Vidyalankar Institute of Technology

An Autonomous Institute affiliated to University of Mumbai

Master of Technology

in

Computer Engineering

First Year Scheme & Syllabus

(As per AICTE guidelines, with effect from the Academic Year 2022-23)

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated, and taken forward in a systematic manner. Therefore, autonomy for Vidyalankar Institute of Technology is not merely a transition from pre-cooked syllabi to self-designed curriculum. Autonomy curriculum of the Institute offers required academic flexibility with emphasis on industry requirements and market trends, employability, problem-solving approach and research ability which leads to improving competency level of learners with diverse strengths. In line with this, the curriculum framework designed is **Choice-Based Credit and Grading System (CBCGS)**. Number of credits for courses learnt by learners, internships and dissertation is finalized considering the scope of study and the ability that a learner should gain through the programme.

The curriculum has core courses of engineering, specific to the branch. These courses are completed in first year of the engineering programme that enables learners to work on their chosen dissertation topic during their final year. The curriculum planned by the Institute offer flexibility and diversity to learners to choose any set of courses from a basket of professional electives. Learner can also choose to specialize in a domain as per their field of interest. The selection of unique specialization tracks based on recent developments and industrial requirements is a salient feature of this curricula ensuring employability. Each specialization track has mandatory courses positioned and sequenced to achieve sequential and integral learning for the required depth of the specific domain. Learner can choose to complete these courses in first year of the engineering program that enables him/her to prepare for research during their final year. Credits additional to core and professional elective courses, include dissertation, internships, advanced courses in the field of computer engineering, multi-disciplinary courses, special skill development courses and similar knowledge that make learner capable to do further research or work in industrial environment.

Thus, the academic plan of VIT envisages a shift from summative to formative and competency-based learning system which will enhance learner's ability towards higher education, employability and entrepreneurship.

Chairman, Board of Studies
Department of Computer Engineering
Vidyalankar Institute of Technology

Chairman, Academic Council
Vidyalankar Institute of Technology

First Year M. Tech. Computer Engineering **Semester: I**

Course Structure and Assessment Guidelines

Course		Head of Learning	Credits	Assessment Guidelines (Marks)				Total marks (Passing@45% of total marks)
Code	Name			ISA	MSE	ESE	Lab Work	
CE63	Advanced Data Structure & Algorithms	Theory+ Practical	4	40	20	40	25	125
CE64	HPC, Cluster and Grid Computing	Theory+ Practical	4	40	20	40	25	125
CEXX	Professional Elective-1	Theory+ Practical	4	40	20	40	25	125
CEXX	Professional Elective-2	Theory+ Practical	4	40	20	40	25	125
OEXX*	Open Elective-1	As per course						

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
*Refer to Appendix B for the list of Open Elective (OE) courses. Selection will be based on the subset of OE courses made available by the Institute for the semester.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Refer Appendix-A for guidelines on Professional Elective Courses and Specialization Certificate

Professional Elective-1 Courses (CEXX)

Course Code	Course Name	Specialization Track Name#
CE71	Probability and Statistics for Data Science	Data Science (DS)
CE75	Smart Sensors and Internet of Things	Internet of Things (IoT)
CE79	Data Encryption and Compression	Computer Security (CSec)

#For details of Specialization Certificate, refer Appendix-A

Professional Elective-2 Courses (CEXX)

Course Code	Course Name	Specialization Track Name#
CE72	Data Preparation and Exploration	Data Science (DS)
CE76	IoT - Application and Communication Protocol	Internet of Things (IoT)
CE80	Ethical Hacking and Digital Forensics	Computer Security (CSec)

#For details of Specialization Certificate, refer Appendix-A

First Year M. Tech. Computer Engineering **Semester: II**

Course Structure and Assessment Guidelines

Course		Head of Learning	Credits	Assessment Guidelines (Marks)				Total marks (Passing@45% of total marks)
Code	Name			ISA	MSE	ESE	Lab Work	
CE65	Parallel Algorithms and Programming	Theory+ Practical	4	40	20	40	25	125
CE66	Computational Intelligence	Theory+ Practical	4	40	20	40	25	125
CEXX	Professional Elective-3	Theory+ Practical	4	40	20	40	25	125
CEXX	Professional Elective-4	Theory+ Practical	4	40	20	40	25	125
OEXX*	Open Elective-2	As per course						

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Professional Elective-3 Courses (CEXX)

Course Code	Course Name	Specialization Track Name#
CE73	Big Data	Data Science (DS)
CE77	Wireless Access Technologies	Internet of Things (IoT)
CE81	Database Security and Access control	Computer Security (CSec)

#For details of Specialization Certificate, refer Appendix-A

Professional Elective-4 Courses (CEXX)

Course Code	Course Name	Specialization Track Name#
CE74	Natural Language Processing	Data Science (DS)
CE78	IOT and Smart Cities	Internet of Things (IoT)
CE82	Intrusion Detection and Prevention	Computer Security (CSec)

#For details of Specialization Certificate, refer Appendix-A

Detailed syllabus of First Year Semester-I

Course Name: Advanced Data Structure and Algorithms

Course Code: CE63

Category: Core

Preamble:

This course introduces different Advanced Data Structures and aims to provide Mathematical Approach for Analysing the Complexities of Algorithms with their real-life applications.

Pre-requisites:

1. Data Structures
2. Analysis of Algorithms

Course Objective:

- To provide mathematical approach for Analysis of Algorithms.
- To understand advanced data structures and its operations.
- To solve complex problems in real life applications.

Course Outcome:

Learner will be able to:
CO1: Describe analysis techniques for algorithms.
CO2: Appreciate the role of probability and randomization in the analysis of algorithm.
CO3: Identify appropriate data structure and design techniques for different problems.
CO4: Identify appropriate algorithm to be applied for the various application like Max Flow, Linear programming etc.
CO5: Understand Approximation and Optimization Algorithms.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be

approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Fundamental of Algorithms	Complexity: Finding complexity by tree method, master method, proving technique (contradiction, mathematical induction). Amortized analysis- aggregate analysis, accounting analysis, potential analysis dynamic tables	6
2	Probabilistic Analysis and Randomized Algorithm	The hiring problem Indicator random variables, Randomized algorithms Probabilistic analysis and further uses of indicator random variable	6
3	Advanced Data Structure	Introduction to trees and heap Red-Black Trees: properties of red-black trees, Operations on Red-black trees Binomial Heaps: Binomial trees and binomial heaps, Operation on Binomial heaps Analysis of all above operations	12
4	Flow N/W Maximum Flow	Shortest Path, The Floyd - Warshall Algorithm, Johnson's Algorithm for sparse graphs, Flow Networks, The Ford-Fulkerson method, Maximum bipartite matching, Push relabel algorithms, The relabel-to-front algorithm.	10
5	Linear Programming	An Introduction to Linear Programming, Flows in networks, Bipartite matching, Duality, Zero- sum games, The simplex algorithm, Post script: circuit evaluation	5
6	Approximation & Optimization Algorithms	Approximation Algorithms: The vertex - cover problem, the travelling salesman problem, the set- covering problem, Randomization and linear programming, The subset- sum problem. Optimization Algorithms: Genetic Algorithm, K- means Algorithm	6
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Programs on Solving Hiring problem.
2.	Program to implement operations on Red black Tree.
3.	Program to implement operations on Red black Tree.
4.	Program on Floyd-Warshall Algorithm for shortest path

Sr No.	Suggested Topic(s)
5.	Program on Johnson's Algorithm for sparse graphs
6.	Program on The Ford-Fulkerson method to determine Maximum Flow.
7.	Program to implement Maximum bipartite matching
8.	Program to implement Simplex Algorithm
9.	Program to implement subset sum problem using Randomization
10.	Program to implement K-Means Algorithm for Optimization.

Text Books:

1. 1.Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, "Introduction to Algorithm" PHI, India Second Edition.
2. Horowitz, Sahani and Rajsekaran, "Fundamentals of Computer Algorithm", Galgotia.
3. Harsh Bhasin, "Algorithms – Design and Analysis", Oxford, 2015.

Reference Books:

1. Rajeev Motwani, Prabhakar Raghavan," Randomized Algorithm", Cambridge University
2. S. K. Basu," Design Methods and Analysis of Algorithm", PHI
3. Vijay V. Vajirani," Approximation Algorithms", Springer.

Course Name: HPC, Cluster and Grid Computing

Course Code: CE64

Category: Core

Preamble:

Goal of this course is to learn basics of High-Performance Computing, clustering and grid computing, it will cover theoretical and practical knowledge regarding parallel computing, high-performance computing, supercomputers, and the development and performance analysis of parallel applications.

Pre-requisites:

1. Computer Networks
2. Microprocessor
3. Operating Systems

Course Objectives:

- Understand different parallel processing approaches and platforms involved in achieving High Performance Computing.
- Understand design issues and limitations in Parallel Computing.
- Programming using message passing paradigm using open-source APIs, design algorithms suited for Multicore processor and OpenMP.
- Analyse and optimize performance parameters, for cluster and grid computing.

Course Outcome:

Learner will be able to:
CO1: Understand the cluster and grid computers
CO2: Understand task scheduling and resource allocation in cluster and grid environment
CO3: Understand middleware architecture in Cluster and Grid Environment
CO4: Understand the cluster and grid computing platform as an alternative to traditional supercomputers
CO5: Understand the use of Globus tools standards by following Cluster and Grid Systems
CO6: Understand the security aspects while computing with HPC and Grid computing

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

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Detailed Syllabus:

Module No.	Module Name	Content	No. of Hours
1	Introduction	Introduction to distributed and high-performance computing. Basic terms: distributed computing, HPC, HPCC, network computing, Internet computing, cluster, grid, meta-computing, middleware, etc; milestones of the history, some representative applications Parallel Architectures Classifications SMP, MPP, NUMA, Clusters and Components of a Parallel Machine, Conventional Supercomputers and its limitations, Multi-processor, and Multi Computer based Distributed Systems.	8
2	Cluster and Grid	Cluster Components Processor/machine, High Speed Interconnections goals, topology, latency, bandwidth, Example Interconnect: Myrinet, Inifiniband, QsNet, Fast Ethernet, Gigabit Ethernet, Light weight Messaging system/Light weight communication Protocols, Cluster Middleware Job/Resource Management System, Load balancing, scheduling of parallel processes, Enforcing policies, GUI,	10
3	Introduction to programming tools	Introduction to programming tools such as PVM, MPI, Cluster Operating Systems Examples: Linux, MOSIX, CONDOR, Message passing standards: PVM (Parallel Virtual Machine), MPI (Message Passing Interface)	4
4	Different components of Grid	Grid fabric, Grid middleware, Grid applications and portal, Globus toolkit Ver.2.4, web services, MDS, GRAM, Grid toolkit approach: Globus Hourglass concept, communication, Grid monitoring, Tasks, Types architecture, components, Characteristics of Grid, Computational services, Computational Grids, Data grids/ Storage grids, management, and applications	10
5	Security	Confidentiality, integrity, and availability. Authentication authorization assurance, auditing accounting. Grid security cryptography	5
6	Fault Tolerance	Fault detection and diagnosis of Clusters and Grids. Recent advances in cluster and grid computing. Integrity, Digital	8

Module No.	Module Name	Content	No. of Hours
		Signature, Digital Certificates, Certificate Authority, MD 5, RSA, GSI, GSSAPI, Directory Service, LDAP, GRID FTP, GASS	
Total			**45**

Suggested List of Practicals:

Solve given problems using OpenMP/MPI/OpenCL and compare their performance on CPU.

Sr No.	Suggested Topic(s)
1.	Matrix-Matrix multiplication – simple algorithm
2.	Sorting – Bitonic/Shell sort/Bucket
3.	All-pairs shortest paths – Dijkstra's algorithm

Text Books:

1. R. K. Buyya, High Performance Cluster Computing: Programming and Applications, PHI , 1999
2. D. Janakiram, Grid Computing, Tata Mcgraw Hill , 2005.
3. Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar, Introduction to Parallel Computing" . Pearson Education, , Second Edition 2007.
4. Benedict R Gaster, Lee Howes, David R KaeliPerhaad Mistry Dana Schaa, "Heterogeneous Computing with OpenCL", Elsevier, Second Edition, 2013

Reference Books:

1. J. J. Jos & R. K. Buyya, High Performance Cluster Computing: Architecture and Systems, PHI , 1999
2. P. Jalote, Fault Tolerance in Distributed Systems, Prentice Hall, 1994, P. Jalote, Fault Tolerance in Distributed Systems, Prentice Hall, 1994, Prentice Hall , 1994

Course Name: Probability and Statistics for Data Science

Course Code: CE71

Category: Professional Elective

Preamble:

This required course for the M.Tech. with specialization in Data Science should be taken in the first year of study. It covers fundamental concepts in probability and statistics from a data-science perspective.

Pre-requisites:

1. Engineering Mathematics
2. Probability and Statistics

Course Objectives:

- To understand basic statistical foundations for roles of Data Scientist.
- To develop problem-solving skills.
- To infer about the population parameters using sample data and perform hypothesis testing.
- To understand importance and techniques of predicting a relationship between data and determine the goodness of model fit.

Course Outcome:

Learners will be able to:
CO1: Develop various visualizations of the data in hand.
CO2: Analyse a real-world problem and solve it with the knowledge gained from sampling and probability distributions.
CO3: Analyse large data sets and perform data analysis to extract meaningful insights.
CO4: Develop and test a hypothesis about the population parameters to draw meaningful conclusions.
CO5: Fit a regression model to data and use it for prediction.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

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Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Introduction	Data and Statistics: Elements, Variables, and Observations, Scales of Measurement, Categorical and Quantitative Data, Cross-Sectional and Time Series Data, Descriptive Statistics, Statistical Inference, Descriptive Statistics: Tabular and Graphical Summarizing Categorical Data, Summarizing Quantitative Data, Cross Tabulations and Scatter Diagram. Descriptive Statistics: Numerical Measures: Measures of Location, Measures of Variability, Measures of Distribution Shape, Relative Location, and Detecting Outliers, Box Plot, Measures of Association Between Two Variables	7
2	Probability	Probability: Experiments, Counting Rules, and Assigning Probabilities, Events and Their Probabilities, Complement of an Event, Addition Law Independent Events, Multiplication Law, Baye's theorem. Discrete Probability Distributions Random Variables, Discrete Probability Distributions, Expected Value and Variance, Binomial Probability Distribution, Poisson Probability Distribution. Continuous Probability Distributions: Uniform Probability Distribution, Normal Curve, Standard Normal Probability Distribution, Computing Probabilities for Any Normal Probability Distribution	8
3	Sampling and Sampling Distributions	Sampling from a Finite Population, Sampling from an Infinite Population, Other Sampling Methods, Stratified Random Sampling, Cluster Sampling, Systematic Sampling, Convenience Sampling, Judgment Sampling. Interval Estimation: Population Mean: Known, Population Mean: Unknown, Determining the Sample Size, Population Proportion.	4
4	Hypothesis Tests	Developing Null and Alternative Hypotheses, Type I	4

Module No.	Module name	Content	No. of Hours
		and Type II Errors, Population Mean: Known Population Mean: Unknown Inference About Means and Proportions with Two Populations-Inferences About Population Variances, Inferences About a Population Variance, Inferences About Two Population Variances. Tests of Goodness of Fit and Independence, Goodness of Fit Test: A Multinomial Population, Test of Independence.	
5	Regression	Simple Linear Regression: Simple Linear Regression Model, Regression Model and Regression Equation, Estimated Regression Equation, Least Squares Method, Coefficient of Determination, Correlation Coefficient, Model Assumptions, testing for Significance, Using the Estimated Regression Equation for Estimation and Prediction Residual Analysis: Validating Model Assumptions, Residual Analysis: Outliers and Influential Observations. Multiple Regression: Multiple Regression Model, Least Squares Method, Multiple Coefficient of Determination, Model Assumptions, Testing for Significance, Categorical Independent Variables, Residual Analysis.	8
6	Time Series Analysis and Forecasting	Time Series Patterns, Forecast Accuracy, Moving Averages and Exponential Smoothing, Trend Projection, Seasonality and Trend and Time Series Decomposition. Nonparametric Methods: Sign Test, Wilcoxon Signed-Rank Test, Mann-Whitney-Wilcoxon Test, Kruskal-Wallis Test, Rank Correlation.	5
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Perform different types of analysis on two E-commerce Datasets. 1. Univariate 2. Bivariate 3. Multivariate Compare the inference between both the datasets
2.	Determination of sample size for the 1000 students (dataset marks) and perform 1. Random Sampling 2. Stratified Sampling

3.	Create tabular machine-learning datasets from the textual data
4.	Perform Linear regression and prediction on the datasets downloaded from the datasets repository. Example Airline dataset. Predict when a flight in delayed.
5.	Perform multiple regression and prediction on the datasets downloaded from the datasets repository. Example Uber Fares Dataset. predict the fare for Uber Rides
6.	Perform test statistics using Python.

Text Books:

1. Data Science from Scratch, FIRST PRINCIPLES WITH PYTHON, O'Reilly, Joel Grus
2. Data Science from Scratch (oreillystatic.com)
3. Practical Time Series Analysis, Prediction with statistics and Machine Learning, O'Reilly, Aileen Nielsen [DOWNLOAD] O'Reilly Practical Time Series Analysis PDF (lunaticai.com)
4. R for data science: Import, Tidy, Transform, Visualize, And Model Data, O'Reilly , Garrett Grolemund, Hadley Wickham
5. Python for Data Analysis, 2nd Edition, O'Reilly Media, Wes McKinney

Reference Books:

1. Data Science for Dummies Paperback, Wiley Publications, Lillian Pierson
2. Storytelling with Data: A Data Visualization, Guide for Business Professionals, Wiley Publications, Cole Nussbaumer Knaflic
3. Probability and Statistics for Engineering and the Sciences, Cengage Publications Jay L. Devore

Course Name: Data Preparation and Exploration

Course Code: CE72

Category: Professional Elective

Preamble:

Learners will learn how to prepare data for visualization, perform exploratory data analysis and develop meaningful data visualization. They will work with variety of real-world data sets and learn how to prepare data sets for analysis by cleaning and reformatting.

Pre-requisites:

1. Python

Course Objectives:

- To prepare data for analysis to uncover interesting structure and unusual observations.
- To learn data exploratory analysis techniques for appropriate analysis and to define what we would expect to see in the data.
- To interpret the results of visual inference and assess the strengths and adequacy of data analysis.

Course Outcomes:

Learners will be able to:
CO1: Find out how analysts decide which data to collect for analysis.
CO2: Learn about structured and unstructured data, data types, and data formats.
CO3: Learn how to gather and prepare data for analysis.
CO4: Identify and apply various data cleaning techniques.
CO5: Learn data exploratory analysis techniques.
CO6: Apply visualization techniques on datax.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

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Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Data types and structures	How to generate data and how analysts decide which data to collect for analysis. Structured and unstructured data, data types, and data formats	6
2	Bias, credibility, privacy, ethics, and access	When data analysts work with data. Identify different types of bias in data and how to ensure credibility in data. Explore open data and the relationship between and importance of data ethics and data privacy.	7
3	Data Gathering and Preparation	Data Munging, Wrangling, Data formats, parsing and transformation, Scalability, and real-time issues	8
4	Data Cleaning	Consistency checking, Heterogeneous and missing data, Data Quality, Data Transformation, and segmentation	8
5	Exploratory Analysis	Descriptive and comparative statistics, Clustering and association, Hypothesis generation	8
6	Visualization	Designing visualizations, Time series, Geolocated data, Correlations and connections, Hierarchies and networks, interactivity	8
Total			**45**

Suggested List of Practicals:

Programming assignments based on following topics to be performed using data analysis tool like R

Sr No.	Suggested Topic(s)
1.	Handling Structured and Unstructured data
2.	Handling different types of bias in data
3.	Perform credibility analysis of data
4.	Data Wrangling
5.	Data Transformation

6.	Data Cleaning
7.	Performing Exploratory Data Analysis (EDA)
8.	Data Vizualization and Analysis

Text Books:

1. Glenn J. Myatt, Making sense of Data: A practical Guide to Exploratory Data Analysis and Data Mining, John Wiley Publishers, 2007.

Reference Books:

1. Data Preparation for Data Mining by Dorian Pyle, Morgan Kaufmann Publishers, Inc.

Course Name: Smart Sensors and Internet of Things

Course Code: CE75

Category: Professional Elective

Preamble:

This course introduces learners an overview of concepts, main trends and challenges of Internet of Things. Develop the ability to use Internet of Things related software and hardware technologies. And provide the knowledge of data management business processes and analytics of IoT

Pre-requisites:

1. Basic programming knowledge
2. Basics of wireless networks

Course Objectives:

- To provide knowledge on Sensor Principles.
- To provide familiarity with different sensors and their application in real life.
- To develop necessary technical skill to select suitable smart sensors, components of IOTs with associated knowledge of interface electronics and signal conditioning

Course Outcome:

Learners will be able to:
CO1: Ability to identify, formulate suitable sensors for engineering applications
CO2: Explain and interpret the Internet of Things concepts and challenges.
CO3: Experiment with the software and hardware IoT Technologies.
CO4: Understand data management and business processes and analytics of IoT
CO5: Design and develop small IoT applications to create smart objects

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

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Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Introduction to Internet of Things and smart sensors	IoT Paradigm, IoT Architecture – State of the Art, IoT Protocols, IoT Communication Models, IoT in Global Context, Cloud Computing, Big Data Analytics, Concepts of Web of Things, Concept of Cloud of Things with emphasis on Mobile Cloud Computing, Smart Objects.	10
2	Open – Source Prototyping Platforms for IoT	Basic Arduino Programming Extended Arduino Libraries, Arduino – Based Internet Communication, Raspberry PI, Sensors and Interfacing.	6
3	IoT Technology	RFID + NFC, Wireless Networks + WSN, RTLS + GPS, Agents + Multi – Agent Systems, Composition Models for the Web of Things and resources on the Web, Discovery, Search, IoT Mashups and Others.	7
4	Wireless Sensor Networks	History and Context, The Node, Connecting Nodes, Networking Nodes, Secured Communication for IoT	6
5	Data Management, Business Process and Analytics	Data Management, Business Process in IoT, IoT Analytics, Creative Thinking Techniques, Modification, Combination Scenarios, Decentralized and Interoperable Approaches, Object – Information Distribution Architecture, Object Naming Service (ONS), Service Oriented Architecture, Network of Information, Etc.	12
6	Application and Use Cases	Concrete Applications and Use – Cases of Web Enabled Things: Energy Management and Smart Homes, Ambient Assisted Living, Intelligent Transport, Etc. M2M, Industrial IoT Applications.	4
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Starting Raspbian OS, Familiarising with Raspberry Pi Components and interface, Connecting to ethernet, Monitor, USB.

Sr No.	Suggested Topic(s)
2.	Displaying different LED patterns with Raspberry Pi.
3.	Displaying Time over 4-Digit 7-Segment Display using Raspberry Pi
4.	Raspberry Pi Based Oscilloscope
5.	Controlling Raspberry Pi with WhatsApp.
6.	Setting up Wireless Access Point using Raspberry Pi
7.	Fingerprint Sensor interfacing with Raspberry Pi
8.	Raspberry Pi GPS Module Interfacing
9.	IoT based Web Controlled Home Automation using Raspberry Pi
10.	Visitor Monitoring with Raspberry Pi and Pi Camera
11	Interfacing Raspberry Pi with RFID.
12	Building Google Assistant with Raspberry Pi.
13	Installing Windows 10 IoT Core on Raspberry Pi

Text Books:

1. The Internet of Things (MIT Press) by Samuel Greengard.
2. The Internet of Things (Connecting objects to the web) by Hakima Chaouchi ,Wiley .
3. Internet of Things (A Hands-on-Approach) by Arshdeep Bhaga and Vijay Madisetti

Reference Books:

1. The Internet of Things Key applications and Protocols, 2nd Edition, (Wiley Publication) by Olivier Hersent, David Boswarthick and Omar Elloumi.
2. IoT –From Research and Innovation to Market development, River Publication by Ovidiu Vermesan and Peter Friess.

Course Name: IoT- Application and Communication Protocol

Course Code: CE76

Category: Professional Elective

Preamble:

The Internet of Things (IoT) is a course about the new paradigm of objects interacting with people, with information systems, and with other objects. The purpose of this course is to impart knowledge on IoT Architecture and various protocols, study their implementations and applications.

Pre-requisites:

1. Wireless sensor network
2. Mobile computing

Course Objectives:

- To equip learners with the fundamental knowledge and basic technical competence in the field of Internet of Things (IoT)
- Introduce multiple way of data communication and networking.
- Identify the IoT networking components with respect to OSI layer

Course Outcome:

Learners will be able to:
CO1: Understand the basics of IoT and communication protocols
CO2: Understand design methodology and hardware platforms involved in IoT
CO3: Understand the different Data link and network layer protocols involved in IoT
CO4: Understand the different transport and session protocols involved in IoT
CO5: Design of Secured IoT applications
CO6: Design IoT Applications using appropriate protocols.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Introduction	IoT architecture outline, standards - IoT Technology Fundamentals- Devices and gateways, IoT Sensors, Sensors for IoT Applications, Local and wide area networking, Data management, Business processes in IoT, Everything as a Service(XaaS), M2M and IoT Analytics. Sensors for IoT Applications	6
2	IoT Reference Architecture	Introduction, Functional View, Information View, Deployment and Operational View, Other Relevant architectural views. Real-World Design Constraints- Introduction, Technical Design constraints	8
3	IoT Data link layer and Network layer protocols	PHY/MAC Lay'er(3GPP MTC, IEEE 802.11, IEEE 802.15), Wireless HART, ZWave, Bluetooth Low Energy, Zigbee Smart Energy, DASH7 - Network Layer-IPv4,IPv6, 6LoWPAN, 6TiSCH,ND, DHCP, ICMP, RPL, CORPL, CARP	12
4	IoT Transport layer and session layer protocols	Transport Layer (TCP, MPTCP, UDP, DCCP, SCTP)-(TLS, DTLS) – Session Layer-HTTP, CoAP, XMPP, AMQP, MQTT	8
5	IoT service layer protocol and security protocol	Service Layer -oneM2M, ETSI M2M, OMA, BBF – Security in IoT Protocols – MAC802.15.4 , 6LoWPAN, RPL, Application Layer	6
6	Application in IoT	IOT Applications. IoT applications in home, infrastructures, buildings, security, Industries, Home appliances, other IoT electronic equipment's, Industry 4.0 concepts. Case study on: Lighting as a service, Intelligent Traffic systems, Smart Parking and Smart water management.	5
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Study of various development boards, concepts & pin configurations
2.	Switch based LED counter using Tinkercad simulation tool.

Sr No.	Suggested Topic(s)
3.	Obstacle detection using IR sensor using Tinkercad simulation tool.
4.	Write a program on arduino or raspberry pi to subscribe to MQTT broker for temperature data and print it
5.	Write a program on arduino/Raspberry pi to send data to thingspeak
6.	To interface bluetooth with arduino/raspberry pi and write a program to send sensor data to smartphone using bluetooth
7.	Smart Environment System simulation using MATLAB and SIMULINK
8.	Smart Liquid Level Detector simulation and analysis of data using MATLAB and SIMULINK
9.	Smart Wall Socket Simulation using MATLAB and SIMULINK

Text Books:

1. Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv6: The EvolvingWorld of M2M Communications", ISBN: 978-1-118-47347-4, Willy Publications ,2016
2. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand,StamatisKarnouskos, David Boyle, "From Machine-to-Machine to the Internet ofThings: Introduction to a New Age of Intelligence", 1st Edition, Academic Press, 2015.

Reference Books:

1. Bernd Scholz-Reiter, Florian Michahelles, "Architecting the Internet of Things",ISBN 978-3-642-19156-5 e-ISBN 978-3-642-19157-2, Springer, 2016.
2. N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014

Course Name: Data Encryption and Compression

Course Code: CE79

Category: Professional Elective

Preamble:

This course introduces learners to process image and video signals which is incredibly important skill to master for engineering learners. The course focusses on details of cryptographic systems as well to make learners aware of the details regarding various encryption algorithms used.

Pre-requisites:

1. Advanced Data Structures and Algorithms
2. Cryptography and Network Security

Course Objectives:

- Understanding of data compression methods for text, images, video, and audio.
- Understand the concepts of cryptography and different algorithms to provide system security.
- Learn the various types of cyber-attacks and methods to mitigate them.

Course Outcome:

Learners will be able to:

CO1: Apply various techniques for text compression and evaluate performance of the coding techniques.

CO2: Explain digital audio, perceptual audio coding and MPEG audio compression standard.

CO3: Describe different lossless and lossy image and video compression techniques and standards.

CO4: Differentiate between symmetric and asymmetric cryptography and describe different symmetric cryptographic techniques and standards.

CO5: Describe different algorithms under public key cryptography and methods that provide the goals of integrity, authentication and non-repudiation

CO6: Explain network security facilities designed to protect a computer system from security threats and ethical issues related to computer and network security.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination

ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Data Compression	Loss less compression, Lossy compression, measure of performance, modelling and coding, different types of models, and coding techniques. Minimum variance Huffman coding, extended Huffman coding, Adaptive Huffman coding. Arithmetic coding, Dictionary coding techniques, LZ 77, LZ 78, LZW.	6
2	Audio Compression	High quality digital audio, frequency and temporal masking, lossy sound compression, μ-law and A-law companding, and MP3 audio standard	6
3	Image and Video Compression	PCM, DPCM JPEG, JPEG –LS, and JPEG 2000 standards, Intra frame coding, motion estimation and compensation, introduction to MPEG - 2 H-264 encoder and decoder	5
4	Data Security	Data Security Concepts, Security goals, cryptography, stenography cryptographic attacks, services and mechanics, Block Cipher and Encryption Link State and Distance Vector algorithms, Routing in the Internet RIP, OSPF, and BGP	10
5	Number Theory and Asymmetric Key Cryptography	Number Theory and Asymmetric Key Cryptography Public Key Encryption and RSA, Cryptographic Data Integrity Algorithms, Message integrity, message authentication, MAC, hash function, HMAC, and digital signature algorithm	10
6	System Security	Malware, Intruders, Intrusion detection system, firewall design, antivirus techniques, digital Immune systems, biometric authentication, and ethical hacking.	8
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Programs on Huffman Coding.
2.	Program to implement text compression technique LZW.

Sr No.	Suggested Topic(s)
3.	Demonstration of Lossy and Lossless compression.
4.	Program on Jpeg compression.
5.	Simulation of RIP using CISCO packet tracer
6.	Program on RSA and distributed RSA.
7.	Simulation of MAC
8.	Case study on security for setting firewall.
9.	Program to implement different transposition technique
10.	Simulation of digital signature

Text books:

1. Khalid Sayood , 3rd Edition, |Introduction to Data Compression|, Morgan Kauffman.
2. Mark Nelson, Jean-Loup Gailly,||The Data Compression Book||, 2nd edition, BPB Publications.
3. William Stallings ,|Cryptography and Network Security Principles and Practices 5th Edition||, Pearson Education.
4. Behrouz A. Forouzan, |Cryptography and Network Security||, Tata McGraw-Hill.

Reference Books:

1. The Data Compression Book – Mark Nelson.
2. Data Compression: The Complete Reference – David Salomon.
3. Introduction to Data Compression – Khalid Sayood, Morgan Kaufmann Publishers.

Course Name: Ethical Hacking and Digital Forensics

Course Code: CE80

Category: Professional Elective

Preamble:

Ethical hacking and Digital evidence feature in just about every part of our personal and business lives. Legal and business decisions hinge on having timely data about what people have done. This course provides understanding of how to conduct investigations to correctly gather, analyse and present digital evidence to both business and legal audiences. It also outlines the tools to locate and analyse digital evidence on a variety of devices, how to keep up to date with changing technologies, and laws and regulations in digital forensics.

Pre-requisites:

1. System security

Course Objectives:

- Understand the concepts of Ethical Hacking and Digital Forensics, various tools and methodologies used in Digital Forensics and concepts of Mobile Forensics.
- Apply Digital Forensics tools to generate Forensic report which can be used for legal or administrative cases.

Course Outcome:

Learners will be able to:
CO1: Understand the fundamentals of Ethical Hacking.
CO2: Understand the fundamentals of Digital Forensics.
CO3: Achieve adequate perspectives of digital forensic investigation in various applications /devices like Windows/Unix system, mobile, email etc.
CO4: Investigate attacks, IDS, technical exploits and router attacks and "Trap and Trace" computer networks.
CO5: Investigate attacks on Mobile devices.
CO6: Apply digital forensic knowledge to use computer forensic tools and investigation report writing.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

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ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Ethical Hacking Methodology	Introduction, Steps of Ethical Hacking: Planning, Reconnaissance, Scanning, Exploitation, post exploitation and result reporting. Ethical Hacking Tool: Metasploit	6
2	Introduction to computer forensics and Digital Forensics	Computer Forensics Fundamentals, Types of Computer Forensics Technology – Types of Computer Forensics Systems-Data Recovery and Evidence Collection– Forensic duplication and preservation of DE, Understanding Computer Investigation. Digital Forensic, Rules for Digital Forensic The Need for Digital Forensics, Types of Digital Forensics, Ethics in Digital Forensics	9
3	Computer Forensics Tools	Evaluating Computer Forensics Tool Needs, Types of Computer Forensics Tools, Tasks Performed by Computer Forensics Tools, Tool Comparisons, Other Considerations for Tools, Computer Forensics Software Tools, Command-Line Forensics Tools, UNIX/Linux Forensics Tools, Other GUI Forensics Tools, Computer Forensics Hardware Tools, Forensic Workstations, Using a Write-Blocker.	9
4	Network Forensics	Technical Exploits and Password Cracking, Introduction to Intrusion Detection systems, Types of IDS Understanding Network intrusion and attacks, Analysing Network Traffic, Collecting Network based evidence, Evidence Handling. Investigating Routers, Handling Router Table Manipulation Incidents, Using Routers as Response Tools	9
5	Mobile Device Forensics	Crime and mobile phones, evidence, forensic procedures, files present in SIM cards, device data, external memory dump, and evidence in memory card, operator's networks.	6
6	Forensic Investigation	Report: Goals of Report, Layout of an Investigative Report, Guidelines for Writing a Report, sample for	6

Module No.	Module name	Content	No. of Hours
	Report and Forensic Tools	writing a forensic report. Computer Forensic Tools: need and types of computer forensic tools, task performed by computer forensic tools. Study of open-source Tools like SFIT, Autopsy etc. to acquire, search, analyse and store digital evidence	
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Vulnerability scanning using namp, Nessus, Nikto.
2.	Performing a penetration testing using Metasploit.
3.	Analysing Digital Evidences Using Win Hex/ helix3pro.
4.	Exploring Router and VLAN security, setting up access lists using Cisco Packet tracer(student edition)
5.	Exploring VPN security using Cisco Packet tracer(student edition)
6.	Analysis of network traffic using open source tools like Snort
7.	Install and use a security app on an Android mobile (e.g. Droidcrypt)
8.	Explore forensics tools in Kali Linux for acquiring, analyzing and duplicating data: dd, dcfldd, foremost, scalpel, debugfs, wireshark, tcptrace, tcpflow
9.	Analysis of forensic images using open source tools like Autopsy, like SIFT, FKT Imager
10.	Use Password cracking using tools like John the Ripper/Cain and Abel/ Ophcrack to detect weak passwords.

Text Books:

1. Jason Luttgens, Matthew Pepe, Kevin Mandia, "Incident Response and computer forensics",3rd Edition Tata McGraw Hill, 2014.
2. Nilakshi Jain, Dhananjay Kalbande, "Digital Forensic : The fascinating world of Digital Evidences" Wiley India Pvt Ltd 2017.

Reference Books:

1. Cory Altheide, Harlan Carvey "Digital forensics with open source tools "Syngress Publishing, Inc. 2011.
2. Chris McNab, Network Security Assessment, By O'Reily.

3. Clint P Garrison "Digital Forensics for Network, Internet, and Cloud Computing A forensic evidence guide for moving targets and data , Syngress Publishing, Inc. 2010
4. Bill Nelson,Amelia Phillips,Christopher Steuart, "Guide to Computer Forensics and Investigations". Cengage Learning, 2014
5. Debra Littlejohn Shinder Michael Cross "Scene of the Cybercrime: Computer Forensics Handbook", 2nd Edition Syngress Publishing, Inc.2008.
6. Marjie T. Britz, Computer Forensics and Cyber Crime, Pearson, Third Edition.

Detailed syllabus of First Year Semester-II

Course Name: Parallel Algorithms and Programming

Course Code: CE65

Category: Core

Preamble:

The goal of the course is to introduce the students, Principles, methodologies and technologies in parallel algorithms and programming. With the help of different tools, it provides algorithm analysis, algorithm design, algorithm optimized, algorithm implementation and evaluation working, and helps in developing the programming ability of student strategies.

Pre-requisites:

1. Computer Network
2. Advance operating system
3. Microprocessor

Course Objectives:

- To understand the concept of parallel algorithms and programming
- To design and understand the performance of parallel algorithm computing resources.
- To understand and analyze performance using Algorithms concepts.
- To develop programs using parallel algorithm concept.

Course Outcome:

Learners will be able to:

CO1: Understand different parallel processing approaches and platforms involved in Achieving Performance.

CO2: Understand design Issues and limitations in Parallel Algorithm.

CO3: Understand and enable matrix multiplication and solving linear system.

CO4: Analyze and optimize performance parameters.

CO5: Understand and enabled combinational search methods for parallel algorithms.

CO6: Learn to programming using message passing paradigm using opensource APIs, design algorithms suited for Multicore processor using OpenCL, OpenMP.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

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The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding table. Notwithstanding the above, each course faculty shall have the choice to decide her/his assessment methodology based on the nature of the course. Faculty may propose the revised assessment methodology for his/her course. However, the revised assessment methodology shall be approved by a panel constituted at institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction	History. Parallel architecture, simple parallel arrays, processor Array , Parallel architecture ,multiprocessor. Parallel algorithm design Elements, task/channel models. Fosters design methodology	06
2	Parallel Algorithm Design	Introduction Boundary value problems: - partition, communication, mapping analysis , finding the maximum, N-body problem, adding data inputs, Ford algorithm	08
3	Matrix Multiplication	Introduction, Sequential matrix multiplication: - Iterative Row-oriented algorithm, recursive block-oriented Algorithm,Row-wise block stripped parallel algorithm, Cannon Algorithm	08
4	Solving linear System	Introduction, terminology ,back substitution ,sequential algorithm, row-orientation parallel algorithm, Gaussian elimination,-sequential parallel, row-orientation ,column -orientation algorithm, Sorting, quick sort, bucket sort.	08
5	Combinational Search	Introduction , Divide and conquer, parallel back track search ,Branch and bound, searching game trees, parallel alpha-beta search :-parallel algorithm search,arallel binary tree, parallel graph tree ,technologies, Firewalls and Routers,	08
6	Programming using Message Passing Paradigm	Principles, building blocks, MPI, Overlapping communication and computation, collective communication operations, Composite synchronization constructs, OpenMP Threading Building blocks; An Overview of Memory Allocators, Parallel programming model, combining MPI and OpenMP, Shared memory programming Installation and Configuration.	07
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Use and configuration of MPI /open
2.	Sorting Shell /quick sort using parallel alogrithm
3.	Using ford algorithm write program
4.	Using concept of matrix write program for multiplication
5.	Write program Using concept of cannon algoithm

Text Books:

1. Michael J. Quinn, "Parallel Programming in C with MPI and OpenMP", McGraw-Hill
2. Ananth Grama, Anshul Gupta, George Karypis, Vipin Kumar , "Introduction to Parallel Computing", Pearson Education, Second Edition, 2007.

References:

1. Laurence T. Yang, Minyi Guo, "High- Performance Computing: Paradigm and Infrastructure" Wiley, 2006.
2. Kai Hwang, Naresh Jotwani, "Advanced Computer Architecture: Parallelism, Scalability, Programmability", McGraw Hill, Second Edition, 2010.
3. https://cse.iitkgp.ac.in/~debdeep/courses_iitkgp/PAlgo21
4. https://www.ques10.com/p/36530/explain-the-various-types-of-parallel-programming-/
5. https://www.spiceworks.com/tech/iot/articles/what-is-parallel-processing/
6. https://www.coursera.org/learn/scala-parallel-programming

Course Name: Computational Intelligence

Course Code: CE66

Category: Core

Preamble:

This course introduces learners to various computational intelligence techniques. Learners will become familiarized with Neural Network, Fuzzy logic & Evolutionary techniques. Course will also offer in-depth understanding to apply computational Intelligence to different applications.

Pre-requisites:

1. Soft Computing
2. Mathematics
3. Artificial Intelligence

Course Objectives:

- To explore the various computational intelligence techniques
- To become familiarize with Neural Network, Fuzzy Logic and Evolutionary techniques.
- To learn to apply computational intelligence to different applications.

Course Outcome:

Learner will be able to:

CO1: Understand the importance of computational Intelligence.
CO2: Examine the nature of problem and find suitable Artificial Neural Network techniques to solve it.
CO3: Understand operations and properties of Fuzzy Sets.
CO4: Compare and contrast traditional algorithms with nature inspired algorithms.
CO5: To apply the concepts of natural immune system using rule-based machine learning and develop artificial immune system.
CO6: Design and implement various intelligent systems.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

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ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

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Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Introduction to Computational Intelligence paradigms	Artificial Neural Networks, Fuzzy Systems, Genetic Algorithms, Swarm Intelligence, Artificial Immune System, Applications.	6
2	Artificial Neural Networks	Basic models of ANN: NN Architecture, MP Neuron, Linear separability, activation functions, types of learning. Learning Rules: Hebbian, Perceptron, Delta, Winner- take all. Supervised NN: Perceptron Network: SDPTA, SCPTA, MCPTA, Adaline networks.	12
3	Fuzzy Logic & Rough Set Theory	Fuzzy Relations and Fuzzy Rules Fuzzy Rules, Modus Ponens and Inference Defuzzification and its Types Fuzzy Inference Systems & Design of Fuzzy Controller Introduction to Rough Sets	11
4	Optimization	GA: Selection, Encoding, Crossover, Mutation, Examples. Swarm Intelligence: Single Solution Particle Swarm Optimization: Guaranteed Convergence PSO, Social-Based Particle Swarm Optimization, Hybrid Algorithms, Sub-Swarm Based PSO, Multi-Start PSO Algorithms, Repelling Methods, Binary PSO. Ant Algorithm: Simple Ant Colony Optimization	10
5	Applications	Typical applications of Fuzzy Inference system, Character Recognition, Colour Recipe prediction- Single MLP approach, ANT algorithm/Swarm Intelligence – TSP, Best path Finding	6
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Create a perceptron with appropriate number of inputs and outputs. Train it using fixed increment learning algorithm until no change in weights is required. Output the final weights
2.	Write a program to implement artificial neural network without back propagation. Write a program to implement artificial neural network with back propagation.
3.	Implement Union, Intersection, Complement and Difference operations on fuzzy sets. Also create fuzzy relation by Cartesian product of any two fuzzy sets and perform max-min composition on any two fuzzy relations.
4.	Implement travelling salesperson problem (TSP) using genetic algorithms.
5.	Implement Particle Swarm Optimization algorithm for given initial positions, velocity and best positions of all particles
6.	To do comparative study of all the variants of Particle Swarm Optimization algorithms.
7.	To do case study of Vehicle routing problem with pick-up and delivery (VRPPD) based on Ant colony optimization algorithm.
8.	To do case study of Natural immune system and Artificial Immune Models
9.	To do the case study of Optimization using Clonal Selection Algorithm.

Text Books:

1. Andries P. Engelbrecht, Computational Intelligence - An Introduction, John Wiley pub
2. J.S.R.Jang "Neuro-Fuzzy and Soft Computing" PHI 2003.
3. Samir Roy, Udit Chakraborty "Introduction to Soft Computing" Pearson Education India.
4. Jacek.M.Zurada "Introduction to Artificial Neural Sytems" Jaico Publishing House
5. Satish Kumar "Neural Networks A Classroom Approach" Tata McGrawHill.
6. S. Rajasekaran and G.A. Vijaylakshmi Pai. Neural Networks Fuzzy Logic, and Genetic Algorithms, Prentice Hall of India.

References:

1. Fuzzy sets, fuzzy membership functions, fuzzy characteristics, fuzzy operations (D'Morgans Theorem) be quickly revised from [5]-2.2,2.3(Transformation excluded), 2.4.
   See NPTEL Video lectures of Prof. Laxmidhar Behra on Intelligent Systems and Control – Module 2.
2. http://www.eecs.ceas.uc.edu/~mazlack/dbm.w2011/Komorowski.RoughSets.tutor.pdf

Course Name: Big Data

Course Code: CE73

Category: Professional Elective

Preamble:

In today's data-driven world, the ability to process and analyze vast amounts of data efficiently is crucial for organizations. This course on Big Data Analytics aims to provide students with a comprehensive understanding of Big Data technologies and tools. Through a combination of theoretical concepts and practical hands-on exercises, participants will learn about various components of the Hadoop ecosystem, including HDFS, MapReduce, Apache Sqoop, NoSQL databases like HBase, Apache Hive, and Apache Spark.

Pre-requisites:

1. Data Structures
2. Analysis of Algorithms

Course Objective:

- To introduce the fundamental concepts and characteristics of Big Data
- To provide an in-depth understanding of Hadoop Distributed File System (HDFS)
- To explore the MapReduce programming model for distributed computing
- To enable students to work with Apache Sqoop, HBase and Hive tools.
- To provide hands-on experience with Apache Spark for fast and efficient data processing

Course Outcome:

Learner will be able to:
CO1: Understand the challenges and characteristics of Big Data and Describe the architecture and components of Hadoop.
CO2: Implement and optimize MapReduce programs to perform distributed computing tasks.
CO3: Use Apache Sqoop for importing and exporting data between Hadoop and relational databases.
CO4: Design and work with NoSQL databases, particularly HBase, for storing and retrieving Big Data efficiently.
CO5: Query and analyze Big Data using Apache Hive, leveraging its SQL-like language (HQL).
CO6: Utilize Apache Spark for processing large-scale data in-memory, enabling faster and more efficient analytics.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

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Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Big Data	1.1 Understanding the concept of Big Data Characteristics and challenges of Big Data 1.2 Introduction to Hadoop and its ecosystem 1.3 Limitation of Hadoop	6
2	HDFS & MapReduce	2.1 Hadoop Distributed File System (HDFS) architecture 2.2 Components of HDFS 2.3 Introduction to MapReduce programming model 2.4 MapReduce workflow and phases.	10
3	Apache Sqoop	3.1 Importing and exporting data between Hadoop and relational databases 3.2 Incremental data imports and data transformations 3.3 Integration of Sqoop with other Hadoop ecosystem tools	5
4	NoSQL databases - HBase	4.1 Overview of HBase architecture and data model 4.2 CRUD operations and data manipulation in HBase 4.3 HBase schema design and best practices	6
5	Apache Hive	5.1 Hive data model and schema design 5.2 Hive Query Language (HQL) for data querying and analysis 5.3 Working with partitions, buckets, and external tables in Hive 5.4 Hive Optimazation	8
6	Apache Spark	6.1 Spark architecture and components 6.2 Spark RDD (Resilient Distributed Datasets) and transformations 6.3 Spark SQL for structured data processing	10
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Set up a Hadoop cluster and verify its functionality.
2.	Create directories and files in HDFS and perform read/write operations.
3.	Develop and execute a simple MapReduce program to count word occurrences in a text file.
4.	Import data from a relational database into HDFS using Sqoop.
5.	Export data from HDFS to a relational database using Sqoop.
6.	Perform incremental data imports and data transformations using Sqoop.
7.	Install and configure HBase on a Hadoop cluster.
8.	Create HBase tables and perform CRUD operations on them.
9.	Design an HBase schema for a given use case and perform queries and scans on the HBase table.
10.	Create a Hive table, load data into it, and define partitions and buckets for efficient storage.
11.	Write and execute HQL queries for data querying and analysis on Hive tables.
12.	Optimize Hive queries using techniques such as indexing, partitioning, and performance tuning.
13.	Create and manipulate RDDs using Spark.
14.	Use Spark SQL to process structured data and perform SQL-like queries on Spark DataFrames.

Textbooks:

1. "Hadoop: The Definitive Guide" by Tom White
2. "Data-Intensive Text Processing with MapReduce" by Jimmy Lin and Chris Dyer
3. "Learning Spark: Lightning-Fast Data Analytics" by Holden Karau, Andy Konwinski, Patrick Wendell, and Matei Zaharia

Reference Books:

1. Hadoop MapReduce Cookbook" by Srinath Perera and Thilina Gunarathne
2. "Apache Hive Cookbook" by Hanish Bansal and Saurabh Chauha "Mastering Apache Spark" by Mike Frampton and Aurobindo Sarkar

Course Name: Database security and access control

Course Code: CE81

Category: Professional Elective

Preamble:

This course aims to provide students with a comprehensive understanding of the principles, techniques, and best practices related to securing and controlling access to databases. Students will gain knowledge and skills in designing secure database systems, implementing access control mechanisms, detecting, and preventing security breaches, and managing user privileges

Pre-requisites:

1. DBMS

Course Objective:

- To introduce the fundamental concepts and principles of database security.
- To explore different types of security threats and vulnerabilities in database systems.
- To examine access control models and mechanisms for protecting data in databases.
- To understand encryption techniques for securing data at rest and in transit.
- To learn about authentication and authorization mechanisms in database systems
- To study techniques for auditing and monitoring database activities to detect security breaches.

Course Outcome:

Learner will be able to:
CO1: Understand the fundamental concepts and principles of database security and access control.
CO2: Understand the access control model.
CO3: Apply appropriate access control mechanisms to protect sensitive data and prevent unauthorized access.
CO4: Identify potential security threats and vulnerabilities in database systems.
CO5: Use tools and techniques for auditing and monitoring database activities to detect and respond to security incidents.
CO6: Evaluate and select appropriate encryption and authentication mechanisms for securing data.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination

ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Database Security	Overview of database security, Importance of database security, Threats and vulnerabilities in database systems, Security goals: confidentiality, integrity, and availability	6
2	Access Control Models and Mechanisms	Discretionary access control (DAC), Mandatory access control (MAC), Role-based access control (RBAC), Attribute-based access control (ABAC), Access control lists (ACLs), Privileges and permissions.	8
3	Authentication and Authorization	User authentication techniques, Password policies and management, multi-factor authentication, Single sign-on (SSO), Authorization and access rights, Role-based authorization	8
4	Encryption and Data Protection	Encryption concepts and algorithms, Symmetric and asymmetric encryption, Secure key management, Database-level encryption, Transparent data encryption (TDE), Secure Socket Layer/Transport Layer Security (SSL/TLS)	10
5	Auditing and Monitoring	Auditing and logging concepts, Audit trails and log management, Database activity monitoring (DAM), Intrusion detection and prevention systems (IDPS), Security Information and Event Management (SIEM)	8
6	Security Best Practices and Standards	Secure database design principles, Secure coding practices for databases, Patch management and vulnerability assessment, Database hardening techniques, Compliance with relevant security standards.	5
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Setting Up Secure Database Environment

Sr No.	Suggested Topic(s)
2.	Creating and managing user roles and permissions
3.	Configuring audit policies and rules
4.	Detecting and investigating suspicious activities.
5.	Configuring secure communication protocols (SSL).
6.	Conducting vulnerability assessments for databases.
7.	Managing encryption keys and certificate
8.	Implementing strong user authentication mechanisms.
9.	Case Study: Identifty database attacks and prevention technique

Textbooks:

1. William Stallings and Lawrie Brown, “Computer Security: Principles and Practice” pearson

Reference Books:

1. Hassan A. Afyouni, “Database Security and Auditing: Protecting Data Integrity and Accessibility"”, Cengage Learning
2. Tom Slodichak, Himanshu Gupta “Database Security and Encryption: A Practical Approach", CRC Press.

Course Name: Natural Language Processing

Course Code: CE74

Category: Professional Elective

Preamble:

This course introduces learners to various techniques for natural language processing. Learners will become familiarized with Morphological analysis, syntactic and semantic analysis of text. Course will also offer in-depth understanding of Natural language processing applications like Machine translation, Question answering system, etc.

Pre-requisites:

1. Theory of Computer Science
2. Compiler Construction
3. Machine Learning

Course Objective:

- To understand the concepts of natural language processing.
- To develop skills of finding solutions and building software using natural language processing techniques.

Course Outcome:

Learner will be able to:
CO1: Understand the importance of Natural language processing
CO2: To design language model for word level analysis for text processing.
CO3: To design various POS tagging techniques and parsers.
CO4: To design, implement and test algorithms for semantic and pragmatic analysis.
CO5: To formulate the discourse segmentation and anaphora resolution.
CO6: To apply NLP techniques to design real world NLP applications.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module name	Content	No. of Hours
1	Introduction to NLP	Generic NLP system, Levels of NLP, Ambiguity in Natural language, stages in NLP, Challenges of NLP, Applications of NLP	02
2	Lexical Analysis	Morphology analysis –survey of English Morphology, Inflectional morphology & Derivational morphology, Lemmatization, Regular expression, finite automata, finite state transducers (FST), Morphological parsing with FST, Lexicon free FST Porter stemmer. Tokenization, Detecting and Correcting Spelling Errors, Minimum Edit Distance. N –Grams- N-gram language model, Smoothing, N-gram for spelling correction.	08
3	Syntax Analysis	Part-Of-Speech tagging (POS)- Tag set for English (Penn Treebank), Rule based POS tagging, Stochastic POS tagging, Issues –Multiple tags & words, Unknown words. Introduction to CFG, Normal Forms for grammar – Dependency Grammar – Syntactic Parsing, Ambiguity, Dynamic Programming parsing – Shallow parsing – Probabilistic CFG, Probabilistic CYK, Probabilistic Lexicalized CFGs – Feature structures, Unification of feature structures. Sequence labeling: Hidden Markov Model (HMM), Maximum Entropy, and Conditional Random Field (CRF).	10
4	Semantics and Pragmatics	Lexical Semantics, First-Order Logic, Description Logics – Syntax-Driven Semantic analysis, Semantic attachments – Word Senses, Relations among lexemes & their senses –Homonymy, Polysemy, Synonymy, Hyponymy, WordNet, Robust Word Sense Disambiguation (WSD), WSD using Supervised, Unsupervised and Dictionary approach, Bootstrapping methods – Word Similarity using Thesaurus and Distributional methods.	08
5	Discourse Analysis and Lexical	Discourse –reference resolution, reference phenomenon, Discourse segmentation, Coherence –	08

Module No.	Module name	Content	No. of Hours
	Resources	Reference Phenomena, Anaphora Resolution using Hobbs and Centering Algorithm – Coreference Resolution, syntactic & semantic constraints on co reference	
6	Applications	Machine translation, Information retrieval, Cross Lingual Information Retrieval (CLIR), Question answers system, categorization, summarization, sentiment analysis.	09
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Pre-processing of text (Tokenization, Filtration, Script Validation, Stop Word Removal, Stemming)
2.	Morphological Analysis
3.	N-gram model
4.	Anaphora resolution
5.	Mini Project based on Application mentioned in Module 6

Text Books:

1. Daniel Jurafsky and James H Martin, "Speech and Language Processing", 3e, Pearson Education, 2018
2. Christopher D.Manning and Hinrich Schutze, — Foundations of Statistical Natural Language Processing —, MIT Press, 1999.
3. Steven Bird, Ewan Klein and Edward Loper, —Natural Language Processing with Python, First Edition, OReilly Media, 2009.
4. Daniel and James H. Martin "Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition", Second Edition, Prentice Hall of India, 2008.

Reference Books:

1. Tanveer Siddiqui, U.S. Tiwary, —Natural Language Processing and Information Retrieval, Oxford University Press, 2008.
2. Alexander Clark (Editor), Chris Fox (Editor), Shalom Lappin (Editor) — The Handbook of Computational Linguistics and Natural Language Processing
3. James Allen "Natural Language Understanding", Pearson Publication 8th Edition. 2012

Course Name: Intrusion Detection and Prevention

Course Code: CE82

Category: Professional Elective

Preamble:

The goal of the course is to introduce the students to principles, methodologies and technologies used in intrusion detection and prevention systems. With the help of tools, it provides analysis, mitigation of intrusion and helps in preventing the same using effective strategies.

Pre-requisites:

1. Computer Network
2. Cyber Security

Course Objective:

- To understand the vulnerabilities and detection techniques of various attacks
- To understand the network intrusion detection & prevention mechanisms
- To understand the countermeasures of various information security attacks
- To design / make use of a typical intrusion detection system

Course Outcome:

Learner will be able to:
CO1: Design and implement Intrusion Detection System
CO2: Understand classes of attacks on computer systems.
CO3: Identify various types of IDS of signature based and anomaly-based techniques to solve problems related to intrusion detection and prevention.
CO4: Employ ID&PS specific feature extraction techniques.
CO5: Interpret and analyze intrusion detection and prevention logs, alerts, and reports to detect security incidents and potential vulnerabilities.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory + Practical
3	2	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory + Practical	40	20	40	25	125

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination
ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction	History of Intrusion detection, Audit, Concept and definition, Internal and external threats to data, attacks, Key functions of IDPS technologies-Common Detection methodologies-Signature & Anomaly based Detection,	4
2	Intrusion Detection Systems Principles	Stateful protocol analysis Types of IDS, Information sources Host based information sources, Network based information sources.	5
3	IDS Technologies	Components & Architecture-Typical components, Network Architectures Security capabilities - Information gathering capabilities, logging capabilities, detection & prevention capabilities. Intrusion Prevention Systems, Network protocol based IDS, Hybrid IDS, Analysis schemes, thinking about intrusion. A model for intrusion analysis, techniques Responses requirement of responses, types of responses mapping responses to policy Vulnerability analysis, credential analysis non credential analysis	9
4	Network Based IDS	Networking Overview-OSI layers. Components and Architecture - Typical components, Network architectures and sensor locations. Security capabilities Wireless IDPS-Wireless Networking overview-WLAN standards & components. Components Network Behavior analysis system.	9
5	Host Based IDS	Components and Architecture-Typical components, Network architectures, Agent locations, host architectures. Security capabilities-Logging, detection, prevention, and other capabilities. Using & Integrating multiple IDPS technologies-Need for multiple IDPS technologies, integrating different IDPS technologies-Direct & Indirect IDPS integration other technologies with IDPS capabilities. Network Forensic Analysis Tool, Anti-	9

		malware technologies, Firewalls and Routers,	
6	IDS Tool : SNORT IDS	Introduction to Snort, Working with Snort Rules, Snort configuration, Snort with MySQL, Running Snort on Multiple Network Interfaces, Snort Modes Snort Alert Modes, Snarf with Snort, Agent development for intrusion detection, Architecture models of IDS and IPS.	9
Total			**45**

Suggested List of Practicals:

Sr No.	Suggested Topic(s)
1.	Use of Wire shark Tool
2.	Set up Snort and study the logs.
3.	Setting up personal Firewall using iptables
4.	SQL injection attack, Cross-Cite Scripting attack simulation
5.	Case Study /Seminar: Topic beyond syllabus related to topics covered.

Text and References books:

1. Carl Endorf, Eugene Schultz and Jim Mellander —" Intrusion Detection & Prevention", 1st Edition, Tata McGraw-Hill, 2006
2. Christopher Kruegel,Fredrik Valeur, Giovanni Vigna: —Intrusion Detection and Correlation Challenges and Solutions, 1st Edition,Springer, 2005.
3. Karen Scarfone, Peter Mell," Guide to Intrusion Detection and Prevention Systems (IDPS)", NIST special publication, 2007
4. Kerry J Cox , Christopher Gerg," Managing Security with Snort and IDS Tools", O'Reilly, 2007.
5. Rafeeq Rehman : — Intrusion Detection with SNORT, Apache,MySQL, PHP and ACID,|| 1st Edition, Prentice Hall , 2003
6. Stephen Northcutt, Judy Novak : —Network Intrusion Detection||, 3rd Edition, New Riders Publishing, 2002.

Detailed syllabus of Open Elective

Course Name: Research Methodology

Course Code: OE07

Category: Open Elective

Preamble:

This course is to make the students understand the importance of research and various methods that researcher used to investigate problems. The course will also help the students to make meaningful decisions.

Pre-requisites:

1. Quantitative Techniques
2. Operations and production management

Course Objective:

- To understand importance of research and various methods that researcher used to investigate problems.
- To write research proposals.
- To perform enriched data collection and analysis.
- To write detailed research reports.

Course Outcome:

Learner will be able to:
CO1: Understand the importance of research and various methods that researcher used to investigate problems.

CO2: Apply Modern Analytical tools for Business Management Decisions.

CO3: Derive strategies from the research.

CO4: Understand the challenges in collecting the data collection and analysis.

CO5: Interpret the data to make meaningful decisions.

Course Scheme:

Contact Hours		Credits Assigned
Theory	Practical	Theory
4	-	4

Assessment Guidelines:

Head of Learning	ISA*	MSE	ESE	Lab Work	Total
Theory	40	30	50	-	120

ISA=In Semester Assessment, MSE= Mid Semester Examination, ESE= End Semester Examination

ISA*: Specific rubric for the 40 marks of the In-Semester Assessment (ISA) will be, as stated by the course teacher in their Academic Administration Plan (AAP) for the current half of the academic year.

The assessment guidelines for the courses of different credits are mentioned above. Notwithstanding the above, each course faculty shall have the choice to propose her/his assessment methodology based on the nature of the course. However, the proposed assessment methodology shall be approved by a panel constituted at Institute level and published to the learners before the commencement of the semester.

Detailed Syllabus:

Module No.	Module Name	Content	No of Hours
1	Introduction to Research	Meaning of research; Types of research- Exploratory research, Conclusive research; The process of research; Research applications in social and business sciences; Features of a Good research study	4
2	Research Problem and Formulation of Research Hypotheses	Defining the Research problem; Management Decision Problem vs Management Research Problem; Problem identification process; Components of the research problem; Formulating the research hypothesis- Types of Research hypothesis; Writing a research proposal- Contents of a research proposal and types of research proposals.	6
3	Research Design	Meaning of Research Designs; Nature and Classification of Research Designs; Exploratory Research Designs: Secondary Resource analysis, Case study Method, Expert opinion survey, Focus group discussions; Descriptive Research Designs: Cross sectional studies and Longitudinal studies; Experimental Designs, Errors affecting Research Design	6
4	Primary and Secondary Data	Classification of Data; Secondary Data: Uses, Advantages, Disadvantages, Types and sources; Primary Data Collection: Observation method, Focus Group Discussion, Personal Interview method	4
5	Attitude Measurement and Scaling	Types of Measurement Scales; Attitude; Classification of Scales: Single item vs Multiple Item scale, Comparative vs non-Comparative scales, Measurement Error, Criteria for Good Measurement	6
6	Questionnaire Design	Questionnaire method; Types of Questionnaires; Process of Questionnaire Designing; Advantages and Disadvantages of Questionnaire Method	4
7	Sampling and Data Processing	Sampling concepts- Sample vs Census, Sampling vs Non Sampling error; Sampling Design- Probability and Non Probability Sampling design; Determination of Sample size- Sample size for estimating population mean,	6

		Determination of sample size for estimating the population proportion Data Editing- Field Editing, Centralized in house editing; Coding- Coding Closed ended structured Questions, Coding open ended structured Questions; Classification and Tabulation of Data.	
8	Univariate and Bivariate Analysis of Data	Descriptive vs Inferential Analysis, Descriptive Analysis of Univariate data- Analysis of Nominal scale data with only one possible response, Analysis of Nominal scale data with multiple category responses, Analysis of Ordinal Scaled Questions, Measures of Central Tendency, Measures of Dispersion; Descriptive Analysis of Bivariate data	6
9	Testing of Hypotheses	Concepts in Testing of Hypothesis – Steps in testing of hypothesis, Test Statistic for testing hypothesis about population mean; Tests concerning Means- the case of single population; Tests for Difference between two population means; Tests concerning population proportion- the case of single population; Tests for difference between two population proportions.	6
10	Chi-square Analysis	Chi square test for the Goodness of Fit; Chi square test for the independence of variables; Chi square test for the equality of more than two population proportions	4
11	Analysis of Variance	Completely randomized design in a one-way ANOVA; Randomized block design in two way ANOVA; Factorial design	4
12	Research Report Writing and Ethics in research	Types of research reports – Brief reports and Detailed reports; Report writing: Structure of the research report- Preliminary section, Main report, Interpretations of Results and Suggested Recommendations; Report writing: Formulation rules for writing the report: Guidelines for presenting tabular data, Guidelines for visual Representations. Meaning of Research Ethics; Clients Ethical code; Researchers Ethical code; Ethical Codes related to respondents; Responsibility of ethics in research	4
Total			**60**

Text and References books:

1. Business Research Methods – Cooper Schindler
2. Research Methodology Methods & Techniques – C.R.Kothari
3. Statistics for Management – Richard L Levin.

Appendix-A

Guidelines for Professional Elective Courses and Specialization Certificate

Professional Elective courses are designed to meet industrial requirements. All learners must opt for 4 professional elective courses as a part of requirement for M.Tech. degree.

Specialization Certificate is introduced in order to build competency of learners in the chosen domain. Department of Computer Engineering offers the following specialization tracks:

1. Artificial Intelligence (AI)
2. Data Science (DS)
3. Internet of Things (IoT)
4. Computer Security (CSec)

Learners can take courses from any track. **However, if learners complete all Professional Elective Courses from the same chosen track, they will be eligible to receive a Specialization Certificate from the Institute.**

Learners who choose professional elective courses from different specialisation tracks will not be eligible for a Specialization Certificate.

It should be noted that there are no additional credit requirements for these specialisations.

DS track: Courses to be chosen for specialization in Data Science

Preferred Semester	Course Code	Course Name
I	CE71	Probability and Statistics for Data Science
I	CE72	Data Preparation and Exploration
II	CE73	Big Data
II	CE74	Natural Language Processing

IoT track: Courses to be chosen for specialization in Internet of Things

Preferred Semester	Course Code	Course Name
I	CE75	Smart Sensors and Internet of Things
I	CE76	IoT - Application and Communication Protocol
II	CE77	Wireless Access Technologies
II	CE78	IOT and Smart Cities

CSec track: Courses to be chosen for specialization in Computer Security

Preferred Semester	Course Code	Course Name
I	CE79	Data Encryption and Compression
I	CE80	Ethical Hacking and Digital Forensics
II	CE81	Database Security and Access control
II	CE82	Intrusion Detection and Prevention

Appendix B

Courses under Open Elective (OE) Category

Sr. No.	Course Code	Course Name	Hours Per Week		Credits	Preferred Semester
			Theory	Practical		
1	OE04	Sustainability Management	4	-	4	-
2	OE05	Operation Research	4	-	4	-
3	OE06	IPR and Patenting	4	-	4	-
4	OE07	Research Methodology	4	-	4	-
5	OE13*	Online Course 1 (MOOC)	As per course		2	-
6	OE14*	Online Course 2 (MOOC)	As per course		2	-

*Online Courses (MOOC) of 2 credits is equivalent to 30 hours course.