VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

School of Computer Science and Engineering

CURRICULUM AND SYLLABI

(2021-2022)

M.Tech (CSE) - Specialization in AI & ML

School of Computer Science and Engineering

M.Tech (CSE) - Specialization in AI & ML

CURRICULUM AND SYLLABUS

(2021-2022 Admitted Students)

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VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

World class Education: Excellence in education, grounded in ethics and critical thinking, for improvement of life.

Cutting edge Research: An innovation ecosystem to extend knowledge and solve critical problems.

Impactful People: Happy, accountable, caring and effective workforce and students.

Rewarding Co-creations: Active collaboration with national & international industries & universities for productivity and economic development.

Service to Society: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF THE SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

To be a world-renowned centre of education, research and service in computing and allied domains.

MISSION STATEMENT OF THE SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

- To offer computing education programs with the goal that the students become technically competent and develop lifelong learning skill.
- To undertake path-breaking research that creates new computing technologies and solutions for industry and society at large.
- To foster vibrant outreach programs for industry, research organizations, academia and society.

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School of Computer Science and Engineering

M.Tech (CSE) - Specialization in AI & ML

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering professionals who will engage in technology development and deployment with social awareness and responsibility.

2. Graduates will function as successful practising engineer / researcher / teacher / entrepreneur in the chosen domain of study.

3. Graduates will have holistic approach addressing technological, societal, economic and sustainability dimensions of problems and contribute to economic growth of the country.

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School of Computer Science and Engineering

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PROGRAMME OUTCOMES (POs)

PO_1 Having an ability to apply mathematics and science in engineering applications

PO_2 Having an ability to design a component or a product applying all the relevant standards and with realistic constraints

PO_3 Having an ability to design and conduct experiments, as well as to analyze and interpret data

PO_4 Having an ability to use techniques, skills and modern engineering tools necessary for engineering practice

PO_5 Having problem solving ability- solving social issues and engineering problems

PO_6 Having adaptive thinking and adaptability

PO_7 Having a clear understanding of professional and ethical responsibility

PO_8 Having a good cognitive load management [discriminate and filter the available data] skills

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M.Tech (CSE) - Specialization in AI & ML

PROGRAMME SPECIFIC OUTCOMES (PSOs)

1. The ability to formulate mathematical models and problem-solving skills through programming techniques for addressing real-life problems using appropriate knowledge representation, problem-solving, and learning methods.

2. Become familiar with the insights of Artificial Intelligence and Machine Learning towards problem solving, inference, perception, knowledge representation, and learning.

3. Ability to bring out the capabilities for research and development in contemporary issues and to exhibit the outcomes as technical report.

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SCHOOL OF COMPUTER SCIENCE AND ENGINEERING
M.Tech. (Computer Science and Engineering-Specialisation in AI & ML)
Curriculum (AY: 2021 -22)

Sl. NO	Category	Total No. of Credits
1	University Core	**27**
2	University Elective	**6**
3	Programme Core	**22**
4	Programme Elective	**15**
	Total	**70**

University Core [27 Credits]

Course Code	Course Title	L	T	P	J	C	Pre-Req	Category
CSE6099	Masters Thesis	0	0	0	0	16	-	E
MAT5014	Mathematics for Artificial Intelligence	3	0	0	0	3	-	S
SET5001	Science, Engineering and Technology Project - I	0	0	0	0	2	-	E
SET5002	Science, Engineering and Technology Project - II	0	0	0	0	2	-	E
EFL5097	English / Foreign Language	0	0	0	0	2	-	H
STS5777	Soft Skills	0	0	0	0	2	-	H
	Total	***27 Credits***						

PROGRAMME CORE (Credits to be earned: 22)

Course Code	Course Title	L	T	P	J	C	Pre-Req
CSE5010	Data Structures and Algorithms Analysis	3	0	2	0	4	-
CSE5002	Operating Systems and Virtualization	2	0	2	0	3	-
CSE5011	Database Systems and Design	2	0	2	0	3	-
MAT6006	Mathematics for Machine Learning	3	0	0	0	3	-
CSE5012	Artificial Intelligence: Principles and Techniques	2	0	2	0	3	-
CSE6024	Machine Learning Techniques	2	0	2	0	3	-
CSE6034	Big-data Analytics	2	0	2	0	3	-
	Total	***22 Credits***					

PROGRAMME ELECTIVE (Credits to be earned: 15)

Course Code	Course Title	L	T	P	J	C	Pre-Req
CSE6069	Advances in Cryptography and Network Security	2	0	2	0	3	-
CSE6072	Web Technologies	2	0	2	0	3	-
CSE5021	Data Warehousing and Mining	2	0	2	0	3	-
CSE5004	Computer Networks	2	0	2	0	3	-
CSE6008	Distributed Systems	2	0	0	0	3	-
CSE6070	Cloud Computing	2	0	0	4	3	-
CSE6071	Cognitive Science	3	0	0	0	3	-
CSE6062	Soft Computing Techniques	3	0	0	0	3	-
CSE6059	Digital Imaging Techniques and Analysis	3	0	0	0	3	-
CSE6063	Knowledge Engineering and Expert Systems	3	0	0	0	3	-
CSE6060	Statistical Natural Language Processing	3	0	0	0	3	-
CSE6037	Deep Learning and its Applications	2	0	2	0	3	-
MATXXX	Stochastic Models and Applications	3	0	0	0	3	-
CSE6064	Intelligent Information Retrieval	3	0	0	0	3	-
CSE6038	Bio-Inspired Computing	3	0	0	0	3	-
CSE6065	Pattern Recognition	3	0	0	0	3	-
CSE6066	Reinforcement Learning	3	0	0	0	3	-
CSE6067	Machine Learning for Signal Processing	3	0	0	0	3	-
CSE6068	Machine Learning with Large Data sets	3	0	0	0	3	-

PROGRAMME CORE

CSE5002	OPERATING SYSTEMS AND VIRTUALIZATION	L	T	P	J	C
		2	0	2	0	3
Pre-requisite	**Nil**	**Syllabus version**				
		1.0				

Course Objectives:

1. To introduce Virtualization, operating systems fundamental concepts and its technologies.
2. To provides skills to write programs that interact with operating system components such as processes, thread,memory during concurrent execution.
3. To provide the skills and knowledge necessary to implement, provisioning and administer server and desktopvirtualization.

Expected Course Outcomes:

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

1. Study operating system layers and kernel architectures.
2. Design various techniques for process management.
3. Construct various address translation mechanism.
4. Perform process threading and synchronization.
5. Study various methods of virtualization and perform desktop and server virtualization.
6. Classify the light-weight virtual machines with dockers and containers.
7. Develop programs related to the simulations of operating systems and virtualization concepts.

Module:1	**INTRODUCTION**	**2 hours**

History of OS - Computer system architecture a layered view with interfaces, Glenford Myer, Monolithic Linux
Hybrid Windows 10 kernels Layered architecture of operating system and core functionalists.

Module:2	**PROCESS**	**5 hours**

Introduction, Process Operations, States, Context switching, Data Structures (Process Control Block (PCB),
Process Scheduling: Multi-Level Feedback Queue, Multi-processor Scheduling, Deadlocks and its detection.

Module:3	**MEMORY**	**4 hours**

Introduction, Address Spaces, Memory API, Address Translation, Paging - Faster Translations (TLB), Smaller
Tables. Virtual Memory System in x86.

Module:4	**CONCURRENCY**	**6 hours**

Introduction, Thread Models, Thread API, Building Evaluating a Lock, TestAndSet, Classical problems handling
using semaphore, Monitors, Persistence - File Organization: The i-node, Crash Consistency file security.

Module:5	**VIRTUAL MACHINES**	**2 hours**

Process and System VMs Taxonomy of VMs.

Module:6	**TYPES OF VIRTUALIZATION**	**4 hours**

Hardware Emulation, Full Virtualization with binary translation, Hardware assisted, Operating System
Virtualization, OS assisted /Para virtualization.

Module:7	**HYPERVISOR**	**5 hours**

Type 1, Type 2, Paravirtualization,Server Virtualization, Desktop Virtualization, Overview VM portability -
Clones, Templates, Snapshots, OVF, Hot and Cold Cloning Protecting Increasing Availability, Light WeightVirtual machine: Container / Docker.

Module:8	**RECENT TRENDS**	**2 hours**

	Total Lecture hours:	**30 hours**	

Text Book(s)				
1.	Silberschatz, Abraham, Greg Gagne, and Peter B. Galvin, "*Operating system concepts"*, 10th Edition, WileyPublishers, 2018.			
2.	Matthew Portnoy, "*Virtualization Essentials*", John Wiley Sons Inc; 2nd Edition Edition, 2016.			
Reference Books				
1.	Thomas Anderson, Michael Dahlin, "*Operating Systems: Principles and Practice*", 2nd Edition, RecursiveBooks, 2014.			
2.	William Stallings, *"Operating Systems: Internals and Design Principles",* 8th Edition, 2014.			
3.	Smith, Nair,*"Virtual Machines: Versatile Platforms for Systems and Processes"*, 1st Edition, MorganKaufmann Publishers, 2005.			
	Authors, book title, year of publication, edition number, press, place			
Mode of Evaluation: CAT / Assignment / Quiz / FAT / LAB / Seminar				
List of Indicative Experiments				
1.	Study of Basic Linux Commands.			3 hours
2.	Shell Programming (I/O, Decision making, Looping, Multi-level branching).			3 hours
3.	Crating child process using fork() system call, Orphan and Zombie process creation.			3 hours
4.	Simulation of CPU scheduling algorithms (FCFS, SJF, Priority and Round Robin).			3 hours
5.	Simulation of Bankersalgorithm to check weather given system is in safe state or not. Also check whether addition resource requested can be granted immediately.			3 hours
6.	Parallel Thread management using pthread library. Implement a data parallelism using multi-threading.			3 hours
7.	Dynamic memory allocation algorithms - first-fit, best-fit, worst-fit algorithms.			3 hours
8.	Page Replacement Algorithms FIFO, LRU and Optimal.			3 hours
9.	Virtualization Setup: Type-1, Type-2 Hypervisor.			3 hours
10.	Implementation of OS / Server Virtualization.			3 hours
Total Laboratory Hours				**30 hours**
Mode of assessment: CAT / Assignment / Quiz / FAT / Seminar				
Recommended by Board of Studies	**13-05-2016**			
Approved by Academic Council	**No. 41**	**Date**	**17-06-2016**	

Course code	Data Structures and Algorithms Analysis	L	T	P	J	C
CSE5010		3	0	2	0	4
Pre-requisite	Nil	Syllabus version				

Course Objectives:

1. To focus on the design of algorithms in various domains
2. To provide a foundation for designing efficient algorithms.
3. To provide familiarity with main thrusts of working algorithms-sufficient to gives context for formulating and seeking known solutions to an algorithmic problem.

Expected Course Outcome:

1. Use the fundamental data types of computing (lists, stacks, queues, priority queues, sets, maps, trees, etc.).
2. Understand the major techniques for implementing the fundamental data types (linked lists, binary search trees, hashing, heaps, etc.) and implement several of them.
3. Properly use and select data structures from language-provided data-structure libraries.
4. Apply basic algorithm analysis.
5. Understand how recursion works and write programs using recursion to solve problems.
6. Make informed decisions about which sorting and searching algorithms to use in specific circumstances.
7. The student can make the distinction between problems and their algorithmic solutions
8. The student can prove the correctness of a subset of the algorithms considered in the course.

Module:1	DATA STRUCTURES	3 hours	

Introduction to data structures- Arrays-Linked Lists-Doubly Linked Lists-Stack, Evaluations of expression-Conversion of Infix to postfix-Multiple stacks-Queues, Circular Queues-Priority queues-Dequeues

Module:2	TREES	5 hours	

Heaps, dictionaries, hash tables, bloom filters, binary search trees-, Creation-Insertion-Deletion-Update-Search operations- Recursive Tree traversal- Non-Recursive Tree Traversal, Interval trees, AVL Trees – Splay Trees – B-Trees – B^+-Trees- Red Black Trees

Module:3	GRAPH REPRESENTATION AND ALGORITHMS	5 hours	

Graphs – Definitions – Representation of Graphs – Graph Traversals– Shortest path algorithm – Minimum spanning tree – graph traversals. Undirected Graphs – Biconnectivity – Directed Graph –Detecting Strong Components – All Pair Shortest paths – Floyd Warshall algorithm – Network Flow Problem – A Simple Maximum Flow Algorithm

Module:4	SEARCHING AND SORTING	3 hours	

Internal Sorting- Bubble sort, Insertion sort, selection sort, Merge sort, bucket and radix sort;

medians and order statistics. Indexed sequential searching and Interpolation search			
Module:5	**ALGORITHM DESIGN ANALYSIS**	**3 hours**	
The Role of Algorithms in Computing – Algorithms – Designing Algorithms – Analysing Algorithms – Iterative Algorithms-Asymptotic notations and their significance, running time of an algorithm, Time-complexity of an algorithm, Performance analysis of an algorithm, Master theorem (without proof)			
Module:6	**COMPUTATIONAL COMPLEXITY CLASSES**	**5 hours**	
Understanding of Computational Complexity – NP-Hard –NP-Completeness – Reducibility – Cook's Theorem – NP-Completeness Proofs – Probabilistic Analysis and Randomized Algorithms – Quicksort – Approximation Algorithms – Set Cover and Vertex Cover- 3-CNF-SAT Reduction Problems			
Module:7	**ADVANCED ALGORITHMS AND ANALYSIS**	**4 hours**	
Divide and Conquer, Brute force, Greedy, Recursive Backtracking, and Dynamic programming, Matrix Chain Multiplication – Elements of Dynamic Programming – Longest Common Subsequence – Basics of String – String Edit Problem-Knuth-Morris-Pratt algorithm - Rabin-Karp algorithm- Line segments: properties, intersections; convex hull finding algorithms-Limitations of approximation - Vertex-cover problem			
Module:8	**RECENT TRENDS**	**2 hours**	
	Total Lecture hours:	**30 hours**	

Reference Books

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, "Introductionto Algorithms", MIT Press, 3rd Edition, 2009.
2. Ellis Horowitz, Sartaj Sahni, Sanguthevar Rajasekaran, "Computer Algorithms", SiliconPress Publications, 2nd Edition, 2008.
3. Ellis Horowitz, Sartaj Sahni, Dinesh Mehta, "Fundamentals of Data Structures using C++", 2nd Edition, Universities Press, 2008.
4. Alfred V. Aho, John E. Hopcroft, Jeffrey D. Ullman, "Data Structures and Algorithms",Pearson, 1st Edition, 2006
5. S.Sridhar, "Design and Analysis of Algorithms", Oxford University Press, 2015

6. Tim Roguhgarden, "Algorithms Illuminated" (Part 3), Soundlikeyourself Publishing, LLC, 2019		
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		
List of Challenging Experiments (Indicative)		
1.	Implementation of Stack, Queue and List Data Structures using Pointers.	2 hours
2.	Implementation of AVL trees.	2 hours
3.	Implementation of Splay Trees.	2 hours
4.	Implementation of a Heap trees.	3 hours
5.	Implementation of Graphs and Sorting of vertices using Topological Sort	3 hours
6.	Implementation of Graph Traversals Algorithms: Breadth-First Search, Depth-FirstSearch.	3 hours
7.	Implementation of Shortest Path Algorithms: Dijkstra's algorithm, Bellman-Fordalgorithm, Floyd-Warshall algorithm.	3 hours
8.	Implementation of Minimum Spanning Tree: Kruskal's and Prim's algorithm.	3 hours
9.	Merge sort algorithm analysis using divide and conquer	3 hours
10.	Quick sort using randomized algorithmic approach	3 hours
11.	Matrix chain multiplication using dynamic programming	3 hours
	Total Laboratory Hours	30 hours
Mode of evaluation:		
Recommended by Board of Studies	01-06-2019	
Approved by Academic Council	No. 55	Date 24-09-2019

Course code	Course title	L	T	P	J	C
CSE5011	DATABASE SYSTEMS AND DESIGN	2	0	2	0	3
Pre-requisite		Syllabus version				
		v. xx.xx				

Course Objectives:

1. To emphasize the underlying principles of Relational Database Management System.
2. To model and design advanced data models to handle threat issues and counter measures.

Expected Course Outcome:

1. Design and implement database depending on the business requirements and considering various design issues. 7-2

2. Analyse the requirements of data and transaction management in mobile and spatial database and differentiate those with RDBMS. 7,17-3

3. Categorize and design the structured, semi structured and unstructured databases. 7,17-2

4. Characterize the database threats and its countermeasures. 5-2

5. Comprehend, design and query the database management system. 5,7-2

Module:1	Database Systems:	5 hours	

Introduction to the Database Systems, Architecture, Concepts of Relational Models and Relational Algebra, Relational Calculus. SQL: Introduction to SQL Queries, Integrity Constraints, Joins, Views, Intermediate and Advanced SQL features and Triggers.

Module:2	Database Design:	5 hours	

Overview of the Design process, E-R Models, E-R Diagrams, Conversion of E-R Diagrams into Tables, Generalization and Specialization, Functional dependencies and other kinds of dependencies, Normal forms, Normalization and Schema Refinement, 1-NF, 2-NF, 3-NF, BCNF, 4-NF, and 5-NF, Join-Dependencies, Non-loss join.

Module:3	Database Application Design and Development:	4 hours	

User Interfaces and Tools, Embedded SQL using C-Language, Dynamic SQL, Cursors and Stored procedures, JDBC, Security and Authorization in SQL, Internet Applications.

Module:4	**Indexing Hashing and Query Evaluation:**	**4 hours**	
File Organization – Indexing - B^+Tree indexing, B-Tree Indexing, Hashing, Static and Dynamic hashing, Query processing, Query optimization, Performance Tuning.			
Module:5	**Transaction Management:**	**4 hours**	
Overview of Transaction Management, Transactions, Concurrency Control Techniques-Lock-based protocols-Two-phase locking protocol-Time-stamp based protocols, Recovery systems-Log based recovery techniques, Shadow paging- Advanced Transaction Processing-Deadlocks Handling.			
Module:6	**Advanced Data Models:**	**4 hours**	
Centralized and Client-Server Databases, Parallel and Distributed database, Object-Oriented databases, XML Databases, Spatial and Temporal Databases-Active and Deductive Databases, Mobile Databases, Cloud Databases.			
Module:7	**Case Studies:**	**2 hours**	
My-SQL, Oracle, IBM DB2 Universal Database, Microsoft SQL Server.			
Module:8	**Contemporary issues:**	**2 hours**	
	Total Lecture hours:	**30 hours**	

Reference Books

1. Abraham Silberschatz, Henry F. Korth, S. Sudarshan, "Database System Concepts", McGraw-Hill, Seventh-Edition, 2014.

2. C.J. Date, A. Kannan, S.Swamynathan, "An Introduction to Database Systems", Eight-Edition, Pearson Education, 2006.

3. Raghu Ramakrishnan, Johannes Gehrke, "Database Management Systems", Tata McGraw-Hill, 2010.

4. Ramez Elmasri, Shamkant B. Navathe, "Fundamentals of Database Systems", Seventh-Edition, Pearson Education, 2017.

5. Carlo Zaniolo, Stefano Ceri, "Advanced Database Systems", Morgan Kaufmann, 1997.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		
List of Challenging Experiments (Indicative)		
	1. Design of a Query language 2. Design of Query processor 3. Design of Query optimizer 4. Transaction manager design 5. Security manager design 6. Front-end and connectivity design 7. Application design and Mini-projects	hours
	Total Laboratory Hours	15 hours
Mode of assessment:		
Recommended by Board of Studies	11-06-2019	
Approved by Academic Council	No. 55	Date 13-06-2019

Course code	Course title	L	T	P	J	C
CSE5012	ARTIFICIAL INTELLIGENCE: PRINCIPLES AND TECHNIQUES	2	0	2	0	3
Pre-requisite	Nil	Syllabus version				
		v. xx.xx				

Course Objectives:

The objective of this course is to

1. Become familiar with basic principles of AI toward problem solving, inference, perception, knowledge representation, and learning.
2. Elucidate the basic knowledge representation, problem solving, and learning methods of Artificial Intelligence
3. Assess the applicability, strengths, and weaknesses of the basic knowledge representation, problem solving, and learning methods in solving particular engineering problems

Expected Course Outcome:

1. Demonstrate fundamental understanding of the evaluation of Artificial Intelligence (AI) and its foundations.
2. Apply basic principles of AI in solutions that require problem solving, perception, knowledge representation, and learning.
3. Design simple software to experiment with various AI concepts and analyse results
4. To show the importance of artificial intelligence and planning in solving real world problems
5. Demonstrate working knowledge of reasoning in the presence of incomplete and/or uncertain information also to show how the searching algorithms playing vital role in problem solving
6. To create interactive and rational system using appropriate learning techniques also, to measure the level of user satisfaction and efficiency of the expert system and ANN

Module:1	INTRODUCTION	4 hours	

Philosophy of artificial intelligence, Definitions - Evolution of AI - Applications of AI, Classification of AI- Intelligent Agents: Agents and Environment-Nature of Environment-Structure Environment

Module:2	SEARCHING BASED PROBLEM SOLVING	5 hours	

Problem Solving Agent - Blind Search- Performance measures - Informed Search: Introduction to Heuristics-Variants of heuristic search-uniform cost, A*,Greedy - Overview of Hill Climbing – Simulated Annealing – Genetic Algorithms – Adversarial Search – Minimax, Alpha beta pruning

Module:3	KNOWLEDGE REPRESENTATION AND REASONING	5 hours	

Logical systems – Knowledge Based systems, Propositional Logic – Constraints, Predicate Logic – First Order Logic, Inference in First Order Logic, Ontological Representations and applications Knowledge representation and reasoning through logic

Module:4	PLANNING	5 hours	

Planning Problem – Planning with State Space Search – Partial order Planning – Planning and Acting in the Real World: Conditional Planning – Re-planning Agents, Robotics-Action

Module:5	UNCERTAINTY AND KNOWLEDGE REASONING	4 hours	

Overview – Definition of uncertainty, Utility Based System, -Bayes Rule – Inference, Belief Network, Markov decision processes, knowledge representation and reasoning through fuzzy logic and Bayesian networks			
Module:6	**VI LEARNING SYSTEMS**	**3 hours**	
Machine learning, Forms of Learning – Types - Supervised, unsupervised, reinforcement learning, Learning Decision Trees, soft computing- Artificial Neural Network.			
Module:7	**EXPERT SYSTEMS & ANN**	**2 hours**	
Introduction to Expert Systems- Architecture, Reasoning, and explanation-Knowledge Acquisition-Introduction to Natural Language Processing-Morphological Analysis-Syntax Analysis-Semantic Analysis.			
Module:8	**CONTEMPORARY ISSUES: RECENT TRENDS & FUTURE OF AI**	**2 hours**	
	Total Lecture hours:	**30 hours**	
Text Book(s)			
1.	One or two books published after 2010 (preferably after 2015) to be given (please give complete bibliography) Authors, book title, year of publication, edition number, press, place		
Reference Books			
	1.Stuart Russell and Peter Norvig Artificial Intelligence - A Modern Approach, Prentice Hall, 3rd edition, 2011. 2. Elaine Rich, Kevin Knight and Shiv Shankar B. Nair, Artificial Intelligence, 3rd edition, Tata McGraw Hill, 2009. 3. Wolfgang Ertel," Introduction to Artificial Intelligence", Second Edition, Springer, 2017. 4. Stephen Lucci and Danny Kopec," Artificial Intelligence in the 21st Century, Second Edition, Mercury Learning and Information, 2015. 5. Deepak Khemani, "A First Course in Artificial Intelligence", McGraw Hill Education, 2013. 6. Miroslav Kubat," An Introduction to Machine Learning", Springer, 2016. 7. David L. Poole and Alan K. Mackworth, "Artificial Intelligence: Foundations of		

	Computational Agents", Second Edition, Cambridge University Press, 2017			
	Authors, book title, year of publication, edition number, press, place			
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar				
List of Challenging Experiments (Indicative)				
	1. Solving Missionaries and cannibals problems 2. Water Jug Problem 3. 8-Queens Problem 4. Travelling Salesman Problem 5. Solving Wampus Problem using Logic 6. Monkeys and Bananas Problem using Logic 7. Bayesian Classification Problem 8. Decision Tree Problem 9. Developing a sentiment analysis systems 10. Development of Medical Expert system with Recommendation system			hours
			Total Laboratory Hours	15 hours
Mode of assessment:				
Recommended by Board of Studies	11-06-2019			
Approved by Academic Council	No. 55	Date	13-06-2019	

Course code	MACHINE LEARNING TECHNIQUES	L	T	P	J	C
CSE6024		2	0	2	0	3
Pre-requisite	Nil	Syllabus version				
		v. xx.xx				

Course Objectives:

1. Acquire theoretical knowledge on setting hypothesis for pattern recognition.
2. Apply suitable machine learning techniques for data handling and to gain knowledge from it.
3. Evaluate the performance of algorithms and to provide solution for various real-world applications.

Expected Course Outcomes:

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

1. Recognize the characteristics of machine learning strategies.
2. Apply various supervised learning methods to appropriate problems.
3. Identify and integrate more than one technique to enhance the performance of learning.
4. Create probabilistic and unsupervised learning models for handling unknown pattern.
5. Analyze the co-occurrence of data to find interesting frequent patterns.
6. Preprocess the data before applying to any real-world problem and can evaluate its performance.

Module:1	INTRODUCTION TO MACHINE LEARNING	3 hours

Introduction, Examples of various Learning Paradigms, Perspectives and Issues, Version Spaces, Finite and
Infinite Hypothesis Spaces, PAC Learning, VC Dimension.

Module:2	SUPERVISED LEARNING ALGORITHMS	9 hours

Learning a Class from Examples, Linear, Non-linear, Multi-class and Multi-label classification, Decision Trees:
ID3, Classification and Regression Trees (CART), Regression: Linear Regression, Multiple Linear Regression,Logistic Regression.

Module:3	ADVANCED SUPERVISED LEARNING	3 hours

Neural Networks: Introduction, Perceptron, Multilayer Perceptron, Support vector machines: Linear and Non-Linear, Kernel Functions, K-Nearest Neighbors

Module:4	ENSEMBLE LEARNING	5 hours

Ensemble Learning Model Combination Schemes, Voting, Error-Correcting Output Codes, Bagging: RandomForest Trees, Boosting: Adaboost, Stacking

Module:5	UNSUPERVISED LEARNING	3 hours

Introduction to clustering, Hierarchical: AGNES, DIANA, Partitional: K-means clustering, K-Mode Clustering,
Self-Organizing Map, Expectation Maximization, Gaussian Mixture Models, Principal Component Analysis(PCA), Locally Linear Embedding (LLE), Factor Analysis

Module:6	PROBABILISTIC LEARNING	3 hours

Bayesian Learning, Bayes Optimal Classifier, Naïve Bayes Classifier, Bayesian Belief Networks, Mining
Frequent Patterns

Module:7	MACHINE LEARNING IN PRACTICE	2 hours

Design, Analysis and Evaluation of Machine Learning Experiments,Other Issues: Handling imbalanced data sets

Module:8	RECENT TRENDS	2 hours

	Total Lecture hours:	**30 hours**	

Text Books	
1.	EthemAlpaydin,"Introduction to Machine Learning", MIT Press, Prentice Hall of India, Third Edition 2014.
2.	MehryarMohri, AfshinRostamizadeh, AmeetTalwalkar "Foundations of Machine Learning", MIT Press, 2012.
Reference Books	
1.	Tom Mitchell, "Machine Learning", McGraw Hill, 3rd Edition,1997.
2.	Charu C. Aggarwal, "Data Classification Algorithms and Applications", CRC Press, 2014.
3.	Stephen Marsland, "Machine Learning – An Algorithmic Perspective", 2nd Edition, CRC Press, 2015.
4.	Kevin P. Murphy "Machine Learning: A Probabilistic Perspective", The MIT Press, 2012
5.	Jiawei Han and MichelineKambers and Jian Pei, "Data Mining –Concepts and Techniques", 3rd Edition,Morgan Kaufman Publications, 2012.
6.	Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, "Mathematics for Machine Learning", Cambridge University Press, 2019.
	Authors, book title, year of publication, edition number, press, place
Mode of Evaluation: CAT / Assignment / Quiz / FAT /Project / Seminar	

List of Indicative Experiments	
1.	Implement Decision Tree learning
2.	Implement Logistic Regression
3.	Implement classification using Multilayer perceptron
4.	Implement classification using SVM
5.	Implement Adaboost
6.	Implement Bagging using Random Forests
7.	Implement k-nearest Neighbors algorithm
8.	Implement K-means, K-Modes Clustering to Find Natural Patterns in Data
9.	Implement Hierarchical clustering
10.	Implement Gaussian Mixture Model Using the Expectation Maximization
11.	Implement Principle Component Analysis for Dimensionality Reduction
12.	Evaluating ML algorithm with balanced and unbalanced datasets Comparison of Machine Learning algorithms
Total Laboratory Hours	30 hours
Mode of assessment: CAT / Assignment / Quiz / FAT / Seminar	

Recommended by Board of Studies	11-06-2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course code	BIG DATA ANALYTICS	L	T	P	J	C
CSE6034		2	0	2	0	3
Pre-requisite	Nil	Syllabus version				
		v. xx.xx				

Course Objectives:

1. To understand the need of Big Data, challenges and different analytical architectures
2. Installation and understanding of Hadoop Architecture and its eco systems
3. Processing of Big Data with Advanced architectures like Spark.
4. Describe graphs and streaming data in Spark

Expected Course Outcomes:

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

1. Discuss the challenges and their solutions in Big Data and work on Hadoop Framework
2. Understand the concepts of visualization through R programming.
3. Explain and Analyse the Big Data using Map-reduce programming in Both Hadoop and Spark framework.
4. Demonstrate spark programming and graph algorithms using programming languages.
5. Analyse and implement different frame work tools by taking sample data sets.
6. Ilustrate and implement the concepts by taking an application problem

Module:1	INTRODUCTION BIG DATA	2 hours

Data Storage and Analysis , Characteristics of Big Data, Big Data Analytics, Typical Analytical Architecture,
Requirement for new analytical architecture, Challenges in Big Data Analytics, Need of big data frameworks,Introduction to Hadoop ecosystems.

Module:2	HADOOP FRAMEWORK	5 hours

Introduction to Hadoop, Requirement of Hadoop Framework, Design principle ofHadoop, Comparison with other system, Hadoop Components, Hadoop Version1 vs Hadoop version2, Hadoop Daemon's, HDFS Commands, Map Reduce Programming: I/O formats, Map side join, Reduce Side Join, Secondary sorting,
Pipelining MapReduce jobs.

Module:3	R PROGRAMMING	4 hours

History and overview of R , Install and configuration of R programming environment , Basic language elements
and data structures, Data input/output, Data storage formats , Sub-setting objects.

Module:4	VISUALIZATION USING R	4 hours

Vectorization, Control structures, Functions, Scoping Rules, Loop functions, Graphics and visualization.

Module:5	SPARK FRAMEWORK	5 hours

Overview of Spark, Hadoop vs Spark, Cluster Design, Cluster Management, performance,Application Programming interface (API): Spark Context, Resilient Distributed Datasets, Creating RDD, RDD Operations, Saving RDD, Lazy Operation, Spark Jobs

Module:6	**DATA ANALYSIS WITH SPARK SHELL**	**4 hours**
Writing Spark Application , Spark Programming in Scala, Python, R,Analyzing big data with twitter ,Big datafor E-Commerce Big data for blogs,Review of Basic Data Analytic Methods using R.		
Module:7	**SPARK SQL AND GRAPHX**	**4 hours**
SQL Context, Importing and Saving data, Data frames, using SQL,GraphX overview, Creating Graph, GraphAlgorithms		
Module:8	**RECENT TRENDS**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Books

1.	Tom White, "Hadoop: The Definitive Guide", O'Reilly, 4th Edition, 2015.
2.	Garrett Grolemund, "Hands-On Programming with R" , O'Reilly Media, Inc, 2014.
3.	Mohammed Guller, Big Data Analytics with Spark, Apress, 2015.
4.	Chuck Lam, "Hadoop in Action", Manning Publications, 2010.

Reference Books

1.	Frank Pane, "Hands On Data Science and Python Machine Learning", Packt Publishers, 2017.
2.	Nick Pentreath, Machine Learning with Spark, Packt Publishing, 2015
3.	Seema Acharya, SubhashiniChellapan, "Big Data and Analytics", Wiley, 2015.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / LAB / Seminar

List of Indicative Experiments

1.	Execution and understanding of HDFS Commands
2.	Implement Map Reduce Programming usning I/O formats, Map side join, Reduce SideJoin
3.	Implement Secondary sorting, Pipelining MapReduce jobs..
4.	Install and configuration of R programming environment,Implement a program using R data input/outputData storage formats, Subsetting objects.
5.	Implement programs using Vectorization, Control structures, Functions, Scoping Rules, Loop functions, Graphics and visualization
6.	Implement Distributed Cache & Map Side Join, Reduce side JoinBuilding and Running a Spark Application
7.	Implement Wordcount in Hadoop and SparkManipulating RDD
8.	Implement Inverted Indexing in Spark and Sequence alignment problem in Spark
9.	Implement Implementation of Matrix algorithms in Spark
10.	Implement Spark Sql programming and Building Spark Streaming application
11.	Implement the programming in Sql: Importing and Saving data using Data frames and SQL.
12.	Creating Graph and evaluate the Graph Algorithms.
Total Laboratory Hours	30 hours

Mode of assessment: CAT / Assignment / Quiz / FAT / Seminar

Recommended by Board of Studies	11-06-2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course code	Course Title	L	T	P	J	C
MAT6006	Mathematics for Machine Learning	3	0	0	0	3
Pre-requisite		Syllabus version				
		1.0				

Course Objectives:

The course is aimed at

1. Enhancing the basic understanding of Application of Mathematics in Computer Science.
2. Imparting design thinking capability to build ML systems
3. Developing design skills of models for machine learning problems

Expected Course Outcomes:

At the end of the course the student should be able to

1. Understand basic concept of statistics
2. Use Probability, Bayes theorem and random variables in applications
3. Build regression models and utilise it to model practical prediction problems
4. Apply Optimization in Machine Learning
5. Comprehend Gradient descent models and interior point methods
6. Utilise dimensionality reduction techniques

Module:1	Statistics	6 hours	

Measures of location- arithmetic, geometric and harmonic means, median, mode, measures of spread – range, variance and standard deviation, mean deviation, concept of skewness – positively and negatively skewed data, kurtosis, covariance.

Module:2	Probability	5 hours	

Probability axioms, classical and frequency approaches, geometric probability, conditional probability, independence of events, Bayes theorem, applications

Module:3	Random Variables	6 hours	

Introduction to random variables, Probability mass functions, distribution and density functions, Discrete distributions– Binomial, Poisson, geometric and negative binomial distributions, Continuous distributions – exponential, Gamma, Normal distribution, T, and F distributions, mathematical expectation of random variables, probability generating function, moment generating function, characteristic function.

Module:4	Regression	6 hours	

Correlation and Regression, types of correlation – Pearson's, Spearman's correlations –Ordinary Least Squares, Fitting a regression line, logistic regression, Rank Correlation- Partial and Multiple correlation- Multiple regression, multi-collinearity.

Module:5	Methods for convex optimization	6 hours	

Unconstrained optimization, Linear optimization, convex quadratic optimization, second order cone optimization, semi-definite optimization, convex composite optimization.

Module:6	Gradient descent models	6 hours	

Gradient descent methods, Newton method, interior point methods, active set, proximity methods, accelerated gradient methods, coordinate descent, cutting planes, stochastic gradient descent.

Module:7	**Dimensionality reduction**	**8 hours**	

Discriminant analysis, Principal component analysis, Factor analysis, k means

Module:8	**Expert Lecture**	**2 hours**	

Maximum likelihood and Bayesian estimation for Machine Learning

	Total Lecture hours:	**45 hours**

Text Book(s)

1. Matrix Methods in Data Mining and Pattern Recognition, Lars Elden. (2016).
2. Introduction to Applied Linear Algebra – Vectors, Matrices, and Least Squares, Stephen Boyd and Lieven Vandenberghe, Cambridge U Press (2018)

Reference Book(s)

1. Probability and Statistics for Engineers and Scientists, Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers, Keying E. Ye, (9th Edition), Pearson Education (2015)
2. Pattern Recognition and Machine Learning, Christopher Bishop, Springer, (2010)
3. Machine Learning: The Art and Science of Algorithms that Make Sense of Data, Flach, Cambridge University Press (2015)
4. Elementary Linear Algebra, Enton Howard, Wiley India (2016)
5. Introduction to Linear Algebra, Gilbert Strang, 5th ed., Cengage Learning, 2015

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

	Recommended by Board of Studies			10-09-2019
	Approved by Academic Council	No.56	Date	24-09-2019

UNIVERSITY CORE

Course code	Master's Thesis	L	T	P	J	C
CSE6099		0	0	0	0	16
Pre-requisite	As per the academic regulations				Syllabus version	
					1.0	

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field and also to give research orientation.

Expected Course Outcome:

At the end of the course the student will be able to

1. Formulate specific problem statements for ill-defined real life problems with reasonable assumptions and constraints.
2. Perform literature search and / or patent search in the area of interest.
3. Conduct experiments / Design and Analysis / solution iterations and document the results.
4. Perform error analysis / benchmarking / costing
5. Synthesise the results and arrive at scientific conclusions / products / solution
6. Document the results in the form of technical report / presentation

Contents

1. Capstone Project may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Project can be for two semesters based on the completion of required number of credits as per the academic regulations.
3. Should be individual work.
4. Carried out inside or outside the university, in any relevant industry or research institution.
5. Publications in the peer reviewed journals / International Conferences will be an added advantage

Mode of Evaluation: Periodic reviews, Presentation, Final oral viva, Poster submission

Recommended by Board of Studies	13.05.2016		
Approved by Academic Council	41st AC	Date	17.06.2016

Course code	Course Title	L	T	P	J	C
MAT5014	Mathematics for Artificial Intelligence	3	0	0	0	3

Pre-requisite	None	Syllabus version
		1.0

Course Objectives(CoB):1,2,3

The course is aimed at

1. Enhancing basic understanding of Applied Mathematics in Computer science.
2. Imparting design thinking capability in AI systems
3. Developing design skills of models for knowledge based systems
4. Introduce the concepts and techniques of Artificial Intelligence and Machine Learning in computational perspectives.

Course Outcome(CO): 1,2,3,4,5

At the end of the course the student should be able to

1. Apply Logic and proof techniques
2. Understand concepts in abstract algebra and algebraic structures
3. Comprehend vectors and vector spaces
4. Apply Linear Algebra in AI
5. Utilise eigen values and matrix factorisation techniques in practical problems

Module:1	Proof Techniques	6 hours	CO: 1

Propositional Logic, Predicate Logic, Higher Order Logic, Descriptive Logic, nested quantifiers, rules of inference, introduction to proof techniques

Module:2	Abstract algebra	6 hours	CO: 2

Partial Order Relations, Lattices, Boolean Algebra, Functions and Recursive functions

Module:3	Algebraic Structures	6 hours	CO: 2

Groups, Semi-groups, Monoids, Rings and Fields, Applications in Cryptography

Module:4	Vectors	6 hours	CO: 3

Vectors: definition, scalars, addition, scalar multiplication, sparse vectors, inner product(dot product), vector projection, cosine similarity, orthogonal vectors, normal and orthonormal vectors, vector norm, vector space, linear combination, linear span, linear independence, basis vectors

Module:5	Matrices	CO: 4	

Matrices:- definition, sparse matrix, addition, transpose, scalar multiplication, matrix multiplication, Hadamard product, matrix functions, linear transformation, determinant, identity matrix, invertible matrix and inverse, rank, trace, popular type of matrices- symmetric, diagonal, orthogonal, orthonormal, positive definite matrix

Module:6	Eigen values and eigenvectors	6 hours	CO: 4

Eigenvalues and eigenvectors- concept, intuition, significance, how to find, Cayley Hamilton theorem, applications of eigen values.			
Module:7	**Matrix decompositions**	**4 hours**	**CO: 5**
LU decomposition, Singular value decomposition, QR factorization, Gram-Schmidt decomposition, concept, properties, applications			
Module:8	**Industry expert lecture**	**5 hours**	**CO: 4,5**
Clustering for Machine Learning			
	Total Lecture hours:	**45 hours**	

Text Book(s)	
1.	Discrete mathematics and its applications, Kenneth H. Rosen, McGraw Hill(2017).
2.	Introduction to Linear Algebra, Gilbert Strang, 4th edition, Wellesley-Cambridge press, 2009.
Reference Books	
1.	Artificial Intelligence, George F. Luger, Addison Wesley (2015)
2	Artificial Intelligence: A modern approach, Stuart Russell and Peter Norvig, Prentice-Hall, (1995)
3	Discrete Mathematics, S. Chakraborty and B.K. Sarkar, Oxford Higher Education, 2016
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar	

	Recommended by Board of Studies	3-6-2019		
	Approved by Academic Council	No.	Date	

SET5001	SCIENCE, ENGINEERING AND TECHNOLOGY PROJECT– I	L	T	P	J	C
		0	0	0	0	2
Pre-requisite		**Syllabus Version**				
Anti-requisite		1.0				

Course Objectives:

1. To provide opportunity to involve in research related to science / engineering
2. To inculcate research culture
3. To enhance the rational and innovative thinking capabilities

Expected Course Outcome:

On completion of this course, the student should be able to:

1. Identify problems that have relevance to societal / industrial needs
2. Exhibit independent thinking and analysis skills
3. Demonstrate the application of relevant science / engineering principles

Modalities / Requirements

1. Individual or group projects can be taken up
2. Involve in literature survey in the chosen field
3. Use Science/Engineering principles to solve identified issues
4. Adopt relevant and well-defined / innovative methodologies to fulfill the specified objective
5. Submission of scientific report in a specified format (after plagiarism check)

Student Assessment : Periodical reviews, oral/poster presentation

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

SET5002	SCIENCE, ENGINEERING AND TECHNOLOGY PROJECT– II	L	T	P	J	C
		0	0	0	0	2
Pre-requisite		**Syllabus Version**				
Anti-requisite		1.0				

Course Objectives:

1. To provide opportunity to involve in research related to science / engineering
2. To inculcate research culture
3. To enhance the rational and innovative thinking capabilities

Expected Course Outcome:

On completion of this course, the student should be able to:

1. Identify problems that have relevance to societal / industrial needs
2. Exhibit independent thinking and analysis skills
3. Demonstrate the application of relevant science / engineering principles

Modalities / Requirements

6. Individual or group projects can be taken up
7. Involve in literature survey in the chosen field
8. Use Science/Engineering principles to solve identified issues
9. Adopt relevant and well-defined / innovative methodologies to fulfill the specified objective
10. Submission of scientific report in a specified format (after plagiarism check)

Student Assessment : Periodical reviews, oral/poster presentation

Recommended by Board of Studies	17-08-2017		
Approved by Academic Council	No. 47	Date	05-10-2017

ENG5001	Fundamentals of Communication Skills	L	T	P	J	C
		0	0	2	0	1
Pre-requisite	Not cleared EPT (English Proficiency Test)	**Syllabus version**				
		1.0				

Course Objectives:

1. To enable learners learn basic communication skills - Listening, Speaking, Reading and Writing
2. To help learners apply effective communication in social and academic context
3. To make students comprehend complex English language through listening and reading

Expected Course Outcome:

1. Enhance the listening and comprehension skills of the learners
2. Acquire speaking skills to express their thoughts freely and fluently
3. Learn strategies for effective reading
4. Write grammatically correct sentences in general and academic writing
5. Develop technical writing skills like writing instructions, transcoding etc.,

Module:1	Listening	**8 hours**

Understanding Conversation
Listening to Speeches
Listening for Specific Information

Module:2	Speaking	**4 hours**

Exchanging Information
Describing Activities, Events and Quantity

Module:3	Reading	**6 hours**

Identifying Information
Inferring Meaning
Interpreting text

Module:4	Writing: Sentence	**8hours**

Basic Sentence Structure
Connectives
Transformation of Sentences
Synthesis of Sentences

Module:5	Writing: Discourse	**4hours**

Instructions
Paragraph
Transcoding

	Total Lecture hours:	**30 hours**

Text Book(s)

1. Redston, Chris, Theresa Clementson, and Gillie Cunningham. *Face2face Upper Intermediate Student's Book.* 2013, Cambridge University Press.

Reference Books

1. Chris Juzwiak .*Stepping Stones: A guided approach to writing sentences and Paragraphs (Second Edition)*, 2012, Library of Congress.
2. Clifford A Whitcomb & Leslie E Whitcomb, *Effective Interpersonal and Team Communication Skills for Engineers*, 2013, John Wiley & Sons, Inc., Hoboken: New Jersey.
3. ArunPatil, Henk Eijkman &Ena Bhattacharya, *New Media Communication Skills for Engineers and IT Professionals,*2012, IGI Global, Hershey PA.
4. Judi Brownell, *Listening: Attitudes, Principles and Skills*, 2016, 5th Edition, Routledge:USA
5. John Langan, Ten Steps to Improving College Reading Skills, 2014, 6th Edition, Townsend Press:USA

6.	Redston, Chris, Theresa Clementson, and Gillie Cunningham. *Face2face Upper Intermediate Teacher's Book*. 2013, Cambridge University Press.	
	Authors, book title, year of publication, edition number, press, place	
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar		
List of Challenging Experiments (Indicative)		
1.	Familiarizing students to adjectives through brainstorming adjectives with allletters of the English alphabet and asking them to add an adjective that starts with the first letter of their name as a prefix.	2 hours
2.	Taking students identify their peer who lack Pace, Clarity and Volume duringpresentation and respond using Symbols.	4 hours
3.	Using Picture as a tool to enhance learners speaking and writing skills	2 hours
4.	Using Music and Songs as tools to enhance pronunciation in the target language / Activities through VIT Community Radio	2 hours
5.	Making students upload their Self- introduction videos in Vimeo.com	4 hours
6.	Brainstorming idiomatic expressions and making them use those in to their writings and day to day conversation	4 hours
7.	Making students Narrate events by adding more descriptive adjectives and add flavor to their language / Activities through VIT Community Radio	4 hours
8	Identifying the root cause of stage fear in learners and providing remedies to make their presentation better	4 hours
9	Identifying common Spelling & Sentence errors in Letter Writing and other day to day conversations	2 hours
10.	Discussing FAQ's in interviews with answers so that the learner gets a betterinsight in to interviews / Activities through VIT Community Radio	2 hours
	Total Laboratory Hours	**32 hours**
Mode of evaluation: Online Quizzes, Presentation, Role play, Group Discussions, Assignments, Mini Project		
Recommended by Board of Studies	22-07-2017	
Approved by Academic Council	No. 46	Date 24-8-2017

ENG5002	Professional and Communication Skills	L	T	P	J	C
		0	0	2	0	1
Pre-requisite	ENG5001	**Syllabus version**				
		1.1				

Course Objectives:

1. To enable students to develop effective Language and Communication Skills
2. To enhance students' Personal and Professional skills
3. To equip the students to create an active digital footprint

Expected Course Outcome:

1. Improve inter-personal communication skills
2. Develop problem solving and negotiation skills
3. Learn the styles and mechanics of writing research reports
4. Cultivate better public speaking and presentation skills
5. Apply the acquired skills and excel in a professional environment

Module:1	**Personal Interaction**	**2hours**
Introducing Oneself- one's career goals Activity: SWOT Analysis		
Module:2	**Interpersonal Interaction**	**2 hours**
Interpersonal Communication with the team leader and colleagues at the workplace Activity: Role Plays/Mime/Skit		
Module:3	**Social Interaction**	**2 hours**
Use of Social Media, Social Networking, gender challenges Activity: Creating LinkedIn profile, blogs		
Module:4	**Résumé Writing**	**4 hours**
Identifying job requirement and key skills Activity: Prepare an Electronic Résumé		
Module:5	**Interview Skills**	**4 hours**
Placement/Job Interview, Group Discussions Activity: Mock Interview and mock group discussion		
Module:6	**Report Writing**	**4 hours**
Language and Mechanics of Writing Activity: Writing a Report		
Module:7	**Study Skills: Note making**	**2hours**
Summarizing the report Activity: Abstract, Executive Summary, Synopsis		
Module:8	**Interpreting skills**	**2 hours**
Interpret data in tables and graphs Activity: Transcoding		
Module:9	**Presentation Skills**	**4 hours**
Oral Presentation using Digital Tools Activity: Oral presentation on the given topic using appropriate non-verbal cues		
Module:10	**Problem Solving Skills**	**4 hours**
Problem Solving & Conflict Resolution Activity: Case Analysis of a Challenging Scenario		
	Total Lecture hours:	**30hours**

Text Book(s)

1	Bhatnagar Nitin and Mamta Bhatnagar, *Communicative English For Engineers And Professionals*, 2010, Dorling Kindersley (India) Pvt. Ltd.

Reference Books				
1	Jon Kirkman and Christopher Turk, *Effective Writing: Improving Scientific, Technical and Business Communication*, 2015, Routledge			
2	Diana Bairaktarova and Michele Eodice, *Creative Ways of Knowing in Engineering*, 2017, Springer International Publishing			
3	Clifford A Whitcomb & Leslie E Whitcomb, *Effective Interpersonal and Team Communication Skills for Engineers*, 2013, John Wiley & Sons, Inc., Hoboken: New Jersey.			
4	ArunPatil, Henk Eijkman &Ena Bhattacharya, *New Media Communication Skills for Engineers and IT Professionals,*2012, IGI Global, Hershey PA.			
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar				
List of Challenging Experiments (Indicative)				
1.	SWOT Analysis – Focus specially on describing two strengths and two weaknesses			2 hours
2.	Role Plays/Mime/Skit -- Workplace Situations			4 hours
3.	Use of Social Media – Create a LinkedIn Profile and also write a page or two on areas of interest			2 hours
4.	prepare an Electronic Résumé and upload the same in vimeo			2 hours
5.	Group discussion on latest topics			4 hours
6	Report Writing – Real-time reports			2 hours
7	Writing an Abstract, Executive Summary on short scientific or research articles			4 hours
8	Transcoding – Interpret the given graph, chart or diagram			2 hours
9	Oral presentation on the given topic using appropriate non-verbal cues			4 hours
10	Problem Solving -- Case Analysis of a Challenging Scenario			4 hours
			Total Laboratory Hours	**32 hours**
Mode of evaluation: : Online Quizzes, Presentation, Role play, Group Discussions, Assignments, Mini Project				
Recommended by Board of Studies	22-07-2017			
Approved by Academic Council	No. 47	Date	05-10-2017	

STS5001	Essentials of Business Etiquettes	L	T	P	J	C
		3	0	0	0	1
Pre-requisite		**Syllabus version**				
		2.0				

Course Objectives:

1. To develop the students' logical thinking skills
2. To learn the strategies of solving quantitative ability problems
3. To enrich the verbal ability of the students
4. To enhance critical thinking and innovative skills

Expected Course Outcome:

1. Enabling students to use relevant aptitude and appropriate language to express themselves
2. To communicate the message to the target audience clearly

Module:1	**Business Etiquette: Social and Cultural Etiquette and Writing Company Blogs and Internal Communications and Planning and Writing press release and meeting notes**	**9 hours**

Value, Manners, Customs, Language, Tradition, Building a blog, Developing brand message, FAQs', Assessing Competition, Open and objective Communication, Two way dialogue, Understanding the audience, Identifying, Gathering Information,. Analysis, Determining, Selecting plan, Progress check, Types of planning, Write a short, catchy headline, Get to the Point –summarize your subject in the first
paragraph., Body – Make it relevant to your audience,

Module:2	**Study skills – Time management skills**	**3 hours**

Prioritization, Procrastination, Scheduling, Multitasking, Monitoring, Working under pressure and adhering
to deadlines

Module:3	**Presentation skills – Preparing presentation and Organizing materials and Maintaining and preparing visual aids and Dealing with questions**	**7 hours**

10 Tips to prepare PowerPoint presentation, Outlining the content, Passing the Elevator Test, Blue sky thinking, Introduction , body and conclusion, Use of Font, Use of Color, Strategic presentation, Importance and types of visual aids, Animation to captivate your audience, Design of posters, Setting out the ground
rules, Dealing with interruptions, Staying in control of the questions, Handling difficult questions

Module:4	**Quantitative Ability -L1 – Number properties and Averages and Progressions and Percentages and Ratios**	**11 hours**

Number of factors, Factorials, Remainder Theorem, Unit digit position, Tens digit position, Averages, Weighted Average, Arithmetic Progression, Geometric Progression, Harmonic Progression, Increase &
Decrease or successive increase, Types of ratios and proportions

Module:5	**Reasoning Ability-L1 – Analytical Reasoning**	**8 hours**
Data Arrangement(Linear and circular & Cross Variable Relationship), Blood Relations, Ordering/ranking/grouping, Puzzle test, Selection Decision table		
Module:6	**Verbal Ability-L1 – Vocabulary Building**	**7 hours**
Synonyms & Antonyms, One word substitutes, Word Pairs, Spellings, Idioms, Sentence completion,Analogies		
	Total Lecture hours:	**45 hours**

Reference Books

1.	Kerry Patterson, Joseph Grenny, Ron McMillan, Al Switzler(2001) Crucial Conversations: Tools forTalking When Stakes are High. Bangalore. McGraw-Hill Contemporary
2.	Dale Carnegie,(1936) How to Win Friends and Influence People. New York. Gallery Books
3.	Scott Peck. M(1978) Road Less Travelled. New York City. M. Scott Peck.
4.	FACE(2016) Aptipedia Aptitude Encyclopedia. Delhi. Wiley publications
5.	ETHNUS(2013) Aptimithra. Bangalore. McGraw-Hill Education Pvt. Ltd.

Websites:

1.	**www.chalkstreet.com**
2.	**www.skillsyouneed.com**
3.	**www.mindtools.com**
4.	**www.thebalance.com**
5.	**www.eguru.ooo**

Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays,3 Assessments with Term End FAT (Computer Based Test)

Recommended by Board of Studies	09/06/2017		
Approved by Academic Council	No. 45th AC	Date	15/06/2017

STS5002	Preparing for Industry	L	T	P	J	C
		3	0	0	0	1
Pre-requisite		**Syllabus version**				
		2.0				

Course Objectives:

1. To develop the students' logical thinking skills
2. To learn the strategies of solving quantitative ability problems
3. To enrich the verbal ability of the students
4. To enhance critical thinking and innovative skills

Expected Course Outcome:

1. Enabling students to simplify, evaluate, analyze and use functions and expressions to simulate real situations to be industry ready.

Module:1	**Interview skills – Types of interview and Techniques to face remote interviews and Mock Interview**	**3 hours**

Structured and unstructured interview orientation, Closed questions and hypothetical questions, Interviewers' perspective, Questions to ask/not ask during an interview, Video interview, Recorded feedback, Phone interview preparation, Tips to customize preparation for personal interview, Practice rounds

Module:2	**Resume skills – Resume Template and Use of power verbs and Types of resume and Customizing resume**	**2 hours**

Structure of a standard resume, Content, color, font, Introduction to Power verbs and Write up, Quiz on types of resume, Frequent mistakes in customizing resume, Layout - Understanding different company's requirement, Digitizing career portfolio

Module:3	**Emotional Intelligence - L1 – Transactional Analysis and Brain storming and Psychometric Analysis and Rebus Puzzles/Problem Solving**	**12 hours**

Introduction, Contracting, ego states, Life positions, Individual Brainstorming, Group Brainstorming, Stepladder Technique, Brain writing, Crawford's Slip writing approach, Reverse brainstorming, Star bursting, Charlette procedure, Round robin brainstorming, Skill Test, Personality Test, More than one answer, Unique ways

Module:4	**Quantitative Ability-L3 – Permutation-Combinations and Probability and Geometry and mensuration and Trigonometry and Logarithms and Functions and Quadratic Equations and Set Theory**	**14 hours**

Counting, Grouping, Linear Arrangement, Circular Arrangements, Conditional Probability, Independent and Dependent Events, Properties of Polygon, 2D & 3D Figures, Area & Volumes, Heights and distances, Simple trigonometric functions, Introduction to logarithms, Basic rules of logarithms, Introduction to functions, Basic rules of functions, Understanding Quadratic Equations, Rules & probabilities of Quadratic Equations, Basic concepts of Venn Diagram

Module:5	**Reasoning ability-L3 – Logical reasoning and**	**7 hours**

	Data Analysis and Interpretation	
Syllogisms, Binary logic, Sequential output tracing, Crypto arithmetic, Data Sufficiency, Data interpretation-Advanced, Interpretation tables, pie charts & bar chats		
Module:6	**Verbal Ability-L3 – Comprehension and Logic**	**7 hours**
Reading comprehension, Para Jumbles, Critical Reasoning (a) Premise and Conclusion, (b) Assumption & Inference, (c) Strengthening & Weakening an Argument		
	Total Lecture hours:	**45 hours**

Reference Books	
1.	Michael Farra and JIST Editors(2011) Quick Resume & Cover Letter Book: Write and Use an Effective Resume in Just One Day. Saint Paul, Minnesota. Jist Works
2.	Daniel Flage Ph.D(2003) The Art of Questioning: An Introduction to Critical Thinking. London. Pearson
3.	David Allen(2002) Getting Things done : The Art of Stress -Free productivity. New York City. Penguin Books.
4.	FACE(2016) Aptipedia Aptitude Encyclopedia.Delhi. Wiley publications
5.	ETHNUS(2013) Aptimithra. Bangalore. McGraw-Hill Education Pvt. Ltd.
Websites:	
1.	**www.chalkstreet.com**
2.	**www.skillsyouneed.com**
3.	**www.mindtools.com**
4.	**www.thebalance.com**
5.	**www.eguru.ooo**

Mode of Evaluation: FAT, Assignments, Projects, Case studies, Role plays,
3 Assessments with Term End FAT (Computer Based Test)

Recommended by Board of Studies	09/06/2017		
Approved by Academic Council	No. 45th AC	Date	15/06/2017

CSE5004	COMPUTER NETWORKS	L	T	P	J	C
		2	0	2	0	3
Pre-requisite	**Nil**	**Syllabus version**				
		1.0				

Course Objectives:

1. Learn the division of network functionalities into layers.
2. Be familiar with the components required to build different types of networks and protocol
3. Understand the basic knowledge of software defined networks.

Expected Course Outcome:

1. Explore the basics of Computer Networks and various protocols.
2. Summarize the simple network management protocol components.
3. Interpret the characteristics of SDN controllers and their implications to learn the board aspects of security, overlay and network model.
4. Elaborate network function virtualization and network virtualization
5. Acquire the knowledge of SDN network security and network design implications of QoE/QoS.

Module:1	**Introduction**	**6 hours**

Network models, Addressing: Classful and Classless, Routing Protocols: unicast, multicast, Congestion control, Host configuration: DHCP, DNS.

Module:2	**Network Management**	**4 hours**

SNMP : Management Components, SMI, MIB, Configuration Management – Fault management – Performance Management – Accounting Management, Case studies.

Module:3	**Software Defined Networks**	**5 hours**

SDN Data plane, Control Plane, Application Plane. SDN security attack vectors and SDN Harderning, Overlay model and network model for cloud computing.

Module:4	**Network Functions Virtualization**	**3 hours**

Concepts, Benefits, requirements, Reference architecture, Management, Functionality and Infrastructure

Module:5	**Network Virtualization**	**4 hours**

Virtual LAN, Virtual Private Networks: IPSEC, MPLS, Network Virtualization Architecture and Benefits

Module:6	**Security**	**2 hours**

Security requirements, Threats to SDN, SDN security, NFV Security and its techniques

Module:7	**Network Design Implications of QoS and QoE**	**4 hours**

QoS Architectural Framework, SLA, IP Performance metrics, QoE: Strategies, Measurements, QoE/QoS Mapping models

Module:8	**RECENT TRENDS**	**2 hours**

	Total Lecture hours:	**30 hours**	

Text Book(s)

Reference Books				
	1. William Stallings, "Data and Computer Communication", Sixth Edition, Pearson Education, 2000. 2. Behrouz A. Forouzan, "TCP/IP Protocol Suite",Tata McGraw Hill edition, Fourth Edition. 2015. 3. William Stallings, "Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud" Pearson,2015 4. James F. Kuross, Keith W. Ross, "Computer Networking, A Top-Down Approach Featuring the Internet", Third Edition, Addison Wesley, 2004. 5. Andrew S. Tanenbaum, "Computer Networks", Fourth Edition, 2003. 6. Forouzan, A. Behrouz. "Data Communications & Networking (sie)". Tata McGraw-Hill Education, 2006. 7. Peterson and Bruce S. Davie Larry L.,"Computer Networks – A Systems approach" - , Morgan Kaufmann Publishers, Elsevier, 5th edition, 2012.			
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar				
List of Challenging Experiments (Indicative)				
1.	Study of different types of Network cables and Practically implement the cross-wired cable and straight through cable using crimping tool.			3 hours
2.	Study of Network Devices in Detail.			3 hours
3.	Study of network IP.			3 hours
4.	Web NMS (SNMP based)			3 hours
5.	Network Simulators			3 hours
6.	Implementation of routing protocols in MANETs			3 hours
7.	Network trouble shooting			3 hours
8.	Programs using network packet tracers			3 hours
9.	SDN Applications and Use Cases			2 hours
10.	Network Virtualization and Slicing			2 hours
11.	Network Function Virtualization (NFV)			2 hours
			Total Laboratory Hours	**30 hours**
Mode of assessment:				
Recommended by Board of Studies	**13.05.2016**			
Approved by Academic Council	**No. 41**	**Date**	**17.06.2016**	

Course code	DATA WAREHOUSING AND MINING	L	T	P	J	C
CSE5021		2	0	2	0	3
Pre-requisite	Nil	Syllabus version				
		v. xx.xx				

Course Objectives:

1. Learn data warehousing components and data models for big data.
2. Understand the fundamentals of data mining and its functionalities
3. Realize the issues regarding classification and prediction.

Expected Course Outcome:

Upon Completion of the course, the students will be able to

1. Have an understanding of data warehousing and business analysis.
2. Possess a knowledge about the principles of data mining the techniques.
3. Implement classification and prediction techniques.
4. Have an understanding of various cluster analysis method.
5. Demonstrate data mining in different domains.
6. To comprehend the techniques and use of web data mining and search engine.

Module:1	DATA WAREHOUSING AND BUSINESSANALYSIS	4 hours

Introduction, Operational data stores, ETL, Data warehouses, design guidelines for data warehouse implementation, Data warehouse metadata; OLAP,introduction, Characteristics, Multidimensional view and data
cube, Data cube operations, Data Warehouse Governance.

Module:2	DATA MINING OVERVIEW AND ADVANCEDPATTERN MINING	4 hours

Data mining tasks – mining frequent patterns, associations and correlations, classification and regression for
predictive analysis, cluster analysis, outlier analysis; Association Rule Mining: Efficient and Scalable FrequentItem set Mining Methods – Mining Various Kinds of Association Rules.

Module:3	CLASSIFICATION AND PREDICTION	7 hours

Classification and Prediction: - Issues Regarding Classification and Prediction, Classification by Decision Tree Introduction, Bayesian Classification, Rule Based Classification ,Classification by Back propagation, Support Vector Machines ,Associative Classification, Lazy Learners, Other Classification Methods, Prediction , Accuracy and Error Measures, Evaluating the Accuracy of a Classifier or Predictor, Ensemble Methods , Model
Section. Classification by back propagation, support vector machines, classification using frequent patterns, other classification methods , genetic algorithms, roughest approach, and fuzzy set approach.

Module:4	CLUSTERING ANALYSIS	6 hours

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

Module:5	WEB AND TEXT MINING	5 hours
Multidimensional Analysis and Descriptive Mining of Complex Data Objects-Introduction, web mining, webcontent mining, web structure mining, we usage mining, Text mining, unstructured text, episode rule discovery for texts, hierarchy of categories, text clustering.		
Module:6	**TEMPORAL AND SPATIAL DATA MINING**	**4 hours**
Introduction; Temporal Data Mining , Temporal Association Rules, Sequence Mining, GSP algorithm, SPADE,SPIRIT Episode Discovery, Time Series Analysis, Spatial Mining, Spatial Mining Tasks, Spatial Clustering. Data Mining Applications.		
Module:7	**ONTOLOGY BASED KNOWLEDGE MANAGEMENT**	**4 hours**
Ontology based Knowledge Management: Introduction, Feasibility Study- Kick off phase Refinement phase- Evaluation phase- Maintenance and Evolution phase, Related Work Ontology Management, Storing, Aligning and Maintaining ontologies: The Requirement for Ontology Management, Aligning Ontologies, Supporting ontology change,organizing ontologies.		
Module:8	**RECENT TRENDS**	**2 hours**
	Total Lecture hours:	**36 hours**

Text Books	
1	Charu C. Aggarwal, Data Mining: The Textbook, Springer 2015 Edition, Kindle Edition
2	Jiawei Han and MichelineKamber “Data Mining Concepts and Techniques” 2nd Edition, Elsevier, Reprinted 2008.
3	Alex Berson and Stephen J. Smith “Data Warehousing, Data Mining & OLAP”, Tata McGraw Hill Edition, Tenth Reprint 2007.

Reference Books	
1.	K.P. Soman, ShyamDiwakar and V. Ajay “Insight into Data mining Theory and Practice”, Easter Economy Edition, Prentice Hall of India, 2006.
2.	G. K. Gupta “Introduction to Data Mining with Case Studies”, Easter Economy Edition, Prentice Hall of India, 2006.
3.	Pang-Ning Tan, Michael Steinbach and Vipin Kumar “Introduction to Data Mining”, Pearson Education, 2007.
4.	Nathan Marz, Samuel E. Ritchie "Big Data Principles and best practices of scalable real time data systems" “, Manning Publications Company, 2013.
5.	J. Davies, “Towards the Semantic Web: Ontology-driven Knowledge Management”, John Wiley & Sons Ltd., 2003.
6.	Tim Berners-Lee, “Spinning the Semantic Web: Bringing the World Wide Web to Its Full Potential”, The MIT Press, 2005.
7.	Shelley Powers, “Practical RDF”, O'Reilly Media, Inc, 1st Edition, 2003.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

List of Indicative Experiments:	
1.	Various data preprocessing techniques
2.	Data warehouse implementation

3.	Association rule mining based examples			
4.	Classifications: Decision Trees			
5.	Bayesian Classification			
6.	Auto Regression (Linear / Non-linear)			
7.	Various clustering techniques: K-means, C-means, etc.			
8.	Spatial & Temporal Analysis			
9.	Relevant Information Retrieval			
10.	Semantic Analysis using Ontology			
	Total No. of hours			30 hours
Mode of assessment: CAT / Assignment / Quiz / FAT / Seminar				
Recommended by Board of Studies	11-06-2019			
Approved by Academic Council	No. 56	Date	24-09-2019	

Course code	DEEP LEARNING AND ITS APPLICATIONS	L	T	P	J	C
CSE6037		2	0	2	0	3
Pre-requisite	Nil	Syllabus version				
		v. xx.xx				

Course Objectives:

1. To understand the theoretical foundations, algorithms and methodologies of Neural Network
2. To design and develop an application using specific deep learning models
3. To provide the practical knowledge in handling and analysing real world applications.

Expected Course Outcomes:

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

1. Recognize the characteristics of deep learning models that are useful to solve real-world problems.
2. Understand different methodologies to create application using deep nets.
3. Identify and apply appropriate deep learning algorithms for analyzing the data for variety of problems.
4. Implement different deep learning algorithms
5. Design the test procedures to assess the efficacy of the developed model.
6. Combine several models in to gain better results

Module:1	MACHINE LEARNING BASICS	3 hours

Learning algorithms, Maximum likelihood estimation, Building machine learning algorithm, Neural Networks Multilayer Perceptron, Back-propagation algorithm and its variants Stochastic gradient decent, Curse of Dimensionality

Module:2	DEEP LEARNING ARCHITECTURES	9 hours

Machine Learning and Deep Learning, Representation Learning, Width and Depth of Neural Networks, Activation Functions: RELU, LRELU, ERELU, Unsupervised Training of Neural Networks, Restricted Boltzmann Machines, Auto Encoders, Deep Learning Applications

Module:3	CONVOLUTIONAL NEURAL NETWORKS	3 hours

Architectural Overview,Motivation, Layers, Filters, Parameter sharing, Regularization, Popular CNN Architectures: ResNet, AlexNet - Applications

Module:4	TRANSFER LEARNING	5 hours

Transfer learning Techniques, Variants of CNN: DenseNet, PixelNet.

Module:5	SEQUENCE MODELLING – RECURRENT AND RECURSIVE NETS	3 hours

Recurrent Neural Networks, Bidirectional RNNs, Encoder-decoder sequence to sequence architectures - BPTT for training RNN, Long Short Term Memory Networks.

Module:6	AUTO ENCODERS	3 hours

Under complete Auto encoder, Regularized Auto encoder, stochastic Encoders and Decoders, Contractive Encoders.

Module:7	**DEEP GENERATIVE MODELS**	**2 hours**
Deep Belief networks, Boltzmann Machines,Deep Boltzmann Machine, Generative Adversial Networks.		
Module:8	**RECENT TRENDS**	**2 hours**
	Total Lecture hours:	**30 hours**

Text Book(s) and Journals	
1.	Ian Goodfellow, YoshuaBengio and Aaron Courville, " Deep Learning", MIT Press, 2017.
2.	Josh Patterson, Adam Gibson "Deep Learning: A Practitioner's Approach", O'Reilly Media, 2017
3.	Umberto Michelucci "Applied Deep Learning. A Case-based Approach to Understanding Deep Neural Networks" Apress, 2018.
Reference Books	
1.	Kevin P. Murphy "Machine Learning: A Probabilistic Perspective", The MIT Press, 2012.
2.	EthemAlpaydin,"Introduction to Machine Learning", MIT Press, Prentice Hall of India, Third
3.	Edition 2014.
4.	Giancarlo Zaccone, Md. RezaulKarim, Ahmed Menshawy "Deep Learning with TensorFlow:
5.	Explore neural networks with Python", Packt Publisher, 2017.
	Antonio Gulli, Sujit Pal "Deep Learning with Keras", Packt Publishers, 2017.
	Francois Chollet "Deep Learning with Python", Manning Publications, 2017.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / LAB / Seminar			
List of Indicative Experiments			
1.	Train a Deep learning model to classify a given image using pre trained model		
2.	Object detection using Convolution Neural Network		
3.	Recommendation system from sales data using Deep Learning		
4.	Improve the Deep learning model by tuning hyper parameters		
5.	Perform Sentiment Analysis in network graph using RNN		
6.	Image generation using GAN		
Total Laboratory Hours			30 hours
Mode of assessment: CAT / Assignment / Quiz / FAT S			
Recommended by Board of Studies	11-06-2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course code	STOCHASTIC MODELS AND APPLICATIONS	L	T	P	J	C
MATXXX		3	0	0	0	3
Pre-requisite		Syllabus version				

Course Objectives:

1. To acquire the knowledge and concepts of stochastic variables, stochastic process and stochastic models.
2. To understand the methods of drawing inferences using simulation and related stochastic methods.
3. To apply stochastic methods and models to solve real time problems.

Expected Course Outcome:

1. Students are able to learn stochastic variables, functions, process and models.
2. Able to describe the Markov chains renewal theories and their applications.
3. Students are able to apply continuous time Markov chain and its application.
3. Able to learn and apply MCMC and Gibbs algorithm.
5. Able to demonstrate and compute the reliability model and related applications.
6. Elucidate the role of stochastic modeling to real time applications.
7. Able to differentiate between deterministic and stochastic approach in problem solving.

Module 1	Introduction to Stochastic Process	6 hours	

Stochastic events, stochastic variables, stochastic versus deterministic models, stochastic process and behavior, steps of stochastic modeling, expectation of random variable, jointly distributed random variable, moment generating function, limits theorem and its application, transition probability.

Module 2	Markov Chains	7 hours	

Introduction, Chapman- Kolmogorov Equations, classification of states, limiting probabilities and some applications, Mean time spent in transient states, time reversible Markov chain, Markov chain, Monte Carlo methods, Markov decision processes, hidden Markov chains.

Module 3	Continuous - Time Markov Chains	6 hours	

Introduction, Birth and Death Processes, The transition probability function P_{ij}(t), limiting probabilities, time reversibility, computing the transition probabilities, uniformization.

Module 4	Renewal Theory and its Application	6 hours	

Introduction, Distribution of N(t), Limit theorem and their applications, renewal reward processes, regenerative processes, Semi-Markov processes, computing the Renewal function, application to patterns.

Module 5	Markov Chain Monte Carlo(MCMC)	6 hours	

Introduction to MCMC, Metropolish Algorithm, The Metropolish-Hastings Algorithm, Gibbs Algorithm, Issues related to MCMC.Problems and applications of MCMC.

Module 6	Reliability model	6 hours	

Introduction, structure functions, reliability of systems of independent components, bounds on the reliability functions, system life as a component of function lives, expected system life time, systems with repair

Module 7	**Simulation**	**6 hours**	
Introduction, general and special techniques for simulating continuous random variables, simulating from discrete distributions, stochastic processes, variance reduction techniques, determining the number of runs,			
Module:8	**Contemporary issues**	**2 hours**	
Guest lectures by industry and R & D organizations			
	Total Lecture hours:	**45 hours**	

Text Book	
1.	Seldom M. Ross, Introduction to Probability Models, 12th Edition(2019), Academic Press.
Reference Books	
1.	J Medhi, Stochastic Processes, 5thEdition (2020), New Age International Ltd.
2.	Ramachandran K. M., Tsokos Chris P., Mathematical Statistics with Applications (2009), Academic Press.
3.	Hiroyuki Matsumoto, SetsuoTaniguchi,"Stochastic Analysis", Cambridge University Press, 2016.
4.	Roy D. Yates and David J. Goodman, Probability and Stochastic Processes, 2nd Edition(2011) Dresden, "Stochastic Models, Statistics and Their Applications", Springer, 2019.

Mode of Evaluation: CAT / Assignment / Quiz / FAT			
Recommended by Board of Studies	30.06.2021		
Approved by Academic Council	No.	Date	

Course code	BIO-INSPIRED COMPUTING	L	T	P	J	C
CSE6038		3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		v. xx.xx				

Course Objectives:

1. To understand the fundamentals of evolutionary theory and cellular automata.
2. To learn the artificial neural systems and swarm optimization for feature selection.
3. To learn the genetic algorithm and hybridization with memetic algorithms.

Expected Course Outcomes:

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

1. Understand basic concepts of evolutionary algorithm
2. Understand the basic features of neural and immune systems and able to build the neural model.
3. Explain how complex and functional high-level phenomena can emerge from low-level interactions.
4. Explain the computational processes derived from neural models.
5. Implement simple bio-inspired algorithms like genetic and Particle Swarm Optimization.

Module:1	INTRODUCTION TO EVOLUTIONARY ALGORITHM	6 hours

Evolutionary algorithm, components of evolutionary algorithm representation (definition of individuals), Evaluation function (Fitness function), Population, parent selection Mechanism, Variation Operators, Survivor Selection Mechanism (Replacement), Initialization, Termination Condition, evolutionary algorithm case study Cellular systems, cellular automata, modeling with cellular systems, other cellular systems, computation with cellular systems, artificial life: analysis and synthesis of cellular systems.

Module:2	NEURAL SYSTEMS	6 hours

Biological nervous systems, artificial neural networks, neuron models, architecture, signal encoding ,synaptic plasticity, unsupervised learning, supervised learning, reinforcement learning, evolution of neural networks, hybrid neural systems, case study.

Module:3	DEVELOPMENTAL AND IMMUNE SYSTEMS	6 hours

Rewriting system, synthesis of developmental system, evolutionary rewriting systems, evolutionary developmental programs, biological immune systems, lessons for artificial immune systems,algorithms and applications, shape space, negative selection algorithm, clonal selection algorithm.

Module:4	BEHAVIORAL SYSTEMS	6 hours

Behavior is cognitive science, behavior in AI, behavior based robotics, biological inspiration for robots, robots as biological models, robot learning, evolution of behavioral systems, learning in behavioral systems, co-evolution of body and control, towards self-reproduction, simulation and reality

Module:5	GENETIC ALGORITHMS	6 hours

Representation of Individuals, Mutation, Recombination, Population Models, Parent Selection, Survivor Selection, Example Application: Solving a Job Shop Scheduling Problem

Module:6	HYBRIDIZATION WITH OTHER TECHNIQUES: MEMETIC ALGORITHMS	6 hours
Introduction to Local Search, Lamarckianism and the Baldwin Effect, Structure of a Memetic Algorithm, Heuristic or Intelligent Initialization, Hybridization within Variation Operators: Intelligent Crossover and Mutation, Local Search Acting on the output from Variation Operators ,Hybridization During the Genotype to Phenotype Mapping, Design Issues for Memetic Algorithms.		
Module:7	**COLLECTIVE SYSTEMS**	**7 hours**
Biological self-organization, Particle Swarm Optimization (PSO), ant colony optimization (ACO), swarm robotics, co-evolutionary dynamics, artificial evolution of competing systems, artificial evolution of cooperation, case study.		
Module:8	**RECENT TRENDS**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Books

1. D. Floreano and C. Mattiussi, "Bio-Inspired Artificial Intelligence", MIT Press, 2008.
2. Tao Song, Pan Zheng, Mou Ling Dennis Wong, Xun Wang, “Bio-Inspired Computing Models and Algorithms”, ISBN: 978-981-3143-19-7, world scientific, 2019
3. F. Neumann and C. Witt, “Bioinspired Computation in combinatorial optimization: Algorithms and their computational complexity”, Springer, 2010.

Reference Books

1. D. E. Goldberg, “Genetic algorithms in search, optimization, and machine learning”, Addison- Wesley, 1989.
2. Simon O. Haykin, “Neural Networks and Learning Machines”, Third Edition, Prentice Hall,
3. 2008.
4. M. Dorigo and T. Stutzle, “Ant Colony Optimization”, A Bradford Book, 2004.
5. R. C. Ebelhart, “Swarm Intelligence”, Morgan Kaufmann, 2001.

Xin-She Yang,Zhihua Cui Renbin Xiao Amir HosseinGandomi Mehmet Karamanoglu “Swarm Intelligence and Bio-Inspired Computation”, 1st Edition, Elsevier, 2013.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Seminar

Recommended by Board of Studies	11-06-2019		
Approved by Academic Council	No. 56	Date	24-09-2019

Course code	DIGITAL IMAGING TECHNIQUES AND ANALYSIS	L	T	P	J	C
CSE6059		3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		v. xx.xx				

Course Objectives:

1. To provide knowledge on image processing concepts.
2. To develop the ability to understand and implement various image processing algorithms.
3. To facilitate the students to recognize the appropriate need to various image processing applications with computer vision and deep learning.

Expected Course Outcome:

1. Ascertain and describe the essentials of image processing concepts through mathematical interpretation.
2. Acquire the knowledge of various image transforms and image enhancement techniques involved.
3. Experiment the various image segmentation and morphological operations for a meaningful partition of objects.
4. Design the various basic feature extraction and selection procedures for various image applications.
5. Evaluate various object detection and recognition techniques for various aspects of image processing.
6. Analyze and implement image processing algorithms for various real-time applications using artificial intelligence and deep learning.

Module:1	INTRODUCTION TO IMAGE PROCESSING	4hours

Introduction, Digital Image Fundamentals, image acquisition and display using digital devices - Human visual perception, properties – Image Formation - Image sampling and quantization-Basic relationship between pixels.

Module:2	IMAGE ENHANCEMENT	12 hours

Image enhancement in the spatial domain: basic grey level transformation, Histogram Processing-Enhancement using arithmetic/Logic operations-Spatial filtering: smoothing and sharpening. Image enhancement in the frequency domain: Introduction to two-dimensional transforms-Discrete Fourier Transform, Discrete Cosine Transform, Haar Transform, Discrete Wavelet Transform - smoothing frequency domain filtering-sharpening frequency domain filtering.

Module:3	MORPHOLOGICAL IMAGE PROCESSING	3 hours

Morphological Image Processing: Dilation and Erosion – Opening and Closing – Hit or Miss Transformation – Thinning – Thickening – Skeleton.

Module:4	IMAGE SEGMENTATION	4hours

Image Segmentation: Detection of discontinuities- Object Detection Methods, Edge Liking and Boundary Detection, Thresholding Methods, Region Oriented Methods.

Module:5	**FEATURE EXTRACTION**	**6hours**
Region of interest (ROI) selection - Feature extraction: Histogram based features - Intensity features-Color, Shape features-Local Binary Patterns (LBP), Texture descriptors- Grey Level Occurrence Matrix (GLCM).		
Module:6	**OBJECT RECOGNITION**	**7hours**
Extracting Interest Points and Their Descriptors (with Harris, SIFT and SURF) in Image Pairs, Principal Component Analysis (PCA) and Linear Discriminant Analysis for Image Recognition.		
Module:7	**IMAGE CLASSIFICATION AND DEEP LEARNING**	**7hours**
Image Classification using SVM, ANN- Feedforward and Backpropagation, Object Detection using CNN, RCNN.		
Module:8	**Recent Trends - Case studies**	**2hours**
	Total Lecture hours:	**45hours**

Text Book(s) and Journals	
1.	Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", Pearson Education, Fourth Edition, 2018.
2.	S. Sridhar, "Digital Image Processing", Second Edition, Oxford University, 2016.
Reference Books	
1.	Anil K. Jain "Fundamentals of Digital Image Processing", PHI, Learning Private Ltd, 2011.
2.	Milan Sonka, VaciavHlavac, Roger Boyle, "Image Processing Analysis and Vision", Fourth Edition, Cengage India, 2017.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Seminar			
Mode of assessment:			
Recommended by Board of Studies	05-02-2020		
Approved by Academic Council	No. 58	Date	26-02-2020

Course code	STATISTICAL NATURAL LANGUAGE PROCESSING	L	T	P	J	C
CSE6060		3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		v. xx.xx				

Course Objectives:

1. To familiarize the concepts and techniques of Natural language Processing for analyzing words based on Morphology and CORPUS.
2. Torelate mathematical foundations, Probability theory with Linguistic essentials such as syntactic and semantic analysis of text.
3. To apply the Statistical learning methodsand cutting-edge research models from deep learning.

Expected Course Outcome:

1. Apply the principles and Process of Human Languages such as English and other Indian Languages using computers.
2. Realize semantics and pragmatics of English language for text processing
3. Create CORPUS linguistics based on digestive approach (Text Corpus method)
4. Check a current methods for statistical approaches to machine translation.
5. Perform POS tagging for a given natural language and Select a suitable language modelling technique based on the structure of the language.
6. Demonstrate the state-of-the-art algorithms and techniques for text-based processing of natural language with respect to morphology.
7. Develop a Statistical Methods for Real World Applications and explore deep learning based NLP.

Module:1	Introduction to NLP	4hours

Introduction to NLP - Various stages of NLP –The Ambiguity of Language: Why NLP Is Difficult-Parts of Speech: Nouns and Pronouns, Words: Determiners and adjectives, verbs, Phrase Structure. Statistics Essential Information Theory : Entropy, perplexity, The relation to language, Cross entropy

Module:2	Text Preprocessing and Morphology	6 hours

Character Encoding, Word Segmentation, Sentence Segmentation, Introduction to Corpora, Corpora Analysis. Inflectional and Derivation Morphology, Morphological analysis and generation using Finite State Automata and Finite State transducer.

Module:3	Language Modelling	6 hours

Words: Collocations- Frequency-Mean and Variance –Hypothesis testing:The t test, Hypothesis testing of differences, Pearson's chi-square test, Likelihood ratios. Statistical Inference: n -gram Models over Sparse Data: Bins: Forming Equivalence Classes- N gram model - Statistical Estimators- Combining Estimators

Module:4	Word Sense Disambiguation	6hours

Methodological Preliminaries, Supervised Disambiguation: Bayesian classification, An information-theoretic approach, Dictionary-Based Disambiguation: Disambiguation based on sense, Thesaurus-based disambiguation, Disambiguation based on translations in a second-language corpus.

Module:5	Markov Model and POS Tagging	7hours

Markov Model: Hidden Markov model, Fundamentals, Probability of properties, Parameter estimation, Variants, Multiple input observation. The Information Sources in Tagging: Markov model taggers, Viterbi algorithm, Applying HMMs to POS tagging, Applications of Tagging

Module:6	**Probabilistic Context Free Grammars and Probabilistic parsing**	**7hours**
The Probability of a String, Problems with the Inside-Outside Algorithm, Parsing for disambiguation, Treebanks, Parsing models vs. language models, Phrase structure grammars and dependency,Lexicalized models using derivational histories, Dependency-based models.		
Module:7	**Syntax and Semantics**	**7hours**
Shallow Parsing and Chunking, Shallow Parsing with Conditional Random Fields (CRF), Lexical Semantics, WordNet, Thematic Roles, Semantic Role Labelling with CRFs. Statistical Alignment and Machine Translation, Text alignment, Word alignment, Information extraction, Text mining, Information Retrieval, NL interfaces, Sentimental Analysis, Question Answering Systems, Social network analysis.		
Module:8	**Recent Trends**	**2hours**
Recent trends in NLP		

	Total Lecture hours:	**45hours**	

Text Book(s) and Journals

1.	Christopher D. Manning and Hinrich Schutze, " Foundations of Natural Language Processing" , 6th Edition, The MIT Press Cambridge, Massachusetts London, England, 2003
2.	Daniel Jurafsky and James H. Martin "Speech and Language Processing", 3rd edition, Prentice Hall, 2009.

Reference Books

1.	NitinIndurkhya, Fred J. Damerau "Handbook of Natural Language Processing", Second Edition, CRC Press, 2010.
2.	James Allen "Natural Language Understanding", Pearson Publication 8th Edition. 2012.
3.	Chris Manning and HinrichSchütze, "Foundations of Statistical Natural Language Processing", 2nd edition, MITPress Cambridge, MA, 2003.
4.	Hobson lane, Cole Howard, Hannes Hapke, "Natural language processing in action" MANNING Publications, 2019.
5.	Alexander Clark, Chris Fox, Shalom Lappin, "The Handbook of Computational Linguistics and Natural Language Processing", Wiley-Blackwell, 2012
6.	Rajesh Arumugam, Rajalingappa Shanmugamani "Hands-on natural language processing with python: A practical guide to applying deep learning architectures to your NLP application". PACKT publisher, 2018.

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project / Seminar

Recommended by Board of Studies	05-02-2020		
Approved by Academic Council	No. 58	Date	26-02-2020

Course code	SOFT COMPUTING TECHNIQUES	L	T	P	J	C
CSE6062		3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		v. xx.xx				

Course Objectives:

1. To introduce soft computing concepts and techniques and foster their abilities in designing appropriate technique for real-world problems.
2. To provide adequate knowledge of non-traditional technologies and fundamentals of artificial neural networks, back propagation networks, fuzzy sets, fuzzy logic, geneticalgorithms in solving social and engineering problems.
3. To provide comprehensive knowledge of associative memory networks and adaptive resonance theory

Expected Course Outcome:

The student will be able

1. Apply neural networks, bidirectional associative memories and adaptive resonance theory for solving different engineering problems
2. Identify and describe soft computing techniques and build supervised learning and unsupervised learning networks.
3. Apply fuzzy logic and reasoning to handle uncertainty and solve various engineering problems.
4. Apply genetic algorithms to combinatorial optimization problems.
5. Evaluate and compare solutions by various soft computing approaches for a given problem.

Module:1	Introduction to Soft Computing	3 hours	CO: 1

Soft computing vs. hard computing, evolution of soft computing, features and types of soft computing, applications of soft computing, basics of machine learning.

Module:2	Neural Networks and Back Propagation networks	8 hours	CO: 2

Basic concepts of Neural Networks, Model of Artificial Neuron, Neural Network Architectures, Characteristics of neural networks, Learning Methods, Early neural network architectures, Application domains. Back propagation network (BPN), Back propagation Learning, Applications of BPN, Parameter selection, Variations of Back propagation Algorithms

Module:3	Associative Memory Networks	7 hours	CO: 3

Auto correlators, hetero correlators: Kosko's discrete Bi-direction associative memory (BAM), Exponential BAM, Application of Character Recognition.

Module:4	Unsupervised learning: Adaptive Resonance Theory	7 hours	CO:3

Adaptive Resonance Theory (ART), Classical ART Networks, Simplifies ART Architecture, Features, algorithms and Illustration of ART1 and ART2 model, Related Applications

Module:5	Fuzzy Sets and Fuzzy Relations	5 hours	CO: 4

Fuzzy versus Crisp, Crisp Sets, Fuzzy sets, Membership functions, fuzzy set operations, properties of Fuzzy sets, Crisp Relations, Fuzzy relations – Fuzzy Cartesian product, Operations of Fuzzy Relations.

Module:6	Fuzzy Logic and Inference	5 hours	CO: 4

Crisp Logic, Predicate Logic, Fuzzy Logic, Fuzzy Quantifiers, Fuzzy Inference, Fuzzy knowledge and rule-based system, fuzzy decision making, Defuzzification, Application of fuzzy logic.			
Module:7	**Genetic Algorithms**	**8 hours**	**CO: 5**
History of Genetic Algorithm, Basic concepts, Creation of offspring, working principles, encoding, fitness function, reproduction, Genetic modeling: Inheritance operator, crossover, inversion & deletion, mutation operator, Bitwise operator, Generational Cycle, Convergence of GA,Applications & advances in GA, Differences & similarities between GA & other traditional method, Hybrid systems, evolutionary computing, Genetic Algorithm based on Backpropagation networks- Implementation and comparison on performance of traditional algorithms with Genetic Algorithm			
Module:8	**Contemporary Issues**	**2 hours**	**CO: 5**
	Total Lecture hours:	**45 hours**	

Text Book(s)

1.	S, Rajasekaran& G.A. VijayalakshmiPai, "Neural Networks, Fuzzy systems and evolutionary algorithms: Synthesis and Applications", PHI Publication, 2nd Ed. 2017.
2.	Timothy J. Ross, "Fuzzy Logic with Engineering Applications", John Wiley and Sons, 3rd ed, 2011.
3.	S.N. Sivanandam& S.N. Deepa, "Principles of Soft Computing", Wiley Publications, 3rd ed, 2018.

Reference Books

1.	Jang, Jyh-Shing Roger, Chuen-Tsai Sun, and EijiMizutani. "Neuro-fuzzy and soft computing-a computational approach to learning and machine intelligence" Pearson, 1997.
2.	Kosko, B., Neural Networks and Fuzzy Systems: A Dynamical Systems Approach to Machine Intelligence, PHI Publication, 1994.
3.	George J. Klir,Fuzzy Sets and Fuzzy Logic: Theory and Applications, Prentice Hall, 2015
4.	Rich E andKnight K, Artificial Intelligence, McGraw Hill Education; 3rd ed, 2017.
5.	S. Haykin, "Neural Networks and Learning Machines", Pearson Education Inc., 3rd Ed 2008.
6.	Goodfellow, Ian, YoshuaBengio, and Aaron Courville. Deep learning: Adaptive Computation and Machine Learning series, MIT press, 2016.

Mode of Evaluation: CAT / Assignment / Quiz / FAT			
Mode of assessment:			
Recommended by Board of Studies	09-09-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course code	KNOWLEDGE ENGINEERING AND INTELLIGENT SYSTEMS	L	T	P	J	C
CSE6063		3	0	0	0	3
Pre-requisite	Nil				Syllabus version	
					v. xx.xx	

Course Objectives:

1. To introduce the fundamentals of Knowledge Engineering and Intelligent Systems.
2. To provide deep understanding of Knowledge Engineering and Intelligent Systems
3. To educate about all aspect of advanced models of KE and Its applications

Expected Course Outcome:

1. Demonstrate the knowledge of fundamental elements and concepts related to Intelligent Systems
2. Demonstrate the fundamental and advanced modules of KEespecially with Searching methods, Representation of knowledge and different reasoningtechniques.
3. Ability to work with Predicate logic, back propagation with respect to the CNNs model parameters and implementing the models successfully.
4. Apply the higher order logics for handling uncertainty
5. Implement an expert system to solve critical problems of medical domain, application of business intelligence and robotics in real life problems.

Module:1	Knowledge Engineering Concepts	6hours	CO:1,2

Definition of Knowledge Engineering – Knowledge base Systems – Knowledge base systems Vs Database systems – Rules Vs Triggers – Domain Expert – Expert Systems –Heuristic Search – A*, AO* and Mini-max algorithms - Knowledge representation – Semantic Networks – Frames- Conceptual Dependency – Scripts – Ontology – Semantic Web– Reasoning Methods

Module:2	First Order Logic	6 hours	CO:2, 3

Role of Logic –Propositional logic – Predicate logic – Syntax – Semantics – Interpretations – Denotation – Satisfaction and models – Pragmatics – Explicit and Implicit Beliefs - Logical Consequence – Expressing Knowledge - Basic and Complex Facts – Terminological facts – Entailment –Abstract Individuals - Other Sorts of Facts –Resolution – The Propositional Case – Predicate Logic – Handling Variables and Quantifiers –First Order Resolution- Answer Extraction – Skolemization – Clause Form – Equality - Dealing with Computational Intractability - The First-Order Case - Herbrand Theorem - The Propositional Case - The Implications - SAT Solvers - Most General Unifiers - Other Refinements

Module:3	Knowledge Representation – Using Rules	6 hours	CO: 2,3

Procedural Versus Declarative Knowledge - Logic Programming - Forward versus Backward Reasoning – Rule Matching – Rules in Production Systems- Working Memory- Conflict Resolution- Rete's Algorithm – Discriminant Networks - Control Knowledge –Reasoning with Horn Clauses – Computing Selective Linear Definite clause resolution Derivatives – Rule Formation and Search Strategy – Algorithm Design – Specifying Goal order – Committing to Proof methods – Controlling Back Tracking – Negation as Failure – Dynamic Databases

Module:4	Object Oriented Representation using Logic	6hours	CO: 5

Object oriented Representation – Objects and Frames – Frame Formalism –Object Driven Programming with Frames – Generic and Individual Frames – Inheritance – Reasoning with Frames – Structured Descriptions – Descriptions – Description Language – Meaning and Entailment – Interpretations – Truth in an Interpretation –Computing Entailments – Simplifying the Knowledge base – Normalization – Structure Matching – Subsumption Computation – Taxonomies and Classification –Inheritance Networks – Handling Defeasible Inheritance – Inheritance Networks			
Module:5	**Uncertainty and Higher Order Logics**	**6hours**	**CO:2,4**
Vagueness- Uncertainty – Degrees of Belief- Defaults – Default Reasoning – Closed World Assumption – Situation Logic - Non Monotonic Logic- Truth Maintenance Systems - Fuzzy Logic – Inference using Fuzzy Rules – Modal Logic – Temporal Logic – Temporal reasoning – Temporal Constraint networks – Epistemic Logic- Statistical Reasoning – Bayesian Networks – Plausibility Theory - Reasoning and Decision Making under Uncertainty			
Module:6	**Expert Systems and Learning**	**6hours**	**CO:6**
Expert Systems – Shells for Expert Systems – Inference Engine – Forward and Backward Chaining Inference – MYCIN - DENDRAL –Knowledge Acquisition - Rote Learning – Learning from Examples – Machine Learning- Neural Networks – Regression Analysis- Predictive Models - Deep Learning			
Module 7: Applications of Knowledge Base Systems		**6hours**	**CO:6**
Factory Automation -Field and Service Robotics–AssistiveRobotics -Military Applications - Medicare–Education – Business Intelligence – Recommendation Systems – Social Network Analysis – Natural Language Processing – Information Retrieval Systems			
Module:8	**Contemporary issues:**	**3hours**	**CO:1, 6**
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	Total Lecture hours:	**45 hours**	

Text Book(s)

1. Ronald Brachman, Hector Levesque, Knowledge Representation and Reasoning, 1st Edition, Morgan Kaufmann, 2004
2. Richard A Frost, “Introduction to Knowledge Based Systems”, Macmillan Publishing Co, 1986.
3. John F. Sowa, Knowledge Representation: Logical, Philosophical, and Computational Foundations, Brooks Cole Publishing Co., Pacific Grove, CA, 2000
4. Building Intelligent SystemsA Guide to Machine Learning Engineering, Authors: Hulten, Geoff, Apress; 1st ed. edition (2018)

Reference Book(s)

1. Elaine Rich, Kevin Knight, Shivashankar B. Nair, “Artificial Intelligence”, Third Edition, Tata McGraw-Hill Education Pvt. Ltd., 2010.
2. Donald A Waterman,”A Guide to Expert Systems”, Addison Wesley, 1986.
3. Schall, Daniel,"Social Network-Based Recommender Systems", Springer, 2015.

Mode of Evaluation: CAT / Assignment / Quiz / FAT

Recommended by Board of Studies		09-09-2020	
Approved by Academic Council	No. 59	Date	24-09-2020

Course Code	INTELLIGENT INFORMATION RETRIEVAL	L	T	P	J	C
CSE6064		3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		v. xx.xx				

Course Objectives:

1. To familiarize with boolean and vector space retrieval models; evaluation and interface issues, text index construction and scoring
2. To develop intelligent systems by applying the methods such as Prediction, Forecasting, Classification, Clustering and Optimization
3. To build working systems that assist users in finding useful information on the Web

Expected Course Outcome:

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

1. Describe the genesis and variety of information retrieval situations;
2. Construct the variety of information retrieval models and techniques;
3. Execute methods and principles of information retrieval systems;
4. Develop Methods for implementing information retrieval systems;
5. Interpret Characteristics of operational and experimental information retrieval systems;
6. Evaluate the emerging information retrieval practices in library services and on the Web

Module:1	Fundamentals of IR Systems, Models and Indexing	7hours	CO1, CO3

Overview of IR Systems,Information retrieval using the Boolean model, The dictionary and postings lists, Tolerant retrieval, Automatic Indexing, Index construction and compression, Scoring, Vector space model and term weighting

Module:2	Document Representation and Analysis	6 hours	CO2

Statistical Characteristics of Text, Regular Expressions, Text Normalization, Edit Distance, N-Gram Language Models, Naive Bayes and Sentiment Classification-Logistic Regression for Document Analysis

Module:3	Query Processing and Evaluation	5 hours	CO5, CO6

Basic Query Processing,Data Structure and File Organization for IR, Evaluation in information retrieval-Relevance feedback, User Profiles, Collaborative Filtering and query expansion

Module:4	Retrieval Models	5hours	CO2

Similarity Measures and Ranking, Boolean Matching, Vector Space Models, Probabilistic Models,XML Retrieval, Language models for information retrieval.

Module:5	Text Classification and Clustering	6hours	CO4

Text classification-vector space classification-support vector machines and machine learning on documents-Clustering-flat clustering- hierarchical clustering- Matrix decompositions and Latent semantic indexing

Module:6	Web Search Analysis	7hours	CO5, CO6

Web search basics. web characteristics-index size and estimation- near duplicates and shingling-web crawling-distributing indexes- connectivity servers-link analysis-web as a graph-PageRank-Hubs and authoritative pages- summarization-question answering

Module:7	Web Mining and Online IR Systems	7hours	CO5, CO6

Web mining and its applications-Mining Twitter, Facebook, Instagram, Linkedin, Mailboxes and GitHub.Online IR systems- online public access catalogs-digital libraries-architectural issues-document models -representations and access protocols			
Module:8	**Recent Trends**	**2hours**	**CO6**
	Total Lecture hours:	**45hours**	

Text Book(s)

1.	C. D. Manning, P. Raghavan, and H. Schutze, Introduction to Information Retrieval, Cambridge University Press (2008)
2.	Ricardo Baezce Yates, Berthier Ribeiro-Neto, Modern Information Retrieval: The Concepts and Technology behind Search (2ndEd, 2010)
3.	Mikhail Klassen, Matthew A. Russell, Mining the Social Web,O'Reilly Media, Inc., 3rd Edition (2019)

Reference Books

1.	Ceri, S., Bozzon, A., Brambilla, M., Della Valle, E., Fraternali, P. and Quarteroni, S., 2013. Web information retrieval. Springer Science & Business Media.
2	D. Jurafsky, and J. Martin, Speech and language processing : an introduction to natural language processing, computational linguistics, and speech recognition, Pearson Prentice Hall, Second Edition (2013)
3	Giles, Mark Smith, John Yen, Advances in Social Network Mining and Analysis ,Springer, 2010
4	Bruce Croft, Donald Metzler and Trevor Strohma, Search Engines: Information Retrieval in Practice (1st Ed 2009)

Mode of Evaluation:CAT / Assignment / Quiz / FAT

Recommended by Board of Studies	09-09-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course code	PATTERN RECOGNITION	L	T	P	J	C
CSE6065		3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		v. xx.xx				

Course Objectives:

1. To understand the concept of a pattern and the basic approach to the development of pattern recognition and machine intelligence algorithms.
2. To apply the knowledge offeature extraction methods, feature evaluation, and data miningon real life
3. To apply both supervised and unsupervised classification methods to detect and characterize patterns in real-world data.

Expected Course Outcome:

On completion of this course the students will be able to

1. Understand the need and significance of mathematical fundamentals in pattern recognition to solve real-time problems.
2. Explore on supervised learning algorithms and to apply them for solving problems.
3. Apply unsupervised techniques for clustering data without prior knowledge.
4. Design pattern recognition models to extract interesting patterns from structured data like graph, syntactic description etc.
5. Understand the impact of dimensionality reduction on the design of intelligent models and to apply the dimensionality reduction techniques on data.
6. Apply various machine learning techniques like artificial neural networks, Support Vector machines, Fuzzy inference engines etc.to solve real-world problems.
7. Develop prototype pattern recognition algorithms that can be used to study algorithm behavior and performance against real-world multivariate data.

Module:1	Classification	5 hours	CO:1

Overview of pattern recognition-Discriminant functions-Supervised learning-Parametric estimation-Maximum likelihood estimation

Module:2	Pattern Classifier	5 hours	CO:2

Bayesian parameter estimation-perceptron algorithm-LMSE algorithm-problems with Bayes approach-Pattern classification by distance functions-Minimum distance pattern classifier.

Module:3	Unsupervised Classification	6 hours	CO:3

Clustering for unsupervised learning and classification-Clustering concept-C-means algorithm-Hierarchical clustering procedures-Graph theoretic approach to pattern clustering-Validity of clustering solutions.

Module:4	Structural Pattern Recognition	6 hours	CO:4

Elements off or mal grammars-String generation as pattern description-Recognition of Syntactic description-Parsing-Stochastic grammars and applications-Graph based structural representation.

Module:5	Feature Extraction and Selection	6 hours	CO:5

Entropyminimization-Karhunen-Loevetransformation-Featureselectionthrough Functions approximation-Binary feature selection.

Module:6	**Neural Networks and Kernel Machines**	**6 hours**	**CO:6**
Neural network structures for pattern recognition-Neural network based pattern associators– Selforganizing networks-Support vector machines (SVM)-Kernel machines, Maximum margin classification, and generalizabilityand VC(Vapnik–Chervonenkis) dimension.			
Module:7	**Neuro Fuzzy and Genetic Algorithm for Pattern classification**	**6 hours**	**CO:7**
Fuzzy logic-Fuzzy pattern classifiers-Neuro-Fuzzy Systems-Pattern classification and optimization Using Genetic Algorithms			
Module:8	**Recent Trends**	**5 hours**	**CO:7**
	Total Lecture hours:		**45 hours**

Text Book(s)

1. Duda R.O., and Hart.P.E.,Pattern Classification and Scene Analysis, second edition, Wiley, 2001. (Modules 1,2,3,5)
2. Robert J.Schalkoff, Pattern Recognition: Statistical, Structural and Neural Approaches, JohnWiley& Sons Inc., New York, 2007. (Modules 2,4)
3. Trevor H, Robert T,Jerome Friedman, The Elements of Statistical Learning, Springer Series,2017 (Modules 3,6,7)
4. Christopher M Bishop, Pattern Recognition and Machine Learning. Springer. 2011.(Module6,7)

Reference Books

1. Tou and Gonzales, Pattern Recognition Principles, Wesley Publication Company, London, 1974.
2. Morton Nadier and Eric Smith P., Pattern Recognition Engineering, John Wiley & Sons, NewYork, 1993.

Mode of Evaluation: CAT / Assignment / Quiz / FAT

Recommended by Board of Studies	09-09-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course code	REINFORCEMENT LEARNING	L	T	P	J	C
CSE6066		3	0	0	0	3
Pre-requisite		Syllabus version				
		v.1				

Course Objectives:

1. Learn how to define RL tasks and the core principals behind the RL, including policies, value functions.
2. Understand and work with tabular methods to solve classical control problems.
3. Recognize current, advanced techniques and applications in RL.

Expected Course Outcome:

1. Implement in-code common algorithms following code standards and libraries used in RL.
2. Understand and work with approximate solutions.
3. Explore imitation learning tasks and solutions.
4. Learn how to define RL tasks and the core principals behind the RL, including policies, value functions.
5. Understand and work with tabular methods to solve classical control problems.
6. Recognize current advanced techniques and applications using RL.

Module:1	Reinforcement Learning Primitives	7 hours	CO: 1, 2

Introduction and Basics of RL, Defining RL Framework, Probability Basics: Probability Axioms, Random Variables, Probability Mass Function, Probability Density Function, Cumulative Distribution Function and Expectation. Introduction to Agents, Intelligent Agents – Problem Solving – Searching, Logical Agents.

Module:2	Markov Decision Process and Dynamic Programming	7 hours	CO: 2, 3

Markov Property, Markov Chains, Markov Reward Process (MRP), Bellman Equations for MRP, Dynamic Programming: Polices (Evaluation, Improvement, Iteration, Value Iteration),Asynchronous Dynamic Programming, Generalized Policy Iteration, Efficiency of Dynamic Programming.

Module:3	Monte Carlo Methods and Temporal Difference Learning	7 hours	CO: 3, 4

Monte Carlo: Prediction, Estimation of Action Values, Control and Control without Exploring Starts, Off-Policy Control, Temporal Difference Prediction:TD(0), SARSA: On-Policy TD control, Q-Learning: Off-Policy TD control, Games, Afterstates, and Other Special Cases.

Module:4	Deep Reinforcement Learning	7 hours	CO: 4, 5

Deep Q-Networks, Double Deep-Q Networks(DQN, DDQN, Dueling DQN, Prioritized Experience Replay).

Module:5	Policy Optimization in RL	7 hours	CO: 6

Introduction to Policy-based Methods, Vanilla Policy Gradient, REINFORCE Algorithm and Stochastic Policy Search, Asynchronous Actor-Critic and Asynchronous Advantage Actor-Critic (A2C, A3C), Advanced Policy Gradient (PPO, TRPO, DDPG).

Module:6	Multi Agent in RL	7 hours	CO: 5, 6

Multi-Agent Learning, Meta-learning, Partially Observable Markov Decision Process, Ethics in RL, Applying RL for Real-World Problems

Module:7	**Recent Trends**	**3 hours**	**CO: 6**
	Total Lecture hours:	**45 hours**	

Text Book(s)

1. Richard S. Sutton and Andrew G. Barto, "Reinforcement learning: An Introduction", Second Edition, MIT Press, 2019.
2. Russell, Stuart J., and Peter Norvig. "Artificial intelligence: a modern approach.", Pearson Education Limited, 2016.
3. Michael Wooldridge, “An Introduction to Multi Agent Systems”, John Wiley, 2002.

Reference Books

1. Ian Goodfellow, YoshuaBengio, and Aaron Courville. "Deep learning." MIT press, 2017.
2. Marco Wiering, Martijn van Otterlo(Ed),"Reinforcement Learning, State-of-the-Art, Adaptation, Learning, and Optimization book series, ALO, volume 12, Springer, 2012.
3. Keng, Wah Loon, Graesser, Laura, "Foundations of Deep Reinforcement Learning: Theory and Practice in Python", Addison Wesley Data & Analytics Series, 2020.
4. Francois Chollet, “Deep Learning with Python”, Manning Publications, 2018.
5. RagavVenkatesan, Baoxin Li, “Convolutional Neural Networks in Visual Computing”, CRC Press, 2018

Mode of Evaluation: CAT / Assignment / Quiz / FAT			
Mode of evaluation:			
Recommended by Board of Studies	09-09-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course code	MACHINE LEARNING FOR SIGNAL PROCESSING	L	T	P	J	C
CSE6067		3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		v. 01				

Course Objectives:

1.To introduce the students with machine learning fundamentals for solving signal processing based applications
2. To implement various mathematical methods involved in Machine Learning
3. To design their own models for the specific applications and optimize them efficiently

Expected Course Outcome:

After successful completion of the course, student will be able to :
1. understand the mathematical methods for implementing signal processing and machine learning techniques
2. Perform the optimization techniques for various Machine Learning models
3. Develop methods of data representations for signal processing in machine learningenvironment
4. Apply Machine Learning models for linear systems
5. Classify Machine Learning models for Non-linear systems
6. Apply basic machine learning models and prediction techniques on signals
7. Apply machine learning models in speech and image processing applications

Module:1	Mathematical Foundations	6hours	CO: 1

Introduction - Notion of a signal- Basic digital representation of data(text, speech, image, video) - Complex Exponential functions- Shannon Information Theory, Convolution, Correlation and Covariance Functions-Wavelets- Fourier Transform - DCT and Wavelets, Gaussian Processes

Module:2	Optimization Techniques	6 hours	CO: 2

Gradient ascent/descent- Basics of convex optimization- Constrained optimization, Convex sets, Hyperplanes/ Half-spaces, Lagrange multipliers, projected gradients- Bio-Inspired Algorithms

Module:3	Data-driven Representations	6 hours	CO: 3

Dictionary based representations - Eigen representations – Karhunen Loeve Theorem - PrincipalComponent Analysis- Properties- Independent Component Analysis(ICA)- ICAfor representations and Denoising - Non-negative matrix factorization

Module:4	Linear Gaussian Systems and Signal Processing	6 hours	CO: 4

Delta and Related Functions- Linear Time Invariant Systems – LTI Signal Processing – Exploiting Statistical Stability for linear- Gaussian DSP- Kalman Filters

Module:5	Non- Linear and non-Gaussian signal Processing	6hours	CO: 5

Running Window filters- Recursive filters- Global Non-linear Filter – Hidden Markov Modelling – Homomorphic Signal Processing

Module:6	Statistical Machine Learning	7hours	CO: 6

Statistical Machine Learning techniques - implementation for signal processing applications :Binary Classification -Linear classifiers – Perceptron's-– SVM-Linear, Kernel SVM - Multiclass Problem - K-means - Nearest Neighbors - Linear regression - Regularization			
Module:7	**Machine Learning Applications for signal processing**	**5hours**	**CO: 7**
Machine Learning for Audio Classification - Time Series Analysis, LSTMs and CNNs. Machine Learning for Image Processing - Transfer Learning, Attention models, Attribute-based learning			
Module:8	**Recent Trends**	**3 hours**	**CO:4,5,6,7**
	Total Lecture hours:	**45hours**	

Text Book(s) and Journals

1. Max A. Little, Machine Learning for Signal Processing: Data Science, Algorithms, and Computational Statistics, Oxford Publisher, 2019
2. Paolo Prandoni , Martin Vetterli, Signal Processing for Communications (Communication and Information Sciences), CRC Press, 2008
3. Stephen Boyd, LievenVandenberghe, Convex Optimization,Cambridge University Press, 2004

Reference Books

1. Francesco Camastra, Alessandro Vinciarelli, Machine Learning for Audio, Image and Video Analysis: Theory and Applications,2nd Edition, 2015 Edition.
2. D. Yu and L. Deng, Automatic Speech Recognition: A Deep Learning Approach, Springer, 2016
3. I. Goodfellow, Y, Bengio, A. Courville, Deep Learning, MIT Press, 2016.
4. C.M. Bishop, Pattern Recognition and Machine Learning, 2nd Edition, Springer, 2011.

Mode of Evaluation: CAT / Assignment / Quiz / FAT			
List of Challenging Experiments (Indicative)		NIL	
Mode of assessment:			
Recommended by Board of Studies	09-09-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course code	MACHINE LEARNING WITH LARGE DATASETS	L	T	P	J	C
CSE6068		3	0	0	0	3
Pre-requisite		Syllabus version				
		v. xx.xx				

Course Objectives:

1.To understand various types of scalable machine learning techniques.
2.To get familiarized with large data handling using Hadoop
3. Acquire skills to apply the algorithms to solve real world problems

Expected Course Outcome:

After successfully completing the course, the student should be able to

1. Learn various types of algorithms to handle the large data
2. Apply parallel and distributed ML techniques to get the insights of the large data
3. Identify suitable ML framework to develop the real world application
4. Demonstrate graph based learning algorithms
5. Develop scalable learning techniques both in standalone and distributed settings
6. Learn the design consideration to develop ML models

Module:1	StreamData Mining Algorithms	8hours	CO: 1

Stream Data model, sampling data in a stream, filtering algorithms, counting distinct elements in a stream, estimating moments, Decaying windows, Naïve Baye's, Frequent Item sets:Handling larger datasets in memory, counting frequent itemsets in a stream

Module:2	Tools for large data sets	6hours	CO: 2

Introduction to Hadoop, Hadoop streaming Debugging Hadoop, Combiners, Scalable classification, Abstracts for map-reduce algorithms, joins in Hadoop, similarity joins, page rank, spark, phrase finding

Module:3	Gradient Descent and Hash kernels	6 hours	CO: 3

Learning as optimization, Logistic regression with SGD, Efficient regularized SGD, Hash kernels for logistic regression, matrix factorization with SGD, Distributed matrix factorization with SGD

Module:4	Parallel machine learning algorithms	6hours	CO: 3

Parallel perceptron, parallel SVM , learning from nearest neighbors, parallel design of Decision trees

Module:5	Open source ML tools	7 hours	CO: 4

Computer vision-SimpleCV, Tessaract OCR, Detectron, Natural Language Processing- Stanford core NLP, Music and Audio analysis-LibROSA, Other tools-KNIME and Orange

Module:6	Randomized algorithms	4 hours	CO: 4

Bloom filters, Locality sensitive hashing, online locality sensitive hashing

Module:7	Graph based learning	6hours	CO: 5,6

Graph based ML architectures,: Pregal, signal-collect, GraphLab, PowerGraph, GraphChi, GraphX, Multi rank-walk SSL method, Modified Adsorption SSL method, Label propagation for SSL - Scalable machine learning algorithms

Module:8	**Contemporary issues**	**2hours**	**CO: 6**
	Total Lecture hours:	**45hours**	

Text Book(s)

1.	Leskovec, Jure, AnandRajaraman, and Jeffrey David Ullman. Mining of massive data sets. Cambridge university press, 2020.
2.	Bekkerman, Ron, Mikhail Bilenko, and John Langford, eds. Scaling up machine learning: Parallel and distributed approaches. Cambridge University Press, 2011.

Reference Books

1.	White, Tom. Hadoop: The definitive guide. " O'Reilly Media, Inc.", 2012.
2.	Goodfellow, Ian, YoshuaBengio, and Aaron Courville. Deep learning. MIT press, 2016.
3.	Wilt, Nicholas. The cuda handbook: A comprehensive guide to gpu programming. Pearson Education, 2013.
4.	Frank Pane, “Hands On Data Science and Python Machine Learning”, Packt Publishers, 2017.
5.	John T. Wolohan, “Mastering Large Datasets with Python”, Manning Publications, 2020.

Mode of Evaluation: CAT / Assignment / Quiz / FAT

Recommended by Board of Studies	09-09-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course Code	ADVANCES IN CRYPTOGRAPHY AND NETWORK SECURITY	L	T	P	J	C
CSE6069		2	0	2	0	3
Pre-requisite	Nil	Syllabus version				
		v. xx.xx				

Course Objectives:

1.To learn the emerging concepts of cryptography and algorithms
2. To defend the security attacks on information systems using secure algorithms and Authentication process
3.To categorize and analyze the key concepts in network and wireless security

Expected Course Outcome:

1. Infer the need of security to introduced strong cryptosystems.
2. Analyze the cryptographic algorithms for information security.
3. Identify the authentication schemes for membership authorization.
4. Identify computer and network security threats, classify the threats and develop a security model for detect and mitigate the attacks.
5. Identify the requirements for secure communication and challenges related to the secure web services
6. Ability to identify the need of ethical and professional practices, riskmanagement Using emerging security solutions.

Module:1	Introduction and Symmetric Key Cryptographic Systems	4hours	CO: 1

Introduction to Cryptography, Types of Attacks, Symmetric Key Cryptography, Data Encryption Standard (DES), Differential and Linear cryptanalysis,Advanced Encryption Standard(AES), Modes of operation, Stream Ciphers: Feedback shift registers, Stream ciphers based on LFSRs.

Module:2	Asymmetric Key Cryptosystems	4 hours	CO: 2

Applications of asymmetric Cryptosystems –RSA Rabin, Elgamal, Probabilistic Cryptosystems, Elliptic Curve Cryptography (ECC), Diffie-Hellman key exchange protocol, Chinese Remainder Theorem (CRT).

Module:3	Advanced Cryptographic Techniques	6 hours	CO:2

Multiparty Computation and Secret Sharing, Introduction-Indistingusihability-Secret-Sharing-Simulation-Based Security-Security against Active Corruption-BGW Protocol (Active, Honest-Majority)- Homomorphic Encryption-Lattice Cryptography

Module:4	Data Integrity and Authentication	6 hours	CO: 3

Message Authentication Code (MAC),Hash function properties,General model for iterated hash functions -MD5,Secure Hash algorithms,HMAC, Attacks on hash functions, Digital Signatures,X. 509 digital certificate,Kerberos, Zero-Knowledge Protocol

Module:5	Electronic Mail Security	5 hours	CO: 4

Distribution lists, Establishing keys, Privacy, source authentication, message integrity, Non-repudiation, Proof of submission, Proof of delivery, Message flow confidentiality, anonymity, Pretty Good Privacy (PGP),S/MIME

Module:6	**Firewalls and Web Security**	**3 hours**	**CO:5**
IPsec: AH and ESP, IKE- SSL/TLS,Secure Shell (SSH) application-OpenSSL,Packet filters, Application level gateways, Intrusion detection and Prevention systems			
Module:7	**Wireless Security**	**2 hours**	**CO: 6**
Attacks in wireless networks: DoS and DDoSattacks, Security issues and challenges in WSN and IOT, Wireless Application Protocol (WAP), Wireless LAN Security, Security in GSM.			
Module:8	**Contemporary issues:**	**2 hours**	**CO:5,6**
	Total	30 hours	

Lab Experiments

1. Implement DES, Triple DES and AES Key Algorithms.
2. ImplementRSA, ECC and Diffie-Hellman Key Establishment.
3. Implement a Secret-Sharing algorithm and Homomorphic Encryption algorithm
4. Implement message authentication (MAC) and HASH algorithms
5. Consider and examine the Wireless network security and technology integration for compliance using the case study of Cisco.
6. Explore the Snort Intrusion Detection Systems. Study Snort IDS, a signature-based intrusion detection system used to detect network attacks. Snort can also be used as a simple packet logger. For the purpose of this lab the students will use snort as a packet sniffer and write their own IDS rules
7. Explore ways to perform wireless attacks and understand potential defences using Wireshark. The attacks that will be covered are inspecting & modifying wireless card parameters, changing the wireless transmission channel, flooding attacks, and cracking keys of WPA2 protected networks.
8. Pretty Good Privacy –
   a. Create a public/private key pair in PGP
   b. Create a revocation ley
   c. Exchange PGP keys with other students
   d. Signing the new key
   e. Encrypting a file using your partner's public key
   f. Decrypting the file using your private key
   g. Encrypting and signing a file
   h. Verifying the signature
   i. Sending secure Email with PGP
   j. Adding a public key and sending secure email.
9. Send and receive an encrypted email message using S/MIME.

Text Book(s)

1. J. Katz and Y. Lindell, Introduction to Modern Cryptography. Chapman & Hall/CRC Press, 2014
2. W. Stallings, Cryptography and Network Security: Principles and Practice, 7th Ed. Pearson Publishers, 2017.
3. Behrouz A. Forouzan,Cryptographyand Network Security:6th Ed. McGraw-Hill,2017
4. Dan Boneh and Victor Shoup, A Graduate Course in Applied Cryptography, Jan 2020

Reference Books

1.	Kaufman, Perlman and Speciner. Network Security: Private Communication in a Public World., 2nd edition,2002,Pearson Publishers (ISBN No.:978-01-3-04601-96)			
2	Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone,Handbook of Applied Cryptography,5th edition,2001,CRC Press,(ISBN No:0-8493-8523-7)			
3	D. R. Stinson, *Cryptography: Theory and Practice*, 3rd Ed. Boca Raton, FL: Chapman &Hall/CRC, 2005. (ISBN No.:978-1-58-488508-5)J. H. Silverman, *A Friendly*			
4	Introduction to Number Theory, 4th Ed. Boston: Pearson, 2012. (ISBN No.:978-0-321-81619-1)			
5	Ronald Cramer, Ivan BjerreDamgård, JesperBuus Nielsen, "Secure Multiparty Computation and Secret Sharing", ISBN 9781107043053, Cambridge University Press, 2015			
6	Philip N. Klein, "A Cryptography Primer-Secrets and Promises", ISBN 9781107603455, Cambridge University Press, 2014			
Mode of Evaluation: CAT / Assignment / Quiz / FAT / Lab				
Recommended by Board of Studies		09-09-2020		
Approved by Academic Council		No. 59	Date	24-09-2020

Course code	CLOUD COMPUTING	L	T	P	J	C
CSE6070		2	0	0	4	3
Pre-requisite	Nil	Syllabus version				
		v. xx.xx				

Course Objectives:

1. To introduce the concept of Virtualization and cloud computing
2. To provide students a sound foundation of the Cloud Computing so that they are able to startusing and adopting Cloud Computing services and tools in their real life scenarios
3. To enable students exploring some important cloud computing driven commercial systems suchas Google Apps, Microsoft Azure and Amazon Web Services and other businesses cloud applications.

Expected Course Outcome:

1. An ability to create VM, migrate and provide QOS to the committed users
2. Analyze, identify and select suitable type of virtualization
3. Appreciate the requirements of various service paradigms in Cloud Computing
4. An ability to use techniques, skills in secured cloud environment
5. Clarity in Service Level Agreement and legal constraints on SLA
6. Design, implement and evaluate a cloud-based system, process, component, or program to meetdesired needs

Module:1	Introduction	3 hours	CO:1

Overview of Computing Paradigm, Cloud Computing- Types of Cloud Deployment Models - Private, Public, Hybrid, Agency Clouds - Cloud Service Models: Infrastructure as a Service(IaaS), Platform as a Service(PaaS), Software as a Service(SaaS), Anything as a Service(XaaS)

Module:2	Virtualization	4 hours	CO:2

Types - Implementation Levels –Structures-Tools, CPU, Memory, I/O Devices, Virtual Clusters and Resource management – Virtualization for Data-centre Automation

Module:3	Virtualization Techniques	6 hours	CO:3

Virtual Machine Basics – Taxonomy of Virtual machines - Server Virtualization – Physical and Logical Partitioning - Types of Server Virtualization, VM Provisioning and Manageability- Virtual Machine Migration Service-Distributed Management of Virtual Machines-Scheduling Techniques

Module:4	Cloud Platforms in Industry	6 hours	CO:4

Cloud Environments - Case study: One cloud service provider per service model (eg. Amazon EC2, Google App Engine, Sales Force, Azure, Open Source tools) - Cloud application development using third party APIs, Working with EC2 API – Google App Engine API - Facebook API, Twitter API , HDFS, Map Reduce Programming Model.

Module:5	Security Overview	3 hours	CO:5

Cloud Security Challenges and Risks – Software-as-a- Service Security – Security Governance – Risk Management – Security Monitoring – Security Architecture Design – Data Security – Application Security – Virtual Machine Security - Identity Management and Access Control – Autonomic Security.			
Module:6	**Legal issues & Metrics**	**3 hours**	**CO:6**
SLA Model-Types of SLA - SLA management. Legal issues in cloud computing, Selected Business Use Cases- The ERP Hosting Use Case Scenario- The Enterprise IT Use Case Scenario - The Service Aggregator Use Case Scenario- The eGovernment Use Case Scenario. - Performance metrics: Consistency, Availability and Partitioning (CAP theorem).			
Module:7	**Advanced concepts in cloud**	**3 hours**	**CO:6**
Scientific cloud applications - Energy efficiency in clouds- Market-based management of clouds - Federated clouds/InterCloud - Third-party cloud services – Mobile Cloud Computing			
Module:8	**Contemporary issues:**	**2 hours**	**CO:6**
	Total Lecture hours:	**30 hours**	

Text Book(s)

1.	RajkumarBuyya, ChirstianVecchiola, S.ThamaraiSelvi, "Mastering Cloud Computing" , Tata McGraw Hill,2017
2	Sehgal, Naresh, Bhatt, Pramod Chandra P., Acken, John M, "Cloud Computing with Security Concepts and Practices, Springer International Publishing", 978-3-030-24612-9,2020
3.	Kai Hwang, Geoffrey C Fox, Jack G Dongarra, "Distributed and Cloud Computing: From Parallel Processing to the Internet of Things", Morgan Kaufmann Publishers,2013

Reference Books& Whitepapers

1. RajkumarBuyya, James Broberg, Andrzej, M. Goscinski, Cloud Computing: Principles and Paradigms, Wiley, 2013
2. Tim Mather, SubraKumaraswamy, and ShahedLatif, "Cloud Security andPrivacy",Oreilly,2009
3. Ronald L. Krutz, Russell Dean Vines, "Cloud Security: A Comprehensive Guide to Secure Cloud Computing", Wiley-India, 2010

4. Reference Links

https://www.tutorialspoint.com/microsoft_azure/index.htm

https://aws.amazon.com/what-is-cloud-computing/

http://web.mit.edu/6.897/www/readings.html

https://cloudacademy.com/library/cloud-fundamentals/

https://cloud.google.com/security/overview/whitepaper

Mode of Evaluation: CAT / Assignment / Quiz / FAT / Project

Mode of assessment:

Recommended by Board of Studies	09-09-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course code	COGNITIVE SCIENCE	L	T	P	J	C
CSE6071		3	0	0	0	3
Pre-requisite	Nil	Syllabus version				
		v. xx.xx				

Course Objectives:

1. To study the basic concepts and approaches in the field of cognitive science
2. To apply the concepts of planning, reasoning and learning models in cognitive applications
3. To analyze language and semantic models of cognitive process.

Expected Course Outcome:

1. Students will be able to understand the basic concept of cognitive science
2. Learn and understand the learning model and apply the same to appropriate real world applications
3. Apply reasoning methodology to real world applications
4. Students will understand and apply declarativeand logic models
5. Envisage the concept of cognitive learning
6. Acquire knowledge in language processing and understanding

Module:1	Introduction to Cognitive Science	5 hours	CO:1

Fundamental Concepts of cognitive science – Computers in Cognitive Science – Applied Cognitive Science – The Interdisciplinary Nature of Cognitive Science – Artificial Intelligence: Knowledge representation, semantic networks, frames, conceptual dependency, scripts, Ontology-Understanding, Common Sense Reasoning.

Module:2	Planning and Learning Methods	5 hours	CO: 2

Planning – Situation Logic- Learning in Cognitive Systems- Rote Learning – Learning by Examples - Incremental Concept Learning – Inductive Learning - Classification Techniques – Statistical Reasoning- Bayesian Classification- Bayesian Networks- Concept Learning- Version Spaces - Discrimination Trees.

Module:3	Reasoning methods	5 hours	CO: 3

Reasoning by analogy – Explanation based reasoning – Case based reasoning- Constraint Satisfaction- Constraint Propagation- Temporal reasoning – Temporal Constraint Networks- Spatial reasoning- Visual Spatial reasoning- Meta reasoning – Learning by correcting mistakes- AI ethics

Module:4	Cognitive Modeling	7 hours	CO: 3

Declarative/ logic-based computational cognitive modelling - connectionist models of cognition - Bayesian
models of cognition - Cognitive Models of Memory and Language - Computational models of episodic andsemantic memory - modelling psycholinguistics (with emphasis on lexical semantics) - towards deep

understanding - modelling the interaction of language, memory and learning.

Module:5	Modeling Paradigm	7 hours	CO: 3

Modelling Select Aspects of Cognition Classical models of rationality - symbolic reasoning and decision making under uncertainty - Formal models of inductive generalization causality - Categorization and similarity analysis.

Module:6	Cognitive Development	7 hours	CO: 4

Child concept acquisition - Child language learning - Acquisition of arithmetic skills – Distributed Cognition and Learning- Simple and Complex Decision Making – Reasoning Under Uncertainty – Natural Language Understanding – Natural Language Processing – Automated Natural Language Generation.			
Module:7	**Language and Semantic Processing**	**7 hours**	**CO: 5,6**
Knowledge Acquisition – Semantics in Cognitive Science – Meaning and Entailment – Cognitive and Computational Models of Semantic Processing – Information Processing Models of the Mind- Physical symbol systems and language of thought- Applying the Symbolic Paradigm- Neural networks and distributed information processing- Neural network models of Cognitive Processes- Dynamical systems and situated cognition.			
Module:8	**Contemporary issues:**	**2 hours**	**CO: 6**
	Total Lecture hours:	**45 hours**	

Text Book(s)

1.	José Luis Bermúdez, "Cognitive Science: An Introduction to the Science of the Mind", Cambridge University Press, New York, 2014.
2.	Mallick, Pradeep Kumar, Borah, Samarjeet," Emerging Trends and Applications in Cognitive Computing", IGI Global Publishers, 2019.
3.	Elaine Rich, Kevin Knight, Shivashankar B. Nair, "Artificial Intelligence", Third Edition, Tata McGraw-Hill Education, 2012.

Reference Books

1.	Stuart J. Russell, Peter Norvig, "Artificial Intelligence - A Modern Approach", Third Edition, Pearson Publishers, 2015.
2.	Paul Miller, "An Introductory Course in Computational Neuroscience", MIT Press, 2018.
3.	Jerome R. Busemeyer, Zheng Wang, James T. Townsend, Ami Eidels(Ed), "The Oxford Handbook of Computational and Mathematical Psychology",Oxford University Press (2015).
4.	Neil Stillings, Steven E. Weisler, Christopher H. Chase and Mark H. Feinstein, "Cognitive Science: An Introduction", Second Edition, MIT press ,1995.

Mode of Evaluation: CAT / Assignment / Quiz / FAT			
List of Challenging Experiments (Indicative)		**NIL**	
Mode of evaluation:			
Recommended by Board of Studies	09-09-2020		
Approved by Academic Council	No. 59	Date	24-09-2020

Course Code	WEB TECHNOLOGIES	L	T	P	J	C
CSE6072		2	0	2	0	3
Pre-requisite	Nil	Syllabus version				
		v. 1.0				

Course Objectives:

1. To comprehend the advanced concepts of web programming and internet
2. To perceive how to use techniques, skills and apply algorithmic principles while analysing their appropriateness
3. To apprehend one or more of the tools to develop interactive, client-side, server-side executable web applications using advanced technologies and evaluate its effectiveness.

Expected Course Outcomes:

After successfully completing the course the student should be able to

1. Understand advanced web Technologies concepts and write a well formed XML document and manipulate the Document Object Model to fetch and display information using jQuery.
2. Avail conveniently, one of the new generations of frameworks, Laravel.
3. Develop build practical, real world web applications using AJAX.
4. Generate dynamic page content using Node.js, use JSON to pass AJAX updates between Client and Server.
5. Create application using Node.js with popular NOSQL database, MongoDB.
6. Build scalable web apps quickly and efficiently using appropriate toolkits and framework.
7. Efficiently create mobile and desktop apps using Frontend Web framework.

Module:1	HTML5, CSS3, XML, JavaScript and JQuery	5 hours	CO: 1

Internet Application –Web architecture – HTML5 – Geolocation - HTML5 API - XHTML-CSS3 - Client side and Server Side Programming - Extensible Markup Language - Document structure, navigation and transformation – XHTML - Javascript -DOM methods -JSON-Jquery - JQuery UI - Document ready function - JQuery templates

Module:2	Web Applications and services	5 hours	CO: 2

Web applications- Web Application Frameworks-MVC (Model-View-Controller) framework-Laravel framework - Angular JS – Single Page Applications-Responsive Web Design

Module:3	Web Communication Processes and Technologies	4 hours	CO: 3

HTTP- Request/Response Model- HTTP Methods- AJAX-Implementing AJAX Frameworks - AJAX with JSON - Implementing Security and Accessibility in AJAX Applications - Secure AJAX Applications

Module:4	Web Servers	5 hours	CO: 4

Node.js- Node Package Manager –REPL(Read-Evaluate-Print-Loop)Terminal, Node.js Webserver - Callbacks -Events- Express framework-Cookies-Sessions-Scaling - Creating a simple server, Rendering HTML, Rendering JSON Data

Module:5	Storage	3 hours	CO: 5

MongoDB-Manipulating and Accessing MongoDB Documents from Node.js

Module:6	Web toolkits - Backend Web frameworks	3 hours	CO: 6

Backend Web frameworks: Node and Express, Django, Ruby on Rails

Module:7	**Frontend Web Frameworks**	**3 hours**	**CO: 7**
Frontend Web frameworks: Angular, React, Vue.js, Ember.js, Meteor - Meteor JS framework			
Module:8	**Contemporary issues**	**2 hours**	**CO: 7**
	Total Lecture hours:	**30 hours**	

Text Book(s)	
1.	Brad Dayley, Node.js, MongoDB, and AngularJS Web Development; 2 edition, Addison Wesley, 2017
2	Jon Duckett, JavaScript and JQuery: Interactive Front-End Web Development,Wiley,2014
3.	Zammetti, Frank, Modern Full-Stack Development, Apress, 2020
Reference Books	
1.	John Duckett, HTML and CSS: Design and Build Websites. ISBN 1118907442, 2014
2.	Anthony T Holdener, Ajax: The Definitive Guide,O'Reilly, 2008
3.	Matt Stauffer, Laravel: Up and Running, 2nd Edition [Book]. Publisher: O'Reilly Media, 2019.
4.	Hartl, Michael. Ruby on Rails Tutorial: Learn Web Development with Rails. Addison-Wesley Professional, 2015.
5.	Elman, Julia, and Mark Lavin. Lightweight Django: Using REST, WebSockets, and Backbone. O'Reilly Media, Inc., 2014.
6.	Seshadri, Shyam, and Brad Green. AngularJS: Up and Running: Enhanced Productivity with Structured Web Apps. O'Reilly Media, Inc., 2014.
7.	Wieruch, Robin. The Road to React: Your journey to master plain yet pragmatic React. js. Robin Wieruch, 2017.
Mode of Evaluation:CAT / Assignment / Quiz / FAT	

List of Experiments (Indicative)	**CO: 1-7**	
1.	Create a user registration webpage for an event using HTML elements like form, image with appropriate CSS,	2 hours
2.	Develop a dynamic web page with validation using JavaScript and handle the events	2 hours
3.	Design a shopping cart application using Laravel framework	3 hours
4.	Create a MongoDB collection of "Research articles" with required details	2 hours
5.	Design an application in node.js for student management.	3 hours
6.	Create an application using Meteor JS framework	3 hours
	Total Laboratory Hours	15 hours
Mode of evaluation: Assignment / Lab FAT		

Recommended by Board of Studies	09-09-2020		
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