MCKV INSTITUTE OF ENGINEERING
NAAC Accredited "A" Grade Autonomous Institute under UGC Act 1956
Approved by AICTE & affiliated to Maulana Abul Kalam Azad University of Technology, West Bengal
243 G.T. Road (N), Liluah, Howrah- 711204, West Bengal, India
Ph: +91 33 26549315/17 Fax +91 33 26549318 Web: www.mckvie.edu.in/

Curriculum for Undergraduate Degree (B.Tech.) in Computer Science and Engineering (Data Science) (w.e.f. AY: 2020-21)

Part III: Detailed Curriculum

Sixth Semester

Course Name:	**Compiler Design**		
Course Code:	PC-CS601	**Category:**	Professional Core
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Basic programming Knowledge, Automata Theory
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To understand and list the different stages in the process of compilation.
2	Identify different methods of lexical analysis
3	Design top-down and bottom-up parsers
4	Identify synthesized and inherited attributes
5	Develop syntax directed translation schemes
6	Develop algorithms to generate code for a target machine

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction: Programs, interpreters, and translators; Analysis-Synthesis model of translation; Examples of translators; Structure of a compiler; Issues in compiler design.	2L
2	Lexical Analysis: Role of a lexical analyzer; Input buffering, Specification of tokens, Recognition of tokens; Languages, Regular expressions, Regular definitions; Finite automata, Nondeterministic and deterministic finite automata, Transitions tables, Acceptance of input strings by automata, Conversion of an NFA to DFA; State-machine-driven lexical analyzers and their implementations	8L
3	Syntax Analysis: Role of a parser, Representative grammars, Context-free grammars, Parse trees, derivations and sentential forms, Ambiguity; Top down parsing, Predictive and Recursive descent parsing, Elimination of left recursions, Left factoring, FIRST and FOLLOW sets and their computations, LL(1) grammars, Error recovery techniques; Bottom up parsing, Reductions, Handle pruning, Shift reduce parsing; LR parsing, Implementing the parser as a state machine, viable prefixes, Items and the LR(0) automaton; Constructing	10L

	SLR parsing tables: LR(0) grammars, SLR(1) grammars; Canonical LR(1) items and constructing canonical LR(1) parsing tables; Constructing LALR parsing tables.	
4	Semantics and Semantic Analysis: Syntax-directed translation, Attribute grammars, Inherited and synthesized attributes, Dependency graphs, Evaluation orders of attributes, S-Attributed definitions, L-attributed definitions, Syntax-directed translation schemes.	3L
5	Intermediate Code Generation & Runtime Environment: Intermediate languages, Graphical representation, Three-address code, Implementation of three address statements (Quadruples, Triples, Indirect triples). Intermediate languages – Declarations – Assignment Statements – Boolean Expressions – Case Statements – Back patching – Procedure calls. Source language issues (Activation trees, Control stack, scope of declaration, Binding of names), Storage organization (Subdivision of run-time memory, Activation records), Storage allocation strategies, Parameter passing (call by value, call by reference, copy restore, call by name), Symbol tables, dynamic storage allocation techniques	6L
6	Code Optimization: Overview of optimization; Data Flow Analysis; Peephole Optimizations; Constant Folding, Common Subexpression Elimination, Copy Propagation, Strength Reduction. Global Optimization: Loop optimizations; Induction Variable elimination, Optimizing procedure calls – inline and closed procedures. Machine-Dependent Optimization: Pipelining and Scheduling	5L
7	Code Generation: Issues in the design of code generator – The target machine, Construction of executable code and libraries.	2L
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Summarize the basic concept of compiler and underlying finite state automata, regular expression, grammars and regular languages.
2	Describe the functional phases of a compiler such as lexical analyzer, parser, code optimizer and code generator
3	Compare LL, LR(0), LR(1) and LALR parser.
4	Construct of semantic rule, quadruple, triples, indirect triple and optimized code.

Learning Resources:	
1	Aho, Sethi, Ullman - "Compiler Principles, Techniques and Tools" - Pearson Education
2	Holub - "Compiler Design in C" - PHI.
3	"Crafting a compiler with C", C. N. Fischer and R. J. LeBlanc, Pearson Education
4	"Compiler Construction: Principles and Practice", Kenneth C. Louden, , Thomson Learning

Course Name:	**Database Management System**		
Course Code:	PC-CS602	**Category:**	Professional Core
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Basic programming Knowledge, Concept of Set theory, Tree Data structure
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To understand the different issues involved in the design and implementation of a database system.
2	To study the physical and logical database designs, database modeling, relational, hierarchical, and network models
3	To understand and use data manipulation language to query, update, and manage a database
4	To design and build a simple database system and demonstrate competence with the fundamental tasks involved with modeling, designing, and implementing a DBMS.
5	To understand the different issues involved in the design and implementation of a database system.

Course Contents:

Module No.	**Description of Topic**	**Contact Hrs.**
1	Introduction to database management, data abstraction and system structure, Database users, Database Administrator	4
2	Entity relational model, entity set, relationship sets, mapping cardinalities, keys, E-R diagrams.	4
3	Relational model, database schema, relational algebra, outer join and manipulation of databases. Tuple relational calculus: Example queries, formal definitions and safety of expressions; SQL: Query processing and optimization, set operations, aggregate functions, data definition language and views, comparison of queries in relational algebra, SQL, tuple relation calculus and domain relation calculus.	8
4	Introduction to Schema Refinement - Problems Caused by redundancy, Decompositions - Problem related to decomposition, Functional Dependencies - Reasoning about FDS, Normal Forms - FIRST, SECOND, THIRD Normal forms - BCNF - Properties of Decompositions - Loss less join Decomposition, Dependency preserving Decomposition, Schema Refinement in Data base Design - Multi valued Dependencies - FOURTH Normal Form, Join Dependencies, FIFTH Normal form, Inclusion Dependencies.	8

5	Transaction Management, ACID property, Transaction state, Serializability and testing for serializability, concurrency control schemes, lock-based protocols, two-phase locking protocols, graph, time stamp-based protocols, deadlocks.	8
6	Recovery systems, log-based recovery, deferred and immediate database modification, object oriented database design.	2
7	Overview of Storage and Indexing: Data on External Storage, File Organization and Indexing - Clustered Indexes, Primary and Secondary Indexes, Index data Structures - Hash Based Indexing, Tree based Indexing, Comparison of File Organizations.	2
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Describe the fundamental concept of File System and DBMS Architecture.
2	Understand the concepts of different types of attribute, keys and Entity Relationship model.
3	Apply concepts of relational algebra, calculus and Structured Query language.
4	Apply concepts of functional dependency and normalization process to construct normalized database.

Learning Resources:	
1	Data base System Concepts, A.Silberschatz, H.F. Korth, S.Sudarshan, McGraw Hill, VI edition, 2006.
2	Elmasi, R. and Navathe, S.B., "Fundamentals of Database Systems", 4th Ed., Pearson Education
3	Date, C. J., "Introduction to Database Systems", Pearson Education.
4	Ramakrishnan, R. and Gekhre, J., "Database Management Systems", 3rd Ed., McGraw-Hill.

Course Name:	**Computer Networks**		
Course Code:	PC-CS603	**Category:**	Professional Core Courses
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Communication Engineering and Operating Systems
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To develop an understanding of modern network design and performance.
2	To introduce the student to the major concepts involved in variety of networks.
3	To provide a foundation to apply in network programming

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Data communication Components, Data Representation and its flow, Networks, Topology, Protocols and Standards, OSI model, TCP/IP, Transmission Media, Switching, Connecting Devices.	5
2	**Physical Layer:** Brief of Data and Signals- Basics, SNR, Bandwidth-Delay, Nyquist theorem, Shannon's Capacity, Baud, Signal Impairments, Data to Signal conversion Techniques- Digital to Analog, Digital to Digital, Scrambling, Multiplexing.	6
3	**Data Link Layer and Medium Access Sub Layer:** Framing, Byte/ Character stuffing, Bit stuffing; Error Detection and Error Correction - Fundamentals, Hamming Distance, Parity, CRC, Checksum; Flow Control and Error control protocols – ARQ- Stop and Wait, Sliding Window- Go- Back- N, Selective Repeat, Piggybacking, HDLC, Multiple access- Pure ALOHA, Slotted ALOHA, CSMA/CD, CDMA/CA, Token Passing, Poll, TDMA, FDMA, CDMA, LAN: Wired LAN, Wireless LAN, VLAN.	9
4	**Network Layer:** Logical addressing and Protocols– IPV4, IPV6; ICMP, Address mapping – ARP, RARP, BOOTP and DHCP–Delivery, Forwarding and Unicast Routing protocols.	8
5	**Transport Layer:** Process to Process Communication, User Datagram Protocol (UDP), Transmission Control Protocol (TCP), Congestion Control, Quality of Service, QoS improving techniques: Leaky Bucket and Token Bucket algorithm.	4
6	**Application Layer:** DNS, Telnet, Email, FTP, HTTP, Firewalls, Basics of Cryptography.	4
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	classify the role of the components of computer networks using addressing mechanisms and layer models.
2	compare different signal conversion techniques, transmission media, switching methodologies.
3	evaluate different error, flow and access control protocols over variety of networks.
4	analyze different network and transport layer protocols.
5	explain variety of protocols and security techniques at application layer.

Learning Resources:	
1	"Data Communications and Networking (4th Ed.)" – B. A. Forouzan, TMH
2	"Computer Networks (4th Ed.)" – A. S. Tanenbaum, Pearson Education/PHI
3	"Data and Computer Communications (5th Ed.)"- W. Stallings, PHI/ Pearson Education

Course Name:	**High-Performance Computing**		
Course Code:	PC-CS (D)604	**Category:**	Professional Core
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Computer Organization and Architecture
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To know how modern high-performance processors are organized their strengths and weaknesses.
2	To study about the architecture of parallel systems.
3	To gain knowledge about the analytical parallel algorithms.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Introduction: Review of basic computer architecture, quantitative techniques in computer design, measuring and reporting performance.	2
2	Parallel Processing Concepts; Levels and model of parallelism: instruction, transaction, task, thread, memory, function, data flow models, demand-driven computation; Parallel architectures: superscalar architectures, multi-core, multi-threaded, server and cloud.	4
3	Fundamental design issues in HPC: Load balancing, scheduling, synchronization, and resource management; Operating systems for scalable HPC; Parallel languages and programming environments; OpenMP, Pthread, MPI, java, Cilk; Performance analysis of parallel algorithms.	10
4	Fundamental limitations in HPC: bandwidth, latency and latency hiding techniques; Benchmarking HPC: scientific, engineering, commercial applications and workloads; Scalable storage systems: RAID, SSD cache, SAS, SAN; HPC based on cluster, cloud, and grid computing: economic model, infrastructure, platform, computation as service; Accelerated HPC: architecture, programming and typical accelerated system with GPU, FPGA, Xeon Phi, Cell BE; Power-aware HPC Design: computing and communication, processing, memory design, interconnect design, power management; Advanced topics: peta scale computing; big data processing, optics in HPC, quantum computers.	8
5	HPC programming assignments: Hands on experiment and programming on parallel machine and HPC cluster using Pthread, OpenMP, MPI, Nvidia Cuda and Cilk. Standard multiprocessor simulator or cloud simulator at an introductory level only.	10

6.	Distributed shared-memory architecture. Cluster computers. Non von Neumann architectures: data flow computers, reduction computer architectures, systolic architectures.	2
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able:	
1	Investigate modern design structures of pipelined and multiprocessors systems.
2	Design the architecture of parallel systems
3	Understand the API for parallel programming in shared-memory environments
4	Understand the implementation of MPI

Learning Resources:	
1	Hennessey and Patterson, "Computer Architecture: A quantitative Approach", Morgan Kaufman.
2	Ananth Grama and George Karypis, "Introduction to parallel computing", Addison -Wesley, 2009.
3	John Levesque and Gene Wagenbreth, "High Performance Computing: Programming and Applications", Chapman & Hall, 2010.
4	John L. Hennessy and David Patterson, "Computer Architecture- A Quantitative Approach", Elsevier, 2012.
5	Michael Quinn, "Parallel Programming in C with MPI and OpenMP", Indian edition, McGraw Hill Education, 2017.

Course Name:	**Data Mining**		
Course Code:	PE-CS601A	**Category:**	Professional Elective
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Basic concepts of Database, Concept of Mathematics
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To identify the scope and essentiality of Data Mining and Warehousing
2	To analyze data, choose relevant models and algorithms for respective applications.
3	To develop research interest towards advances in data mining.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Data Mining overview, Data Warehouse and OLAP technology, Data Warehouse Architecture, Steps for the Design and Construction of Data Warehouses, A Three – tier Data Warehouse Architecture, OLAP, OLAP queries, metadata repository, Data Preprocessing, Data – Integration and Transformation, Data Reduction, Data Mining Primitives: What defines a Data Mining Task? Task Relevant Data, The Kind of Knowledge to be mined, KDD.	06
2	Mining Association rules in Large Databases, Association Rule Mining, Market Basket Analysis: Mining a Road Map, The Apriori Algorithm: Finding Frequent Itemsets using Candidate Generation, Generating Association Rules from Frequent Itemsets, Improving the Efficiency of Apriori, Mining Frequent Itemsets without Candidate Generation, Multilevel Association Rules, Approaches to Mining Multilevel Association Rules, Mining Multidimensional Association Rules for Relational Databases and Data Warehouses, Multidimensional Association Rules, Mining Quantitative Association Rules, Mining Distance Based Association Rules, From Association Mining to Correlation Analysis.	10
3	Classification and Prediction, Issues regarding Classification and Prediction, Classification by Decision Tree Induction, Bayesian Classification, Bayes Theorem, Naïve Bayesian Classification. Classification based on Concepts from Association Rule Mining and Other Classification methods like k-Nearest Neighbor Classifiers, Prediction, Linear and Multiple Regression, Non Linear Regression, Other Regression Models, Classifier Accuracy.	10
4	Cluster Analysis, Data types in Cluster Analysis, Categorization of Major Clustering Methods, Classical Partitioning Methods: k-Means and k-Medoids, Partitioning Methods in Large Databases i.e k-Medoids to CLARANS, Hierarchical Methods, Agglomerative and Divisive Hierarchical Clustering, Density-Based Methods, CLIQUE: Clustering High-Dimensional Space, Model Based Clustering Methods.	10
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Identify the key processes of data mining, data warehousing and knowledge discovery process.
2	Identify appropriate data mining algorithms to solve real world problems
3	Compare and evaluate different data mining techniques like classification, prediction, clustering and association rule mining
4	Describe complex data types with respect to spatial and web mining.

Learning Resources:	
1	Jiawei Han and M Kamber, Data Mining Concepts and Techniques,, Second Edition, Elsevier Publication, 2011
2	Vipin Kumar, Pang-Ning Tan, Michael Steinbach, Introduction to Data Mining - Addison Wesley,2006.
3	Arun K. Pujari, Data Mining Techniques, Universities Press, 2001
4	Alex Berson and Stephen J. Smith, Data Warehousing, Data Mining, & OLAP, Second Edition Tata McGraw Hill Education
5	Pang-Ning Tan, "Introduction to Data Mining", Addison Wesley, 2006.

Course Name:	**Pattern Recognition**		
Course Code:	PE-CS 601B	**Category:**	Professional Elective Courses
Semester:	Seventh	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Discrete Mathematics
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To introduce students to the application of the Bayesian Decision theorem for pattern classification
2	To make the students realize the need for dimensionality reduction and choosing a proper dimensionality reduction model depending on the problem statement
3	To introduce students to different classification and clustering methods depending on the nature of the pattern

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction:** Pattern; Feature; Feature Selection; Dimensionality; Types of Learning	
2	**Basics of Probability:** Probability; Independence of events, conditional and joint probability, Bayes' theorem; Distribution Functions; Bayes Decision Theory	3
3	**Bayes Decision Theory:** Minimum-error-rate classification, Classifiers, Discriminant functions, Decision surfaces, Normal density and discriminant functions, discrete features, Naïve Bayesian Classifier	5
4	**Parameter Estimation Methods:** Maximum-Likelihood estimation: Gaussian case; Maximum a Posteriori estimation; Bayesian estimation: Gaussian case **Nonparametric techniques for density estimation:** Histogram Based Method, Windows Based Methods, Parzen-window method; K-Nearest Neighbour method	5
5	**Dimensionality reduction:** Introduction, Problems of High dimensionality, Principal component analysis; Linear Discriminant Analysis	4
6	**Sequential Pattern Recognition:** Hidden Markov Models (HMMs); Discrete HMMs	5
7	**Linear discriminant functions:** Gradient descent procedures; Perceptron; Support vector machines (brief introduction)	8

	Non-linear discriminant functions: Introduction to Multilayer Perceptron; Brief introduction to Back Propagation Algorithm	
8	**Non-metric methods for pattern classification**: Non-numeric data or nominal data; Decision trees: ID3	4
9	**Unsupervised learning and clustering:** Criterion functions for clustering; Algorithms for clustering: K-Means, Hierarchical clustering, Self-Organizing Map	4
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Demonstrate the concept of Bayesian Decision Theory for classification of data having parametric and non-parametric PDF
2	Compare different dimensionality reduction methods
3	Solve problems related to sequential data using Discrete Hidden Markov Model
4	Differentiate problems related to linear classifiers and non-linear classifier
5	Solve problems related to non-metric methods of pattern classifications
6	Demonstrate the concept of clustering

Learning Resources:	
1	R.O.Duda, P.E.Hart and D.G.Stork, Pattern Classification, John Wiley, 2001
2	S.Theodoridis and K.Koutroumbas, Pattern Recognition, 4th Ed., Academic Press, 2009
3	C.M.Bishop, Pattern Recognition and Machine Learning, Springer, 2006

Course Name:	**Image Processing**		
Course Code:	PE-CS601C	**Category:**	Professional Elective
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Mathematics I (BS-M-101) Mathematics II (BS-M-201) Computer Graphics (PE-CS501C)
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To understand the fundamentals of digital image processing.
2	To familiarize with the basic image model suitable for computer processing
3	To familiarize with mathematical preliminaries of digital image processing.
4	To understand different image enhancement methods.
5	To understand different image restoration procedures.
6	To understand applications of different image processing techniques in image segmentation

Course Contents:		
Module No.	**Description of Topic**	**Contact Hrs.**
1	**Introduction:** Digital Images, Fundamental steps in Digital Image Processing, Components of Digital Image Processing system. Elements of Digital Image Processing - Image Acquisition, Storage, Processing, Communication, Display.	3
2	**Image Model:** Image model suitable for computer processing, Sampling & Quantization - Uniform & Non uniform.	3
3	**Mathematical Preliminaries:** Neighborhood, Connectivity, boundaries, Relations, Distance Measures, Arithmetic/Logic Operations. Complex Numbers, Fourier Transformation and its properties. Two Dimensional Fourier Transform and Discrete Fourier Transform basic and applications.	6
4	**Image Enhancement:** Spatial Domain Method, Frequency Domain Method, Basic Intensity Transformation: Image negative, Log transform, Gamma transform, Piecewise linear transform, Histogram Processing: Histogram equalization, Histogram specification, Global and local histogram processing, Histogram statistics	8

	Spatial Filtering: Correlation and Convolution, Spatial filter mask, Smoothing spatial filters-Linear and Non-linear, sharpening Spatial filters-Gradient, Laplacian, Unsharp masking, Highboost filtering.	
5	**Image Restoration:** Degradation Model, Discrete Formulation, Differences in noise removal and restoration, noise models, Different spatial and frequency domain filters, Estimation of degradation function, Inverse filters; Wiener Filtering, Geometric Transformation - Spatial Transformation, Gray Level Interpolation.	8
6	**Image Segmentation:** Point, Line and Edge detection, Gradient operator, Combined detection, Edge Linking & Boundary Detection - Local Processing, Global Processing via Hough Transform; Thresholding – Otsu method, Single and multiple threshold, Variable thresholding, Region Oriented Segmentation - Region Growing, Region Splitting & Merging.	8
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Understand the basic concepts of digital image fundamentals and computer processing of image models.
2	Comprehend different image enhancement techniques.
3	Develop Fourier transform for image processing in frequency domain.
4	Learn to apply the knowledge of different image processing techniques for image restoration and segmentation.

Learning Resources:	
1	Digital Image Processing by Richard E. Woods and Rafael C.Gonzalez, Pearson
2	Digital Image Processing and Analysis by Chanda Bhabatosh, Majumder Dutta Dwijesh, PHI.
3	Digital Image Processing, Castleman, Pearson
4	Fundamentals of Digital Image Processing, A. K. Jain, PHI

Course Name:	**Distributed Computing**		
Course Code:	PE-CS602A	**Category:**	Professional Elective
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Java Programming, Operating Systems, Computer Networks
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To introduce the fundamental concepts and issues of managing large volume of shared data in a parallel and distributed environment, and to provide insight into related research problems.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Fundamentals**: Evolution of Distributed Computing Systems, System models, issues in the design of Distributed Systems, Distributed computing environment, web-based distributed model, computer networks related to distributed systems and web-based protocols.	6
2	**Message Passing:** Interprocess Communication, Desirable Features of Good Message-Passing Systems, Issues in IPC by Message, Synchronization, Buffering, Multidatagram Messages, Encoding and Decoding of Message Data, Process Addressing, Failure Handling, Group Communication.	6
3	**Remote Procedure Calls** The RPC Model, Transparency of RPC, Implementing RPC Mechanism, Stub Generation, RPC Messages, Marshaling Arguments and Results, Server Management, Communication Protocols for RPCs, Complicated RPCs, Client-Server Binding, Exception Handling, Security, Some Special Types of RPCs, Lightweight RPC, and Optimization for Better Performance.	6
4	**Synchronization** Clock Synchronization, Event Ordering, Mutual Exclusion, Election Algorithms.	3
5	**Resource and Process Management** Desirable Features of a good global scheduling algorithm, Task assignment approach, Load Balancing approach, Load Sharing Approach, Process Migration, Threads, Processor allocation, Real time distributed Systems.	6
6	**Distributed File Systems** Desirable Features of a good Distributed File Systems, File Models, File Accessing Models, File-sharing Semantics,	6

	File caching Schemes, File Replication, Fault Tolerance, Design Principles, Sun's network file system, Andrews file system, comparison of NFS and AFS	
7	Introduction to parallel and cluster computing.	3
Total		**36**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Demonstrate knowledge of the basic elements and concepts related to distributed system technologies
2	Illustrate the middleware technologies that support distributed applications such as RPC, RMI and Object based middleware.
3	Analyze the various techniques used for clock synchronization and mutual exclusion.
4	Demonstrate the concepts of Resource and Process management and synchronization algorithms.
5	Apply the knowledge of Distributed File System to analyze various file systems like NFS, AFS and the experience in building large-scale distributed applications.

Learning Resources:	
1	Andrew S. Tanenbaum and Maarten Van Steen, Distributed Systems: Principles and Paradigms, 2nd edition, Pearson Education.
2	George Coulouris, Jean Dollimore, Tim Kindberg, "Distributed Systems: Concepts and Design", 4th Edition, Pearson Education, 2005.
3	M. L. Liu, Distributed Computing Principles and Applications, Pearson Addison Wesley, 2004.

Course Name:	**Soft Computing**		
Course Code:	PE-CS602B	**Category:**	Professional Elective
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Basic knowledge of Set theory
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To familiarize the students with the basic concepts of soft computing and its techniques.
2	To acquaint the students with fuzzy logic and Genetic Algorithm.
3	To develop the ability to perform different types of learning with the help of Artificial Neural networks.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Introduction to Soft Computing:** Introduction to soft computing; introduction to fuzzy sets and fuzzy logic systems; introduction to biological and artificial neural network; introduction to Genetic Algorithm.	2
2	**Fuzzy Logic:** Introduction, Operations on Classical sets, properties of classical sets, Properties of fuzzy sets, Linguistic Hedges, Fuzzy set operations. Features of membership functions, standard forms and boundaries, different fuzzification methods, Lambda Cuts for fuzzy sets, Defuzzification methods. Crisp Logic, Fuzzy Logic, Fuzzy Rule based Inference System – Mamdani FIS, Sugeno FIS. Applications of Fuzzy Inference System	10
3	Artificial Neural Network: Introduction to Artificial Neural Networks, Biological Neurons and Artificial Neural Network, Resemblance of Biological neuron and ANN, Basic Idea of learning. Basic terminology of ANN, Topology of ANN, Different Activation Function, MP Neural Network. Neural Network for Supervised Learning: Perceptron and Delta learning Rule, ADALINE, Single layer Perceptron, MADALINE, Multilayer Perceptron with Back propagation Algorithm Neural Network for Unsupervised Learning: Hebbian Learning Rule, Competitive ANN like Kohonen's Self Organizing Feature Map. Associative Memory using ANN: Associative memory, Bi-directional Associative Memory, Binary Hopfield Networks. Neuro-Fuzzy modelling: Applications of Neural Networks: Pattern Recognition and classification	14
4	**Genetic Algorithms**: Basic Idea of Optimization, Introduction to Simple GA, brief introduction to other optimization techniques with Pros and Cons, Simple GA Algorithm	8

	GA operator: Different selection techniques, Different non-constrained and constrained Crossover and Mutation techniques Introduction to Multi-objective Genetic Algorithm (MOGA), pareto Optimal Solutions Genetic algorithms in search and optimization, GA based clustering Algorithm, Image processing, and Pattern Recognition	
5	**Other Soft Computing techniques:** Simulated Annealing, Ant colony optimization (ACO), Particle Swarm Optimization (PSO).	**2**
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Identify the difference between Hard Computing and Soft Computing
2	Practice fuzzy set theory and fuzzy logic to illustrate Fuzzy Inference System
3	Identify and implement appropriate Artificial Neural Network for solving a given problem
4	Describe the Simple Genetic Algorithm and its operators
5	Recall the other Soft Computing Techniques such as Simulated Annealing, ACO, Swarm Optimization, MOGA

Learning Resources:	
1	Principles of Soft Computing, S N Sivanandam, S.N. Deepa, Wiley India
2	S. Rajasekaran and G.A.V.Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithms", PHI
3	Neural Networks: A Classroom Approach,1/e by Kumar Satish, TMH,
4	Soft Computing and Intelligent System Design, Theory, Tools and Applications, F.O. Karray, C. De Silva, Pearson
5	Genetic Algorithms in search, Optimization & Machine Learning by David E. Goldberg
6	Neuro-Fuzzy and Soft computing, Jang, Sun, Mizutani, PHI
7	Fuzzy logic with engineering applications, Timothy J. Ross, John Wiley and Sons.
8	Genetic Algorithms in search, Optimization & Machine Learning by David E. Goldberg, Pearson/PHI
9	A beginner's approach to Soft Computing, Samir Roy & Udit Chakraborty, Pearson
10	Fuzzy Sets and Fuzzy Logic: Theory and Applications, George J. Klir and Bo Yuan, Prentice Hall
11	Neural Networks: A Comprehensive Foundation (2nd Edition), Simon Haykin, Prentice-Hall.

Course Name:	**Data Analytics and Visualization**		
Course Code:	PE-CS602C	**Category:**	Professional Elective
Semester:	Sixth	**Credit:**	3
L-T-P:	3-0-0	**Pre-Requisites:**	Concept of Data Science and Machine Learning
Full Marks:	100		
Examination Scheme:	Semester Examination: 70	Continuous Assessment: 25	Attendance: 05

Course Objectives:	
1	To understand Data Analytics Life Cycle and Business Challenges
2	To understand Analytical Techniques and Statistical Models

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Module 1: Data Analytics Lifecycle** Data analytics, Drivers of data analytics, Typical analytical architecture, Need of Data analytic lifecycle, Various phases of Data analytic lifecycle: Discovery, Data Preparation, Model Planning, Model Building, Communicating Results, Operationalization, Key roles for successful analytic projects	6L
2	**Module 2: Data Cleaning, Preparation and Visualization** Data Cleaning and Preparation: Handling Missing Data - Data Transformation: Removing Duplicates, Transforming Data Using a Function or Mapping, Replacing Values, Detecting and Filtering Outliers- String Manipulation: Vectorized String Functions in pandas.	6L
3	**Module 3: Data Visualization Foundation** Exploring the Visual Data Spectrum- Charting Primitives (Data Points, Line Charts, PerfChart, Seasonality Chart, Bar Charts, Pie Charts, Donut Charts, Area Charts), Exploring advanced Visualizations (Candlestick Charts, Bubble Charts, Surface Charts, Map Charts, Heat Maps, Gantt Chart, Polygon Maps, Infographics).	6L
4	**Module 4: Introduction to Data Visualization** Acquiring Data, Visualizing Data, Simultaneous Acquisition and Visualization, Plotting with pandas: Line Plots, Bar Plots, Histograms and Density Plots, Scatter or Point Plots. Applications of Data Visualization (Uses in the Public Sector, Business-to-Business and inter-Business Uses, Business-to-Consumer Uses),	8L
5	**Module 5: Introduction to Tableau** Overview, Environment Setup, Design Flow, File Types, Data Types, Tableau data sources: Data Sources, Custom Data View, Extracting Data, Fields Operations, Editing Metadata, Data Joining, Data Blending, Tableau Worksheets**:** Add Worksheets, Rename Worksheet, Save & Delete Worksheet, Reorder Worksheet, Paged Workbook, Tableau Calculations: Operators,	10L

	Functions, Numeric Calculations, String Calculations, Date Calculations, Table Calculations, LOD Expressions, Tableau Sort & Filters: Basic Sorting, Basic Filters, Quick Filters, Context Filters, Condition Filters, Top Filters, Filter Operations	
Total		**36L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Deploying the Data Analytics Lifecycle to address big data analytics projects
2	Applying appropriate analytic techniques and tools to analyze big data, create statistical models, and identify insights that can lead to actionable results
3	Selecting appropriate data visualizations to clearly communicate analytic insights to business sponsors and analytic audiences
4	Using tools such as Tableau Software in database analytics

Learning Resources:	
1	R N Prasad and Seema Acharya, Fundamentals of Business Analytics, Wiley (Latest Edition)
2	Wes McKinney, "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython", O'Reilly, 2nd Edition,2018.
3	Daniel G. Murray, Tableau Your Data!: Fast and Easy Visual Analysis with Tableau Software, Wiley (Latest Edition)
4	Jon Raasch, Graham Murray, Vadim Ogievetsky, Joseph Lowery, JavaScript and JQuery for Data analysis and visualization, Wiley (Latest Edition)

Course Name:	**Database Management System Lab**		
Course Code:	PC-CS 692	**Category:**	Professional Core
Semester:	Sixth	**Credit:**	1.5
L-T-P:	0-0-3	**Pre-Requisites:**	Basic understanding in database management
Full Marks:	100		
Examination Scheme:	Semester Examination: 60	Continuous Assessment: 35	Attendance: 05

Course Objectives:	
1	Learn to create and use a database.
2	Be familiarized with a query language.
3	Have a good understanding of DDL, DML and DCL commands.
4	Familiarize advanced SQL queries.

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	**Structured Query Language** Creating Database, Creating a Table, Specifying Relational, Data Types Specifying Constraints, Creating Indexes.	3
2	**Table and Record Handling** INSERT statement, Using SELECT and INSERT together, DELETE, UPDATE, TRUNCATE statements, DROP, ALTER statements.	6
3	**Retrieving Data from a Database** The SELECT statement, Using the WHERE clause, Using Logical Operators in the WHERE clause, Using IN, BETWEEN, LIKE, ORDER BY, GROUP BY and HAVING Clause *Using Aggregate Functions *Combining Tables Using JOINS * Subqueries	9
4	**Database Management** Creating Views, Creating Column Aliases, Creating Database ,Users, Using GRANT and REVOKE commands – Commit, Rollback, Save point.	9
5	**PL/SQL Concepts** Introduction, Cursors, Stored Procedures, Stored Functions, Database Triggers.	9
Total		**36P**

Course Outcomes:
After completion of the course, students will be able to:

1	Apply the basic concepts of Database Systems and Applications.
2	Use the basics of SQL and construct queries using SQL in database creation and interaction.
3	Design a commercial relational database system (Oracle, MySQL) by writing SQL using the system.
4	Analyze and Select storage and recovery techniques of database system.

Learning Resources:	
1	Beginning SQL Programming,Kauffman, SPD/WROX
2	Ivan Bayross, "SQL, PL/SQL the Programming Language of Oracle"

Course Name:	**Computer Networks lab**		
Course Code:	PC-CS693	**Category:**	Professional Core Courses
Semester:	Sixth	**Credit:**	1.5
L-T-P:	0-0-3	**Pre-Requisites:**	Operating System, Programming knowledge
Full Marks:	100		
Examination Scheme:	Semester Examination: 60	Continuous Assessment: 35	Attendance: 5

Course Objectives:	
1	To develop an understanding of modern network design and configuration methodologies.
2	To introduce the student to the major concepts involved in network communication.
3	To apply the communication concepts in network programming

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Familiarization with network cables (CAT5/5e/6 UTP), connectors (RJ45, T-connector), Ethernet driver, connecting devices (Hubs, Switches, Routers) etc. and preparation of crossover and/or straight-through patch cable using color code.	3
2	System Configuration (Windows and/or Linux) with implementation of subnetting. Familiarization of network related commands like ping, netstat, ifconfig/ ipconfig, netconfig, traceroute, telnet, finger, iptables, ipchains etc.	6
3	Familiarization of network simulator and/or packet tracer, configuration of router and configuration of DNS, FTP, HTTP, Mail server etc.	3
4	Implementation of IPC using Pipe.	3
5	Implementation of IPC using connection-oriented (TCP) and connection-less (UDP) socket in both iterative and concurrent (multi-process and/or multi-threaded approach) modalities.	18
6	Implementation of Data Link Layer Flow Control Mechanism (Sliding Window).	3
Total		**36**

Course Outcomes:	
After completion of the course, students will be able to:	
1	prepare network cable to connect devices for network design.
2	apply configuration knowledge and skill to setup Ethernet Card in Windows and Linux.
3	implement of Inter-Process Communication using Pipe.
4	design variety of iterative and concurrent servers to implement client-server communication using TCP and UDP socket.

Learning Resources:	
1	"Unix Network Programming: The Sockets Networking API Vol 1" – W. Richard Stevens, Bill Fenner, Andrew M. Rudoff, Third Edition, Addison Wesley
2	"UNIX Network Programming: Interprocess Communications, Volume 2" – W. Richard Stevens, 2nd Edition, Prentice Hall
3	"Hands-On Network Programming with C: Learn socket programming in C and write secure and optimized network code"- Lewis Van Winkle, Packt Publishing Limited

Course Name:	**Software Development and IT Operations Lab**		
Course Code:	PC CS 694	**Category:**	Professional Core
Semester:	Sixth	**Credit:**	1
L-T-P:	0-0-2	**Pre-Requisites:**	The basic idea of the Computer Networks, and Database Management System
Full Marks:	100		
Examination Scheme:	Semester Examination: 60	Continuous Assessment: 35	Attendance: 5

Course Objectives:	
1	To learn the design and development process involved in creating a cloud-based application
2	Able to maintain cloud security.
3	Able to use different web service automation tools

Course Contents:

Module No.	Description of Topic	Contact Hrs.
1	Identity Access Management, Root Account Vs IAM user, Multi-Factor Authentication for Users, IAM Password Policies, Creating Customer Managed Policies, Glacier Storage, what is Simple Storage Service (S3), Storage Classes, Cross-region replication, Life Cycle Management, Security & Encryption, Static Webhosting with S3 bucket, Events configuration on S3 buckets, Enabling cross-account access for S3, S3 Data management and backup using 3rd Party applications, S3 Cross-Account Access and Pre-Signed URLs Storage Gateway.	2
2	Basics of Linux for AWS, Web Server and Services Configurations, EC2 Instance Launch Wizard, EC2 Instance Types, Generating custom Public Key and Private keys for EC2 instances, Security groups, Volumes and Snapshots, Creating customized Amazon Machine Images , User. Data and Metadata, Elastic Load Balancers & Health Checks, Auto Scaling Groups, CloudWatch, Creating Billing Alarm and EC2 instance alarms, AWS CLI&EC2 Roles, Elastic File System, AWS Lightsail, Elastic Beanstalk Placement Groups.	6
3	DNS Records overview Routing Policies, Hosting sample Website and configuring Policies, Simple Routing Policy, Latency Routing Policy Failover Routing Policy Weighted Routing Policy, Geolocation Routing Policy, Databases, Launching a RDS Instances (MySQL, MSSQL & Aurora), Multi-AZ & Read Replicas for RDS instances, DynamoDB, Redshift, Elastichache, Database Migration Service and Schema conversion tool.	2
4	VPC (Virtual Private Cloud), Networking Basics, Creating custom VPCs and custom Subnets, Network ACL's, Route Tables & IGW, VPC Peering, Flow log creation VPN Configuration with AWS (OpenVPN). Security Options, CloudTrail, AWS Config, Key Management Services, AWS Certificate Manager, AWS Trusted Advisor Content Delivery Networks / CloudFront.	2
5	Application Services, Simple Email Service, Simple Queue Service, Simple Workflow Service, Simple Notification Service, SMS — Server Migration Service, Migrating server from on-premises to cloud, Cloud Formation, Directory Services and Adding EC2	2

	instance to Domain, AWS TCO Calculator and Simple Monthly calculator.	
6	Dev0ps Tools Overview, What is Dev0ps in Cloud, Code Pipeline, Code Commit, Code Build, Code Deploy Lambda.	8
7	Monitoring Tools, Creating Custom Metrics with CloudWatch, Deploy node project in AWS.	2
Total		**24**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Use various web cloud services like storage, network, compute, and databases in different applications.
2	Use DevOps tool to build and deploy applications in a cloud infrastructure.
3	Learn how to simulate a cloud environment.
4	Use different AWS automation tools like Chef, Terraform, Packer, CloudFormation, OpsWorks, and Beanstalk.

Learning Resources:	
1	Aws: The Ultimate Guide from Beginners To Advance For The Amazon Web Services (2020 Edition) by Theo H. King.
2	Amazon Web Services in Action by Andreas Wittig, Michael Wittig, Ben Whaley.
3	Aws: Amazon Web Services. The Ultimate Guide for Beginners, Intermediates, and Expert by Phillip Broyles.

Course Name:	**Aptitude Skill Development-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: 100		

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/Short cuts and Mock test	**6L**
	Total	**24L**

Course Outcomes:	
After completion of the course, students will be able to:	
1	Express idea in verbal and non-verbal communication in an effective manner
2	Apply cognitive skills in problem solving
3	Apply reasoning skills in problem solving

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