireless Networks by Clint Smith and Daniel Collins, McGrawHill
3. Mobile Communications by Jochen Schiller, Pearson Education

Reference Books:

1. Computer Networks by Andrew S. Tanenbaum, Pearson Education
2. Computer Networking by James F. Kurose and Keith W. Ross, Pearson Education
3. Data and Computer Communications by William Stallings, PHI
4. Communication Networks Fundamental concepts and key architecture by Alberto Leon-Garcia and Indra Widjaja, Tata McGrawHill
5. Data Communications and Networking by Behrouz A. Forouzan, Tata McGrawHill
6. Wireless Communications Principles and Practice by Theodore E. Rapaport, PHI

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD504	Computer Vision	3	0	0	9

Course Objective
To meet the requirement of the current trends in the industry and academic fields pertaining to machine vision
Learning Outcomes
• The students are expected to acquire knowledge and develop expertise

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction, challenges	2	The students would learn about the need, scopes, application areas, role and importance of the subject
2	images and imaging operations in low level vision, edge detection, corner, interest point and invariant feature detection	7	The basic input for the subject comes from the images and the students would acquire the basics of image processing operations with objectives
3	texture analysis, binary shape analysis, boundary pattern analysis,	5	The students will pick up concepts of handling the texture features, shape features, pattern analysis which are basic cues to machine vision related tasks
4	detection of linear, circular and elliptic structures, the generalised Hough transform, pattern matching techniques	5	The students will learn concepts related to detection of linear and curvilinear structures from a scene which constitute the complex structures in natural objects and scenes and need proper interpretation in machine vision tasks
5	object segmentation and shape models, basic classification concepts	8	The students would learn the most difficult task of object detection via segmentation - a mid level processing highly essential for recognition in machine vision
6	the three-dimensional world, invariants and perspective, image transformations and camera calibration and motion	6	The students would learn to handle more practical and more difficult and realistic problems encountered by machine vision in real 3D world
7	real time vision systems, face detection and recognition, surveillance in-vehicle vision systems,	5	In continuation with module 6 the students would learn to deal with more complex systems with more practical problems in vision
8	machine learning and deep learning concepts in vision	4	The students would learn the modern trend in vision related task with the concepts of intelligent processing

Text Books: Text Books:

1. Computer vision by Dana H. Ballard, Christopher M. Brown, Prentice Hall

Reference Books:

1. 3D computer vision: efficient methods and applications by Christian Wohler, Springer Berlin Heidelberg

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD514	**MOBILE AND WIRELESS NETWORK SECURITY**	3	0	0	9

Course Objective
The students should understand and know the existing security mechanisms/techniques and new developments as well used for securing wireless communications along with wireless networking.
Learning Outcomes
The students would get well exposure in securing wireless applications.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Mobile and Wireless Communications: Overview, 1G-4G Cellular Systems, Cellular Communication Fundamentals.	4	Understanding the basics of Mobile and Wireless Communications
2	Multiple Access Techniques- FDD, TDD, FDMA, TDMA, DS-CDMA, Spread Spectrum and CDMA, CSMA/CA,	5	Understanding the Multiple Access Techniques
3	Mobile Ad Hoc Routing Protocols- DSDV, AODV, DSR, CGSR,	5	Understanding the Mobile Ad Hoc Routing Protocols
4	Cellular Communication standards- GSM, IS-95 CDMA, WiMAX.	4	Understanding the Cellular Communication standards
5	Wireless Security: Security and Privacy needs of Wireless System, Challenges of Broadcast Communication and Security Requirements	4	Understanding the Wireless Security
6	TESLA Broadcast Authentication, Instant Key Disclosure, Time Synchronization, Denial-of-Service Protection,	4	Understanding the TESLA Broadcast Authentication and others
7	BiBa Signature Algorithm and Broadcast Authentication, Merkle Hash Trees for Ball Authentication, Efficient Multicast Stream Signature (EMSS), MESS,	5	Understanding the BiBa Signature Algorithm and Broadcast Authentication and Merkle tree
8	WLAN Standards, 802.11 Security, WEP Protocols, WAP Security Architecture, Comparison of TCP/IP, OSI and WAP models,	5	Understanding the WLAN Standards, 802.11 security, and models
9	Bluetooth networking and Security protocols.	4	Understanding the Bluetooth networking and Security protocols.

Text Books:

1. William Stallings, ‘Wireless Communications and Networks’, Pearson Education, and Different security based Journal research articles.
2. Jochen Sciller, ‘Mobile Communications’ Addison Wesley.
3. T.S. Rappaport, ‘Wireless Communication- Principles and Practice’ Prentice Hall

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD513	Internet of Things	3	0	0	9

Course Objective
This course teaches basic concepts and practices in development of IoT Prototypes for real world applications. It deals with connectivity, building systems to enable delivery of software services networked to the cloud platforms. At the end of the course the students will be in a position to launch an IoT product.
Learning Outcomes
Understand the usability of the IoTs across various real-world applications. Understand and design different application and communication protocols for IoTs. Understand integration of IoTs with cloud platform. Understand the distributed data analysis for IoTs. Design solutions for several applications using IoTs.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Internet of Things: An overview: Introduction, IoTs Definition Evolution, IoT Architectures, Resource Management, IoT Data Management & Analytics, Communication protocols, IoT applications. Open Source Semantic	6	Understanding and leaning various concept in IoT especially renouncement management, communication protocols
2	Web Infrastructure for Managing IoT Resources in the Cloud: Introduction, Background, OpenIoT Architecture for IoT/Cloud Convergence, Scheduling Process and IoT service lifecycle, Scheduling and Resource management.	5	Learning topics like OpenIoT architecture, IoT life cycle and scheduling.
3	Programming Frameworks for Internet of Things: Introduction, Background, Survey of IoT programming frameworks.	6	Understanding and learning programming environment for IoT application development
4	Virtualization on Embedded Boards as Enabling Technology for the Cloud of Things: Introduction, Background, Virtualization and Real-time.	5	Learning how to handle and deal with embedded boards and their programming.
5	Stream Processing in IoT: Foundations, State-of-the-Art, and Future Directions: Introduction, The foundation of Stream processing in IoT, Continuous Logic processing system, challenges and future directions.	6	Understanding various stream processing in IoT
6	A Framework for Distributed Data Analysis for IoT: Introduction, Preliminaries, Anomaly Detection, Problem statement and definitions, Distributed anomaly detection.	5	Understanding and learning data analysis in IoT, and other concepts like anomaly detection.
7	Internet of Things—Robustness and Reliability: Introduction, IoT characteristics and Reliability Issues, Addressing Reliability. Applied Internet of Things: Introduction, Scenario, Architecture Overview, Sensors, The gateway, Data Transmission.	4	Study of reliability issues in IoT including sensors, gateway and data transmission.
8	Internet of Vehicles and Applications: Basics of IoV, Characteristics and Challenges, Enabling Technologies, Applications.	4	Study of internet of vehicles, basics of IoV and its applications.

Text Book:

1. Internet of Things: Principles and Paradigms, Rajkumar buyya and Amir Vahid Dastjerdi, MK Elsevier

Reference Book:

2. Internet of Things: A Hands-on Approach, Arshdeep Bahga and Vijay K. Madisetti, Universities Press

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD516	**OPTIMIZATION TECHNIQUES**	3	0	3	12

Course Objective

Understand the need of optimization methods

Get a broad view of the various applications of optimization methods used in engineering

Learning Outcomes

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

Understand importance of optimization of industrial process management

Upply basic concepts of mathematics to formulate an optimization problem

Analyse and appreciate variety of performance measures for various optimization problems

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction: General statement of optimization problem, Classification of optimization Problems.	2	Understanding the basics of optimization techniques
2	Classical Optimization Techniques: single-variable and multi-variable optimization, Network Analysis.	4	Understanding the basics of single/multi-variable optimization techniques and network analysis
3	Genetic algorithms: representation of design variables, objective function and constraints.	4	Learning about the Genetic algorithms
4	Particle Swarm Optimization, Jaya algorithm, TLBO	5	Understanding the advanced optimization techniques
5	Central force optimization (CFO): Main algorithm, basic components, issues and variations	4	Understanding the CFO
6	Chemical reaction optimization (CRO): Main algorithm, basic components, issues, Simulated Annealing	5	Understanding the CRO
7	Neural network based optimization	3	Understanding the Neural network based optimization techniques
8	Most recent optimization techniques such as Gravitational Search, CRO and many others.	5	Understanding the Gravitational Search, CRO etc. optimization techniques
9	Practical and computational aspects of optimization.	4	Understanding the Practical and computational aspects of optimization
10	Few applications based on nature inspired optimization techniques.	4	Understanding the applications based on nature inspired optimization techniques.

Text Books:

1. Optimization in operations research by Ronald L. Rardin.
2. Operation Research by Kanti Swarup, P. K. Gupta, Man Mohan.
3. Optimization Methods: From Theory to Design Scientific and Technological Aspects in Mechanics by Cavazzuti Marco

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD 506	CRYPTOLOGY	3	0	0	9

Course Objective
Understanding about topics Cryptography and Cryptanalysis for information and cyber security
Learning Outcomes
Ability for the following. ● The basics of cryptographic fundamentals namely confidentiality, integrity, authentication and availability ● Classical and modern methods for encryption/decryption and their cryptanalysis ● Public key cryptosystems and their cryptanalysis, ECC ● Cryptographic hash functions, Digital Signatures

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction: Security goals, Attacks, Security services and mechanisms, Security techniques;	2	The basics about Security goals, Attacks, Security services and mechanisms, Security techniques
2	Classical encryption techniques: Additive ciphers, Monoalphabetic, Playfair cipher, Polyalphabetic; Block ciphers:	4	Understanding classical / traditional symmetric encryption / decryption with cryptanalysis
3	Modern symmetric cryptosystems-DES, AES,	6	Learning of DES and AES, and their cryptanalysis
4	Public-key ciphers: RSA, Rabin, ElGamal, Elliptic curve cryptography;	6	Understanding of public-key cryptosystems and their cryptanalysis, ECC
5	Message authentication and cryptographic hash algorithms; MAC, MD5, SHA-1;	6	Learning of MAC for message authentication and cryptographic hash functions, and their cryptanalysis
6	Message integrity and authentication-Digital Signatures: RSA, ElGamal, DSS;	6	Learning about different digital signature schemes and their cryptanalysis
7	Key management: Diffie-Hellman key exchange protocol, Shamir's secret sharing scheme, PKI (Public-Key Infrastructure);	6	Understanding of different key management techniques and their cryptanalysis
8	Zero knowledge protocols: Fiat-Shamir, Feige-Fiat-Shamir.	4	Learning of different entity authentication ZKP schemes and their cryptanalysis

Text Books:

1. William Stallings, 'Cryptography and Network Security- Principles and Practices' Pearson Education,

Reference Books:

1. B.A. Forouzan, 'Cryptography and Network Security' Tata McGraw-Hill,

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD519	Software Testing	3	0	0	9

Course Objective
Develop methods and procedures that can be used to consistently produce high-quality software at low cost. How to use available resources to develop software, reduce cost of software and how to maintain quality of software. Methods and tools of testing and maintenance of software.
Learning Outcomes
Types of errors and fault models. Methods of test generation from requirements. Test adequacy assessment using: control flow, data flow, and program mutations. Application of software testing techniques in commercial environments.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction to Software Testing: Fundamentals of Verification and Testing, Review of Software Development Models, Test Metrics, Software Testing Principles, Testing and Debugging.	6	A revision of the Software Development Models and Fundamental Concepts related to Software Testing
2	Software Quality Assurance and Quality control, Quality factors, Quality standards – TQM, ISO, SEI CMM, PCMM, Six sigma.	5	A brief introduction to the globally discussed frameworks for Quality and their application to Software Systems
3	Requirement Behavior and Correctness, Fundamentals of Test Process, The Tester's Role in a Software Development Organization.	4	An overview of the Human aspect of Testing (i.e., understanding the challenges in Testing due to communication)
4	Static Testing: Structured examination, Control flow & Data flow, Determining Metrics.	4	An overview of the Static Testing Methods
5	Dynamic Testing: Black Box Testing, Gray Box Testing, Intuitive and Experience Based Testing.	4	An overview of the Dynamic Testing Methods
6	Test Management: Test Organization, Test Planning, Test Strategies, Testing Tools.	4	Understanding Software Configuration Management
7	Automation of Test Execution: Types of test Tools, Selection and Introduction of Test Tools.	5	An introduction to popular Testing Tools
8	Testing Object Oriented Software: Introduction to Object Oriented testing concepts, Differences in Object Oriented testing.	3	An understanding of the recommended methods for testing Software with Object Oriented Design
9	Discussion on Reliability Models.	2	A brief overview of major Software Reliability models

Textbooks:

3. Mall, Rajib. Fundamentals of Software Engineering (5th Edition). PHI Learning Pvt. Ltd., 2018.
4. Jalote, Pankaj. An Integrated Approach to Software Engineering. Springer Science & Business Media, 2012.

Reference Books:

1. Sommerville, Ian. Software Engineering (7th Edition), Pearson Addison Wesley, 2004.
2. Pressman, Roger S. Software engineering: A Practitioner's Approach (6th Edition), McGraw-Hill, 2005.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD508	Distributed Systems	3	0	0	9

Course Objective

This course provides an in-depth knowledge about concepts in distributed systems, knowledge about their construction, and understanding of advantages and disadvantages of their application. It covers distributed operating system in detail, including communication process, file system and memory management synchronization and so on. The various design and implementation issues will be discussed.

Learning Outcomes

The students will gain an understanding of the principles and techniques behind the design of distributed systems, such as locking, concurrency, scheduling, and communication across networks. Students will identify the way in which several machines orchestrate to correctly solve problems in an efficient, reliable and scalable way.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction to Distributed Systems: Introduction to Distributed Computing System Models, Distributed Operating System, Difference between Network and Distributed System, Goals of Distributed System.	4	Understanding of various distributing computing system models along with the issues in designing a DOS.
2	Message Passing: Desirable features, Issues in IPC, Synchronization, Buffering, Encoding and Decoding, Process Addressing, Failure Handling, Group Communication.	4	Presents a desirable features and the issues in designing a good message passing system
3	Remote Procedure Calls: RPC Model, Transparency of RPC, Implementation of RPC Mechanism, RPC Messages, Marshalling, Server Management (Stateful and Stateless Server), Parameter-Passing Semantics (Call-by-Value, Call-by Reference), Call-Semantics, Communication Protocols for RPCs, Client-Server Binding, Special Types of RPCs.	4	Learn about a general IPC protocol that can be used for designing several distributed applications.
4	Distributed Shared Memory: General Architecture of DSM Systems, Design and Implementation Issues of DSM, Structure of Shared-Memory Space, Consistency Models, Replacement Strategy, Thrashing, Advantages of DSM.	6	Know about the general architecture of DSM systems along with the design and implementation issues of the same.
5	Synchronization: Clock Synchronization, Event Ordering, Mutual Exclusion, Deadlock, Election Algorithms.	6	Understand the synchronization mechanisms that are suitable for distributed systems.
6	Resource Management: Task Assignment Approach, Load-Balancing Approach, Load-Sharing Approach.	4	Concepts related to widely differing techniques and methodologies for scheduling processes of a distributed systems.

7	Process Management: Process Migration, Threads.	6	The best possible use of the processing resources of the entire system by sharing them among all processes running in distributed environment.
8	Distributed File Systems: File Models, File-Accessing Models, File Sharing Semantics, File-Caching Schemes, and File Replication.	4	Understanding about the desirable features of a good distributed file system along with the concepts of design and implantation of a distributed file system.
9	Security: Potential Attacks to Computer Systems, Cryptography, Authentication, Access Control, Digital Signatures.	2	This unit will help in understanding the need of security in distributed systems.

Text Books:

1. “Distributed Operating Systems – Concepts and Design”, by Pradeep K. Sinha (PMH)

Reference Books:

1. “Distributed Systems – Principles and Paradigms”, by Andrew S. Tanenbaum and Maarten Van Steen (PHI)
2. “Distributed Systems – Concepts and Design”, by G. Coulouris, J Dollimore and T. Kindberg (Pearson Education)

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD502	**Cloud Computing**	3	0	0	9

Course Objective
Students will try to learn: 1. Basics of cloud computing. 2. Key concepts of virtualization. 3. Different Cloud Computing services 4. Cloud Implementation, Programming and Mobile cloud computing 5. Key components of Amazon Web Services 6. Cloud Backup and solutions
Learning Outcomes
To learn how to use Cloud Services. To implement Virtualization To implement Task Scheduling algorithms. Apply Map-Reduce concept to applications. To build Private Cloud. Broadly educate to know the impact of engineering on legal and societal issues involved

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction: Overview of Distributed Computing Cloud introduction and overview Different types of cloud services Deployment models Advantages and Disadvantages, Companies in the Cloud	5	This section provides a brief introduction about cloud methodologies.
2	**Infrastructure as a Service (IaaS):** Introduction, CPU Virtualization - Hyper Storage Virtualization – SAN, ISCSI, Network Virtualization - VLAN	6	The section encompasses the structure of Infrastructure required for cloud computing
3	**Platform/Software as a Service (PaaS / SaaS):** From IaaS to PaaS, Introduction PaaS properties and Characteristics PaaS Techniques: File System GFS, HDFS	6	The section encompasses the structure of platform required for cloud computing
4	PaaS: Programming Model – Map Reduce Storage System , BigTable, HBase	6	This section supports the computing paradigms required for PaaS
5	Software as a Service (**SaaS):** Web Service, Applications and Web Portal	5	The section encompasses the structure of software services required for cloud computing
6	**Security in Cloud Environment:** Cloud Computing Threats, Security for Cloud Computing	5	This section briefs about security paradigms required for cloud environment.
7	Case Studies: Amazon EC2, Google App Engine, IBM Clouds, Microsoft's Windows Azure	3	This will discuss about case studies with suitable architectures

Text Books:

1. Raj Kumar Buyya, “Cloud Computing: Principles and Paradigms”, Wiley Press.
2. Barrie Sosinsky, “Cloud Computing Bible”, Wiley India.
3. Borko Furht and Armando Escalante, “Hand Book of Cloud Computing”, Springer.

Course Type	Course Code	Name of Course	L	T	P	Credit
DC	CSD518	**PATTERN RECOGNITION**	3	0	0	9

Course Objective
• To train the students about the key concepts and enable them to apply them in real life applications in various related fields like AI, Multi-biometric processing for security, authenticity, data and knowledge engineering
Learning Outcomes
• The knowledge and concepts in these topics are likely to help the students do better in future in job as well as in higher studies.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction, fundamentals and definitions	2	The students will be made familiar what this subject is for and what are the major application areas
2	Features: types and traits, scaling, ordering, measurements , normalization, invariance, dimensionality reduction of feature space, dimensionality reduction by feature selection, PCA,KPCA, ICA, MDA	10	This fundamental part will teach how to handle data and extract features so as to proceed with finding, locating and quantifying patterns in the data set
3	Bayesian decision theory;	6	This important part will teach them tro handle the problem of pattern recognition from a statistical and probabilistic point of view
4	Parameter estimation: MLE, LSE	5	This part will teach the student to find/predict the underlying statistical process associated with pattern classification and will learn the popular techniques for estimation of parameters using maximum likelihood and leat square estimation techniques
5	Parameter free methods:KNN, Clustering,	5	The students will learn about popular techniques of clustering - an unsupervised technique extensively used in pattern recognition tasks
6	special classifiers: linear regression, LDA, SVM, deep learning, CNN;	10	The students will learn some of the very widely used and popular techniques in pattern recognition and can apply them in real life problems
7	Classification with nominal features : decision tree, random forest; classifier independent concepts.	4	The students will teach some more about some mathematical concepts

Text Books:

1. Pattern Recognition and Machine Learning Christopher M Bishop, Springer
2. Pattern recognition by Sergios Theodoridis, Konstantinos Koutroumbas, Academic Press

Reference Books:

A Probabilistic Theory of Pattern Recognition by Luc Devroye, László Györfi, Gábor Lugosi , Springer Verlag.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD 515	Multimedia Systems & Security	3	0	0	9

Course Objective
To provide fundamental knowledge related to Multimedia Systems, and to know how the security may be incorporated with Multimedia Systems.
Learning Outcomes
Upon successful completion of this course, students will: • Enhance the ability to understand different Multimedia related applications. • Know how to ensure the security with Multimedia based applications. • To realize the security features in real time scenario. • This course will also provide a strong foundation for research in this particular area.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Multimedia Fundamentals and Representation: Introduction to Multimedia, Multimedia Data Representation, Classification of Multimedia Systems, Image Representation and Enhancement, Color Models, Fundamental Concepts in Video, Basics of Digital Audio.	8	• To provide the course outline. • To give some view of different multimedia formats
2	Multimedia Coding Techniques: Lossless Compression Algorithms: Run-Length Coding, Variable-Length Coding (Huffman Coding, Adaptive Huffman Coding), Arithmetic Coding, Adaptive Arithmetic Coding, Dictionary-Based Coding, Context-based Coding, CALIC, Lossy Compression Algorithms: Vector Quantization, Standard Image Compression Techniques (JPEG, JPEG 2000), Video Compression Technique (MPEG), Audio Coding.	12	• To understand different approaches for data compression • To learn some standard data compression algorithms like JPEG, MPEG
3	Multimedia Communication and Retrieval: Media Distribution across Internet, Mobile Multimedia Service over Wireless Networks, Content Based Image Retrieval	6	• To know some multimedia communication techniques • To learn multimedia retrieval process like CBIR
4	Multimedia Security: Performance Requirement of Multimedia Content Encryption, Modes of Block Ciphers, Complete, and Partial Encryption, Compression-Combined Encryption, Perceptual Encryption, Key Management, Typical Attacks on Multimedia Encryption, Multimedia Encryption in Typical Applications, Steganography, Digital Image Watermarking, Image Authentication, Visual Cryptography, Multimedia Forensics.	12	• To know the security requirements for multimedia data • To understand different security mechanism and • To learn security based some Multimedia applications.

Text Books:

5. Ze-Nian Li, and Mark S. Drew, “Fundamentals of Multimedia”, PHI Learning.
6. Fred Halsall, “Multimedia Communications: Applications, Networks, Protocols and Standards”, Pearson.
7. Shiguo Lian, “Multimedia Content Encryption: Techniques and Applications”, CRC Press

Reference Books:

1. Khalid Sayood, "Introduction to Data Compression", Elsevier Publication.
2. Latest publications in multimedia related conferences and journals.

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD 501	**ALGORITHMS FOR BIOINFORMATICS**	3	0	0	9

Course Objective
To provide knowledge of applications of computational methods in biological problems. This course will provide a scope for research in many areas of computer science to apply them in biology.
Learning Outcomes
Upon successful completion of this course, students will: ● Have a broad understanding of Basics and understanding of various tasks of bioinformatics that uses computational methods. ● Helps students to do interdisciplinary work and in biology with the help of computational tools and techniques, approaches. ● Students will learn advanced algorithms especially suited for bioinformatics research.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction to bioinformatics, biological sequence/structure, Central dogma of Molecular Biology, Genome Projects, Pattern recognition and prediction, Folding problem, Sequence Analysis, Homology and analogy	5	All basics of the subjects will be known and also learn the scope of the bioinformatics course.
2	Classical algorithms, exact matching problem, suffix trees, dynamic programming, fundamental preprocessing, Naive method, Boyer-Moore and Knuth-Morris-Pratt, keyword trees, linear-time construction of suffix trees,	8	Able to know all the classical approaches in various methods of bioinformatics
3	Pairwise alignment, scoring model, dynamic programming algorithms, Hidden Markov Models, Multiple sequence alignment	8	Understand Alignment methods and its applications.
4	Motif finding, Secondary database searching, Advanced topics in phylogenetic tree	8	Able to understand Motif finding in the sequence and its applications
5	Biological databases, Primary sequence databases, Protein classification databases. DNA databases, Specialized Genomic Resources, Importance of DNA analysis, Gene structure and DNA sequences, protein sequence and structure	8	Able to know Preparation Specialized Genomic Resources.
6	Gene expression analysis using microarray data, Application of Computational techniques on gene expression data, EST searches.	3	able to understand Microarray data preparation and processing for its analysis and EST process

Text Books:

1. Essential Bioinformatics 1st Edition, Jin Xiong
2. Algorithms on Strings, Trees and Sequences: Computer Science and Computational Biology (28 May 1997) by Dan Gusfield
3. Introduction to Bioinformatics By T. K. Attwood, Pearson education.

Reference Books:

1. An Introduction to Bioinformatics Algorithms By Neil C. Jones, Pavel A. Pevzner, Pavel Pevzner

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD510	Information Retrieval	3	0	0	9

Course Objective
This Subject provides students with an in-depth knowledge about the Information Retrieval. The students will be able to understand the various Retrieval Models, Link Analysis, Social Search techniques and related applications.
Learning Outcomes
• Knowledge and understanding: Outline the potential benefits Information Retrieval

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction: Basic IR system structure	2	Gives Basic understand the need of IR and its Structure
2	Retrieval techniques: Boolean retrieval, term-vocabulary, postings-lists, Dictionaries and tolerant retrieval: Wildcard queries, Spelling correction, Phonetic correction;	4	Describe various retrieval techniques and understanding Dictionaries
3	Inverted indices: Preprocessing steps, tokenization, stemming, stopword removal, term weighting;	4	Understanding how inverted indices are done.
4	Models: vector space model, probabilistic model, language models;	5	Understanding different models to analyze data.
5	Evaluation: standard test collection, concept of relevance, precision-recall based metrics, reciprocal rank;	4	Understanding Evaluation methods
6	Relevance feedback and query expansion: Rocchio algorithm;	4	Understanding Different expansion methods
7	Text classification: Naïve Bayes; Text clustering: Flat Clustering, Hierarchical Clustering;	8	Understanding Text classification
8	XML Retrieval: Basic concepts, Challenges, Evaluation; Web search: Structure of Web, web graph, Hidden Web, User intent, Web crawl.	4	Understanding XML Retrieval, Web search
9	Link Analysis: Web as a graph, PageRank, Hubs and Authorities; Social search: Community-based search activities, Question Answering, Collaborative Searching.	4	

Text Books:

1. An Introduction to Information Retrieval, By Christopher D. Manning, Prabhakar Raghavan, Hinrich Schütze, Cambridge University Press.

Reference Books:

1. Information Retrieval: Algorithms and Heuristics, By David A. Grossman, Ophir Frieder

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD503	**COMPUTATIONAL NUMBER THEORY**	**3**	**0**	**0**	**9**

Course Objective
To give students a detailed description of the main modern algorithms in computational number theory
Learning Outcomes
To use the modern algorithms in computational number theory for searching information in targeted areas such as cryptography, coding theory

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction, Prime Number Theorem, Goldbach and Twin Primes conjectures, Fermat primes, Mersenne primes, Euler primes, Miller-Robinson primes.	6	Understanding the different prime numbers
2	Euclid's algorithm, LCM, Theorem of arithmetic, Canonical prime factorization, Dirichlet's Theorem on primes in arithmetic progressions.	5	Understanding the Euclid's algorithm and others
3	Algebraic Structure: Groups, Ring, Field, Extension field.	7	Understanding the different Algebraic Structure
4	Modular arithmetic, Congruence: Linear congruence in one variable, CRT, Wilson theorem, Fermat's theorem, Pseudoprimes, Carmichael numbers.	6	Understanding the Modular arithmetic, Congruence related theorems
5	Arithmetic functions: Multiplicative functions, Moebius function, Euler phi function, Perfect numbers, Legendre symbol, Jacobi symbol;	5	Understanding the various Arithmetic functions
6	Continued Fractions.	2	Understanding the Continued Fractions
7	Quadratic residue: Quadratic congruence with primes and composites, Exponentiation and Logarithm.	5	Understanding the Quadratic residues
8	Elliptic Curves: Curve over real numbers and GF(2^n)	4	Understanding the Elliptic Curves

Text Books:

1. Elementary Number Theory: Primes, Congruences, and Secrets: A Computational Approach By William Stein.
2. A Computational Introduction to Number Theory and Algebra By Victor Shoup.
3. Computational Number Theory and Modern Cryptography By Song Y. Yan.
4. Elementary Number Theory with Applications By Thomas Koshy

Course Type	Course Code	Name of Course	L	T	P	Credit
DE	CSD511	Information Theory and Coding	3	0	0	9

Course Objective
The objective of the course is to give an insight into Information Theory, Source Coding, and Error Control Coding.
Learning Outcomes
Upon successful completion of this course, students will: ● Have a broad understanding of Information Theory, Source Coding, and Error Control Coding. ● Have a high-level understanding of different approaches so that digital data can be reliably transmitted over a noisy channel.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction to Information Theory, Uncertainty and Information, Information Measure, Entropy of Markov Sources, Extensions of Sources; Channel Models, Channel Capacity, Information Capacity Theorem.	6	Comprehensive introduction about the course content will be delivered.
2	Source Coding: Instantaneous Codes, Kraft Inequality, Source Coding Theorem, Shannon Codes, Shannon-Fano Codes, Huffman Codes, Arithmetic Codes.	4	To learn the need of source coding and to get an overview of different categories of source codes.
3	Fundamentals of Channel Coding: Decoding Rules, Definition of Block code, Single parity check codes, Product code, Hamming codes, Error-detection and error-correction capabilities of block codes. Bounds on the size of codes.	6	To understand the need for channel coding in a communication system and to learn some special class of Block codes and their encoding-decoding procedures.
4	Definition of linear codes, Parity Check Matrix, Decoding of Linear Block code.	4	This unit will help students to understand another class error control codes like Linear Code and its encoding-decoding mechanism.
5	Definition of Cyclic codes, Encoding and Decoding of Cyclic codes, LFSR based Cyclic code Encoding-decoding.	8	To understand encoding-decoding mechanism of cyclic codes and to realize encoding-decoding of cyclic codes using LFSR.

6	Definition of BCH codes, Encoding and Decoding of BCH codes, PGZ Decoder, Reed-Solomon codes.	6	To learn BCH and Reed-Solomon codes.
7	Convolution codes: Encoding, State diagram, Trellis diagram, Viterbi Decoder, Turbo codes.	6	To understand encoding-decoding of Convolution codes and Turbo codes

Text Books:

1. R. Togneri and C. J. S. deSilva, Fundamentals of Information Theory and Coding Design, CRC Press
2. S. Gravano, Introduction to Error Control Codes, Oxford

Reference Books:

1. K. Sayood, Introduction to Data Compression, Morgan Kaufmann
2. S. Lin and D. J. Costello, Error Control Coding, Prentice Hall
3. Todd K. Moon, Error Correction Coding, Wiley-Interscience

List of Subjects for Open Electives

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	CSO503	Data Mining	3	0	0	9

Course Objective
Course Objective: This Subject provides students with an in-depth knowledge about the Data Mining. The students will be able to understand the various Techniques like Associations, Classification and Clustering and related applications.
Learning Outcomes
Knowledge and understanding: Outline the potential benefits of Data Mining.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction: Data mining functionalities, classification and integration, major issues in data mining	4	Understanding introduction concepts
2	Data preprocessing: data summarization, data cleaning, data integration and transformation and data reduction;	4	Understanding Preprocessing techniques
3	Data warehouse and OLAP Technology: a multidimensional data model, data warehouse architecture;	3	Understanding Data warehouse and OLAP
4	Mining Frequent Patterns; Associations and correlations: efficient and scalable frequent item-set mining methods, mining various kinds of association rules, constraints based association mining;	6	Understanding Associations rules and related topics
5	Classification: Basic concepts and advanced Methods, Prediction, Accuracy and Error Measures, Evaluating the accuracy of a classifier or Predictor, Ensemble Methods,	7	Understanding classifications techniques
6	Clustering: Partitioning Methods, Hierarchical Methods, Density-Based Methods, Model-Based Clustering Methods, Clustering High-Dimensional Data.	8	Understanding clustering techniques
7	Outlier Detection, Mining Stream.	8	Understanding Outlier detection Stream Mining
8	Time-Series, and Sequence Data, Text Mining	4	Understanding Time Series
9	Applications and Trends in Data Mining	5	

Text Books:

1. Data Mining: Concepts and Techniques, By Jiawei Han, Jian Pei, Micheline Kamber, Elsevier.

Reference Books:

2. Data Mining: The Textbook, By Charu C. Aggarwal, Springer International.

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	CSO505	Soft Computing	3	0	0	9

Course Objective: To make familiarize with Fundamentals of Soft Computing
Learning Outcomes
• To make familiarize with Fundamentals of Soft Computing so that learner may start working for Soft Computing applications

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Artificial Neural Networks (ANN): Basics Characteristics of artificial neural networks, Comparison with biological neural networks, Advantages and disadvantages of ANNs, Synaptic dynamics, Applications of ANNs, Basic Models: Mc-Culloch Pitt's model, Single Layer and Multilayer Perceptron model of neural networks, Hebb's model,	8	To make familiarize with basics and models of Artificial neurons
2	Learning Laws; Learning: Supervised, unsupervised, Reinforcement Law of learning; Differences among learning laws; LMS and Delta Learning, Gradient descent method, Multilayer Perceptron Model (MLP), Back propagation algorithm for weight updates, classification problem using MLP; Architecture for complex pattern recognition tasks;	6	To make familiarize with various learning paradigms with few ANN models
3	Genetic Algorithm: working Principle, Cross-over mutation, roulette wheel selection, tournament selection, population, binary encoding and decoding for any optimization problem, Multi objective Gas, Concepts on Non-domination, tournament selection, crowding distance operator, ranking,	6	To make familiarize with working principles of various meta-heuristic algorithms for search and optimizations
4	Fuzzy Logic: Fuzzy sets, basic operations, membership functions, Fuzzy Relations, Fuzzification, Fuzzy Inference, Fuzzy Rule Based System, Defuzzification;	6	To make familiarize with Fuzzy concepts
5	Rough Sets: basic operations, lower and upper, approximations, discernibility matrix, distinction table; Accuracy of Approximations.	6	To make familiarize with Rough Sets Theory
6	Hybridization of Soft Computing tools like Neuro-fuzzy, Rough fuzzy, Rough-Fuzzy-GA etc. boundary region. Applications	6	To make familiarize with Hybridizing the components for various applications

Text Books:

1. Principles of Soft Computing, 2ed (WILEY) 2011, S.N. Deepa S.N. Sivanandam

Reference Books:

2. Kalyanmoy Deb, Multi-Objective Optimization using Evolutionary Algorithms Paperback – 2010, Wiley
3. GENETIC ALGORITHMS: in search, optimization and machine learning 1 Dec 2008, D. E. GOLDBERG, P
4. Artificial Neural Networks 1998 B. Yegnanarayana, PHI
5. Neural Networks: Algorithms, Applications, and Programming Techniques, 1e – 2002, James FREEMAN and David Skapura, Pearson

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	CSO504	Machine Learning	3	0	0	9

Course Objective: To make familiarize with Fundamentals of Machine Learning
Learning Outcomes
• To make familiarize with Fundamentals of Machine Learning so that learner may start working for machine learning applications

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction: Well Defined Learning Problems, Designing A Learning System, Issues In Machine Learning. Learning Tasks: General-To-Specific Ordering Of Hypotheses, Candidate Elimination Algorithm, Inductive Bias.	6	To make familiarize with basics of Machine learning
2	Decision Tree Learning: Decision Tree Learning Algorithm-Inductive Bias- Issues In Decision Tree Learning. Evaluating Hypotheses – Estimating Hypotheses Accuracy Basics Of Sampling Theory, Comparing Learning Algorithms, Bayesian Learning – Bayes Theorem, Concept Learning, Bayes Optimal Classifier, Naïve Bayes Classifier, Bayesian Belief Networks, EM Algorithm,	8	To make familiarize with decision tree based learning and statistical learning
3	Computational Learning Theory – Sample Complexity For Finite Hypothesis Spaces. Artificial Neural Networks: Perceptron, Gradient Descent And The Delta Rule, Adaline, Multilayer Networks, Derivation Of Backpropagation Rule backpropagation Algorithm.	6	To make familiarize with Artificial Neural Networks
4	Generalization. Genetic Algorithms – An Illustrative Example, Hypothesis Space Search, Genetic Programming, Models Of Evolution And Learning;	6	To make familiarize with Meta-heuric techniques
5	Reinforcement Learning 13 - The Learning Task, Q Learning, Instance-Based Learning – K-Nearest Neighbor Learning, Locally Weighted Regression, Radial Basis Function Networks, Case-Based Learning	8	To make familiarize with Reinforcement Learning

Text Books:

1. Artificial Neural Networks 1998 B. Yegnanarayana, PHI
2. Neural Networks: Algorithms, Applications, and Programming Techniques, 1e – 2002, James FREEMAN and David Skapura, Pearson

Reference Books:

1. Kalyanmoy Deb, Multi-Objective Optimization using Evolutionary Algorithms Paperback – 2010, Wiley
2. GENETIC ALGORITHMS: in search, optimization and machine learning 1 Dec 2008, D. E. GOLDBERG,

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	CSO502	Data Analytics	3	0	0	9

Course Objective

The main goal of this course is to help students learn, understand, and practice big data analytics and machine learning approaches, which include the study of modern computing big data technologies and scaling up machine learning techniques focusing on industry applications. Mainly the course objectives are: conceptualization and summarization of big data and machine learning, trivial data versus big data, big data computing technologies, machine learning techniques, and scaling up machine learning approaches.

Learning Outcomes

- Ability to identify the characteristics of datasets and compare the trivial data and big data for various applications.
- Ability to select and implement machine learning techniques and computing environment that are suitable for the applications under consideration.
- Ability to recognize and implement various ways of selecting suitable model parameters for different machine learning techniques.
- Ability to integrate machine learning libraries and mathematical and statistical tools with modern technologies like Hadoop and map reduce.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Introduction, Big Data; Descriptive Statistics: Descriptive Statistics and Probability Distributions.	3	Understanding what is Big data and use of statistics for various data analysis.
2	Inferential Statistics: Inferential Statistics through hypothesis tests Permutation & Randomization Test.	4	To get knowledge of inferential statistics.
3	Regression & ANOVA: Regression and ANOVA (Analysis of Variance).	3	To know how to predict next by the use of regression technique and using ANOVA related to given data set.
4	Machine Learning: Introduction and Concepts: Differentiating algorithmic and model based Frameworks.	3	To know the application of machine learning in data analytics.
5	Regression: Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbours Regression & Classification.	5	To have the knowledge of prediction and classification techniques for a given data set.
6	Supervised Learning with Regression and Classification techniques -1: Bias-Variance Dichotomy; Model Validation Approaches; Logistic Regression; Linear Discriminant Analysis; Quadratic Discriminant Analysis.	7	To know various techniques related to different learning techniques.
7	Regression and Classification Trees Support Vector Machines; Ensemble Methods: Random Forest; Neural Networks; Deep learning; Unsupervised Learning and Challenges for Big Data Analytics: Clustering, Associative Rule Mining Challenges for big data analytics.	8	Further to know various approaches related to different learning techniques.
8	Scalable Computing: Hadoop and Map Reduce.	3	To have the knowledge of using Hadoop and Map Reduce.

Text Books:

8. Data Analytics Made Accessible, by A. Maheshwari
9. Big Data Analytics, By Seema Acharya, Wiley

Reference Books:

1. Machine Learning and Big Data by Kareem Alkaseer
2. Predictive Analytics: The Power to Predict Who Will Click, Buy, Lie, or Die by E. Siegel
3. Too Big to Ignore: The Business Case for Big Data, by award-winning author P. Simon,

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	CSO501	Principles of Artificial Intelligence	3	0	0	9

Course Objective

Course will introduce the basic principles in artificial intelligence, which covers blind and heuristic search strategies, simple knowledge representation schemes, introduction to CSP problems and use for general purpose heuristic for constraint propagation, genetic algorithm, rule based system, Introduction to probabilistic reasoning, planning and learning neural network models, Areas of application, natural language processing, will be explored. The PROLOG programming language will also be introduced.

Learning Outcomes

Understanding of the following: Problem as Search - Converting real world problems into AI search problems and explain important search concepts, such as the difference between informed and uninformed search, the definitions of admissible and consistent heuristics and completeness and optimality. Understanding of various heuristic search techniques, MiniMax search for game playing. Constraint Satisfaction - Formulation of real world problem as CSP problem and solution for CSP using general purpose heuristics, Genetic Algorithm for optimization. Knowledge representation using First order logic, proofs in first order using techniques such as resolution, unification. Rule based system and logic programming using Prolog programming language, Planning techniques, Bayesian network and reasoning Fundamentals of learning using neural net, decision tree, naïve- Bayes, nearest neighbor, inductive learning, Fundamentals of NLP.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	Artificial Intelligence Introduction, Brief history, Problem solving by search: state space, Search and Knowledge representation. Uninformed search : Breadth First Search, Depth First Search, Depth First with Iterative Deepening and Uniform Cost Search,	4	Learning various Informed and Uninformed search techniques.
2	Heuristic Search: Hill climbing, Simulated Annealing, A*, problem reduction, Algorithm, Minimax search	5	Learning heuristic search
3	Binary and Higher order CSP, Constraint Satisfaction Graph, MRV, Degree, Least Constraining, Forward Checking and Arc Consistency General purpose heuristics for CSP	4	Learning various techniques constraint satisfaction problems.
4	Introduction to genetic algorithm, operations: selection, crossover, mutation examples	3	Learning various techniques in the context of AI.
5	Propositional logic, Definition of logic formula, Meaning of logic formula, Classification of logic formula, unification and resolution, horn clause, Logic based representations (PL, FoL) and inference, Logic Programming: Prolog. Rule based representations, forward and backward chaining, matching algorithms.	7	Learning various logic representation techniques includes forward and backward chaining. Understanding towards inference mechanism in declarative programming languages through Prolog programming language
6	Planning Techniques: Goal Stack Planning, Constraint posting	4	Learning various planning techniques in the context of AI.
7	Probabilistic Reasoning: Bayesian Network and reasoning.	3	Learning various probabilistic techniques includes Bayesian network and reasoning.
8	Learning: Neural Network models, Statistical methods: Naive-Bayes, Nearest Neighbor, Decision trees, Inductive Learning	4	Learning various techniques in NN, Decision tree and learning methods.
9	Introduction to Natural Language Processing	2	Learning various techniques in NLP.
10	Introduction to Fuzzy Logic, Reasoning through fuzzy logic, Expert system, Definition of fuzzy set, Membership function ,Notation of fuzzy set, Operations of fuzzy set • Fuzzy number and operations, Extension principle , Fuzzy rules, De-fuzzification, Fuzzy control	4	Understanding of fuzzy fundamentals and fuzzy inference systems

Text Books:

1. Artificial Intelligence Modern Approach Third Edition by S. Russell. Norvig,PHI

Reference Books:

1. Artificial Intelligence Third Edition by Kevin Knight (Author), Elaine Rich (Author)
2. Artificial Intelligence, Structures and Strategies for Complex Problem Solving George F Luger, Sixth Edition, Pearson.
3. Machine Learning by Mitchell, Tom M. Indian Edition.

Course Type	Course Code	Name of Course	L	T	P	Credit
OE	CSO506	Principles of Blockchain Technology	3	0	0	9

Course Objective
The objective of the course is to present an understanding of Blockchain Technology, Cryptocurrency, the research gap, and its applications.
Learning Outcomes
Upon successful completion of this course, students will: • Have an insight into the structure of Blockchain Technology and its importance. • Know how to build cryptocurrency applications based on Blockchain Technology. • Know how to explore the possible realization of Blockchain technology for applications other than cryptocurrency.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1.	Introduction- Concepts of cryptocurrency and Blockchain, Consensus Algorithms- Security of Blockchain, Blockchain Programs and Network, Concept of Blockchain parameters- Header, Miners, Difficulty, Nonce, Stakes, Forking, Double-Spending Problem;	3	#Basic overview and understanding about the Cryptocurrency and Blockchain Technology.
2.	Preliminaries: Security Services and Mechanisms, Public Key Cryptosystem, ECC, Cryptographic Hash Functions, Digital Signatures, PKI, Merkle Tree	7	#To present the fundamental cryptographic concepts that are essential for Blockchain technology. #To learn about Merkle Data structures, that is commonly used in storing large amounts of data in Blockchain
3.	Bitcoin Cryptocurrency: Transactions, Mining, Consensus Mechanisms and Validation: Poof of Work (PoW), Proof of Stake (PoS), Practical Byzantine Fault Tolerance (PBFT), Ripple Protocol Consensus Algorithm (RPCA), Bitcoin Security issues, Introduction of Bitcoin Program	7	#Basic understanding of Blockchain technology through Bitcoin application.
4.	Ethereum Cryptocurrency: Ethereum vs. Bitcoin, Transactions, Ethereum Blocks, Mining Algorithm, GHOST Protocol, Privacy, Security issues in Blockchain: Anonymity, Sybil Attacks, Selfish Mining, 51/49 ratio Attacks	7	#Basic understanding of Ethereum based Blockchain technology. # To learn some Privacy and Security issues in Blockchain
5.	Study and comparison of different consensus algorithms: PoS, PoS, Algorand, Ouroboros, Ethereum's consensus etc.	5	#To understand different consensus algorithms in details.
6.	Smart Contract Fundamentals: Introduction to Smart Contracts, Framework of smart contract, Life cycle of smart contract, Challenges of Smart Contract.	5	# To get an overview on Smart Contracts
7.	Case Studies as Blockchain technology based Applications (like in e-Governance, e-Commerce, Database Applications where third party is involved)	6	#Understanding the possible research scope based on studies of some recent research papers.

Text Books:

1. A. Narayanan, J. Bonneau, E. Felten, A. Miller, and S Goldfeder, "Bitcoin and Cryptocurrency Technologies", Princeton University Press, 2016

2. Xiwei Xu, I. Weber, M. Staples, “Architecture for Blockchain Applications”, Springer, 2018.

Reference Books

1. M. Swan, “Blockchain: Blueprint for a New Economy”, OReilly, 2015
2. Lecture Note of S.Vijayakumaran (IIT Bombay), “An Introduction to Bitcoin”.
3. Lecture Note of S. Shukla (IIT Kanpur), “Introduction to Blockchain Technology and Applications”.