Study Scheme & Syllabus of

Master of Technology
Computer Science & Engineering

M. Tech (CSE)

Batch 2019 onwards

By

Board of Study- CSE; on 27th April 2018
Department of Academics

IK Gujral Punjab Technical University

PROGRAM: Master of Technology in Computer Science & Engineering
It is a Post Graduate (PG) Programme of 2 years' duration (4 semesters)
Courses & Examination Scheme:

First Semester

Course Code	Course Type	Course Title	Load allocation			Marks Distribution		Total Marks	Credits
			L*	T*	P	Internal	External		
MTCS 101-18	Program Core I	Mathematical foundations of Computer Science	3	0	0	40	60	100	3
MTCS 102-18	Program Core II	Advanced Data Structures	3	0	0	40	60	100	3
MTCS 105-18	Program Elective I	Machine Learning	3	0	0	40	60	100	3
MTCS 106-18		Wireless Sensor Networks							
MTCS 107-18		Introduction to Intelligent Systems							
MTCS 108-18	Program Elective II	Data Science	3	0	0	40	60	100	3
MTCS 109-18		Distributed Systems							
MTCS 110-18		Advanced Wireless and Mobile Networks							
MTRM 101-18		Research Methodology and IPR	2	0	0	40	60	100	2
MTA-xx	Audit Course **		2	0	0	0	0	0	0
MTCS 103-18	Laboratory 1	Advanced Data Structures Lab.	0	0	4	60	40	100	2
MTCS 104-18	Laboratory 2	Based on Electives	0	0	4	60	40	100	2
	TOTAL		**16**	**0**	**8**	**320**	**380**	**700**	**18**

*A course can either have four Hrs Lecture or Three Hrs Lecture + One Hrs Tutorial as per requirement

Second Semester

Course Code	Course Type	Course Title	Load allocation			Marks Distribution		Total Marks	Credits
			L*	T*	P	Internal	External		
MTCS 201-18	Program Core III	Advance Algorithms	3	0	0	40	60	100	3
MTCS 202-18	Program Core IV	Soft Computing	3	0	0	40	60	100	3
MTCS 206-18	Program Elective III	Data Preparation and Analysis	3	0	0	40	60	100	3
MTCS 207- 18		Secure Software Design &Enterprise Computing							
MTCS 208-18		Computer Vision							
MTCS 209-18	Program Elective IV	Human and Computer Interaction	3	0	0	40	60	100	3
MTCS 210-18		GPU Computing							
MTCS 211-18		Digital Forensics							
MTA-xxx	Audit Course**		2	0	0	0	0	0	0
MTCS 203-18	Laboratory 3	Based on cores	0	0	4	60	40	100	2
MTCS 204-18	Laboratory 4	Based on Electives	0	0	4	60	40	100	2
MTCS 205-18		Mini Project with Seminar	2	0	0	60	40	100	2
	TOTAL		**16**	**0**	**8**	**320**	**380**	**700**	**18**

*A course can either have four Hrs Lecture or Three Hrs Lecture + One Hrs Tutorial as per requirement

Third Semester

Course Code	Course Type	Course Title	Load allocation			Marks Distribution		Total Marks	Credits
			L*	T*	P	Internal	External		
MTCS 302-18	Program Elective V	Mobile Applications and Services	3	0	0	40	60	100	03
MTCS 303-18		Compiler for HPC							
MTCS 304-18		Optimization Techniques							
MTOE 301-18	Open Elective	1.Business Analytics	3	0	0	40	60	100	03
MTOE 302-18		Industrial Safety							
MTOE 303-18		Operations Research							
MTOE 304-18		Cost Management of Engineering Projects							
MTOE 305-18		Composite Materials							
MTOE 306-18		Waste to Energy							
MTCS 301-18	Dissertation -I		0	0	20	60	40	100	7
MTCS 302-18	Training**	Industry/ Institutional	0	0	0	60	40	100	3
	TOTAL		**6**	**0**	**20**	**200**	**200**	**400**	**16**

** This is to be taken up after 2nd semester, for 6-8 weeks in summer, in industry / institution of repute.

Fourth Semester

Course Code	Course Type	Course Title	Load allocation			Marks Distribution		Total Marks	Credits
			L*	T*	P	Internal	External		
MTCS 401-18	Thesis	Dissertation - II	0	0	32	-	-	S/US	16
	TOTAL		**0**	**0**	**32**				**16**

*A course can either have four Hrs Lecture or Three Hrs Lecture + One Hrs Tutorial as per requirement

Total Marks of M. Tech Program:1700
Total Credit of M. Tech Program:68

**** Audit courses:**

COURSE CODE: MTA-xxx

A01. English for Research Paper Writing
A02. Disaster Management
A03. Sanskrit for Technical Knowledge
A04. Value Education
A05. Constitution of India
A06. Pedagogy Studies
A07. Stress Management by Yoga
A08. Personality Development through Life Enlightenment Skills.

Syllabus, course objective and course outcomes for various M.TECH -CSE Subjects:

Course Code	MTCS101-18
Course Name	Mathematical Foundation of Computer Science
Credits	3
Pre-Requisites	Discrete Mathematics

Total Number of Lectures:48

COURSE OBJECTIVE
• To understand the mathematical fundamentals that is prerequisites for a variety of courses like Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning.
• To develop the understanding of the mathematical and logical basis to many modern techniques in information technology like machine learning, programming language design, and concurrency.
• To study various sampling and classification problems.

LECTURE WITH BREAKUP	**NO. OF LECTURES**
Unit 1 Probability mass, density, and cumulative distribution functions, Parametric families of distributions, Expected value, variance, conditional expectation, Applications of the univariate and multivariate Central Limit Theorem, Probabilistic inequalities, Markovchains.	7
Unit 2 Random samples, sampling distributions of estimators**,** Methods of Moments and Maximum Likelihood.	7
Unit 3 Statistical inference**,** Introduction to multivariate statistical models: regression and classification problems, principal components analysis**,** The problem of overfitting model assessment.	8
Unit 4 Graph Theory: Isomorphism, Planar graphs, graph coloring, Hamilton circuits and Euler cycles. Permutations and Combinations with and without repetition. Specialized techniques to solve combinatorial enumeration problems.	11
Unit 5 **Computer science and engineering applications** Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning.	10

Unit 6 Recent Trends in various distribution functions in mathematical field of computer science for varying fields like bioinformatics, soft computing, and computer vision.	5

COURSE OUTCOMES
After completion of course, students would be able to:
• To understand the basic notions of discrete and continuous probability.
• To understand the methods of statistical inference, and the role that sampling distributions play in those methods.
• To be able to perform correct and meaningful statistical analyses of simple to moderate complexity.

References:

1. John Vince, Foundation Mathematics for Computer Science, Springer.
2. K. Trivedi. Probability and Statistics with Reliability, Queuing, and Computer Science Applications. Wiley.
3. M. Mitzenmacher and E. Upfal. Probability and Computing: Randomized Algorithms and Probabilistic Analysis.
4. Alan Tucker, Applied Combinatorics, Wiley

Course Code	MTCS102-18
Course Name	Advanced Data Structures
Credits	3
Pre-Requisites	UG level course in Data Structures

Total Number of Lectures:48

COURSE OBJECTIVE
• The student should be able to choose appropriate data structures, understand the ADT/libraries, and use it to design algorithms for a specific problem.
• Students should be able to understand the necessary mathematical abstraction to solve problems.
• To familiarize students with advanced paradigms and data structure used to solve algorithmic problems.
• Student should be able to come up with analysis of efficiency and proofs of correctness.

LECTURE WITH BREAKUP	NO. OF LECTURES
Unit 1 **Dictionaries:** Definition, Dictionary Abstract Data Type, Implementation of Dictionaries. **Hashing:** Review of Hashing, Hash Function, Collision Resolution Techniques in Hashing, Separate Chaining, Open Addressing, Linear Probing, Quadratic, Probing, Double Hashing, Rehashing, Extendible Hashing.	7
Unit 2 **Skip Lists:** Need for Randomizing Data Structures and Algorithms, Search and Update Operations on Skip Lists, Probabilistic Analysis of Skip Lists, Deterministic Skip Lists	5
Unit 3 **Trees:** Binary Search Trees, AVL Trees, Red Black Trees, 2-3 Trees, B-Trees, Splay Trees	9
Unit 4 **Text Processing:** Sting Operations, Brute-Force Pattern Matching, The Boyer-Moore Algorithm, The Knuth-Morris-Pratt Algorithm, Standard Tries, Compressed Tries, Suffix Tries, The Huffman Coding Algorithm, The Longest Common Subsequence Problem (LCS), Applying Dynamic Programming to the LCS Problem.	12
Unit 5 **Computational Geometry:** One Dimensional Range Searching, Two Dimensional Range Searching, Constructing a Priority Search Tree, Searching a Priority Search Tree, Priority Range Trees, Quadtrees, k-D Trees.	10
Unit 6 Recent Trends in Hashing, Trees, and various computational geometry methods for efficiently solving the new evolving problem.	5

COURSE OUTCOMES
After completion of course, students would be able to:
• Understand the implementation of symbol table using hashing techniques.
• Develop and analyze algorithms for red-black trees, B-trees and Splay trees.
• Develop algorithms for text processing applications.
• Identify suitable data structures and develop algorithms for computational geometry problems.

References:

1. Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, 2nd Edition, Pearson, 2004.
2. M T Goodrich, Roberto Tamassia, Algorithm Design, John Wiley, 2002.

Course Code	MTCS201-18
Course Name	Advanced Algorithms
Credits	3
Pre-Requisites	UG level course in Algorithm Design and Analysis

Total Number of Lectures:48

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

LECTURE WITH BREAKUP	**NO. OF LECTURES**
Unit1 **Sorting:** Review of various sorting algorithms, topological sorting **Graph:** Definitions and Elementary Algorithms: Shortest path by BFS, shortest path in edge-weighted case (Dijkasra's), depth-first search and computation of strongly connected components, emphasis on correctness proof of the algorithm and time/space analysis, example of amortized analysis.	6
Unit 2 **Matroids:** Introduction to greedy paradigm, algorithm to compute a maximum weight maximal independent set. Application to MST. **Graph Matching:** Algorithm to compute maximum matching. Characterization of maximum matching by augmenting paths, Edmond's Blossom algorithm to compute augmenting path.	8
Unit 3 **Flow-Networks:** Maxflow-mincut theorem, Ford-Fulkerson Method to compute maximum flow, Edmond-Karp maximum-flow algorithm. **Matrix Computations:** Strassen's algorithm and introduction to divide and conquer paradigm, inverse of a triangular matrix, relation between the time complexities of basic matrix operations, LUP-decomposition.	9

Unit 4 **Shortest Path in Graphs:** Floyd-Warshall algorithm and introduction to dynamic programming paradigm. More examples of dynamic programming. **Modulo Representation of integers/polynomials:** Chinese Remainder Theorem, Conversion between base-representation and modulo-representation. Extension to polynomials. Application: Interpolation problem. **Discrete Fourier Transform (DFT):** In complex field, DFT in modulo ring. Fast Fourier Transform algorithm. Schonhage-Strassen Integer Multiplication algorithm.	10
Unit 5 **Linear Programming:** Geometry of the feasibility region and Simplex algorithm. **NP-completeness:** Examples, proof of NP-hardness and NP-completeness. **One or more of the following topics based on time and interest** Approximation algorithms, Randomized Algorithms, Interior Point Method, Advanced Number Theoretic Algorithm.	10
Unit 6 Recent Trends in problem solving paradigms using recent searching and sorting techniques by applying recently proposed data structures.	5

COURSE OUTCOMES
After completion of course, students would be able to:
• Analyze the complexity/performance of different algorithms.
• Determine the appropriate data structure for solving a particular set of problems.
• Categorize the different problems in various classes according to their complexity.
• Students should have an insight of recent activities in the field of the advanced data structure.

References:

1. "Introduction to Algorithms" by Cormen, Leiserson, Rivest, Stein.
2. "The Design and Analysis of Computer Algorithms" by Aho, Hopcroft, Ullman.
3. "Algorithm Design" by Kleinberg and Tardos.

Research Methodology and IPR	
Course Code: MTRM-101-18, Credits :2 Lectures: 1hrs/week	

Course Outcomes:

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

- Understand research problem formulation.
- Analyze research related information
- Follow research ethics
- Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
- Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Syllabus Contents:

Unit 1: Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Unit 2: Effective literature studies approaches, analysis Plagiarism, Research ethics,

Unit 3: Effective technical writing, how to write report, Paper

Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Unit 4: Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit 5: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Unit 6: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

References:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"

3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
5. Mayall , "Industrial Design", McGraw Hill, 1992.
6. Niebel , "Product Design", McGraw Hill, 1974.
7. Asimov, "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, "Intellectual Property in New Technological Age", 2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

Course Code	MTCS202-18
Course Name	Soft Computing
Credits	3
Pre-Requisites	Basic knowledge of mathematics

Total Number of Lectures: 48

COURSE OBJECTIVE
• To introduce soft computing concepts and techniques and foster their abilities in designing appropriate technique for a given scenario.
• To implement soft computing based solutions for real-world problems.
• To give students knowledge of non-traditional technologies and fundamentals of artificial neural networks, fuzzy sets, fuzzy logic, genetic algorithms.
• To provide student hand-on experience on MATLAB to implement various strategies.

LECTURE WITH BREAKU	**NO. OF LECTURES**
Unit 1: **INTRODUCTION TO SOFT COMPUTING AND NEURAL NETWORKS:** Evolution of Computing: Soft Computing Constituents, From Conventional AI to Computational Intelligence: Machine Learning Basics.	7
Unit 2 **FUZZY LOGIC:** Fuzzy Sets, Operations on Fuzzy Sets, Fuzzy Relations, Membership Functions: Fuzzy Rules and Fuzzy Reasoning, Fuzzy Inference Systems, Fuzzy Expert Systems, Fuzzy Decision Making.	8
Unit 3 **NEURAL NETWORKS:** Machine Learning Using Neural Network, Adaptive Networks, Feed forward Networks, Supervised Learning Neural Networks, Radial Basis Function Networks: Reinforcement Learning, Unsupervised Learning Neural Networks, Adaptive Resonance architectures, Advances in Neural networks	10

Unit 4 **GENETIC ALGORITHMS:** Introduction to Genetic Algorithms (GA), Applications of GA in Machine Learning: Machine Learning Approach to Knowledge Acquisition.	5
Unit 5 **Matlab/Python Lib:** Introduction to Matlab/Python, Arrays and array operations, Functions and Files, Study of neural network toolbox and fuzzy logic toolbox, Simple implementation of Artificial Neural Network and Fuzzy Logic.	13
Unit 6 Recent Trands in deep learning, various classifiers, neural networks and genetic algorithm. Implementation of recently proposed soft computing techniques.	5

COURSE OUTCOMES
After completion of course, students would be able to:
• Identify and describe soft computing techniques and their roles in building intelligent machines
• Apply fuzzy logic and reasoning to handle uncertainty and solve various engineering problems.
• Apply genetic algorithms to combinatorial optimization problems.
• Evaluate and compare solutions by various soft computing approaches for a given problem.

References:

1. Jyh:Shing Roger Jang, Chuen:Tsai Sun, EijiMizutani, Neuro:Fuzzy and Soft Computing17, Prentice:Hall of India, 2003.
2. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications17, Prentice Hall, 1995.
3. MATLAB Toolkit Manual

ELECTIVE SUBJECTS

Course Code	MTCS 105-18
Course Name	Machine learning
Credits	3
Pre-Requisites	

Total Number of Lectures:48

COURSE OBJECTIVE
• To learn the concept of how to learn patterns and concepts from data without being explicitly programmed in various IOT nodes.

• To design and analyse various machine learning algorithms and techniques with a modern outlook focusing on recent advances.
• Explore supervised and unsupervised learning paradigms of machine learning.
• To explore Deep learning technique and various feature extraction strategies.

LECTURE WITH BREAKUP	NO. OF LECTURES
Unit 1: **Supervised Learning (Regression/Classification)** • Basic methods: Distance-based methods, Nearest- Neighbors, Decision Trees, Naive Bayes • Linear models: Linear Regression, Logistic Regression, Generalized Linear Models • Support Vector Machines, Nonlinearity and Kernel Methods • Beyond Binary Classification: Multi-class/Structured Outputs, Ranking	10
Unit 2: **Unsupervised Learning** • Clustering: K-means/Kernel K-means • Dimensionality Reduction: PCA and kernel PCA • Matrix Factorization and Matrix Completion • Generative Models (mixture models and latent factor models)	7
Unit 3 Evaluating Machine Learning algorithms and Model Selection, Introduction to Statistical Learning Theory, Ensemble Methods (Boosting, Bagging, Random Forests).	6
Unit 4 Sparse Modeling and Estimation, Modeling Sequence/Time-Series Data, Deep Learning and Feature Representation Learning.	9

Unit 5 Scalable Machine Learning (Online and Distributed Learning) A selection from some other advanced topics, e.g., Semi-supervised Learning, Active Learning, Reinforcement Learning, Inference in Graphical Models, Introduction to Bayesian Learning and Inference.	9
Unit 6: Recent trends in various learning techniques of machine learning and classification methods for IOT applications. Various models for IOT applications.	5

COURSE OUTCOMES
After completion of course, students would be able to:
• Extract features that can be used for a particular machine learning approach in various IOT applications.
• To compare and contrast pros and cons of various machine learning techniques and to get an insight of when to apply a particular machine learning approach.
• To mathematically analyse various machine learning approaches and paradigms.

References:

1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009 (freely available online)
3. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.

Course Code	MTCS106-18
Course Name	Wireless Sensor Networks
Credits	3
Pre-Requisites	Wireless Communication

Total Number of Lectures: 48

COURSE OBJECTIVE
• Architect sensor networks for various application setups.
• Devise appropriate data dissemination protocols and model links cost.
• Understanding of the fundamental concepts of wireless sensor networks and have a basic knowledge of the various protocols at various layers.
• Evaluate the performance of sensor networks and identify bottlenecks.

LECTURE WITH BREAKUP	NO. OF LECTURES
Unit 1: **Introduction to Wireless Sensor Networks:** Course Information, Introduction to Wireless Sensor Networks: Motivations, Applications, Performance metrics, History and Design factors **Network Architecture:** Traditional layered stack, Cross-layer designs, Sensor Network Architecture **Hardware Platforms:** Motes, Hardware parameters	9
Unit 2: **Introduction to ns-3: I**ntroduction to Network Simulator 3 (ns-3), Description of the ns-3 core module and simulation example.	9
Unit 3: **Medium Access Control Protocol design:** Fixed Access, Random Access, WSN protocols: synchronized, duty-cycled **Introduction to Markov Chain:** Discrete time Markov Chain definition, properties, classification and analysis **MAC Protocol Analysis:** Asynchronous duty-cycled. X-MAC Analysis (Markov Chain)	8
Unit 4: **Security**: Possible attacks, countermeasures, SPINS, Static and dynamic key distribution.	8
Unit 5: **Routing protocols:** Introduction, MANET protocols **Routing protocols for WSN**: Resource-aware routing, Data-centric, Geographic Routing, Broadcast, Multicast **Opportunistic Routing Analysis**: Analysis of opportunistic routing (Markov Chain) Advanced topics in wireless sensor networks.	10
Unit 6: **ADVANCED TOPICS** Recent development in WSN standards, software applications.	4

COURSE OUTCOMES
After completion of course, students would be able to:
• Describe and explain radio standards and communication protocols for wireless sensor networks.
• Explain the function of the node architecture and use of sensors for various applications.
• Be familiar with architectures, functions and performance of wireless sensor networks systems and platforms.

References:

1. W. Dargie and C. Poellabauer, "Fundamentals of Wireless Sensor Networks – Theory and Practice", Wiley 2010
2. Kazem Sohraby, Daniel Minoli and TaiebZnati, "wireless sensor networks - Technology, Protocols, and Applications", Wiley Interscience 2007
3. Takahiro Hara,Vladimir I. Zadorozhny, and Erik Buchmann, "Wireless Sensor Network Technologies for the Information Explosion Era", springer 2010.

Course Code	MTCS107-18
Course Name	Introduction to Intelligent Systems
Credits	3
Pre-Requisites	Data Structures and Data Management or Data Structures

Total Number of Lectures: 48

COURSEOBJECTIVE
• The aim of the course is to introduce to the field of Artificial Intelligence (AI) with emphasis on its use to solve real world problems for which solutions are difficult to express using the traditional algorithmic approach. It explores the essential theory behind methodologies for developing systems that demonstrate intelligent behavior including dealing with uncertainty, learning from experience and following problem solving

LECTURE WITH BREAKUP	**NO. OF LECTURES**
Unit 1: Biological foundations to intelligent systems I: Artificial neural networks, Back-propagation networks, Radial basis function networks, and recurrent networks.	9
Unit 2: Biological foundations to intelligent systems II: Fuzzy logic, knowledge Representation and inference mechanism, genetic algorithm, and fuzzy neural networks.	6
Unit 3: Search Methods Basic concepts of graph and tree search. Three simple search methods: breadth-first search, depth-first search, iterative deepening search. Heuristic search methods: best-first search, admissible evaluation functions, hill- climbing search. Optimization and search such as stochastic annealing and genetic algorithm.	7
Unit 4: Knowledge representation and logical inference Issues in knowledge representation. Structured representation, such as frames, and scripts, semantic networks and conceptual graphs. Formal logic and logical inference. Knowledge-based systems structures, its basic components. Ideas of Blackboard architectures.	9
Unit 5: Reasoning under uncertainty and Learning Techniques on uncertainty reasoning such as Bayesian reasoning, Certainty factors and Dempster-Shafer Theory of Evidential reasoning, A study of different learning and evolutionary algorithms, such as statistical learning and induction learning.	7

Unit 6: Recent trends in Fuzzy logic, Knowledge Representation.	5

COURSE OUTCOMES
After completion of course, students would be:
• Able to demonstrate knowledge of the fundamental principles of intelligent systems and would be able to analyses and compare the relative merits of a variety of AI problem solving techniques.

References:

1. Luger G.F. and Stubblefield W.A. (2008). Artificial Intelligence: Structures and strategies for Complex Problem Solving. Addison Wesley, 6th edition.
2. Russell S. and Norvig P. (2009). Artificial Intelligence: A Modern Approach. Prentice-Hall, 3rd edition.

Course Code	MTCS108-18
Course Name	Data Science
Credits	3
Pre-Requisites	

Total Number of Lectures:48

COURSE OBJECTIVE
• Provide you with the knowledge and expertise to become a proficient data scientist.
• Demonstrate an understanding of statistics and machine learning concepts that are vital for data science;
• Produce Python code to statistically analyses a dataset;
• Critically evaluate data visualizations based on their design and use for communicating stories from data;

LECTURE WITH BREAKUP	**NO. OF LECTURES**
Unit 1: Introduction to core concepts and technologies: Introduction, Terminology, data science process, data science toolkit, Types of data, Example applications.	6
Unit 2: Data collection and management: Introduction, Sources of data, Data collection and APIs, Exploring and fixing data, Data storage and management, Using multiple data sources.	7

Unit 3: Data analysis: Introduction, Terminology and concepts, Introduction to statistics, Central tendencies and distributions, Variance, Distribution properties and arithmetic, Samples/CLT, Basic machine learning algorithms, Linear regression, SVM, Naive Bayes.	10
Unit 4: Data visualization:Introduction, Types of data visualization,Data for visualization:Data types, Data encodings, Retinal variables, Mapping variables to encodings, Visual encodings.	11
Unit 5: Applications of Data Science,Technologies for visualization, Bokeh (Python)	7
Unit 6: Recent trends in various data collection and analysis techniques, various visualization techniques, application development methods of used in data science.	7

COURSE OUTCOMES
On completion of the course the student should be able to
• Explain how data is collected, managed and stored for data science;
• Understand the key concepts in data science, including their real-world applications and the toolkit used by data scientists;
• Implement data collection and management scripts using MongoDB

References:

1. Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk fromthe Frontline. O'Reilly.
2. Jure Leskovek, Annand Rajaraman and Jeffrey Ullman. Mining of Massive Datasets. v2.1, Cambridge University Press.

Course Code	MTCS109-18
Course Name	Distributed Systems
Credits	3
Pre-Requisites	Database Management Systems

Total Number of Lectures: 48

COURSEOBJECTIVE
• 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.

LECTURE WITH BREAKUP	NO. OF LECTURES
Unit 1: INTRODUCTION Distributed data processing; What is a DDBS; Advantages and disadvantages of DDBS; Problem areas; Overview of database and computer network concepts **DISTRIBUTED DATABASE MANAGEMENT SYSTEM ARCHITECTURE** Transparencies in a distributed DBMS; Distributed DBMS architecture; Global directory issues.	8
Unit 2: **DISTRIBUTED DATABASE DESIGN** Alternative design strategies; Distributed design issues; Fragmentation; Data allocation. **SEMANTICS DATA CONTROL** View management; Data security; Semantic Integrity Control. **QUERY PROCESSING ISSUES** Objectives of query processing; Characterization of query processors; Layers of query processing; Query decomposition; Localization of distributed data.	11
Unit 3: **DISTRIBUTED QUERY OPTIMIZATION** Factors governing query optimization; Centralized query optimization; Ordering of fragment queries; Distributed query optimization algorithms. **TRANSACTION MANAGEMENT** The transaction concept; Goals of transaction management; Characteristics of transactions; Taxonomy of transaction models. **CONCURRENCY CONTROL** Concurrency control in centralized database systems; Concurrency control in DDBSs; Distributed concurrency control algorithms; Deadlock management.	11
Unit 4: **RELIABILITY** Reliability issues in DDBSs; Types of failures; Reliability techniques; Commit protocols; Recovery protocols.	8

Unit 5: **PARALLEL DATABASE SYSTEMS** Parallel architectures; parallel query processing and optimization; load balancing.	6
Unit 6: **ADVANCED TOPICS** Mobile Databases, Distributed Object Management, Multi-databases.	4

COURSE OUTCOMES
After completion of course, students would be:
• Design trends in distributed systems.
• Apply network virtualization.
• Apply remote method invocation and objects.

References:

1. Principles of Distributed Database Systems, M.T. Ozsu and P. Valduriez, Prentice-Hall, 1991.
2. Distributed Database Systems, D. Bell and J. Grimson, Addison-Wesley, 1992.

Course Code	MTCS110-18
Course Name	Advanced Wireless and Mobile Networks
Credits	3
Pre-Requisites	Computer Networks

Total Number of Lectures: 48

COURSE OBJECTIVE
• The students should get familiar with the wireless/mobile market and the future needs and challenges.
• To get familiar with key concepts of wireless networks, standards, technologies and their basic operations
• To learn how to design and analyse various medium access
• To learn how to evaluate MAC and network protocols using network simulation software tools.
• The students should get familiar with the wireless/mobile market and the future needs and challenges.

LECTURE WITH BREAKUP	NO. OF LECTURES
Unit 1: INTRODUCTION: Wireless Networking Trends, Key Wireless Physical Layer Concepts, Multiple Access Technologies -CDMA, FDMA, TDMA, Spread Spectrum technologies, Frequency reuse, Radio Propagation and Modelling, Challenges in Mobile Computing: Resource poorness, Bandwidth, energy etc. **WIRELESS LOCAL AREA NETWORKS:** IEEE 802.11 Wireless LANs Physical & MAC layer, 802.11 MAC Modes (DCF& PCF) IEEE 802.11 standards, Architecture & protocols, Infrastructure vs. Adhoc Modes, Hidden Node & Exposed Terminal Problem, Problems, Fading Effects in Indoor and outdoor WLANs, WLAN Deployment issues.	11
Unit 2: **WIRELESS CELLULAR NETWORKS:** 1G and 2G, 2.5G, 3G, and 4G, Mobile IPv4, Mobile IPv6, TCP over Wireless Networks, Cellular architecture, Frequency reuse, Channel assignment strategies, Handoff strategies, Interference and system capacity, Improving coverage and capacity in cellular systems, Spread spectrum Technologies.	10
Unit 3: WiMAX (Physical layer, Media access control, Mobility and Networking), IEEE 802.22 Wireless Regional Area Networks, IEEE 802.21 Media Independent Handover Overview **WIRELESS SENSOR NETWORKS** Introduction, Application, Physical, MAC layer and Network Layer, Power Management, Tiny OS Overview.	8
Unit 4: WIRELESS PANs Bluetooth AND Zigbee, Introduction to Wireless Sensors.	4
Unit 5: SECURITY Security in wireless Networks Vulnerabilities, Security techniques, Wi-Fi Security, DoS in wireless communication.	10

Unit 6: **ADVANCED TOPICS** IEEE 802.11x and IEEE 802.11i standards, Introduction to Vehicular Adhoc Networks	5

COURSE OUTCOMES
After completion of course, students would be:
• Demonstrate advanced knowledge of networking and wireless networking and understand various types of wireless networks, standards, operations and use cases.
• Be able to design WLAN, WPAN, WWAN, Cellular based upon underlying propagation and performance analysis.
• Demonstrate knowledge of protocols used in wireless networks and learn simulating wireless networks.
• Design wireless networks exploring trade-offs between wire line and wireless links.
• Develop mobile applications to solve some of the real world problems.

References:

1. Schiller J., Mobile Communications, Addison Wesley 2000
2. Stallings W., Wireless Communications and Networks, Pearson Education 2005
3. Stojmenic Ivan, Handbook of Wireless Networks and Mobile Computing, John Wiley and Sons Inc 2002
4. Yi Bing Lin and Imrich Chlamtac, Wireless and Mobile Network Architectures, John Wiley and Sons Inc 2000
5. Pandya Raj, Mobile and Personal Communications Systems and Services, PHI 200

Course Code	MTCS206-18
Course Name	Data Preparation and Analysis
Credits	3
Pre-Requisites	

Total Number of Lectures: 48

COURSEOBJECTIVE
• To prepare the data for analysis and develop meaningful Data Visualizations

LECTURE WITH BREAKUP	**NO. OF LECTURES**
Unit1: **Data Gathering and Preparation:** Data formats, parsing and transformation, Scalability and real-time issues.	9
Unit2: **Data Cleaning:** Consistency checking, Heterogeneous and missing data, Data Transformation and segmentation.	11
Unit3: **Exploratory Analysis:** Descriptive and comparative statistics, Clustering and association, Hypothesis generation.	13
Unit4: Visualization: Designing visualizations, Time series, Geolocated data, Correlations and connections, Hierarchies and networks, interactivity.	15

COURSE OUTCOMES
After completion of course, students would be:
• Able to extract the data for performing the Analysis.

References:

1. Making sense of Data: A practical Guide to Exploratory Data Analysis and Data Mining, by Glenn J. Myatt

Course Code	MTCS207-18
Course Name	Secure Software Design and Enterprise Computing
Credits	3
Pre-Requisites	Computer Programming, Software Engineering

Total Number of Lectures:48

COURSE OBJECTIVE
• To fix software flaws and bugs in various software.
• To make students aware of various issues like weak random number generation, information leakage, poor usability, and weak or no encryption on data traffic
• Techniques for successfully implementing and supporting network services on an enterprise scale and heterogeneous systems environment.
• Methodologies and tools to design and develop secure software containing minimum vulnerabilities and flaws.

LECTURE WITH BREAKUP	**NO. OF LECTURES**
Unit 1: **Secure Software Design** Identify software vulnerabilities and perform software security analysis, Master security programming practices, Master fundamental software security design concepts, Perform security testing and quality assurance.	8

Unit 2: **Enterprise Application Development** Describe the nature and scope of enterprise software applications, Design distributed N-tier software application, Research technologies available for the presentation, business and data tiers of an enterprise software application, Design and build a database using an enterprise database system, Develop components at the different tiers in an enterprise system, Design and develop a multi-tier solution to a problem using technologies used in enterprise system, Present software solution.	11
Unit 3: **Enterprise Systems Administration** Design, implement and maintain a directory-based server infrastructure in a heterogeneous systems environment, Monitor server resource utilization for system reliability and availability, Install and administer network services (DNS/DHCP/Terminal Services/Clustering/Web/Email).	8
Unit 4: Obtain the ability to manage and troubleshoot a network running multiple services, Understand the requirements of an enterprise network and how to go about managing them.	8
Unit 5: Handle insecure exceptions and command/SQL injection, Defend web and mobile applications against attackers, software containing minimum vulnerabilities and flaws.	9
Unit 6: Case study of DNS server, DHCP configuration and SQL injection attack.	4

COURSE OUTCOMES
After completion of course, students would be able to:
• Differentiate between various software vulnerabilities.
• Software process vulnerabilities for an organization.
• Monitor resources consumption in a software.
• Interrelate security and software development process.

References:

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

Course Code	MTCS208-18
Course Name	Computer Vision
Credits	3
Pre-Requisites	Linear algebra, vector calculus, Data structures and Programming.

Total Number of Lectures: 48

COURSE OBJECTIVE
• Be familiar with both the theoretical and practical aspects of computing with images.
• Have described the foundation of image formation, measurement, and analysis.
• Understand the geometric relationships between 2D images and the 3D world.
• Grasp the principles of state-of-the-art deep neural networks.

LECTURE WITH BREAKUP	**NO. OF LECTURES**
Unit 1: Overview, computer imaging systems, lenses, Image formation and sensing, Image analysis, pre-processing and Binary image analysis.	8
Unit 2: Edge detection, Edge detection performance, Hough transform, corner detection.	9
Unit 3: Segmentation, Morphological filtering, Fourier transform.	9
Unit 4: Feature extraction, shape, histogram, color, spectral, texture, using CVIPtools, Feature analysis, feature vectors, distance /similarity measures, data pre- processing.	9

Unit 5: Pattern Analysis: Clustering: K-Means, K-Medoids, Mixture of Gaussians Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised. Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA, and Non-parametric methods.	9
Unit 6: Recent trends in Activity Recognition, computational photography, Biometrics.	4

COURSE OUTCOMES
After completion of course, students would be able to:
• Developed the practical skills necessary to build computer vision applications.
• To have gained exposure to object and scene recognition and categorization from images.

References:

1. Computer Vision: Algorithms and Applications by Richard Szeliski.
2. Deep Learning, by Goodfellow, Bengio, and Courville.
3. Dictionary of Computer Vision and Image Processing, by Fisheretal.

Course Code	MTCS209-18
Course Name	Human and Computer Interaction
Credits	3
Pre-Requisites	

Total Number of Lectures: 48

COURSEOBJECTIVE
• Learn the foundations of Human Computer Interaction • Be familiar with the design technologies for individuals and persons with disabilities • Be aware of mobile Human Computer interaction. • Learn the guidelines for user interface.

LECTURE WITH BREAKUP	NO. OF LECTURES
Unit 1: Human: I/O channels – Memory – Reasoning and problem solving; The computer: Devices – Memory – processing and networks; Interaction: Models– frameworks – Ergonomics – styles – elements – interactivity- Paradigms.	9
Unit 2: Interactive Design basics – process – scenarios – navigation – screen design – Iteration and prototyping. HCI in software process – software life cycle – usability engineering – Prototyping in practice – design rationale. Design rules– principles, standards, guidelines, rules. Evaluation Techniques – Universal Design.	12
Unit 3: Cognitive models –Socio-Organizational issues and stake holder requirements –Communication and collaboration models-Hypertext, Multimedia	8
Unit 4: Mobile Ecosystem: Platforms, Application frameworks- Types of Mobile Applications: Widgets, Applications, Games- Mobile Information Architecture, Mobile 2.0, Mobile Design: Elements of Mobile Design, Tools.	8
Unit 5: Designing Web Interfaces – Drag & Drop, Direct Selection, Contextual Tools, Overlays, Inlays and Virtual Pages, Process Flow. Case Studies.	8
Unit 6: Recent Trends: Speech Recognition and Translation, Multimodal System.	3

COURSE OUTCOMES
After completion of course, students would be:

• Understand the structure of models and theories of human computer interaction and vision. • Design an interactive web interface on the basis of models studied.

References:

1. Alan Dix, Janet Finlay, Gregory Abowd, Russell Beale, "Human Computer Interaction",3rd Edition, Pearson Education, 2004 (UNIT I, II & III)
2. Brian Fling, "Mobile Design and Development", First Edition, O17Reilly Media Inc., 2009 (UNIT – IV)
3. Bill Scott and Theresa Neil, "Designing Web Interfaces", First Edition, O17Reilly, 2009. (UNIT-V)

Course Code	MTCS210-18
Course Name	GPU Computing
Credits	3
Pre-Requisites	

Total Number of Lectures: 48

COURSE OBJECTIVE
• To learn parallel programming with Graphics Processing Units (GPUs).

LECTURE WITH BREAKUP	**NO. OF LECTURES**
Unit 1: **Introduction**: History, Graphics Processors, Graphics Processing Units, GPGPUs. Clock speeds, CPU / GPU comparisons, Heterogeneity, Accelerators, Parallel programming, CUDA Open CL / Open ACC, Hello World Computation Kernels, Launch parameters, Thread hierarchy, Warps/ Wavefronts, Thread blocks / Workgroups, Streaming multiprocessors,	13
Unit 2: **Memory**: Memory hierarchy, DRAM / global, local / shared, private / local, textures, Constant Memory, Pointers, Parameter Passing, Arrays and dynamic Memory, Multi-dimensional Arrays, Memory Allocation, Memory copying across devices, Programs with matrices, Performance evaluation with different memories.	7

Unit 3: **Synchronization**: Memory Consistency, Barriers (local versus global), Atomics, Memory fence. Prefix sum, Reduction. Programs for concurrent Data Structures such as Worklists, Linked-lists. Synchronization across CPU and GPU **Functions**: Device functions, Host functions, Kernels functions, Using libraries (such as Thrust), and developing libraries.	10
Unit 4: **Support**: Debugging GPU Programs. Profiling, Profile tools, Performance aspects **Streams**: Asynchronous processing, tasks, Task-dependence, Overlapped data transfers, Default Stream, Synchronization with streams. Events, Event-based- Synchronization - Overlapping data transfer and kernel execution, pitfalls.	8
Unit 5: **Case Studies**: Image Processing, Graph algorithms, Simulations, Deep Learning.	5
Unit 6: **Advanced topics**: Dynamic parallelism, Unified Virtual Memory, Multi-GPU processing, Peer access, Heterogeneous processing.	5

COURSE OUTCOMES
After completion of course, students would be:
• Students would learn concepts in parallel programming, implementation of programs on GPUs, debugging and profiling parallel programs.

References:

1. Programming Massively Parallel Processors: A Hands-on Approach; David Kirk, Wen-meiHwu; Morgan Kaufman; 2010 (ISBN: 978-0123814722)
2. CUDA Programming: A Developer's Guide to Parallel Computing with GPUs; Shane Cook; Morgan Kaufman; 2012 (ISBN: 978-0124159334)

Course Code	MTCS211-18
Course Name	Digital Forensics
Credits	3
Pre-Requisites	Cybercrime and Information Warfare, Computer Networks

Total Number of Lectures: 48

COURSE OBJECTIVE
• Provides an in-depth study of the rapidly changing and fascinating field of computer forensics.
• Combines both the technical expertise and the knowledge required to investigate, detect and prevent digital crimes.
• Knowledge on digital forensics legislations, digital crime, forensics processes and procedures, data acquisition and validation, e-discovery tools.
• E-evidence collection and preservation, investigating operating systems and file systems, network forensics, art of steganography and mobile device forensics.

LECTURE WITH BREAKUP	NO. OF LECTURES
Unit 1: **Digital Forensics Science:** Forensics science, computer forensics, and digital forensics. **Computer Crime:** Criminalistics as it relates to the investigative process, analysis of cyber-criminalistics area, holistic approach to cyber-forensics.	9
Unit 2: **Cyber Crime Scene Analysis:** Discuss the various court orders etc., methods to search and seizure electronic evidence, retrieved and un-retrieved communications, Discuss the importance of understanding what court documents would be required for a criminal investigation.	8
Unit 3: **Evidence Management & Presentation:** Create and manage shared folders using operating system, importance of the forensic mindset, define the workload of law enforcement, Explain what the normal case would look like, Define who should be notified of a crime, parts of gathering evidence, Define and apply probable cause.	9
Unit 4: **Computer Forensics:** Prepare a case, begin an investigation, understand computer forensics workstations and software, conduct an investigation, complete a case, Critique a case, **Network Forensics:** open-source security tools for network forensic analysis, requirements for preservation of network data.	10

Unit 5: **Mobile Forensics:** mobile forensics techniques, mobile forensics tools. **Legal Aspects of Digital Forensics:** IT Act 2000, amendment of IT Act 2008.	8
Unit 6: Recent trends in mobile forensic technique and methods to search and seizure electronic evidence.	4

COURSE OUTCOMES
After completion of course, students would be able to:
• Understand relevant legislation and codes of ethics
• Computer forensics and digital detective and various processes, policies and procedures
• E-discovery, guidelines and standards, E-evidence, tools and environment.
• Email and web forensics and network forensics

References:

1. John Sammons, The Basics of Digital Forensics, Elsevier
2. John Vacca, Computer Forensics: Computer Crime Scene Investigation, Laxmi Publications

Course Code	MTCS302-18
Course Name	Mobile Applications and Services
Credits	3
Pre-Requisites	Wireless Communication and Mobile Computing

Total Number of Lectures:48

COURSE OBJECTIVE
• This course presents the three main mobile platforms and their ecosystems, namely Android, iOS, and Phone Gap/Web OS.
• It explores emerging technologies and tools used to design and implement feature-rich mobile applications for smartphones and tablets.
• It also take into account both the technical constraints relative to storage capacity, processing capacity, display screen, communication interfaces, and the user interface, context and profile

LECTURE WITH BREAKUP	NO. OF LECTURES
Unit 1: **Introduction**: Introduction to Mobile Computing, Introduction to Android Development Environment, Factors in Developing Mobile Applications, Mobile Software Engineering, Frameworks and Tools, Generic UI Development Android User.	8
Unit 2: **More on Uis**: VUIs and Mobile Apps, Text-to-Speech Techniques, Designing the Right UI, Multichannel and Multimodal Uis,.Storing and Retrieving Data, Synchronization and Replication of Mobile Data, Getting the Model Right, Android Storing and Retrieving Data, Working with a Content Provider.	8
Unit 3: **Communications via Network and the Web:** State Machine, Correct Communications Model, Android Networking and Web, Telephony Deciding Scope of an App, Wireless Connectivity and Mobile Apps, Android Telephony. **Notifications and Alarms**: Performance, Performance and Memory Management, Android Notifications and Alarms, Graphics, Performance and Multithreading, Graphics and UI Performance, Android Graphics.	10
Unit 4: **Putting It All Together**: Packaging and Deploying, Performance Best Practices, Android Field Service App, Location Mobility and Location Based Services Android. **Multimedia**: Mobile Agents and Peer-to-Peer Architecture, Android Multimedia.	9
Unit 5: **Platforms and Additional Issues**: Development Process, Architecture, Design, Technology Selection, Mobile App Development Hurdles, Testing, Security and Hacking, Active Transactions, More on Security, Hacking Android.	8
Unit 6: Recent trends in Communication protocols for IOT nodes, mobile computing techniques in IOT, agents based communications in IOT.	5
COURSEOUTCOMES	
• On completion of the course the student should be able to identify the target platform and users and	

• Understand the fundamentals, frameworks, and development lifecycle of mobile application platforms including iOS, Android, and PhoneGap.
• Design and develop a mobile application prototype in one of the platform (challenge project)

References:

1. Wei-Meng Lee, Beginning Android™ 4 Application Development, 2012 by John Wiley & Sons

Course Code	MTCS303-18
Course Name	Compiler for HPC
Credits	3
Pre-Requisites	Data Structure, Compiler Design, Theory of Computation

Total Number of Lectures: 48

COURSE OBJECTIVE
• The objective of this course is to introduce structure of compilers and high performance compiler design for students. Concepts of cache coherence and parallel loops in compilers are included.

LECTURE WITH BREAKUP	**NO. OF LECTURES**
Unit1: **High Performance Systems,** Structure of a Compiler, Programming Language Features, Languages for High Performance.	7
Unit2: **Data Dependence:** Data Dependence in Loops, Data Dependence in Conditionals, Data Dependence in Parallel Loops, Program Dependence Graph. **Scalar Analysis with Factored Use-Def Chains:** Constructing Factored Use- Def Chains, FUD Chains for Arrays, Induction Variables Using FUD Chains, Constant Propagation with FUD Chains, Data Dependence for Scalars. Data Dependence Analysis for Arrays.	7

Unit3: Array Region Analysis, Pointer Analysis, I/O Dependence, Procedure Calls, Inter-procedural Analysis. **Loop Restructuring:** Simple Transformations, Loop Fusion, Loop Fission, Loop Reversal, Loop Interchanging, Loop Skewing, Linear Loop Transformations, Strip-Mining, Loop Tiling, Other Loop Transformations, and Inter-Procedural Transformations. **Optimizing for Locality:** Single Reference to Each Array, Multiple References, General Tiling, Fission and Fusion for Locality.	10
Unit4: **Concurrency Analysis:** Concurrency from Sequential Loops, Concurrency from Parallel Loops, Nested Loops, Round off Error, Exceptions and Debuggers. **Vector Analysis:** Vector Code, Vector Code from Sequential Loops, Vector Code from For all Loops, Nested Loops, Round off Error, Exceptions, and Debuggers, Multi-vector Computers.	10
Unit5: **Message-Passing Machines:** SIMD Machines, MIMD Machines, Data Layout, Parallel Code for Array Assignment, Remote Data Access, Automatic Data Layout, Multiple Array Assignments, Other Topics. **Scalable Shared-Memory Machines:** Global Cache Coherence, Local Cache Coherence, Latency Tolerant Machines.	10
Unit 6: Recent trends in compiler design for high performance computing and message passing machines and scalable shared memory machine.	4

COURSE OUTCOMES
After completion of course, students would be:
• Familiar with the structure of compiler. • Parallel loops, data dependency and exception handling and debugging in compiler.

References:

1. Michael Wolfe, High-Performance Compilers for Parallel Computing, Pearson

Course Code	MTCS304-18
Course Name	Optimization Techniques
Credits	3
Pre-Requisites	Linear Algebra and Numerical Methods

Total Number of Lectures: 48

COURSE OBJECTIVE

- The objective of this course is to provide insight to the mathematical formulation of real world problems.
- To optimize these mathematical problems using nature based algorithms. And the solution is useful especially for NP-Hard problems.

LECTURE WITH BREAKUP	**NO. OF LECTURES**
Unit 1: Engineering application of Optimization, Formulation of design problems as mathematical programming problems.	7
Unit 2: General Structure of Optimization Algorithms, Constraints, The Feasible Region.	7
Unit 3: Branches of Mathematical Programming: Optimization using calculus, Graphical Optimization, Linear Programming, Quadratic Programming, Integer Programming, Semi Definite Programming.	11
Unit 4: Optimization Algorithms like Genetic Optimization, Particle Swarm Optimization, Ant Colony Optimization etc.	12

Unit 5: Real life Problems and their mathematical formulation as standard programming problems.	6
Unit 6: Recent trends: Applications of ant colony optimization, genetics and linear and quadratic programming in real world applications.	5

COURSE OUTCOMES
After completion of course, students would be:
• Formulate optimization problems.
• Understand and apply the concept of optimality criteria for various types of optimization problems.
• Solve various constrained and unconstrained problems in Single variable as well as multivariable.
• Apply the methods of optimization in real life situation.

References:

1. Laurence A. Wolsey (1998). Integer programming. Wiley. ISBN 978-0-471-28366-9.
2. Practical Optimization Algorithms and Engineering Applications Andreas Antoniou.
3. An Introduction to Optimization Edwin K., P. Chong & Stanislaw h. Zak.
4. Dimitris Bertsimas; Robert Weismantel (2005). Optimization over integers. Dynamic Ideas. ISBN 978- 0-9759146-2-5.
5. John K. Karlof (2006). Integer programming: theory and practice.CRC Press. ISBN 978-0-8493-1914-3.
6. H. Paul Williams (2009). Logic and Integer Programming. Springer. ISBN 978-0-387-92279-9.
7. Michael Jünger; Thomas M. Liebling; Denis Naddef; George Nemhauser; William R. Pulleyblank; Gerhard Reinelt; Giovanni Rinaldi; Laurence A. Wolsey, eds. (2009). 50 Years of Integer Programming 1958-2008: From the Early Years to the State-of-the- Art. Springer. ISBN 978-3- 540-68274-5.
8. Der-San Chen; Robert G. Batson; Yu Dang (2010). Applied Integer Programming: Modeling and Solution. John Wiley and Sons. ISBN 978-0-470-37306-4.

OPEN ELECTIVES

Business Analytics

Teaching scheme Lecture: - 3 h/week

Course Code	MTOE301-18
Course Name	**Business Analytics**
Credits Prerequisites	

Total Number of Lectures: 48

Course objective

1. Understand the role of business analytics within an organization.
2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
4. To become familiar with processes needed to develop, report, and analyze business
5. Use decision-making tools/Operations research techniques.
6. Mange business process using analytical and management tools.
7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

LECTURE WITH BREAKUP	NO. OFLECTURES
Unit1: Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organization, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.	9
Unit 2: Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression. Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.	8
Unit 3: Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.	9
Unit 4: Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.	10

Unit 5: Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.	8
Unit 6: Recent Trends in: Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.	4

COURSE OUTCOMES	
1.	Students will demonstrate knowledge of data analytics.
2.	Students will demonstrate the ability of think critically in making decisions based on data and deep analytics.
3.	Students will demonstrate the ability to use technical skills in predicative and prescriptive modeling to support business decision-making.
4.	Students will demonstrate the ability to translate data into clear, actionable insights.

Reference:

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.

OPEN ELECTIVES

Industrial Safety

Teaching scheme Lecture: - 3 h/week

Unit-I: Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc., Safety color codes. Fire prevention and firefighting, equipment and methods.

Unit-II: Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Unit-III: Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications,

i. Screw down grease cup,
ii. Pressure grease gun,
iii. Splash lubrication,
iv. Gravity lubrication,
v. Wick feed lubrication
vi. Side feed lubrication,
vii. Ring lubrication,

Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Unit-IV: Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like,

I. Any one machine tool,
II. Pump,
III. Air compressor,
IV. Internal combustion engine,
V. Boiler,
VI. Electrical motors,

Types of faults in machine tools and their general causes.

Unit-V: Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

Reference:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.

3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

OPEN ELECTIVES

Operations Research

Teaching Scheme Lectures: 3 hrs/week

Course Outcomes:

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

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

Syllabus Contents: Unit 1:

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

Unit 2

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

Unit 3:

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

Unit 4

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Unit 5

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

References:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008.
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009.
5. Pannerselvam, Operations Research: Prentice Hall of India 2010.
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010.

Open Elective

Cost Management of Engineering Projects

Teaching scheme

Lecture: - 3 h/week

Introduction and Overview of the Strategic Cost Management Process.

Cost concepts in decision-making; relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and non-technical activities. Detailed Engineering activities. Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality

Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

References:

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

Open Elective Composite Materials

Teaching Scheme
Lecture: 3h/week

UNIT–I: INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT – II: REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT – III: Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

UNIT–IV: Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

UNIT – V: Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength- ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TEXT BOOKS:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

References:

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

Open Elective Waste to Energy

Teaching Schema
Lecture: 3h/week

Unit-I: Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

Unit-II: Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit-III: Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Unit-IV: Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit-V: Biogas: Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

References:

1. Non-Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.

AUDIT 1 and 2: ENGLISH FOR RESEARCH PAPER WRITING

Course objectives:

Students will be able to:

Understand that how to improve your writing skills and level of readability

Learn about what to write in each section

Syllabus

Units	CONTENTS	Hours
1	Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	4
2	Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction	4
3	Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.	4
4	key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,	4
5	skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions	4
6	useful phrases, how to ensure paper is as good as it could possibly be the first- time submission	4

Suggested Studies:

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books)
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook
4. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

AUDIT 1 and 2: DISASTER MANAGEMENT

Course Objectives: -Students will be able to:

1. Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.

Syllabus

Units	CONTENTS	Hours
1	**Introduction** Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.	4
2	**Repercussions of Disasters and Hazards**: Economic Damage, Loss of Human and Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.	4
3	**Disaster Prone Areas in India** Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics	4

4	**Disaster Preparedness and Management** Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.	4
5	**Risk Assessment** Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co- Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival.	4
6	**Disaster Mitigation** Meaning, Concept and Strategies of Disaster Mitigation, Emerging Trends in Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.	4

SUGGESTED READINGS:

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal Book Company.
2. Sahni, PardeepEt.Al. (Eds.)," Disaster Mitigation Experiences and Reflections", Prentice Hall of India, New Delhi.
3. Goel S. L., Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.
4.

AUDIT 1 and 2: SANSKRIT FOR TECHNICAL KNOWLEDGE

Course Objectives

1. To get a working knowledge in illustrious Sanskrit, the scientific language in the world
2. Learning of Sanskrit to improve brain functioning
3. Learning of Sanskrit to develop the logic in mathematics, science & other subjects
4. enhancing the memory power

5. The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

Syllabus

Unit	Content	Hours
1	• Alphabets in Sanskrit, • Past/Present/Future Tense, • Simple Sentences	8
2	• Order • Introduction of roots • Technical information about Sanskrit Literature	8
3	• Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics	8

Suggested reading

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumb shastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

Course Output

Students will be able to

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students

AUDIT 1 and 2: VALUE EDUCATION

Course Objectives

Students will be able to

1. Understand value of education and self- development
2. Imbibe good values in students
3. Let the should know about the importance of character

Syllabus

Unit	Content	Hours
1	• Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. • Moral and non- moral valuation. Standards and principles. • Value judgements	4
2	• Importance of cultivation of values. • Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. • Honesty, Humanity. Power of faith, National Unity. • Patriotism, Love for nature ,Discipline	6

3	• Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. • Punctuality, Love and Kindness. • Avoid fault Thinking. • Free from anger, Dignity of labour. • Universal brotherhood and religious tolerance. • True friendship. • Happiness Vs suffering, love for truth. • Aware of self-destructive habits. • Association and Cooperation. • Doing best for saving nature	6
4	• Character and Competence –Holy books vs Blind faith. • Self-management and Good health. • Science of reincarnation. • Equality, Nonviolence, Humility, Role of Women. • All religions and same message. • Mind your Mind, Self-control. • Honesty, Studying effectively	6

Suggested reading

1. Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

Course outcomes

Students will be able to

1. Knowledge of self-development
2. Learn the importance of Human values
3. Developing the overall personality

AUDIT 1 and 2: CONSTITUTION OF INDIA

Course Objectives:

1. Students will be able to:
2. Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
3. To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
4. 3. To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

Syllabus		
Units	**Content**	**Hours**
1	• **History of Making of the Indian Constitution:** • History • Drafting Committee, (Composition & Working)	4
2	• Philosophy of the Indian Constitution: • Preamble Salient Features	4

3	• Contours of Constitutional Rights & Duties: • Fundamental Rights • Right to Equality • Right to Freedom • Right against Exploitation • Right to Freedom of Religion • Cultural and Educational Rights • Right to Constitutional Remedies • Directive Principles of State Policy • Fundamental Duties.	4
4	• Organs of Governance: • Parliament • Composition • Qualifications and Disqualifications • Powers and Functions • Executive • President • Governor • Council of Ministers • Judiciary, Appointment and Transfer of Judges, Qualifications • Powers and Functions	4

5	• Local Administration: • District's Administration head: Role and Importance, • Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. • Pachayati raj: Introduction, PRI: ZilaPachayat. • Elected officials and their roles, CEO ZilaPachayat: Position and role. • Block level: Organizational Hierarchy (Different departments), • Village level: Role of Elected and Appointed officials, • importance of grass root democracy	4
6	• Election Commission: • Election Commission: Role and Functioning. • Chief Election Commissioner and Election Commissioners. • State Election Commission: Role and Functioning. • Institute and Bodies for the welfare of SC/ST/OBC and women.	4

Suggested reading

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

Course Outcomes:

Students will be able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.

3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.

4. Discuss the passage of the Hindu Code Bill of 1956.

AUDIT 1 and 2: PEDAGOGY STUDIES

Course Objectives:

Students will be able to:

1. Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
2. Identify critical evidence gaps to guide the development.

Syllabus

Units	Content	Hours
1	• Introduction and Methodology: • Aims and rationale, Policy background, Conceptual framework and terminology • Theories of learning, Curriculum, Teacher education. • Conceptual framework, Research questions**.** • Overview of methodology and Searching.	4
2	• Thematic overview: • Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. • Curriculum, Teacher education.	2

3	• Evidence on the effectiveness of pedagogical practices • Methodology for the in depth stage: quality assessment of included studies. • How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? • Theory of change. • Strength and nature of the body of evidence for effective pedagogical practices. • Pedagogic theory and pedagogical approaches. • Teachers' attitudes and beliefs and Pedagogic strategies.	4
4	• Professional development: alignment with classroom practices and follow- up support • Peer support • Support from the head teacher and the community. • Curriculum and assessment • Barriers to learning: limited resources and large class sizes	4

5	• Research gaps and future directions
	  • Research design
	  • Contexts
	  • Pedagogy
	  • Teacher education
	  • Curriculum and assessment
	  • Dissemination and research impact.
		2

Suggested reading

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.

2. Agrawal M (2004) curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.

3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.

4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.

5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.

6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.

7. www.pratham.org/images/resource%20working%20paper%202.pdf.

Course Outcomes:

Students will be able to understand:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?

2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?

3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

AUDIT 1 and 2: STRESS MANAGEMENT BY YOGA

Course Objectives

1. To achieve overall health of body and mind

2. To overcome stress

Syllabus

Unit	*Content*	*Hours*
1	• Definitions of Eight parts of yog. (Ashtanga)	8
2	Yam and Niyam. Do`s and Don't's in life. i) Ahinsa, satya, astheya, bramhacharya and aparigraha ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan	8
3	• Asan and Pranayam i) Various yog poses and their benefits for mind & body ii)Regularization of breathing techniques and its effects-Types of pranayam	8

Suggested Reading

1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

Course Outcomes:

Students will be able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

AUDIT 1 and 2: PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS

Course Objectives

1. To learn to achieve the highest goal happily
2. To become a person with stable mind, pleasing personality and determination
3. To awaken wisdom in students

Syllabus

Unit	Content	Hours
1	Neetisatakam-Holistic development of personality • Verses- 19,20,21,22 (wisdom) • Verses- 29,31,32 (pride & heroism) • Verses- 26,28,63,65 (virtue) • Verses- 52,53,59 (dont's) • Verses- 71,73,75,78 (do's)	8
2	• Approach to day to day work and duties. • Shrimad BhagwadGeeta : Chapter 2-Verses 41, 47,48, • Chapter 3-Verses 13, 21, 27, 35, Chapter 6-Verses 5,13,17, 23, 35, • Chapter 18-Verses 45, 46, 48.	8
3	• Statements of basic knowledge. • Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68 • Chapter 12 -Verses 13, 14, 15, 16,17, 18 • Personality of Role model. Shrimad Bhagwad Geeta: Chapter2-Verses 17, Chapter 3-Verses 36,37,42, • Chapter 4-Verses 18, 38,39	8

Suggested reading

1. "Srimad Bhagavad Gita" by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

Course Outcomes

Students will be able to

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.

LIST of EXPERIMENTS for

LABORATORIES of M. TECH- CSE

COURSE CODE: MTCS103-18
COURSE NAME: LAB. ON ADVANCED DATA STRUCTURES
CREDITS: 02, HOURS: 04

Programs may be implemented using C/C++/java

EXP 1: WAP to store k keys into an array of size n at the location computed using a hash function, loc = key % n, where k<=n and k takes values from [1 to m], m>n. To handle the collisions, use the following collision resolution techniques,

a. Linear probing
b. Quadratic probing
c. Double hashing/rehashing
d. Chaining

EXP 2: WAP for Binary Search Tree to implement following operations:

a. Insertion
b. Deletion i. Delete node with only child ii. Delete node with both children
c. Finding an element
d. Finding Min element
e. Finding Max element
f. Left child of the given node
g. Right child of the given node
h. Finding the number of nodes, leaves nodes, full nodes, ancestors, descendants.

EXP 3: WAP for AVL Tree to implement following operations: (For nodes as integers)

a. Insertion: Test program for all cases (LL, RR, RL, LR rotation)
b. Deletion: Test Program for all cases (R0, R1, R-1, L0, L1, L-1)
c. Display: using set notation.

EXP 4: WAP to implement Red-Black trees with insertion and deletion operation for the given input data as Integers/Strings

EXP 5: WAP to implement insertion, deletion, display and search operation in m-way B tree (i.e. a non-leaf node can have at most m children) for the given data as integers.

EXP 6: WAP to perform string matching using Knuth-Morris-Pratt algorithm.

EXP 7: WAP to perform string matching using Boyer-Moore algorithm.

EXP 8: WAP to implement 2-D range search over computational geometry problem

EXP 9: WAP on latest efficient algorithms on trees for solving contemporary problems.

Mini Project: Student has to do a project assigned from course contents in a group of two or three students. The team will have to demonstrate as well as have to give a presentation of the same.

COURSE CODE: MTCS104-18
COURSE NAME: LABORATORY. 2 (BASED ON ELECTIVE I and II)
CREDITS: 02, (Elective I + Elective II)

HOURS: 2 hours for Lab based on ElectiveI & 2 hours for Lab based on Elective II

ELECTIVE – I

MACHINE LEARNING LAB: Programs may be implemented using WEKA/R/PYTHON etc. similar software

Expt. 1: Study of platform for Implementation of Assignments

Download the open source software of your interest. Document the distinct features and functionality of the software platform. You may choose WEKA, R or any other software.

Expt. 2: Supervised Learning – Regression

Generate a proper 2-D data set of N points.

Split the data set into Training Data set and Test Data set.

i) Perform linear regression analysis with Least Squares Method.
ii) Plot the graphs for Training MSE and Test MSE and comment on Curve Fitting and Generalization Error.
iii) Verify the Effect of Data Set Size and Bias-Variance Trade off.
iv) Apply Cross Validation and plot the graphs for errors.
v) Apply Subset Selection Method and plot the graphs for errors. Describe your findings in each case.

Expt. 3: Supervised Learning – Classification

Implement Naïve Bayes Classifier and K-Nearest Neighbour Classifier on Data set of your choice. Test and Compare for Accuracy and Precision.

Expt. 4: Unsupervised Learning

Implement K-Means Clustering and Hierarchical clustering on proper data set of your choice. Compare their Convergence.

Expt. 5: Dimensionality Reduction

Principal Component Analysis-Finding Principal Components, Variance and Standard Deviation calculations of principal components.

Expt. 6: Supervised Learning and Kernel Methods

Design, Implement SVM for classification with proper data set of your choice. Comment on Design and Implementation for Linearly non-separable Dataset.

Mini Project: Student has to do a project assigned from course contents in a group of two or three students. The team will have to demonstrate as well as have to give a presentation of the same**.**

WIRELESS SENSOR NETWORKS LAB:Programs may be implemented using NS2/NS3 Expt.

EXPt1: Introduction to Network Simulators used for Wireless Sensor Networks.

Expt. 2: Introduction to TCL scripting: Demonstration of one small network simulator setup.

Expt. 3: To study various trace files formats of Network Simulators.

Expt. 4: To create a sensor network setup using the nodes configured with fixed initial energy, transmission power, reception power, routing agent, transport agent and application in rectangular area.
Expt. 5: Create different simulation scenarios by varying MAC protocols.
Expt. 6: Compute the performance of above created simulation scenarios of network in terms of total energy consumption, transmission latency, number of packets generated, received and dropped.
Expt. 7: To implement and compare various routing protocols using above mentioned performance metrics.

Mini Project: Student has to do a project assigned from course contents in a group of two or three students. The team will have to demonstrate as well as have to give a presentation of the same.

INTRODUCTION TO INTELLIGENT SYSTEMS LAB: Programs may be implemented using Matlab/Python

Expt. 1: Implementation of simple artificial neural network.
Expt. 2: Implementation of neural network with backpropagation.
Expt. 3: Implementation of radial basis function network.
Expt. 4: Implementation of recurrent neural network.
Expt. 5: Implementation of fuzzy neural network.
Expt. 6: Implementation of iterative deepening search.
Expt. 7: Implementation of Hill climbing Search algorithm. **Expt. 8:** Implementation of optimization genetic algorithm.
Expt. 9: Implementation of induction based learning method such as decision tree.
Expt. 10: Implementation of statistical learning methods such as naive Bayes.

Mini Project: Student has to do a project assigned from course contents in a group of two or three students. The group of students must submit a project report of 8 to 10 pages (approximately) and the team will have to demonstrate as well as have to give a presentation of the same**.**

ELECTIVE – II

DATA SCIENCE: Programs may be implemented using Matlab/Python/R

Expt. 1: Introduction to R

This Cycle introduces you to the use of the R statistical package within the Data Science and Big Data Analytics environment. After completing the tasks in this cycle you shouldableto:

a. Read data sets into R,savethem, and examine thecontents.

Tasks you will complete in this Cycle include:

a. Invoke the R environment and examine the R workspace.
b. Created table and datasets in R.
c. Examine, manipulate and save datasets.
d. Exit the R environment.

Expt. 2: Basic Statistics and Visualization

This Cycle introduces you to the analysis of data using the R statistical package within the Data Science and Big Data Analytics environment. After completing the tasks in Tins Cycle you should able to:

a. Perform summary (descriptive) statistics on the datasets.
b. Create basic visualizations using Rboth to support investigation of the data as well as exploration of the data.
c. Create plot visualizations of the data using a graphics package. Tasks you will complete in this Cycle include:

a. Reload data sets into the R statistical package.
b. Perform summary statistics on the data.
c. Remove outliers from the data.
d. Plot the data using R.
e. Plot the data using lattice and plot.

Expt. 3: K-means Clustering

This Cycle is designed to investigate and practice K-means Clustering. After completing the tasks in This Cycle you should able to:

a. Use R functions to create K-means Clustering models.
b. Use ODBC connection to the database and execute SQL statements and load datasets from the database in an R environment.
c. Visualize the effectiveness of the K-means Clustering algorithm using graphic capabilities in R.
d. Use the ODBC connection in the R environment to create the average household income from the census database as test data for K-means Clustering.
e. Use R graphics functions to visualize the effectiveness of the K-means Clustering algorithm.

Expt. 4: Association Rules

This Cycle is designed to investigate and practice Association Rules. After completing the tasks in This Cycle you should able to:

a. Use R functions for Association Rule based

models. Tasks you will complete in this Cycle include:

a. Use the R-Studio environment to code Association Rule models.

b. Apply constraints in the Market Basket Analysis methods such as minimum thresholds on support and confidence measures that can be used to select interesting rules from the set of all possible rules.

c. Use R graphics "a rules" to execute and inspect the models and the effect of the various thresholds.

Expt. 5: Linear Regression

a. This Cycle is designed to investigate and practice linear regression. After completing the tasks in This Cycle you should able to:

a. Use R functions for Linear Regression (Ordinary Least Squares - OLS).
b. Predict the dependent variables based on the model.
c. Investigate different statistical parameter tests that measure the effectiveness of the model.

Tasks you will complete in This Cycle include:

a. Use the R-Studio environment to code OLS models
b. Review the methodology to validate the model and predict the dependent variable for a set of given independent variables
c. Use R graphics functions to visualize the results generated with the mode

Expt. 7: Naïve Bayesian Classifier

This Cycle is designed to investigate and practice Navive Bayesian classifier. After completing the tasks in This Cycle you should able to:

a. Use R functions for Naïve Bayesian Classification
b. Apply the requirements for generating appropriate training data
c. Validate the effectiveness of the Naïve Bayesian Classifier with the

big data Tasks you will complete in Tins Cycle include:

a. Use R-Studio environment to code the Naïve Bayesian Classifier
b. Use the ODBC connection to the "census" database to create a training data set for Naïve Bayesian Classifier from the big data.
c. Use the Naive Bayesian Classifier program and evaluate how well it predicts the results using the training data and then compare the results with original data.

Expt. 8: Decision Trees

This Cycle is designed to investigate and practice Decision Tree (DT) models covered in the course work. After completing the tasks in This Cycle you should able to:

a. Use R functions for Decision Tree models.
b. Predict the outcome of an attribute based on' the

model. Tasks you will complete in This Cycle include:

a. Use the R-Studio environment to code Decision Tree Models.
b. Build a Decision Tree Model based on data whose schema is composed of attributes.
c. Predict the outcome of one attribute based on the model.

Mini Project: Student has to do a project assigned from course contents in a group of two or three students. The team will have to demonstrate as well as have to give a presentation of the same.

DISTRIBUTED SYSTEMS LAB: Programs may be implemented using any open source tool

Expt. 1: Installation and configuration of database packages.
Expt. 2: Creating and managing database objects (Tables, views, indexes etc.) **Expt. 3:** Creating and managing database security through user management. **Expt. 4:** Creating and maintaining database links.
Expt. 5: Implement Partitioning on the database tables.
Expt. 6: Implement various Transaction concurrency control methods [i.e. lock's] by executing multiple update and queries.
Expt. 7: Performance tuning of SQL queries.
Mini Project: Student has to do a project assigned from course contents in a group of two or three students. The team will have to demonstrate as well as have to give a presentation of the same.

ADVANCED WIRELESS AND MOBILE NETWORKS: Programs may be implemented using NS2/NS3/Omnet++

Expt. 1: Setup & Configuration of Wireless Access Point (AP) **Expt. 2:** Study of WLAN: Ad Hoc & Infrastructure Model **Expt. 3:** Study of Bluetooth Protocol and Applications
Expt. 4: GSM modem study and SMS client-server application
Expt. 5: Mobile Internet and WML
Expt. 6: J2ME Program for Mobile Node Discovery
Expt. 7: Mobile protocol study using omnet++
Expt. 8: Wireless Network Security: kismet and Netstumbler
Expt. 9: Design and Program Income Tax and Loan EMI Calculator for Mobile Phones

Mini Project: Implementation of Mobile Network using Network Simulator (NS2/NS3)

COURSE CODE: MTCS203-18
COURSE NAME: LABORATORY 3; LAB. ON ADVANCED ALGORITHMS AND SOFT COMPUTING

CREDITS: 02, HOURS: 04 per week

ADVANCED ALGORITHMS: Programs may be implemented using C/C++/java

Expt. 1: WAP to implement Dijkstra's algorithm for single-source shortest path in a weighted directed graph.
Expt. 2: WAP to find all-pairs shortest path using Floyd-Warshall algorithm.
Expt. 3: WAP to find inverse of a triangular matrix using divide and conquer strategy. **Expt. 4**: WAP to convert base (decimal/hexa) representation to modulo representation. **Expt. 5**: WAP to implement FFT.

SOFT COMPUTING: Programs may be implemented using Matlab/Python

Expt. 1: WAP to implement array operations in Python
Expt. 2: WAP to append strings using functions in Python
Expt. 3: Study of Neural Network Tool Box/ use of Library functions **Expt. 4**: Study of Fuzzy Logic Tool Box/ use of Library functions **Expt. 5**: WAP to perform opeartions on fuzzy sets.
Mini Project: Student has to do a project assigned from course contents in a group of two or three students. The team will have to demonstrate as well as have to give a presentation of the same.

COURSE CODE: MTCS204-18
COURSE NAME: LABORATORY 4; (BASED ON ELECTIVES)
CREDITS: 02, (Elective III + Elective IV)
HOURS: 2 hours for Lab based on Elective III & 2 hours for Lab based on Elective IV

ELECTIVE – III

DATA PREPARATION AND ANALYSIS LABORATORY: Programs to be implemented using WEKA.

Expt. 1: Using weka tool to explore the data.
Expt. 2: Using weka tool to do Parametric–
Means. **Expt. 3:** Using weka tool to do
Parametric -T-Test. **Expt. 4:** Using weka tool
to do Correlation analysis
Expt. 5: Preprocess the given data using weka tool.
Expt. 6: Apply different classification techniques to classify the given data set.
Expt. 7: Apply various clustering techniques to cluster the data.
Expt. 8: Apply various association rule mining algorithms.
Expt. 9: Implement classification using Decision tree.
Expt. 10: Apply Visualization methods using weka tool.

Mini Project: Student has to do a project assigned from course contents in a group of two or three students. The team will have to demonstrate as well as have to give a presentation of the same.

Secure Software Design and Enterprise Computing

1. Write a program to implement authentication to prevent various attacks.
2. Write a program to Limit or increasingly delay failed login attempts.
3. Create a scenario to test authentication of various security attacks.
4. Write a program to debug backdrop entry of given source code.
5. Write a program to debug HTTP headers, input fields, hidden fields, drop down lists, and other web components.
6. Write a program to test Input filtering via white list validation
7. Create a scenario to Set Up Your Own Private Cloud Storage.
8. Setup and configuration Various network services (DNS/ DHCP/ Terminal Services/ Clustering/ Web/ Email)
9. Design and build a database using an enterprise database system
10. Design and implement a directory-based server infrastructure in a heterogeneous systems environment.
11. An attacker wishing to execute SQL injection manipulates a standard SQL query to exploit non-validated input vulnerabilities in a database. Show different ways that this attack vector can be executed.
12. Install IBM Rhapsody Tool using NetBeans for Java and Junit (a unit testing tool).
13. Create a Unified Modelling Language (UML) Class diagram and a UML Sequence diagram using IBM's Rhapsody modelling tool.
14. Configure NetBeans to use JUnit and test code written for the classes and methods described in the UML.

COMPUTER VISION LABORATORY: Programs may be implemented using MATLAB/C/C++/Java/Python on binary/grayscale/color images.

Expt. 1: Implementation of basic image transformations:

a. Log
b. Power law
c. Negation

Expt. 2: Implementation the following:

a. Histogram processing
b. Histogram equalization/matching

Expt. 3: Implementation of piecewise linear transformations

a. Contrast stretching
b. Grey level slicing
c. Bit plane slicing

Expt. 4: Implementation of image enhancement/smoothing using

a. Linear (weighted and non-weighted filters)
b. Order statistics filters (Nonlinear filters)
    i. Mean
    ii. Median
    iii. Min
    iv. Max
    v. Average

Expt. 5: Implementation of image enhancement/sharpening using

a. Laplacian operators
b. Sobel's operators
c. Robert's cross operators

Expt. 6: Implement the 2D-DFT to obtain Fourier coefficients and reconstruct the image, i.e., IDFT.

Expt. 7: Implement image enhancement using Fourier low pass filters

a. Ideal
b. Butterworth
c. Gaussian

Expt. 8: Implement image enhancement using Fourier high pass filters

a. Ideal
b. Butterworth
c. Gaussian

Expt. 9: Implement algorithms to detect the following in an image

a. Point
b. Line
c. Boundary

Expt. 10: Implement Hough transform to detect a line.

Mini Project: Student has to do a project assigned from course contents in a group of two or three students. The team will have to demonstrate as well as have to give a presentation of the same.

ELECTIVE – IV

Human and Computer Interaction Lab: Programs may be implemented using C., C++, Python Expt. 1: To understand the trouble of interacting with computers - Redesign interfaces of home appliances.
Expt. 2: Design a system based on user-centered approach.
Expt.3: Understand the principles of good screen design.
Expt.4: Redesign existing Graphical User Interface with screen complexity
Expt.5: Implementation of Different Kinds of Menus **Expt. 6:** Implementation of Different Kinds of Windows **Expt. 7:** Design a system with proper guidelines for icons

Mini Project: Student has to do a project assigned from course contents in a group of two or three students. The team will have to demonstrate as well as have to give a presentation of the same.

GPU COMPUTING LABORATORY: Programs may be implemented using C. Expt. 1: Setting up Cuda environment.

Expt. 2: Program for parallel matrix multiplication with Cuda. **Expt. 3:** Program to demonstrate grids, blocks and threads. **Expt. 4:** Program for parallel radix sort.

Expt. 5: Demonstrate parallel reduction with Cuda.

Expt. 6: Program to demonstrate parallel programming for merging two lists.

Expt. 7: Program to demonstrate concept of global memory.

Expt. 8: Program to demonstrate concept of multi-GPUs.

Expt. 9: Program to demonstrate concept of profiling with parallel Nsight.

Expt. 10: Implementation of deep networks for image classification with GPU programming.

DIGITAL FORENSICS:Programs may be implemented usingtools mentioned below:

1. **SysInternals Suite**
   Microsoft System utilities for diagnosis of Windows systems

2. SANS SIFT

SANS Investigate Forensic Toolkit (SIFT)

3. Wireshark
   Network protocol analyzer
4. Trinity Rescue Kit
   A Linux based recovery and repair toolkit for Windows computers.
5. Kali Linux
   A Pen Test toolkit based on Linux. This should only be used to check your own equipment or equipment you have been asked to test.

Expt. 1: To Develop multifaceted cyber-crime scenario (cyber-crime and cyber-terrorism)

- Build a top-down systematic process
- Structure the team and players
- Use an integrated Framework (SI-FI)
- Integrate GOTS, COTS, and R&D Tools
- Use real investigators / compliment with technology experts
- Carefully collect all data, decisions actions during experiment
- Develop metrics for evaluation that match scenario
- Quantify results

Expt. 2: To perform packet-level analysis using appropriate tools (e.g., Wireshark, tcpdump). **Expt. 3:** To identify and extract data of forensic interest in diverse media (i.e., media forensics). **Expt. 4:** To identify, modify, and manipulate applicable system components within Windows, UNIX, or Linux (e.g., passwords, user accounts, files).

Expt. 5: To collect, process, package, transport, and store electronic evidence to avoid alteration, loss, physical damage, or destruction of data.

Expt. 6: To set up a forensic workstation.

Expt. 7: To use forensic tool suites (e.g., EnCase, Sleuthkit, FTK).

Expt. 8: To use virtual machines. (e.g., Microsoft Hyper-V, VMWare vSphere, Citrix XenDesktop/Server, Amazon Elastic Compute Cloud, etc.).

Expt. 9: To conduct forensic analyses in multiple operating system environments (e.g., mobile device systems).

Expt. 10: To analyze captured malicious code (e.g., malware forensics).

Expt. 11: To use binary analysis tools (e.g., Hexedit, command code xxd, hexdump).

Expt. 12: To implement one-way hash functions (e.g., Secure Hash Algorithm [SHA], Message Digest Algorithm [MD5]).

Expt. 13: To analyze anomalous code as malicious or benign.

Expt. 14: To identify obfuscation techniques.

Expt. 15: To interpret results of debugger to ascertain tactics, techniques, and procedures.