Curriculum for Undergraduate Degree (B.Tech.) inArtificial Intelligence and Machine Intelligence (w.e.f. AY: 2021-22)

Part III: Detailed Curriculum

Sixth Semester

Course Name:	**Advanced Machine Learning**			
Course Code:	PC-AIML601	**Category:**	Professional CoreCourse	
Semester:	Sixth	**Credit:**	3	
L-T-P:	3-0-0	**Pre-Requisites:**	Concepts of Machine Learning	
Full Marks:	100			
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05	

Course Objectives:	
1	To learn design and evaluation of a machine learning algorithm
2	To learn the methods to analyse machine learning algorithms

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	• Introduction to Machine Learning Problems • Data Representations, measurements • Dimensionality reduction components ✓ Feature selection ✓ Feature extraction • Dimensionality reduction methods ✓ Principal Component Analysis(PCA) ✓ Linear Discriminant Analysis (LDA)	6L
2	• Statistical Machine Learning Theory • Analysis and Evaluation of Statistical Models • Gaussian Processes	6L
3	• Support Vector Machine: From 0-1 Loss to Hinge Loss • Kernel Methods	4L
4	• Non-parametric Bayesian methods • Ensemble methods	4L

5	• Spectral clustering • Model based clustering,	4L
6	• Deep Learning Architectures ✓ CNN architecture ✓ RNN architecture • Recent applications in Deep learning	8L
7	Model Interpretation and Recent applications using machine learning	4L
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Present the design and evaluation of a machine learning algorithm, describing the design processes and evaluation
2	Explain the nature of the statistical foundations of designing or adapting learning algorithms
3	Explain the variance and bias trade-off in machine learning algorithms
4	Demonstrate knowledge of the introduced machine learning models and the relative strengths and weaknesses of each and their most appropriate uses
5	Demonstrate knowledge of methods to analyse machine learning algorithms

Learning Resources:	
1	C. Bishop. *Pattern Recognition and Machine Learning.* Springer 2006
2	T. Hastie, R. Tibshirani, and J. Friedman. *The Elements of Statistical Learning: Data Mining, Inference and Prediction.* Springer, 2001
3	Mohri, Mehryar, Afshin Rostamizadeh, and Ameet Talwalkar. *Foundations of machine learning*. MIT press, 2018
4	D. Barber. *Bayesian Reasoning and Machine Learning*. Cambridge University Press.
5	K. Murphy. *Machine Learning: A Probabilistic Perspective*. MIT, 2012
6	S. Shalev-Shwartz, and S. Ben-David. *Understanding Machine Learning: From Theory to Algorithms*. Cambridge University Press, 2014

Course Name:	**Soft Computing**			
Course Code:	PC-AIML602	**Category:**	Professional Core Course	
Semester:	Sixth	**Credit:**	3	
L-T-P:	3-0-0	**Pre-Requisites:**	Set Theory	
Full Marks:	100			
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05	

Course Objectives:	
1	To provide the students with the concepts of soft computing techniques such as neural networks, fuzzy systems, genetic algorithms.
2	To develop the ability to apply knowledge of Soft Computing for solution of Business problems.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Introduction: Introduction to Evolutionary Computing; introduction to fuzzy sets and fuzzy logic systems; introduction to biological and artificial neural network; introduction to Genetic Algorithm	**5L**
2	Classical Sets and Fuzzy Sets:Fuzzy Operations, Membership functions, Different fuzzification methods, Fuzzy to Crisp conversions, Defuzzification methods, Fuzzy relations, Classical Logic and Fuzzy Logic, Fuzzy Implication , Fuzzy Rule based Systems, Fuzzy Inference System, Applications of Fuzzy Logic	**10L**
3	Introduction to Neural Networks: Advent of Modern Neuroscience, AI and Neural Networks, Biological Neurons and Artificial neural network, model of artificial neuron, Learning Methods, Neural Network models, single layer network, Competitive learning networks, Hebbian learning, Hopfield Networks. Neuo-Fuzzy modelling, Applications of Neural Networks, Pattern Recognition and classification	**8L**
4	Genetic Algorithms: crossover and mutation, Multi-objective Genetic Algorithm (MOGA), Applications of Genetic Algorithm: genetic algorithms in search and optimization, GA based clustering Algorithm, Image processing and pattern Recognition	**8L**
5	Other Soft Computing Technique: Simulated Annealing, Tabu search, Ant colony optimization(ACO), Particle Swarm Optimization (PSO).	**5L**
	Total	**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Know Artificial Intelligence, various types & characteristics of production systems.
2	Explain the concept of Neural Networks, architecture, functions and various algorithms involved.
3	Explain the concept of Fuzzy Logic, Various fuzzy systems and their functions.
4	Know Genetic algorithms, its applications and advances.
5	Explain the unified and exact mathematical basis to some extent as well as the general principles of various soft computing techniques.

Learning Resources:	
1	Fuzzy logic with engineering applications, Timothy J. Ross, John Wiley and Sons.
2	S. Rajasekaran and G.A.V.Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms", PHI
3	Principles of Soft Computing , S N Sivanandam, S. Sumathi, John Wiley & Sons
4	Genetic Algorithms in search, Optimization & Machine Learning by David E. Goldberg
5	Neuro-Fuzzy and Soft computing, Jang, Sun, Mizutani, PHI
6	Neural Networks: A Classroom Approach,1/e by Kumar Satish, TMH.
7	Genetic Algorithms in search, Optimization & Machine Learning by David E. Goldberg, Pearson/PHI
8	A beginners approach to Soft Computing, Samir Roy &UditChakraborty, Pearson

Course Name:	**Computer Networks**		
Course Code:	PE-AIML601A	**Category:**	Professional Core Course
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	A course on "Data Structures".
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment:25	Attendance: 05

Course Objectives:	
1	To develop an understanding of modern network architectures from a design and Performance perspective.
2	To introduce the student to the major concepts involved in wide-area networks(WANs), local area networks (LANs) and Wireless LANs(WLANs).
3	To equip the students with a general overview of the concepts and fundamentals of computer networks.
4	To familiarize the students with the standard models for the layered approach to communication between machines in a network and the protocols of the various layers.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Data communication Components: Representation of data and its flow. Networks, Various Connection Topology, Protocols and Standards, OSI model, Transmission Media, LAN: Wired LAN, Wireless LANs, Connecting LAN and Virtual LAN, Techniques for Bandwidth utilization: Multiplexing - Frequency division, Time division, and Wave division, Concepts on spread spectrum.	8L
2	Data Link Layer and Medium Access Sub Layer: Error Detection and Error Correction - Fundamentals, Block coding, Hamming Distance, CRC; Flow Control and Error control protocols - Stop and Wait, Go back –N ARQ, Selective Repeat ARQ, Sliding Window, Piggybacking, Random Access, Multiple access protocols - Pure ALOHA, Slotted ALOHA, CSMA/CD, CDMA/CA	8L
3	Network Layer: Switching, Logical addressing – IPV4, IPV6; Address mapping – ARP, RARP, BOOTP, and DHCP–Delivery, Forwarding, and Unicast Routing protocols.	8L
4	Transport Layer: Process to Process Communication, User Datagram Protocol (UDP), Transmission Control Protocol (TCP), SCTP Congestion Control; Quality of Service, QoS improving techniques: Leaky Bucket and Token Bucket algorithm.	8L
5	Application Layer: Domain Name Space (DNS), DDNS, TELNET, EMAIL, File Transfer Protocol (FTP), WWW, HTTP, SNMP, Bluetooth, Firewalls, Basic concepts of Cryptography.	8L
Total		**40L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Identify different types of network devices and their functions within a network.
2	Explain basic protocols of computer networks, and how they can be used for network design and implementation.
3	Solve network administration problems by applying the Computer Networking concept

Learning Resources:	
1	Data Communications and Networking – Behrouz A. Forouzan. Third Edition TMH.
2	Computer Networks -- Andrew S Tanenbaum, David. j. Wetherall, 5th Edition. Pearson Education/PHI
3	An Engineering Approach to Computer Networks-S. Keshav, 2nd Edition, Pearson Education
4	Computer Networks -- Andrew S Tanenbaum, David. j. Wetherall, 5th Edition. Pearson Education/PHI
5	Computer Networking: A Top-Down Approach - James Kurose and Keith Ross, Pearson ,7th edition

Course Name:	**Data Visualization**			
Course Code:	PE-AIML601B	**Category:**	Professional Elective Course	
Semester:	Sixth	**Credit:**	3	
L-T-P:	3-0-0	**Pre-Requisites:**	Python Programming	
Full Marks:	100			
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05	

Course Objectives:	
1	To understand the need and benefits of data visualization
2	To create systematically univariate and bivariate graphs from data
3	To analyse and draw conclusions from visualizations

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**

1	**Introduction :**About data visualization, The need for data visualization, Brief history of data visualization **Statistical Preliminaries :**Different types of data, Measures of Centrality, Measures of Dispersion, Measures of Association	8L
2	**Univariate Visualizations:**Stem-and-Leaf Plot, Pie Chart, Bar Graph, Histogram, Line Chart, Box Plot, Analysis and drawing conclusions **Bivariate Visualizations:**Scatter Plot, Bivariate Line Chart, Hex Plot, Analysis and drawing conclusions	8L
3	**Data Visualizations using Python :** NumPy Library, Plotting with matplotlib, Univariate graphs using matplotlib,Bivariategraphsusingmatplotlib,plottingthroughpandas,Improvingplotaesthetics	12L
4	**Recent Trends**: High-dimensional data, Visualizing large graphs and networks, Topological abstraction and summarization for data visualization, Personalized visualization: humanistic approach to data	7L
5	**Overview of Tableau:** Data Visualization using Tableau.	4L
Total		**39L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Create visualizations from data
2	Explain a better understanding of data from visualizations
3	Explain the trends in data from visualizations

Learning Resources:	
1	Sheldon M Ross ,Introduction to Probability and Statistics for Engineers and Scientists ISBN: 0123948118 , Elsevier
2	B. Lubanovic , Introducing Python ,ISBN: 9781492051367 ,O'Reilly
3	Murray R. Spiegel, Larry J. Stephens, Schaum's Outlines on Statistics , ISBN: 9780070602816 McGraw-Hill
4	Ivan Idris , Numpy Beginner's Guide ISBN : 1785281968, Packt Publishing

Course Name:	**Deep Learning**		
Course Code:	PE-AIML601C	**Category:**	Professional Elective Course
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Concept of AI
Full Marks:	100		

Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To understand the basic ideas and principles of Neural Networks
2	To understand the basic concepts of Big Data and Statistical Data Analysis
3	To familiarize the student with The Image Processing facilities like Tensorflow and Keras
4	To appreciate the use of Deep Learning Applications
5	To understand and implement Deep Learning Architectures

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	BASICS OF NEURAL NETWORKS: Basic concept of Neurons, Perceptron Algorithm – Feed Forward and Back Propagation Networks, Role of Neural Networks, Boltzmann Machine and Perception.	6L
2	INTRODUCTION TO DEEP LEARNING: Feed Forward Neural Networks, Gradient Descent, Back Propagation Algorithm, Vanishing Gradient problem, Mitigation, RelU Heuristics for Avoiding Bad Local Minima, Heuristics for Faster Training, Nestors Accelerated Gradient Descent, Regularization, Dropout, Role of Gradient Descent in Deep Learning, Gradient Descent Problem, Feature extraction and feature learning, Survey of Deep Learning Development Frameworks.	7L
3	CONVOLUTIONAL NEURAL NETWORKS: CNN Architectures, Convolution, Pooling Layers, Transfer Learning, Image Classification using Transfer Learning, Role of Convolutional Networks in Machine Learning, Concept of convolution and need for Pooling.	8L
4	MORE DEEP LEARNING ARCHITECTURES: LSTM, GRU, Encoder/Decoder Architectures, Autoencoders, Standard, Sparse, De-noising, Contractive, Variational Autoencoders, Adversarial Generative Networks, Autoencoder and DBM, Role of Deep Learning architectures, Compression of features using Autoencoders.	8L

5	APPLICATIONS OF DEEP LEARNING: Image Segmentation, Object Detection, Automatic Image Captioning, Image generation with Generative Adversarial Networks, Video to Text with LSTM Models, Attention Models for Computer Vision, Case Study: Named Entity Recognition, Opinion Mining using Recurrent Neural Networks, Parsing and Sentiment Analysis using Recursive Neural Networks, Sentence Classification using Convolutional Neural Networks, Dialogue Generation with LSTMs, Role of Deep Learning in Image and NLP applications.	7L
Total		**40L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Explain the role of Deep learning in Machine Learning Applications.
2	Demonstrate the use of TensorFlow/Keras in Deep Learning Applications.
3	Design and implement Deep Learning Applications.
4	Analyze Different Deep Learning Models in Image Related Projects.
5	Design and implement Convolutional Neural Networks.
6	Apply Deep Learning in NLP and Image Processing.

Learning Resources:	
1	"Deep Learning" by Ian Good Fellow, YoshuaBengio and Aaron Courville, MIT Press, 2017.
2	"Deep Learning with Python" by Francois Chollet, Manning Publications, 2018.
3	"Matlab Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence" by Phil Kim, Apress , 2017.
4	"Convolutional Neural Networks in Visual Computing" by Ragav Venkatesan and Baoxin Li, CRC Press, 2018.

Course Name:	**Advanced Algorithm**		
Course Code:	PE-AIML601D	**Category:**	Professional Elective Course
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	PC-IT402(Design & Analysis of Algorithms)
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:

1	Introduce students to the advanced methods of designing and analysing algorithms
2	The student should be able to choose appropriate algorithms and use it for a specific problem
3	To familiarize students with basic paradigms and data structures used to solve advanced algorithmic problems
4	Students should be able to understand different classes of problems concerning their computation difficulties
5	To introduce the students to recent developments in the area of algorithmic design

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Sorting: Review of various sorting algorithms, topological sorting	3L
2	Graph: Definitions and Elementary Algorithms: Shortest path by BFS, shortest path in edge-weighted case (Dijkasra's), depth-first search and computation of strongly connected components, emphasis on correctness proof of the algorithm and time/space analysis, example of amortized analysis	4L
3	Matroids: Introduction to greedy paradigm, algorithm to compute a maximum weight maximal independent set. Application to MST	3L
4	Graph Matching: Algorithm to compute maximum matching. Characterization of maximum matching by augmenting paths, Edmond's Blossom algorithm to compute augmenting path.	3L
5	Flow-Networks: Maxflow-mincut theorem, Ford-Fulkerson Method to compute maximum flow, Edmond-Karp maximum-flow algorithm.	3L
6	Matrix Computations: Strassen's algorithm and introduction to divide and conquer paradigm, inverse of a triangular matrix, relation between the time complexities of basic matrix operations, LUP-decomposition.	3L
7	Shortest Path in Graphs: Floyd-Warshall algorithm and introduction to dynamic programming paradigm. More examples of dynamic programming.	3L
8	Modulo Representation of integers/polynomials: Chinese Remainder Theorem, Conversion between base-representation and modulo-representation. Extension to polynomials. Application: Interpolation problem	3L
9	Discrete Fourier Transform (DFT): In complex field, DFT in modulo ring. Fast Fourier Transform algorithm. Schonhage-Strassen Integer Multiplication algorithm	3L
10	Linear Programming: Geometry of the feasibility region and Simplex algorithm	3L

11	NP-completeness: Examples, proof of NP-hardness and NP-completeness	3L
12	Approximation algorithms, Randomized Algorithms, Interior Point Method, Advanced Number Theoretic Algorithm	3L
13	Recent Trends in problem solving paradigms using recent searching and sorting techniques by applying recently proposed data structures.	3L
Total		**40L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Analyze the complexity/performance of different algorithms.
2	Determine the appropriate data structure for solving a particular set of problems.
3	Categorize the different problems in various classes according to their complexity.
4	Apply the knowledge of recent activities in the field of the advanced data structure.

Learning Resources:	
1	"Introduction to Algorithms" by Cormen, Leiserson, Rivest, Stein.
2	"The Design and Analysis of Computer Algorithms" by Aho, Hopcroft, Ullman.
3	"Algorithm Design" by Kleinberg and Tardos.
4	"Design and Analysis of Algorithms" by Gajendra Sharma
5	"Introduction to Algorithms" by Cormen, Leiserson, Rivest, Stein.

Course Name:	**Big Data**			
Course Code:	OE-CS601C	**Category:**	Open Elective Course	
Semester:	Sixth	**Credit:**	3	
L-T-P:	3-0-0	**Pre-Requisites:**	Database Management System	
Full Marks:	100			
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05	

Course Objectives:	
1	To understand big data for business intelligence with business case studies for big data analytics.
2	To understand nosql big data management & perform map-reduce analytics using Hadoop and related tools

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Introduction, convergence of key trends, unstructured data, industry examples of big data, web analytics, big data and marketing, fraud and big data, risk and big data, credit risk management, big data and algorithmic trading, big data and healthcare, big data in medicine, advertising and big data, big data technologies, introduction to Hadoop, open source technologies, cloud and big data, mobile business intelligence, Crowd sourcing analytics, inter and trans firewall analytics.	6L
2	Introduction to NoSQL, aggregate data models, aggregates, key-value and document data models, relationships, graph databases, schemaless databases, materialized views, distribution models, sharding, master-slave replication, peer-peer replication, sharding and replication, consistency, relaxing consistency, version stamps, map-reduce, partitioning and combining, composing map-reduce calculations.	8L
3	Data format, analyzing data with Hadoop, scaling out, Hadoop streaming, Hadoop pipes, design of Hadoop distributed file system (HDFS), HDFS concepts, Java interface, data flow, Hadoop I/O, data integrity, compression, serialization, Avro, file-based data structures	6L
4	MapReduce workflows, unit tests with MRUnit, test data and local tests, anatomy of MapReduce job run, classic Map-reduce, YARN, failures in classic Map-reduce and YARN, job scheduling, shuffle and sort, task execution, MapReduce types, input formats, output formats	8L
5	Hbase, data model and implementations, Hbase clients, Hbase examples, praxis. Cassandra, Cassandra data model, Cassandra examples, Cassandra clients, Hadoop integration.	6L
6	Pig, Grunt, pig data model, Pig Latin, developing and testing Pig Latin scripts. Hive, data types and file formats, HiveQL data definition, HiveQL data manipulation, HiveQL queries.	6L
Total		**40L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Describe big data and use cases from selected business domains
2	Explain NoSQL big data management
3	Use Hadoop related tools such as HBase, Cassandra, Pig, and Hive for big data

	analytics.

Learning Resources:	
1	Michael Minelli, Michelle Chambers, and Ambiga Dhiraj, "Big Data, Big Analytics: Emerging
2	V.K. Jain, Big Data and Hadoop, Khanna Publishing House, New Delhi (2017).
3	V.K. Jain, Data Analysis, Khanna Publishing House, New Delhi (2019).
4	Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.
5	P. J. Sadalage and M. Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", Addison-Wesley Professional, 2012.
6	Tom White, "Hadoop: The Definitive Guide", Third Edition, O'Reilley, 2012.
7	Eric Sammer, "Hadoop Operations", O'Reilley, 2012
8	E. Capriolo, D. Wampler, and J. Rutherglen, "Programming Hive", O'Reilley, 2012.
9	Lars George, "HBase: The Definitive Guide", O'Reilley, 2011.
10	Eben Hewitt, "Cassandra: The Definitive Guide", O'Reilley, 2010.
11	Alan Gates, "Programming Pig", O'Reilley, 2011.

Course Name:	**Operations Research and Optimizing Technique**		
Course Code:	OE-M601A	**Category:**	Open Elective course
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	School mathematics, BS-M101, BS-M201
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To impart knowledge in concepts and tools of Operations Research
2	To understand mathematical models used in Operations Research
3	To apply these techniques constructively to make effective business decisions

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	**Solving Linear Programming Problems:** Formulation, Solving LPP :Using Simultaneous Equations and Graphical Method; Simplex, Duality, Big-M method, Transportation & Assignment, Travelling Salesman problem.	11L
2	**Game Theory**: Introduction ; 2- person Zero – sum Game; Saddle Point ; Mini-Max and Maxi-Min Theorems (statement only); Games without saddle point ; Graphical Method ; Principle of Dominance	7L
3	**Queuing Theory:**Introduction; Basic Definitions and Notations; Axiomatic Derivation of the 7LArrival & Departure (Poisson Queue). Pure Birth and Death Models; Poisson Queue Models: M/M/1: □/FIFO and M/M/1: N/ FIFO.	6L
4	**Network Analysis:** Shortest Path: Floyd Algorithm; Maximal Flow Problem(Ford-Fulkerson); PERT-CPM (Cost Analysis, Crashing, Resource Allocation excluded).	6L
5	**Non-linear Programming:** Integer Programming, Dynamic Programming.	6L
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Solve linear programming problems using appropriate techniques and optimization solvers, interpret the results obtained.
2	Determine optimal strategy for Minimization of Cost of shipping of products from source to Destination/ Maximization of profits of shipping products using various methods, Finding initial basic feasible and optimal solution of the Transportation problems
3	Optimize the allocation of resources to Demand points in the best possible way using various techniques and minimize the cost or time of completion of number of jobs by number of persons
4	Analyse competitive real-world phenomena using concepts from game theory. Analyse pure and mixed strategy games
5	Formulate Network models for service and manufacturing systems, and apply operations research techniques and algorithms to solve these Network problems

Learning Resources:	
1	H. A. Taha, "Operations Research", Pearson
2	P. M. Karak – "Linear Programming and Theory of Games", ABS Publishing House
3	Ghosh and Chakraborty, "Linear Programming and Theory of Games", Central Book Agency
4	Ravindran, Philips and Solberg - "Operations Research", WILEY INDIA
5	KantiSwaroop — "Operations Research", Sultan Chand & Sons
6	Rathindra P. Sen—"Operations Research: Algorithms and Applications", PHI
7	R. Panneerselvam - "Operations Research", PHI
8	A.M. Natarajan, P. Balasubramani and A. Tamilarasi - "Operations Research", Pearson
9	M. V. Durga Prasad – "Operations Research", CENGAGE Learning
10	J. K. Sharma - "Operations Research", Macmillan Publishing Company

Course Name:	**Distributed System**		
Course Code:	OE-CS601G	**Category:**	Open Elective Course
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Database Management System, Operating System
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To understand the fundamentals of distributed systems.
2	To understand theoretical concepts, namely, virtual time, agreement and consensus protocols.
3	To understand IPC, Group Communication & RPC Concepts.
4	To understand the DFS and DSM Concepts.
5	To understand the concepts of transaction in distributed environment and associated concepts, namely, concurrency control, deadlocks and error recovery.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Characterization of Distributed Systems:** Introduction, Examples of Distributed Systems, Resource Sharing and the Web, Challenges. **System Models:** Introduction, Architectural Models, Fundamental Models	5L
2	**Time and Global States:** Introduction, Clocks Events and Process States, Synchronizing Physical Clocks, Logical Time and Logical Clocks, Global States, Distributed Debugging. **Coordination and Agreement:** Introduction, Distributed Mutual Exclusion, Elections, Multicast Communication, Consensus and Related Problems.	8L
3	**Inter Process Communication:** Introduction, The API for the Internet Protocols, External Data Representation and Marshalling, Client-Server Communication, Group Communication, Case Study: IPC in UNIX. **Distributed Objects and Remote Invocation:** Introduction, Communication between Distributed Objects, Remote Procedure Call, Events and Notifications, Case Study: JAVA RMI.	9L
4	**Distributed File Systems:** Introduction, File Service Architecture Case Study 1: Sun Network File System, Case Study 2: The Andrew File System. **Name Services:** Introduction, Name Services and the Domain Name System, Directory Services, Case Study of the Global Name Services. **Distributed Shared Memory:** Introduction, Design and Implementation Issues, Sequential Consistency and IVY case study, Release Consistency, Other Consistency Models	8L
5	**Transactions and Concurrency Control:** Introduction, Transactions, Nested Transactions, Locks, Optimistic Concurrency Control, Timestamp Ordering, Comparison of Methods for Concurrency Control. **Distributed Transactions:** Introduction, Flat and Nested Distributed Transactions, Atomic Commit Protocols, Concurrency Control in Distributed Transactions, Distributed Deadlocks, Transaction Recovery	6L
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Explain the concept of Distributed Systems.
2	Explain the various synchronization issues and global state for distributed systems.
3	Explain the Mutual Exclusion and Deadlock Detection algorithms in distributed

	systems.
4	Describe the agreement protocols and fault tolerance mechanisms in distributed systems.
5	Describe the features of peer to peer and distributed shared memory systems

Learning Resources:	
1	Andrew S. Tanenbaum, Maarten Van Steen, "Distributed Systems, Principles and Paradigms"PHI.
2	Sukumar Ghosh,"Distributed Systems, An Algorithm Approach", Chapman & Hall/CRC, Taylor &Fransis Group.
3	Pradeep K. Sinha," Distributed Operating Systems: Concepts and Design", PHI.
4	Mukesh Singhal and Niranjan G. Shivratri," Advanced concepts in Operating Systems", McGraw-Hill Inc.

Course Name:	**Game Theory**			
Course Code:	OE-CS601I	**Category:**	Open Elective Course	
Semester:	Sixth	**Credit:**	3	
L-T-P:	3-0-0	**Pre-Requisites:**	Calculus, Linear algebra, and Probability	
Full Marks:	100			
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05	

Course Objectives:	
1	The aim of this course is to introduce students to the novel concepts of game theory including cooperative games, non-cooperative games and mechanism design concepts.
2	The course will also give a special emphasis on its applications in current day computer engineering domains including cloud computing systems, social media analytics, security mechanisms, Internet marketing strategies, wireless networks, communication systems, cyber physical systems etc.
3	Students should also be able to model and solve problems in interdisciplinary domains.
4	After this course the students should be able to model several real situations using game-theory and design solutions (mechanisms, algorithms, protocols etc.) that are robust even in presence of "self-centered" entities.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Introduction to Game Theory, Current trends and modern applications, Non-Cooperative Games – Strategic form, Preferences, Utilities, Extensive Form Games, Strategic Form Games - Matching Pennies, Prisoners Dilemma, Coordination Game, Dominant Strategy Equilibria, Pure Strategy Nash Equilibria, Mixed strategies, Nixed strategy Nash Equilibria, Matrix Games	12L
2	Cooperative Games - Correlated Equilibrium, Bargaining Games, Nash Bargaining Solution, Coalitional Games, Core of Coalitional Games, Shapely Value, Stable Matching – Matching problem, Evolutionary Games – Evolutionary stable strategy	12L
3	Bayesian Games, Bayesian Nash Equilibria, Mechanism Design – Introduction, Examples, implementation of Social Choice functions by Mechanisms, Incentive Compatibility and Revelation theorem, VCG Mechanisms, Auctions, Mechanism design for Sponsored search auctions	12L
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Apply various types of non-cooperative game theory concepts
2	Apply various types of cooperative game theory concepts.
3	Apply various mechanism design concepts including auctions.
4	Design robust and efficient solutions (mechanisms, algorithms, protocols) that would work for agents that are rational and intelligent in interdisciplinary domains.
5	Model real-world situations such as social media marketing, social analytics, cloud computing issues, wireless networks etc using game theory.

Learning Resources:	
1	Y. Narahari, "Game Theory and Mechanism Design",IISc Press and the World Scientific Publishing Company, March 2014
2	Roger B. Myerson, "Game Theory: Analysis of Conflict", Harvard University Press, Cambridge, Massachusetts, USA, 1997
3	Martin J. Osborne,"An Introduction to Game Theory", The MIT Press, 2003
4	Michael Maschler, EilonSolan, and Shmuel Zamir, "Game Theory", Cambridge University Press, 2013

5	Philip D. Straffin Jr., "Game Theory and Strategy", The Mathematical Association of America, 1993.

Course Name:	**Multimedia Technology**		
Course Code:	OE-CS601K	**Category:**	Open ElectiveCourse
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Fundamental knowledge of Computation, Networking and DBMS
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To give each student a firm grounding in the fundamentals of the underpinning technologies in graphics and multimedia.
2	To teach students the principled design of effective media for entertainment, communication, training and education.
3	To provide each student with experience in the generation of animations, virtual environments and multimedia applications, allowing the expression of creativity.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Multimedia today, Impact of Multimedia, Multimedia Systems, Components and Its Applications	2L
2	**Text and Image:** Text: Types of Text, Ways to Present Text, Aspects of Text Design, Character, Character Set, Codes, Unicode, Encryption. Image: Formats, Image Color Scheme, Image Enhancement.	5L
3	**Audioand Video:** Audio: Basic Sound Concepts, Types of Sound, Digitizing Sound, Computer Representation of Sound (Sampling Rate, Sampling Size, Quantization), Audio Formats, Audio tools,	6L

	MIDI. Video: Analogue and Digital Video, Recording Formats and Standards (JPEG, MPEG, H.261) Transmission of Video Signals, Video Capture, and Computer based Animation.	
4	**Synchronization, Storage models and Access Techniques:** Temporal relationships, synchronization accuracy specification factors, quality of service, Magnetic media, optical media, file systems (traditional, multimedia) Multimedia devices – Output devices, CD-ROM, DVD, Scanner, CCD	7L
5	**Image and Video Database, Document Architecture and Content Management:** Image representation, segmentation, similarity based retrieval,image retrieval by color, shape and texture; indexing- kd trees, R-trees, quad trees; Case studies- QBIC, Virage. Video Content, querying, video segmentation, indexing, Content Design and Development, General Design Principles Hypertext: Concept, Open Document Architecture (ODA), Multimedia and Hypermedia Coding Expert Group (MHEG), Standard Generalized Markup Language (SGML), Document Type Definition (DTD), Hypertext Markup Language (HTML) in Web Publishing. Case study of Applications	13 L
6	**Multimedia Applications:** Interactive television, Video-on-demand, Video Conferencing, Educational Applications, Industrial Applications, Multimedia archives and digital libraries, media editors	3L
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to :	
1	Demonstrate knowledge and understanding of the concepts, principles and theories of Multimedia Applications and Virtual environments
2	Demonstrate knowledge and understanding of the current issues involved with development and deployment of multimedia system
3	Analyze and solve problems related to their expertise in Multimedia Applications and Virtual Environments.
4	Demonstrate their ability to extend their basic knowledge to encompass new principles and practice
5	Demonstrate their computing, technical and theoretical skills by developing a substantial Multimedia application.
6	Plan, conduct and report on the development of an Multimedia Application

Learning Resources:	
1	"Multimedia: Computing, Communications & Applications" by Ralf Steinmetz and Klara Nahrstedt, Pearson Ed.
2	"Multimedia and Animation" by V.K. Jain, Khanna Publishing House, 2019.
3	"Multimedia Information System" by Nalin K. Sharda ,PHI.
4	"Multimedia Communications" by Fred Halsall, Pearson Ed.
5	"Multimedia Systems" by Koegel Buford, Pearson Ed.
6	"Multimedia Literacy" by Fred Hoffstetter, McGraw Hill.
7	"Multimedia Fundamentals: Vol. I1 - Media Coding and Content Processing" by Ralf Steinmetz and Klara Nahrstedt, PHI.
8	"Multimedia in Practice: Technology and Application" by J. Jeffcoate, PHI.

Course Name:	**Human Computer Interaction**			
Course Code:	OE-CS601J	**Category:**	Open ElectiveCourse	
Semester:	Sixth	**Credit:**	3	
L-T-P:	3-0-0	**Pre-Requisites:**	Prior knowledge of device to user Interface : UI / UX	
Full Marks:	100			
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05	

Course Objectives:	
1	Learn the foundations of Human Computer Interaction.
2	Be familiar with the design technologies for individuals and persons with disabilities.
3	Be aware of mobile Human Computer interaction.
4	Learn the guidelines for user interface.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Human: I/O channels – Memory – Reasoning and problem solving; The Computer: Devices – Memory – processing and networks; Interaction: Models – frameworks – Ergonomics – styles – elements – interactivity- Paradigms.	8L
2	Interactive Design basics – process – scenarios – navigation – screen design – Iteration and prototyping. HCI in software process – software life cycle – usability engineering – Prototyping in practice – design rationale. Design rules – principles, standards, guidelines,	8L

	rules. Evaluation Techniques – Universal Design.	
3	Cognitive models – Socio-Organizational issues and stake holder requirements – Communication and collaboration models-Hypertext, Multimedia and WWW.	8L
4	Mobile Ecosystem: Platforms, Application frameworks –Different type of Mobile Applications, Mobile Design: Elements of Mobile Design, Tools.	6L
5	Designing Web Interfaces – Drag & Drop, Direct Selection, Contextual Tools, Overlays, Inlays and Virtual Pages, Process Flow. Case Studies. Evaluation models of UI: Donald Norman's seven stage model of interaction.	8L
6	Recent Trends: Speech Recognition and Translation, Multimodal System, Intelligent User Interfaces and help systems.	2L
Total		**40L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Differentiate between various software vulnerabilities.
2	Develop software process vulnerabilities for an organization.
3	Monitor resources consumption in a software.
4	Interrelate security and software development process.

Learning Resources:	
1	Theodor Richardson, Charles N Thies, "Secure Software Design", Jones & Bartlett.
2	Kenneth R. Van Wyk, Mark G. Graff, Dan S. Peters, Diana L. Burley, "Enterprise Software Security", Addison Wesley

Course Name:	**Cloud Computing**		
Course Code:	OE-CS601D	**Category:**	Open Elective Course
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	PC-IT602(Computer Network)
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To be familiar with service oriented computing
2	To have knowledge about cloud architecture and management

3	To understand the necessity of security in cloud computing
4	To be familiar with well-known cloud service providing organizations

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Overview of Computing Paradigm: • Recent trends in Computing : Grid Computing, Cluster Computing, Distributed Computing, Utility Computing, Cloud Computing • Evolution of cloud computing • Business driver for adopting cloud computing	3L
2	Introduction to Cloud Computing: • Cloud Computing (NIST Model) : Introduction to Cloud Computing, History of Cloud Computing, Cloud service providers • Properties, Characteristics & Disadvantages : Pros and Cons of Cloud Computing, Benefits of Cloud Computing, Cloud computing vs. Cluster computing vs. Grid computing • Role of Open Standards	3L
3	**Cloud Computing Architecture :** • Cloud computing stack : Comparison with traditional computing architecture (client/server), Services provided at various levels, How Cloud Computing Works, Role of Networks in Cloud computing, protocols used, Role of Web services • Service Models (XaaS) : ➢ Infrastructure as a Service(IaaS) ➢ Platform as a Service(PaaS) ➢ Software as a Service(SaaS) • Deployment Models ➢ Public cloud ➢ Private cloud ➢ Hybrid cloud ➢ Community cloud	4L
4	**Infrastructure as a Service(IaaS) :** • Introduction to IaaS : IaaS definition, Introduction to virtualization, Different approaches to virtualization, Hypervisors, Machine Image, Virtual Machine(VM) • Resource Virtualization ➢ Server	4L

	➢ Storage ➢ Network • Virtual Machine(resource) provisioning and manageability, storage as a service, Data storage in cloud computing(storage as a service) • Examples ➢ Amazon EC2 : Renting, EC2 Compute Unit, Platform and Storage, pricing, customers ➢ Eucalyptus	
5	**Platform as a Service (PaaS) :** • Introduction to PaaS : What is PaaS, Service Oriented Architecture (SOA) • Cloud Platform and Management ➢ Computation ➢ Storage • Use of Platforms in Cloud Computing ➢ Concepts of Abstraction and Virtualization, Virtualization technologies: Types of virtualization (access, application, CPU, storage) ➢ Mobility patterns (P2V, V2V, V2P, P2P, D2C, C2C, C2D, D2D) • Load Balancing and Virtualization: Basic Concepts, Network resources for load balancing, Advanced load balancing (including Application Delivery Controller and Application Delivery Network) • Examples ➢ Google App Engine ➢ Microsoft Azure ➢ SalesForce.com's Force.com platform	3L
6	**Software as a Service (SaaS) :** • Introduction to SaaS • Web services • Web 3.0 • Web OS • Case Study on SaaS	4L
7	**Service Management in Cloud Computing** : • Service Level Agreements (SLAs) • Billing & Accounting • Comparing Scaling Hardware: Traditional vs. Cloud • Economics of scaling: Benefitting enormously • Managing Data	5L

	➢ Looking at Data, Scalability & Cloud Services ➢ Database & Data Stores in Cloud ➢ Large Scale Data Processing	
8	**Cloud Security :** • Infrastructure Security : Network level security, Host level security, Application level security • Data security and Storage • Data privacy and security Issues, Jurisdictional issues raised by Data location • Identity & Access Management • Access Control • Trust, Reputation, Risk • Authentication in cloud computing, Client access in cloud, Cloud contracting Model, Commercial and business considerations	5L
9	**Case Study on Open Source & Commercial Clouds** : • Eucalyptus • Microsoft Azure • Amazon EC2	9L
Total		**40L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Analyze the necessity of service oriented computing
2	Explain the cloud architecture and its management
3	Analyze the importance of securing the services
4	Know how the current organizations providing the cloud services

Learning Resources:	
1	"Cloud Computing Bible, Barrie Sosinsky, Wiley-India, 2010
2	"Cloud Computing: Principles and Paradigms, Editors: Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Wile, 2011
3	"Cloud Computing: Principles, Systems and Applications, Editors: Nikos Antonopoulos, Lee Gillam, Springer, 2012
4	"Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Ronald L. Krutz, Russell Dean Vines, Wiley-India, 2010

Course Name:	**Cryptography and Network Security**		
Course Code:	OE-CS601E	**Category:**	Open Elective Course
Semester:	Sixth	**Credit:**	3

L-T-P:	3 - 0 - 0	**Pre-Requisites:**	Computer Networks	
Full Marks:	100			
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25		Attendance: 05

Course Objectives:	
1	To familiarize the students with Cryptography: Concepts, Techniques & Algorithm.
2	To introduce the student about the major concepts involved in Internet Security Protocols & User Authentication.
3	To familiarize the students with the Firewall.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction, Need for Security, Security approaches, Principles of Security, Types of attack	5L
2	Cryptography: Concepts & Techniques-Introduction, Plaintext & Cipher text, Substitution Techniques, Transposition Techniques, Encryption& Decryption, Symmetric & Asymmetric key Cryptography, Key Range & Key Size	7L
3	Symmetric Key Algorithm - Introduction, Algorithm types & Modes, Overview of Symmetric Key Cryptography, DES(Data Encryption Standard)algorithm, IDEA(International Data Encryption Algorithm) algorithm, RC5(Rivest Cipher 5) algorithm.	7L
4	Asymmetric Key Algorithm, Digital Signature and RSA - Introduction, Overview of Asymmetric key Cryptography, RSA algorithm, Symmetric &Asymmetric key Cryptography together, Digital Signature, Basic concepts of Message Digest and Hash Function (Algorithms on Message Digest and Hash function not required).	8L
5	Internet Security Protocols, User Authentication -Basic Concepts, SSL protocol, Authentication Basics, Password, Authentication Token, Certificate based Authentication, Biometric Authentication.	6L
6	Electronic Mail Security - Basics of mail security, Pretty Good Privacy, S/MIME.	4L
7	Firewall - Introduction, Types of firewall, Firewall Configurations, DMZ Network	3L

Total	**40L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Describe information security concepts and techniques.
2	ExplainCryptographic Algorithms.
3	Explain Internet Security Protocols&Firewall.

Learning Resources:	
1	"Cryptography and Network Security", William Stallings, 2nd Edition, Pearson Education Asia
2	"Network Security private communication in a public world", C. Kaufman, R. Perlman and M. Speciner, Pearson
3	"Cryptography & Network Security", Atul Kahate, TMH.
4	"Network Security Essentials: Applications and Standards" by William Stallings,Pearson.
5	"Designing Network Security", Merike Kaeo, 2nd Edition, Pearson Books
6	"Building Internet Firewalls", Elizabeth D. Zwicky, Simon Cooper, D. Brent Chapman, 2nd Edition, Oreilly .
7	"Practical Unix & Internet Security", Simson Garfinkel, Gene Spafford, Alan Schwartz, 3rd Edition, Oreilly
8	"Cryptography and Network Security", V.K. Jain, Khanna Publishing House, 2017.

Course Name:	**Advanced Machine Learning Lab**			
Course Code:	PC-AIML691	**Category:**	Professional CoreCourse	
Semester:	Sixth	**Credit:**	2	
L-T-P:	0-0-4	**Pre-Requisites:**	Concept of probability and Python Programming	
Full Marks:	100			
Examination Scheme:	Semester Examination: 60	Continuous Assessment: 35	Attendance: 05	

Course Objectives:	
1	To learn design and development of machine learning algorithm
2	To learn the methods to analyse machine learning algorithms

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Lab 1: Problems using statistical methods Lab 2: Problems on dimension reduction	8P
2	Lab 3: Problems on Regression Lab 4 and 5: Problems on Classification algorithms	8P
3	Lab 6: Problems on clustering algorithms Lab 7: Problems on Ensemble Learning	8P
4	Lab 8: Problems on plotting of under fitting & over fitting concept related to a data set	8P
5	Lab 9: Expert System Development using machine learning algorithms	8P
6	Lab 10: Recommendation system Development using machine learning algorithms	8P
Total		**48P**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Develop statistical model by understanding the nature of the problem
2	Implement the knowledge of designing and analysing machine learning algorithms
3	Developdifferent machine learning based model to solve real life problems

Learning Resources:	
1	Machine Learning using Python, Manaranjan Pradhan, U Dinesh Kumar, Wiley
2	Introduction to Machine Learning with Python: A Guide for Data Scientists (Greyscale Indian Edition)

Course Name:	**Soft Computing Lab**			
Course Code:	PC-AIML692	**Category:**	Professional Core Course	
Semester:	Sixth	**Credit:**	2	
L-T-P:	0-0-4	**Pre-Requisites:**	Python & Statistics	
Full Marks:	100			
Examination Scheme:	Semester Examination: 60	Continuous Assessment: 35	Attendance: 05	

Course Objectives:

1	To provide the students with the concepts of soft computing techniques such as neural networks, fuzzy systems, genetic algorithms.
2	To develop the ability to apply knowledge of Soft Computing for solution of Business problems.

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Implementation of different fuzzy membership functions, Fuzzy set operations & its properties.	4P
2	Implementation of composition of fuzzy & crisp relations.	4P
3	Implementation of fuzzy information system.	4P
4	Implementation of McCulloh-Pitts neural network for generation of AND, Or functions.	4P
5	Implementation of Perceptron learning for particular set of problem.	8P
6	Implementation of OR function with bipolar inputs & target using Adaline network.	4P
7	Implementation of XOR functions with bipolar inputs & target using Madaline network.	4P
8	Implementation of maximizing $F(x) = x^2$, where x ranges from say 0 to 31 using Genetic Algorithm.	4P
9	Implementation of Simple Genetic Algorithm in C for solving optimization problem.	4P
10	Use of Genetic Algorithm toolbox in matlab for optimization problem solving	8P
Total		**48P**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Know the concept of Artificial Intelligence, Various types of production systems, characteristics of production systems.
2	Explain the concept of Neural Networks, architecture, functions and various algorithms involved.
3	Know the concept of Fuzzy Logic, Various fuzzy systems and their functions.
4	Explain the concept of Genetic algorithms, its applications and advances.
5	Know the concept of unified and exact mathematical basis to some extent as well as the general principles of various soft computing techniques.

Learning Resources:	
1	Fuzzy logic with engineering applications, Timothy J. Ross, John Wiley and Sons.
2	S. Rajasekaran and G.A.V.Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms", PHI
3	Principles of Soft Computing , S N Sivanandam, S. Sumathi, John Wiley & Sons
4	Genetic Algorithms in search, Optimization & Machine Learning by David E. Goldberg
5	Neuro-Fuzzy and Soft computing, Jang, Sun, Mizutani, PHI
6	Neural Networks: A Classroom Approach,1/e by Kumar Satish, TMH,
7	Genetic Algorithms in search, Optimization & Machine Learning by David E. Goldberg, Pearson/PHI
8	A beginners approach to Soft Computing, Samir Roy &UditChakraborty, Pearson

Course Name:	**Computer Networks Lab**		
Course Code:	PE-AIML691A	**Category:**	Professional Core Course
Semester:	Sixth	**Credit:**	2
L-T-P:	0-0-4	**Pre-Requisites:**	Knowledge of programming
Full Marks:	100		
Examination Scheme:	Semester Examination: 60	Continuous Assessment:35	Attendance: 05

Course Objectives:	
1	To familiarize the students with the basic taxonomy and terminology of the computer networking and enumerate the layers of OSI model and TCP/IP model.
2	To familiarize the students with the Application layer and Presentation layer paradigms and protocols. Study Session layer design issues, Transport layer services, and protocols.
3	To familiarize the students with the Network layer routing protocols and IP addressing. Study data link layer concepts, design issues, and protocols.
4	To familiarize the students with fundamentals and basics of Physical layer, and will apply them in real time applications.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	NIC Installation & Configuration (Windows/Linux)	4P
2	Understanding IP address, subnet etc Familiarization withNetworking cables (CAT5, UTP), Connectors (RJ45, T-connector), Hubs, Switches	4P
3	TCP/UDP Socket Programming: Simple, TCP based, UDP based, Multicast & Broadcast Sockets, Implementation of a Prototype Multithreaded Server	16P

4	Implementation of Data Link Layer Flow Control Mechanism (Stop & Wait, Sliding Window) Data Link Layer Error Detection Mechanism (Cyclic Redundancy Check) Data Link Layer Error Control Mechanism (Selective Repeat, Go Back N)	12P
5	Server Setup/Configuration: FTP, TelNet, NFS, DNS, Firewall	12P
Total		**48P**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Explain basic protocols of computer networks.
2	Identify the different types of network devices and their functions within a network.
3	Solve network administration problems by applying Computer Networking Concepts.

LearningResources:	
1	Data Communications and Networking – Behrouz A. Forouzan. Third Edition TMH.
2	Computer Networks -- Andrew S Tanenbaum, David. j. Wetherall, 5th Edition. Pearson Education/PHI
3	An Engineering Approach to Computer Networks-S. Keshav, 2nd Edition, Pearson Education
4	Computer Networks -- Andrew S Tanenbaum, David. j. Wetherall, 5th Edition. Pearson Education/PHI
5	Computer Networking: A Top-Down Approach - James Kurose and Keith Ross, Pearson ,7th edition
6	Red Hat Linux Networking & System Administration by Terry Collings & Kurt Wall
7	System Programming by John J Donovan

Course Name:	**Data Visualization Lab**		
Course Code:	PE-AIML691B	**Category:**	Professional Elective Course
Semester:	Sixth	**Credit:**	2
L-T-P:	0-0-4	**Pre-Requisites:**	Knowledge of Python Programming
Full Marks:	100		
Examination Scheme:	Semester Examination: 60	Continuous Assessment: 35	Attendance: 05

Course Objectives:	
1	To learn the details of Visualization Techniques using Python
2	To develop the data analysis skills from visualization

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Lab1: Plotting Stem-and-Leaf Plot, Pie Chart, Bar Graph, Histogram Lab 2: Plotting Line Chart, Box Plot, Analysis and drawing conclusions	8P
2	Lab 3: Plotting Scatter Plot, Bivariate Line Chart, Hex Plot Analysis and drawing conclusions Lab 4: Creating n-d arrays in NumPy, Slicing operation onn-darray Lab 5: Plotting with matplotlib	12P
3	Lab 6 & 7:Univariate graphs using matplotlib, Plotting High-dimensional data	8P
4	Lab 8: Plotting bivariate graphs using matplotlib, Lab 9: Plotting through pandas manipulation Lab 10: Problems to be solved using matplotlib,	12P
5	Lab 11: Concepts of visualizing graphs and networks related problems Lab 12: Problems involving data visualization for summarizationusing Tableau	8P
Total		**48P**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Explain the details of data interpretation skills using statistics
2	Solve the Data analysis job from visualizations
3	Create Visualization from any kind of data

Learning Resources:	
1	Python Programming: Using Problem Solving Approach" by Reema Thareja
2	Data Structure and Algorithmic Thinking with Python" by Narasimha Karumanchi
3	Eric Matthes , Python Crash Course, ISBN : 1593279280, No Starch Press
4	Ivan Idris,Numpy Beginner's Guide, ISBN : 1785281968 , Packt Publishing

Course Name:	**Deep Learning Lab**		
Course Code:	PE-AIML691C	**Category:**	Professional ElectiveCourse
Semester:	Sixth	**Credit:**	2
L-T-P:	0-0-4	**Pre-Requisites:**	Concept of AI

Full Marks:	100		
Examination Scheme:	Semester Examination: 60	Continuous Assessment: 35	Attendance: 05

Course Objectives:	
1	To familiarize the student with The Image Processing facilities like Tensorflow and Keras
2	To understand the basic ideas and principles of Neural Networks
3	To understand the basic concepts of Big Data and Statistical Data Analysis
4	To appreciate the use of Deep Learning Applications
5	To understand and implement Deep Learning Architectures

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Lab1:**Implementation ofsimple Programs like vector addition in TensorFlow. **Lab2:**Implementation of a simple problem like regression model in Keras.	8P
2	**Lab3:**Implementation of a perceptron in TensorFlow/Keras Environment. **Lab4:** Implementation of a Feed-Forward Network in TensorFlow/Keras.	8P
3	**Lab5:** Implementation of an Image Classifier using CNN in TensorFlow/Keras. **Lab6:** Implementation of a Transfer Learning concept in Image Classification.	8P
4	**Lab7:** Implementation of an Autoencoder in TensorFlow/Keras. **Lab8**: Implementation of a Simple LSTM using TensorFlow/Keras.	8P
5	**Lab9:** Implementation of an Opinion Mining in Recurrent Neural network. **Lab10:** Implementation of an Object Detection using CNN.	8P
6	**Lab11 & Lab12:**Mini Project	8P
Total		**48P**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Demonstrate the role of Deep learning in Machine Learning Applications.

2	Use of TensorFlow/Keras in Deep Learning Applications.
3	Design and implement Deep Learning Applications.
4	Analyse Different Deep Learning Models in Image Related Projects.
5	Design and implement Convolutional Neural Networks.
6	Apply Deep Learning in NLP and Image Processing.

Learning Resources:	
1	"Deep Learning with Applications Using Python" by Navin Kumar Manaswi, Apress.
2	"R Deep Learning Essentials" by Joshua F. Wiley, Packt Publications, 2016.

Course Name:	**Advanced Algorithm Lab**		
Course Code:	PE-AIML691D	**Category:**	Professional Elective Course
Semester:	Sixth	**Credit:**	2
L-T-P:	0-0-4	**Pre-Requisites:**	PC-IT492(Design & Analysis of Algorithms Laboratory)
Full Marks:	100		
Examination Scheme:	Semester Examination: 60	Continuous Assessment: 35	Attendance: 05

Course Objectives:	
1	Introduce students to the advanced methods of designing and analysing algorithms
2	The student should be able to choose appropriate algorithms and use it for a specific problem
3	To familiarize students with basic paradigms and data structures used to solve advanced algorithmic problems
4	Students should be able to understand different classes of problems concerning their computation difficulties
5	To introduce the students to recent developments in the area of algorithmic design

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Sorting: various sorting algorithms, topological sorting	8P
2	Graph: Shortest path by BFS, DFS in edge-weighted case (Dijkasra's)	4P
3	Matroids: to compute a maximum weight maximal independent set	4P
4	Graph Matching: to compute maximum matching. Edmond's Blossom algorithm to compute augmenting path.	4P

5	Flow-Networks: Ford-Fulkerson Method to compute maximum flow, Edmond-Karp maximum-flow algorithm.	8P
6	Matrix Computations: Strassen's algorithm.	4P
7	Shortest Path in Graphs: Floyd-Warshall	4P
8	Discrete Fourier Transform (DFT): Schonhage-Strassen Integer Multiplication algorithm	4P
9	Recent Trends in problem solving paradigms using recent searching and sorting techniques by applying recently proposed data structures.	8P
Total		**48P**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Analyze the complexity/performance of different algorithms.
2	Determine the appropriate data structure for solving a particular set of problems.
3	Categorize the different problems in various classes according to their complexity.
4	Apply the knowledge of recent activities in the field of the advanced data structure.

Learning Resources:	
1	"Introduction to Algorithms" by Cormen, Leiserson, Rivest, Stein.
2	"The Design and Analysis of Computer Algorithms" by Aho, Hopcroft, Ullman.
3	"Algorithm Design" by Kleinberg and Tardos.
4	“Design and Analysis of Algorithms” by Gajendra Sharma
5	"Introduction to Algorithms" by Cormen, Leiserson, Rivest, Stein.

Course Name:	**Project-II**		
Course Code:	PW-AIML681	**Category:**	Sessional Course
Semester:	Sixth	**Credit:**	1
L-T-P:	0-0-2	**Pre-Requisites:**	Knowledge of engineering, science and management subjects
Full Marks:	100		
Examination Scheme:	Semester Examination: 20		Continuous Assessment: 80

Course Objectives:	
1	In depth knowledge gain in the domain of the assigned topic.
2	To be able to formulate the problem in the assignedtopic.
3	To be able to execute the action plan for conducting the project as a team work.
4	To be able to perform development of product/process, testing, analysing the results and future scope.

Course Outcomes:	
After completion of the course, students will be able to:	
1	Work as a team member
2	Prepare a report in the standard format
3	Perform Seminar Presentation before any standard body

Course Name:	**Aptitude Skill Course-II**		
Course Code:	MC671	**Category:**	**Mandatory Courses**
Semester:	Sixth	**Credit:**	0
L-T-P:	2-0-0	**Pre-Requisites:**	Quantitative Ability, Logical and Verbal Reasoning
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To be prepared in the area of Quantitative Ability as well as Logical and Verbal Reasoning for Campus Placements and different Competitive Exams

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	Verbal: Reading Comprehension, Para Jumbles, Email Writing, Resume Writing	3L
2	Game based Cognitive Skills, Tournaments	3L
3	Solve company oriented campus placements aptitude papers covering Quantitative Ability, Logical Reasoning and Verbal Ability.	12L
4	MCQ Based Strategies/Sort cuts and Mock test	6L
Total		**24L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Prepared for Campus Placements and different Competitive Exams

Learning Resources:	
1	Arun Sharma, "Quantitative abilities", McGraw-Hill
2	R.S.Agrawal, "Quantitative Aptitude for Competitive Examinations", S. Chand
3	R.S.Agarwal,"A Modern Approach to Verbal & Non-Verbal Reasoning ", S.Chand