CURRICULUM & SYLLABUS

CHOICE BASED CREDIT SYSTEM (CBCS)

FOR

MASTER OF TECHNOLOGY (M.Tech.)

(2 Year Postgraduate Degree Programme)

IN

COMPUTER SCIENCE AND ENGINEERING
IN BIG DATA ANALYTICS

[w. e. f. 2021-2022]

FACULTY OF ENGINEERING AND TECHNOLOGY

SRM UNIVERSITY DELHI-NCR, SONEPAT

39, Rajiv Gandhi Education City, Sonepat

Haryana-131029

ENGINEERING POST GRADUATES EMPLOYABILITY ATTRIBUTES

Sound Knowledge and Skills of Basic Sciences & Engineering Sciences	An Engineer should be able to apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
Problem Formulation, Analysis & Solving	An Engineer should be able to identify, formulate, review research literature, and analyze complex Engineering problems reaching substantiated conclusions using principles of mathematics, natural sciences, and engineering sciences.
Design and Development of a Solution	An Engineer must be able to design solutions for complex Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
Investigation	An Engineer should use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
Modern Tools Usage	An Engineer should be able to create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
The Engineer and the Society	An Engineer should be able to apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional Engineering practice.
Environment and Sustainability	An Engineer must understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
Ethics	An Engineer should be able to apply ethical principles and commit to professional ethics and responsibilities and norms of the Engineering practice.
Individual and Teamwork	An Engineer should be able to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

Effective Communication	An Engineer should be able to communicate effectively on complex Engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
Project Management and Finance	An Engineer must demonstrate knowledge and understanding of the engineering and management principles and apply these to Engineering work environment, as a member and leader in a team, to manage projects and in multidisciplinary environments.
Lifelong Learning	An Engineer must recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

SRM UNIVERISTY DELHI-NCR, SONEPAT

FACULTY OF ENGINEERING AND TECHNOLOGY

ENGINEERING PROGRAMME EDUCATIONAL OBJECTIVES (EPEOs)

1. Advancement to a professional position by virtue of their knowledge, skills and attitude.
2. Recognition for solving engineering problems and developing design solutions that consider safety and sustainability.
3. Work as successful professionals in diverse engineering disciplines and enterprises;
4. Increasing responsibilities of technical and managerial leadership in their work organizations;
5. Professional development through a commitment to career-long learning.

ENGINEERING PROGRAMME LEARNING OUTCOMES (EPLOs)

1. An ability to identify, formulate, and solve real time engineering& socio-economic problems by applying principles of engineering, science, mathematics, humanities and social sciences
2. An ability to use the advanced skill enhancement techniques and modern engineering tools as per industry 4.0 necessary for engineering practice.
3. An ability to apply engineering design to produce solutions that meet specified needs with realistic considerations of environmental, ethical, health & safety and sustainability
4. An ability to adapt and work with multidisciplinary teams and communicate effectively;
5. An ability to function effectively on a team whose members together provide leadership, to create a collaborative environment, to establish goals and to execute plan tasks.
6. An understanding of professional and ethical responsibility;
7. An ability to acquire and apply new knowledge using appropriate learning strategies with inner quest to learn, unlearn and relearn.

MAPPING OF ENGINEERING PROGRAMME EDUCATIONAL OBJECTIVES

AND ENGINEERING PROGRAMME LEARNING OUTCOMES

ENGINEERING PROGRAMME EDUCATIONAL OBJECTIVES	ENGINEERING PROGRAMME LEARNING OUTCOMES
Advancement to a professional position by virtue of their knowledge, skills and attitude.	1. An ability to identify, formulate, and solve real time engineering and socio-economic problems by applying principles of engineering, science, mathematics, humanities and social sciences 2. An ability to use the advanced skill enhancement techniques and modern engineering tools as per industry 4.0 necessary for engineering practice.
Recognition for solving engineering problems and developing design solutions that consider safety and sustainability	2. An ability to use the advanced skill enhancement techniques and modern engineering tools as per industry 4.0 necessary for engineering practice. 3. An ability to apply engineering design to produce solutions that meet specified needs with realistic considerations of environmental, ethical, health & safety and sustainability
Work as successful professionals in diverse engineering disciplines	3. An ability to apply engineering design to produce solutions that meet specified needs with realistic considerations of environmental, ethical, health & safety and sustainability 4. an ability to adapt and work with multidisciplinary teams and communicate effectively;
Increasing responsibilities of technical and managerial leadership in their work organizations;	4. an ability to adapt and work with multidisciplinary teams and communicate effectively; 5. An ability to function effectively on a team whose members together provide leadership, to create a collaborative environment, to establish goals and to execute plan tasks. 6. an understanding of professional and ethical responsibility;
Professional development through a commitment to career-long learning.	6. an understanding of professional and ethical responsibility; 7. An ability to acquire and apply new knowledge using appropriate learning strategies with inner quest to learn, unlearn and relearn.

MAPPING MATRIX OF ENGINEERING PROGRAMME EDUCATIONAL OBJECTIVES AND ENGINEERING PROGRAMME LEARNING OUTCOMES (TABULAR FORMAT)

EPLO → / EPEO ↓	EPLO1	EPLO2	EPLO3	EPLO4	EPLO5	EPLO6	EPLO7
EPEO1	✓	✓					
EPEO2		✓	✓				
EPEO3			✓	✓			
EPEO4				✓	✓	✓	
EPEO5						✓	✓

M.TECH- COMPUTER SCIENCE ENGINEERING POST GRADUATE EMPLOYABILITY ATTRIBUTES

EA1. A Knowledge Base for Engineering: Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.

EA2. Problem Analysis: An ability to use appropriate knowledge and skills to identify, formulate, analyse, and solve complex engineering problems in order to reach substantiated conclusions

EA3. Investigation: An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data and synthesis of information in order to reach valid conclusions.

EA4. Design: An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.

EA5. Use of Engineering Tools: An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.

EA6. Individual and Teamwork: An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.

EA7. (Comm.) Communication skills: An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

EA8. Professionalism: An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.

EA9. Impact of Engineering on Society and the Environment: An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

EA10. Ethics and Equity: An ability to apply professional ethics, accountability, and equity.

EA11. Economics and Project Management: An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.

EA12. Life-long Learning: An ability to identify and to address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge

M.TECH- COMPUTER SCIENCE ENGINEERING PROGRAMME EDUCATIONAL OBJECTIVES (PEO)

The aim of the Programme is to produce data scientists with advanced knowledge and skills in the field of analytic, data architecture and the intelligence of data integration leading to big data.

PEO1. To possess competency in Data Analytics and innovative applications.

PEO2. To communicate effectively in leading and engaging multidisciplinary fields.

PEO3. To competent in research and development with potential to become data technopreneurs at global level

PEO4. To mould the students to become future engineers, scientists, researchers, and innovators and make substantial contributions to the society of Computer science and engineers.

PEO5. To provide students with the necessary skills and practical experience to fulfil their professional duties and responsibilities in teamwork, ethics, technical leadership, business acumen and lifelong learning.

M.TECH- COMPUTER SCIENCE ENGINEERING PROGRAMME LEARNING OUTCOMES (PLO)

PLO1. An ability to possess fundamental knowledge of Data Analytics.

PLO2. An ability to develop analytical and critical thinking by utilizing Data Analytics knowledge in solving various problems.

PLO3. An ability to design, implement and manage data resources using various Data Analytics technologies.

PLO4. An ability to show interpersonal and social skills.

PLO5. An ability to communicate ideas in appropriate forms, various mediums, and to a range of audiences in different situations effectively.

PLO6. An ability to take responsibility as a leader effectively.

PLO7. An ability to show enthusiasm, independent learning, intellectual, self-control, confident and professionalism in completing the task.

PLO8. An ability to develop entrepreneurial skills.

PLO9. An ability to show professional and ethical responsibility.

PLO10. An ability to have a good cognitive load management [discriminate and filter the available data] skills.

MAPPING MATRIX OF PROGRAMME EDUCATIONAL OBJECTIVES (PEO) AND PROGRAMME LEARNING OUTCOMES (PLO)

PEO ↓ / PLO →	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
PEO1	✓	✓								
PEO2			✓							
PEO3				✓						
PEO4					✓	✓	✓			
PEO5								✓	✓	✓

M.TECH –COMPUTER SCIENCE ENGINEERING
SPECIALIZATION: BIG DATA ANALYTICS
PROGRAMME STRUCTURE

The Computer Science and Engineering curriculum is geared towards providing the student with a strong foundation in the discipline and the tools and competence to address new and challenging problems that they have not seen before. In order to earn a M. Tech. degree in Big Data Analytics, a student should earn 69 credits in the course of their study. The credit requirements for their Programme of study is comprised of the following Programme Structure:

- **Professional Core Courses (PC):** The Professional core courses are aimed at providing the student with a solid foundation in their chosen field of study as per Industry 4.0 skills and knowledge.
- **Professional Electives (PE)-Programme specific Specialization Electives :**
  The Professional electives, on the other hand, provide the student with an option to gain exposure to different specializations within the discipline, or an opportunity to study one of the subfields in some depth.
- **Open Electives-Courses from other Technical areas and Emerging fields (OE):**
  The open subject elective courses provide the student wide latitude to pursue their interests, be it in humanities, arts, their chosen field of study, a related discipline, or use it towards developing a concentration in another field as a Minor.
  Students have choice to select Advanced graduate Subjects, from other technical areas and Emerging fields for acquiring sound holistic multidisciplinary knowledge & skills. The students can elect to consider these additional options upon joining the university.
- **Live Project (LP)**
  Live Projects is being introduced for all Engineering disciplines to develop an ability to apply skills and knowledge attained to solve real life complex problems.The students will build a big data ecosystem using tools and methods form the earlier courses in this specialization.
- **Practical (P):**
  The labs are fully furnished and well equipped with latest software's to conduct practical as per the requirement of the University Curriculum.

M.TECH-COMPUTER SCIENCE ENGINEERING
SPECIALIZATION: BIG DATA ANALYTICS
PROGRAMME STRUCTURE

Category of Courses	Category	No. of Courses
Professional Core Courses	PC	7
Professional Electives- **Programme Specific Specialization Electives**	PE	5
Open Electives- **Courses from Other Areas & Emerging Fields**	OE	1
Live Projects	LP	4
Practicals	P	6
TOTAL		23

MASTER OF TECHNOLOGY

(COMPUTER SCIENCE & ENGINEERING)

SPECIALIZATION: BIG DATA ANALYTICS

POST GRADUATION COURSE

PROGRAMME CREDIT STRUCTURE SEMESTER WISE

SEMESTER → / COURSE CATEGORY ↓	DENOTE	I	II	III	IV	TOTAL	%AGE
PROFESSIONAL CORE	PC	16	8	4	0	28	**35**
PROGRAMME ELECTIVE	PE	4	8	8	0	20	**25**
OPEN ELECTIVE	OE	0	3	0	0	3	**3.75**
LIVE PROJECTS	LP	0	3	8	12	23	**28.75**
PRACTICALS	P	4	2	0	0	6	**7.5**
TOTAL		**24**	**24**	**20**	**12**	**80**	100.0

COURSE CURRICULUM

MASTER OF TECHNOLOGY

(COMPUTER SCIENCE& ENGINEERING)

POST GRADUATION COURSE

PROGRAMME COURSES SRUCTURE SEMESTERWISE

SEMESTER – I

COURSE CODE	COURSE	CATEGORY	HOURS PER WEEK				CREDITS
			L	T	P	TOTAL HOURS	
21MBDA101	ADVANCED OPERATING SYSTEMS	PC	3	1	0	4	4
21MBDA102	ADVANCED DATA STRUCTURES & ALGORITHMS	PC	3	1	0	4	4
21MBDA103	ADVANCED HADOOP	PC	3	1	0	4	4
21MBDA104	RESEARCH METHODOLOGY AND IPR	PC	4	0	0	4	4
21MBDA11X	PROFESSIONAL ELECTIVE – I	PE	4	0	0	4	4
21MBDA121	ADVANCED DATA STRUCTURES & ALGORITHMS LAB	P	0	0	2	2	1
21MBDA122	ADVANCED HADOOP LAB	P	0	0	2	2	1
21MBDA123	ADVANCED OPERATING SYSTEM LAB	P	0	0	2	2	1
21MBDA124	TECHNICAL TRAINING	P	0	0	2	2	1
TOTAL			**17**	**3**	**8**	**28**	**24**

MASTER OF TECHNOLOGY

(COMPUTER SCIENCE& ENGINEERING)

POST GRADUATION COURSE

PROGRAMME COURSES SRUCTURE SEMESTERWISE

SEMESTER-II

COURSE CODE	COURSE	CATEGORY	HOURS PER WEEK				CREDITS
			L	T	P	TOTAL HOURS	
21MBDA201	BIG DATA ANALYTICS	PC	3	1	0	4	4
21MBDA202	ADVANCED DATABASE MANAGEMENT SYSTEM	PC	3	1	0	4	4
21MBDA203	LIVE PROJECT-I	LP	0	0	6	6	3
21MBDA21X	PROFESSIONAL ELECTIVE – II	PE	4	0	0	4	4
21MBDA23X	PROFESSIONAL ELECTIVE – III	PE	4	0	0	4	4
21MBDA2XX	OPEN ELECTIVE-I	OE	3	0	0	3	3
21MBDA221	IBM COGNOS LAB	P	0	0	2	2	1
21MBDA222	SEMINAR	P	0	0	2	2	1
TOTAL			**17**	**2**	**10**	**29**	**24**

MASTER OF TECHNOLOGY

(COMPUTER SCIENCE& ENGINEERING)

POST GRADUATION COURSE

PROGRAMME COURSES SRUCTURE SEMESTERWISE

SEMESTER-III

COURSE CODE	COURSE	CATEGORY	HOURS PER WEEK				CREDITS
			L	T	P	TOTAL HOURS	
21MBDA301	DATA ANALYSIS AND REGRESSION	PC	4	0	0	4	4
21MBDA302	LIVE PROJECT – II	LP	0	0	8	8	4
21MBDA31X	PROFESSIONAL ELECTIVE – IV	PE	4	0	0	4	4
21MBDA32X	PROFESSIONAL ELECTIVE-V	PE	4	0	0	4	4
21MBDA311	DISSERTATION PART-I	LP	0	0	8	8	4
TOTAL			**12**	**0**	**16**	**28**	**20**

MASTER OF TECHNOLOGY

(COMPUTER SCIENCE& ENGINEERING)

POST GRADUATION COURSE

PROGRAMME COURSES SRUCTURE SEMESTERWISE

SEMESTER-IV

COURSE CODE	COURSE	CATEGORY	HOURS PER WEEK				CREDITS
			L	T	P	TOTAL HOURS	
21MBDA401	DISSERTATION PART– II	LP	0	0	24	24	12
TOTAL			**0**	**0**	**24**	**24**	**12**

LIST OF PROFESSIONAL ELECTIVE COURSES (PEs)

S. No.	COURSE CODE	COURSE	L	T	P	C
PROFESSIONAL ELECTIVE - I						
1	21MBDA111	ADVANCED EVOLUTIONARY ALGORITIHMS	4	0	0	4
2	21MBDA112	ARTIFICIAL INTELLIGENCE AND NEURAL NETWORKS	4	0	0	4
3	21MBDA113	DISTRIBUTED SYSTEMS	4	0	0	4
PROFESSIONAL ELECTIVE -II						
3	21MBDA211	DATA SCIENCE	4	0	0	4
4	21MBDA212	ARCHITECTURE OF HIGH-PERFORMANCE COMPUTER SYSTEMS	4	0	0	4
5	21MBDA213	DATA WAREHOUSING & DATA MINING	4	0	0	4
6	21MBDA214	SOFTWARE RELIABILITY & FAULT TOLERANT SYSTEM	4	0	0	4
PROFESSIONAL ELECTIVE-III						
7	21MBDA231	ADHOC & SENSOR NETWORK	4	0	0	4
8	21MBDA232	COMPILER FOR HPC	4	0	0	4
9	21MBDA233	ADVANCED MACHINE LEARNING	4	0	0	4
10	21MBDA234	MATHEMATICAL FOUNDATIONS OF COMPUTER SCIENCE	4	0	0	4
PROFESSIONAL ELECTIVE-IV						
11	21MBDA311	OPTIMIZATION TECHNIQUES	4	0	0	4
12	21MBDA312	CLOUD COMPUTING	4	0	0	4
13	21MBDA313	COMPUTER NETWORK AND DISTRIBUTED SYSTEMS	4	0	0	4
PROFESSIONAL ELECTIVE-V						

S. No.	COURSE CODE	COURSE	L	T	P	C
14	21MBDA321	APPLIED WIRELESS SENSOR NETWORKS	4	0	0	4
15	21MBDA322	SOFT COMPUTING	4	0	0	4
16	21MBDA323	COMPUTER VISION	4	0	0	4

LIST OF OPEN ELECTIVE COURSES (OEs)

S. No.	COURSE CODE	COURSE	L	T	P	C
1	21MBDA222	QUANTITATIVE TECHNIQUES	3	0	0	3
2	21MBDA224	INTRODUCTION TO BIOINFORMATICS	3	0	0	3
3	21MBDA225	BUSINESS ANALYTICS	3	0	0	3
4	21MBDA226	DESIGN OF EMBEDDED SYSTEMS	3	0	0	3

EVALUATION SCHEMES

The bifurcation of Continuous Evaluation (Internal) and End Semester Evaluation marks are as under:

S.No	Course	Continuous Evaluation (Internal)	End Semester
1	Professional (PC) : Theory	40	60
2	Professional Electives –Programme Specific Electives-Theory	40	60
3	Open Electives-Theory	40	60
4	Humanities & Social Sciences including Management Courses (HSS)-Theory	40	60
5	Practical /Workshop - Practical	60	40
6	Skill Enhancement Courses (SEC)	70	30
7	Technical Enhancement Courses (TEC)	70	30
8	Live Projects & Industry Visits (LP/IV) and Internship	60	40
9	Dissertation/Project	60	40

SEMESTER-I

ADVANCED OPERATING SYSTEMS	
Course Code: 21MBDA101	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	
Pre-Requisites: UG level course in Operating System	

COURSE OBJECTIVE

- To provide introduction to operating system design and concept of process, process lifecycle and scheduling approaches.
- To understand the services provided multiprocessor operating system.
- To understand the structure and organization of the file system.
- To understand what is File system and how processes are synchronized and scheduled.
- To understand different approaches to memory management

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand advanced concepts in operating systems.
- Learn principles of Distributed and multiprocessor operating systems.
- Understand File System Interface and Implementation -Access methods, Directory Structure, Protection.
- Understand File System Structure, Allocation methods, Free-space Management, Directory.
- Learn Memory Management, Directory Implementation, Efficiency and Performance.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	✓
CO5					✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**INTRODUCTION TO OPERATING SYSTEMS:**

UNIT NUMBER	COURSE CONTENTS
	Operating System Introduction, Structures - Simple Batch, Multi programmed, time-shared, Personal Computer, Parallel, Distributed Systems, Real-Time Systems, System components, Operating-System services, System Calls
UNIT-II	**PROCESS MANAGEMENT:** Process Concepts, Operations on Processes, Cooperating Processes, Threads, Inter Process Communication, Process Scheduling, Scheduling Algorithms, Multiple - Processor Scheduling. Thread Scheduling. Process Synchronization & Deadlocks: The Critical Section Problem, Semaphores, And Classical Problems Of Synchronization, Critical Regions, Monitors, Deadlocks,-System Model, Deadlocks Characterization, Methods For Handling Deadlocks, Deadlock- Prevention, Avoidance, Detection,& Recovery from Deadlocks
UNIT-III	**MEMORY MANAGEMENT & FILE SYSTEM:** Logical versus Physical Address Space, Swapping, Contiguous Allocation, Paging, Segmentation, Segmentation with Paging. Demand Paging, Performance of Demanding Paging, Page Replacement, Page Replacement Algorithm, Allocation of Frames, Thrashing. File System Interface and Implementation -Access methods, Directory Structure, Protection, File System Structure, Allocation methods, Free-space Management, Directory Management, Directory Implementation, Efficiency and Performance.
UNIT-IV	**DISTRIBUTED OPERATING SYSTEMS:** Distributed System Goals, Types of Distributed Systems, and Styles & Architecture Of Distributed Systems, Threads, Virtualization, Clients, Servers, Code Migration, and Communication in Distributed Systems.
UNIT-V	**DISTRIBUTED SYSTEMS & SYNCHRONIZATION:** Clock Synchronization, Logical Clocks, Mutual Exclusion, Global Positioning Of Nodes, Data-Centric Consistency Models, Client-Centric Consistency Models, Consistency Protocols. Fault Tolerance, Security: Introduction to Fault Tolerance, Process Resilience, Reliable Client Server Communication, Reliable Group Communication, Distributed Commit, Recovery, Secure Channels, Access Control, Security Management. Case Study: Over View of UNIX, LINUX, Windows NT, Android and IOS Operating systems.

TEXT BOOKS

- Silberschatz& Galvin, 'Operating System Concepts',Wiley.
- "DISTRIBUTED SYSTEMS", Second edition, Andrew S.Tanenbaum, Maarten Vanteen.
- William Stallings-"Operating Systems"- 5th Edition -PHI
- Charles Crowley, 'Operating Systems: A Design-Oriented Approach', Tata Hill Co., 1998 edition.
- Andrew S.Tanenbaum, 'Modern Operating Systems', 2nd edition, 1995,PHI.

REFERENCE BOOKS

- Advanced Concepts in Operating systems. Distributed, Database and Multiprocessor operating systems, Mukesh singhal, Niranjan G.Shivaratri, Tata McGraw HillEdition.
- Dhamdhere, "Operating Systems - A concept based approach", 2nd Edition, TMH,2006.
- Daniel P Bovet and Marco Cesati, "Understanding the Linux Kernel ", 3rd Edition,' Reilly,2005.

ADVANCED DATA STRUCTURES AND ALGORITHMS	
Course Code: 21MBDA102	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	
Pre-Requisites: UG level course in Data Structures	

COURSE OBJECTIVE

- To introduce to the advanced methods of designing and analyzing hashing algorithms.
- To learn 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.
- To understand different classes of problems concerning their computation difficulties.
- To come up with analysis of efficiency and proofs of correctness.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand the implementation of symbol table using hashing techniques.
- 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.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓	✓	
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**DICTIONARIES:**

UNIT NUMBER	COURSE CONTENTS
	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.
UNIT-II	**BASIC ALGORITHMS:** Asymptotic notation, recursion, divide-and-conquer paradigm, basic data structures; possibly fast Fourier Transform. Need for Randomizing Data Structures and Algorithms, Search and Update Operations on Skip Lists, Probabilistic Analysis of Skip Lists, Deterministic Skip Lists
UNIT-III	**ALGORITHMS AND TREES:** Dynamic programming, graph algorithms: DFS, BFS, topological sorting, shortest path algorithms, network flow problems. Binary Search Trees, AVL Trees, Red Black Trees, 2-3 Trees, B-Trees, Splay Trees
UNIT-IV	**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.
UNIT-V	**PROGRAMMING:** String algorithms, suffix trees, geometric algorithms.

TEXT BOOKS

- Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, 2nd Edition, Pearson,2004.
- M T Goodrich, Roberto Tamassia, Algorithm Design, John Wiley, 2002.
- Jeff Edmonds, "How to Think about Algorithms", Cambridge University Press, 2008.

REFERENCE BOOKS

- Thomsas H. Coremen et.al "Introduction to Algorithms" Third Edition, PHI, 2009.
- Parag Himanshu Dave " Design and Analysis of Algorithm" First Edition, Pearson Education, 2008.

ADVANCED HADOOP	
Course Code: 21MBDA103	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	
Pre-Requisites: NIL	

COURSE OBJECTIVES

- To teach how to capture structured, semi structured and unstructured data from several different data source types using IBM Info Sphere BigInsights.
- To learn to perform manipulations and analysis on the gathered data. This course will focus on using the Graphical User Interface of Info Sphere Big Insights to collect, manipulate, analyze, view and export data.
- To understand the problems associated with batch learning and online learning
- To implement various ways of selecting suitable model parameters
- To understand machine learning libraries and mathematical and statistical tools with modern technologies like Hadoop and Mapreduce.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After the completion of course, students would be able to:

- Identify the characteristics of datasets and compare the trivial data and big data for various applications.
- Select and implement machine learning techniques and computing environment that are suitable for the applications under consideration.
- Solve problems associated with batch learning and online learning, and the big data characteristics such as high dimensionality, dynamically growing data and in particular scalability issues.
- Recognize and implement various ways of selecting suitable model parameters for different machine learning techniques.
- Integrate machine learning libraries and mathematical and statistical tools with modern technologies like Hadoop and Mapreduce.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓	✓		
CO3			✓		
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**INTRODUCTION:** Motivation for Hadoop, Big Data Characteristics, Challenges with traditional system, Hadoop's History, Core Hadoop Concepts, Hadoop Clusters, Installation and Configuration
UNIT-II	**INSTALLATION:** Setup, Configuration, Administration of a Hadoop Cluster, Exercise - Hadoop Configuration
UNIT-III	M**APREDUCE:** GPFS, FPO, Big Insights Web Console Security, Introduction to MapReduce, Adaptive MapReduce, Exercise - MapReduce
UNIT-IV	**OOZIE:** Overview of Oozie, Exercise - Controlling Workloads with Oozie
UNIT-V	**PRACTICAL ASPECTS:** Managing Job Execution, Moving Data into Hadoop, Exercise - Using Flume for Data Loading

TEXTBOOKS
• Data Analytics with Hadoop: An Introduction for Data Scientists • Programming Hive: Data Warehouse and Query Language for Hadoop

RESEARCH METHODOLOGY AND IPR	
Course Code: 21MBDA104	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: Research Structures	

COURSE OBJECTIVE

- To make the students aware of their rights for the protection of their invention done in their project work.
- To get registration in our country and foreign countries of their invention, designs and thesis or theory written by the students during their project work and for this they must have knowledge of patents, copy right, trademarks, designs and information Technology Act.
- To demonstrate with products and ask the student to identify the different types of IPR's
- To learn about Computer, Information Technology
- To learn research implementation.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would 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.
- Understand research implementation.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓	✓		
CO3			✓		
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**INTRODUCTION:**

UNIT NUMBER	COURSE CONTENTS
	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-II	**APPROACHES:** Effective literature studies approaches, analysis Plagiarism, Research ethics.
UNIT-III	**TECHNICAL WRITING:** 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-IV	**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-V	**PATENT RIGHTS:** Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. 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.

TEXT BOOKS

- Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
- Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
- Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
- Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.

REFERENCE BOOKS

- Mayall, "Industrial Design", McGraw Hill,1992.
- Niebel, "Product Design", McGraw Hill,1974.
- Asimov, "Introduction to Design", Prentice Hall,1962.

ADVANCED DATA STRUCTURES & ALGORITHMS LAB	
Course Code: 21MBDA121	Continuous Evaluation: 40 Marks
Credits: 1	End Semester Examination: 60 Marks
L T P : 0 0 2	
Prerequisite: Knowledge of C/C++ Programming	

COURSE OBJECTIVE

To introduce advanced methods of designing and analyzing algorithms.

- 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.
- To understand different classes of problems concerning their computation difficulties.
- To come up with analysis of efficiency and proofs of correctness.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand the implementation of symbol table using hashing techniques.
- 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.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3		✓	✓		
CO4				✓	
CO5					✓

LIST OF PROGRAMS

1. Write a Program that uses functions to perform the following operations on singly linked list i) Creation ii) Insertion iii) Deletion iv) Traversal.

2. Write a Programme that uses functions to perform the following operations on doubly linked list i) Creation ii) Insertion iii) Deletion iv) Traversal.
3. Write a Program that uses functions to perform the following operations on circular linked List i) Creation ii) Insertion iii) Deletion iv) Traversal.
4. Write a Program that implement stack (its operations) using i) Arrays ii) Linked list(Pointers).
5. Write a Program that implement Queue (its operations) using i) Arrays ii) Linked list(Pointers).
6. Write a Program that implement Circular Queue using arrays. ii) Write a Programme that uses both recursive and non recursive functions to perform the following searching operations for a Key value in a given list of integers: a) Linear search b) Binary search.
7. Write a Program that implements the following sorting i) Bubble sort ii) Selection sort iii)Quick sort

TEXT BOOKS

- Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, 2nd Edition, Pearson, 2004.
- M T Goodrich, Roberto Tamassia, Algorithm Design, John Wiley, 2002.
- Jeff Edmonds, "How to Think about Algorithms", Cambridge University Press, 2008.

REFERENCE BOOKS

- Thomsas H. Coremen et.al "Introduction to Algorithms" Third Edition, PHI, 2009.
- Parag Himanshu Dave " Design and Analysis of Algorithm" First Edition, Pearson Education, 2008.

ADVANCED HADOOP LAB	
Course Code: 21MBDA122	Continuous Evaluation: 40 Marks
Credits: 1	End Semester Examination: 60 Marks
L T P : 0 0 2	
Prerequisite: Knowledge of C/C++ Programming	

COURSE OBJECTIVES

- To learn about structured, semi structured and unstructured data from several different data source types using IBM Info Sphere Big Insights
- To manipulate and analyse the gathered data. This course will focus on using the Graphical User Interface of Info Sphere Big Insights to collect, manipulate, analyze, view and export data.
- To understand the problems associated with batch learning and online learning.
- To implement various ways of selecting suitable model parameters
- To understand machine learning libraries and mathematical and statistical tools with modern technologies like Hadoop and Mapreduce.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Identify the characteristics of datasets and compare the trivial data and big data for various applications.
- Select and implement machine learning techniques and computing environment that are suitable for the applications under consideration.
- Solve problems associated with batch learning and online learning, and the big data characteristics such as high dimensionality, dynamically growing data and in particular scalability issues.
- Recognize and implement various ways of selecting suitable model parameters for different machine learning techniques.
- Integrate machine learning libraries and mathematical and statistical tools with modern technologies like Hadoop and Mapreduce.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5					✓

LIST OF PROGRAMS

1. Implement the following Data structures in Java:
   - Linked Lists
   - Stacks
   - Queues
   - Set
   - Map

2. (i)Perform setting up and Installing Hadoop in its three operating modes: Standalone, Pseudo distributed, Fully distributed. (ii)Use web based tools to monitor your Hadoop setup.

3. Implement the following file management tasks in Hadoop:
   • Adding files and directories • Retrieving files • Deleting files Hint: A typical Hadoop workflow creates data files (such as log files) elsewhere and copies them into HDFS using one of the above command line utilities.

4. Run a basic Word Count Map Reduce Programme to understand Map Reduce Paradigm.

5. Write a Map Reduce Program that mines weather data. Weather sensors collecting data every hour at many locations across the globe gather a large volume of log data, which is a good candidate for analysis with MapReduce, since it is semi structured and record-oriented.

6. Implement Matrix Multiplication with Hadoop Map Reduce.

7. Install and Run Pig then write Pig Latin scripts to sort, group, join, project, and filter your data.

8. Install and Run Hive then use Hive to create, alter, and drop databases, tables, views, functions, and indexes.

TEXT BOOKS
• Data Analytics with Hadoop: An Introduction for Data Scientists
• Programming Hive: Data Warehouse and Query Language for Hadoop

REFERENCE BOOKS
• Hadoop: The Definitive Guide: Storage and Analysis at Internet Scale
• Hadoop Operations: A Guide for Developers and Administrators

ADVANCED OPERATING SYSTEM LAB	
Course Code: 21MBDA123	Continuous Evaluation: 40 Marks
Credits: 1	End Semester Examination: 60 Marks
L T P : 0 0 2	
Prerequisite: C/C++, UNIX Programming	

COURSE OBJECTIVES

- To provide introduction to operating system design and concept of process, process lifecycle and scheduling approaches.
- To understand the services provided by and the design of an operating system.
- To understand the structure and organization of the file system.
- To understand what a process is and how processes are synchronized and scheduled.
- To understand different approaches to memory management

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand advanced concepts in operating systems.
- Learn principles of Distributed and multiprocessor operating systems.
- Understand File System Interface and Implementation -Access methods, Directory Structure, Protection.
- Understand File System Structure, Allocation methods, Free-space Management, Directory.
- Learn Management, Directory Implementation, Efficiency and Performance.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5					✓

LIST OF PROGRAMS

1. Write a C Program to simulate the following non-preemptive CPU scheduling algorithms to find turnaround time and waiting time. a) FCFS b) SJF c) Round Robin d) Priority.
2. Write a C Program to simulate all the processes in the system are divided into two categories – system processes and user processes. System processes are to be given higher priority than user processes.

3. Write a Program to implement FCFS scheduling for the processes in each queue.
4. Write a C Programme to simulate the following file allocation strategies. a) Sequential b) Indexed c) Linked
5. Write a C Program to simulate the MVT and MFT memory management techniques.
6. Write a C Program to simulate the following contiguous memory allocation techniques a) Worst-fit b) Best-fit c) First-fit
7. Write a C Program to simulate paging technique of memory management.
8. Write a C Program to simulate the following file organization techniques a) Single level directory b) Two level directory c) Hierarchical
9. Write a C Program to simulate Bankers algorithm for the purpose of deadlock avoidance.

TEXT BOOKS

- Silberschatz& Galvin, 'Operating System Concepts',Wiley.
- "DISTRIBUTED SYSTEMS", Second edition, Andrew S.Tanenbaum, Maarten Vanteen.
- William Stallings-"Operating Systems"- 5th Edition -PHI
- Charles Crowley, 'Operating Systems: A Design-Oriented Approach', Tata Hill Co., 1998 edition.
- Andrew S.Tanenbaum, 'Modern Operating Systems', 2nd edition, 1995,PHI.

REFERENCE BOOKS

- Advanced Concepts in Operating systems. Distributed, Database and Multiprocessor operating systems, Mukesh singhal, Niranjan G.Shivaratri, Tata McGraw HillEdition.
- Dhamdhere, "Operating Systems - A concept based approach", 2nd Edition, TMH,2006.
- Daniel P Bovet and Marco Cesati, "Understanding the Linux Kernel" , 3rd Edition,' Reilly,2005.

SEMESTER-II

BIG DATA ANALYTICS	
Course Code: 21MBDA201	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	
Prerequisite: C/C++, DBMS	

COURSE OBJECTIVE

- To provide an overview of an exciting growing field of big data analytics
- To introduce the tools required to manage and analyze big data like Hadoop, NoSQL MapReduce
- To teach the fundamental techniques and principles in achieving big data analytics with scalability and streaming capability.
- To enable students to have skills that will help them to solve complex real-world problems in for decision support.
- To understand Pig, Hive, Pig Latin.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand the vision of Big Data from a global context.
- Understand and apply Hadoop in Market perspective of Big Data.
- Apply and analyze architecture and APIs with use of Devices, Gateways and Data Management in Big data.
- Evaluate the application of Big Data in Industrial and Commercial Building Automation, evaluating Big Data performance using MapReduce and Real-World Design Constraints.
- Build and create state of the art architecture in Big Data. Creating projects and research activities based on Pig, Hive, Pig Latin.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**BIG DATA** Definition with Real Time Examples, How BigData is generated with Real Time Generation, Use of BigData-How Industry is utilizing BigData, Future of BigData.
UNIT-II	**HADOOP** Why Hadoop? What is Hadoop? Hadoop vs RDBMS, Hadoop vs BigData, Brief history of Hadoop, Problems with traditional large-scale systems, Requirements for a new approach, Anatomy of a Hadoop cluster.
UNIT-III	**HDFS** Concepts & Architecture, Data Flow (File Read , File Write), Fault Tolerance, Shell Commands, Java Base API, Data Flow Archives, Coherency, Data Integrity, Role of Secondary Name Node, Zookeeper
UNIT-IV	**MAPREDUCE** Theory, Data Flow (Map – Shuffle - Reduce), MapRed vs MapReduce APIs, Programming Mapper, Reducer, Combiner, Partitioner, Implementation of Mahout, R, Sqoop, Yarn, Flume, Ambari, Oozie
UNIT-V	**HIVE AND PIG:** **Hadoop Eco systems:** Hive – Architecture - data type - File format – HQL – SerDe - User defined functions - Pig: Features – Anatomy - Pig on Hadoop - Pig Philosophy - Pig Latin overview - Data types - Running pig - Execution modes of Pig - HDFS commands - Relational operators - Eval Functions - Complex data type - Piggy Bank - User defined Functions - Parameter substitution - Diagnostic operator. Jasper Report: Introduction - Connecting to Mongo DB - Connecting to Cassandra - Introduction to Machine learning: Linear Regression – Clustering - Collaborative filtering - Association rule mining - Decision tree.

TEXT BOOKS

- Gelman, Andrew, and Jennifer Hill. Data Analysis Using Regression and Multilevel/Hierarchical Models. 1st ed. Cambridge, UK: Cambridge University Press, 2006. ISBN:9780521867061.
- Gelman, Andrew, John B. Carlin, Hal S. Stern, and Donald B. Rubin. Bayesian Data Analysis. 2nd ed. New York, NY: Chapman & Hall, 2003. ISBN:9781584883883
- Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data" by EMC Education Services

REFERENCE BOOKS

- Analytics: Data Science, Data Analysis and Predictive Analytics for Business" by Daniel Covington.
- Machine Learning for Big Data: Hands-On for Developers and Technical Professionals" by Jason Bell.

ADVANCED DATABASE MANAGEMENT SYSTEM	
Course Code: 21MBDA202	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 3 1 0	
Pre-Requisites: UG level course in DBMS	

COURSE OBJECTIVE

- To understand the data and various databases used for handling them.
- To develop an understanding of distributed database systems.
- To learn how the object- oriented concepts are incorporated in DBMS.
- To design and build a simple database system and demonstrate competence with the fundamental tasks involved with modelling, designing, and implementing a DBMS.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Learn and understand the requirement of relational and NoSQL databases.
- Understand the concepts of distributed databases.
- Understand and apply the concepts of NoSQL Databases.
- Understand the role of parallelism in DBMS.
- Emphasis on how to organize, maintain and retrieve - efficiently, and effectively - information from a DBMS.
- Understand the concepts of multimedia databases with the emerging technologies.

COURSE LEARNING OUTCOME (CLO) - COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
CO1	✓					
CO2		✓	✓			
CO3				✓		
CO4					✓	✓

COURSE CONTENTS

UNIT NUMBER	CONTENTS
UNIT-I	**EVOLUTION OF DATABASES** Introduction to Structured Data, Semi-Structured and Unstructured Data, Databases for handling these data, History of all the Databases with various application areas, Motivation for Relational Databases and NoSQL Databases, Moving from Relational Database to NoSQL databases

UNIT-II	**DISTRIBUTED DATABASES** Distributed databases: homogeneous and heterogeneous databases, distributed data storage, distributed transactions, commit protocols, concurrency control in distributed databases, distributed query processing, heterogeneous distributed databases. NoSQL Databases, Categories of NoSQL Databases (Key-Value, Column-Oriented Databases, Document Databases, Graph Databases).
UNIT-III	**OBJECT- ORIENTED AND PARALLE DATABASES:** Overview of Object-Oriented Concepts, Object Identity, Object Structure, Type Constructor, Encapsulation of Operations, Methods and Persistence; Parallel databases: Introduction, I/O parallelism, interquery parallelism, intraquery parallelism, intra-operational parallelism, inter-operational parallelism, design of parallel systems.
UNIT-IV	**XML QUERY PROCESSING:** XML query languages: XML-QL, Lorel, Quilt, XQL, XQuery, and Approaches for XML query processing, Query processing on relational structure and storage schema, XML database management system.
UNIT-V	**ENHANCED DATA MODELS: FOR ADVANCED APPLICATIONS:** Active database concepts, temporal database concepts, spatial databases: concept and architecture, deductive databases and query processing, mobile databases, Geographic Information Systems (GIS).

TEXT BOOKS

- Elmsari and Navathe, Fundamentals of Database Systems.
- Principles of Distributed Database Systems, Second Edition, M. Tamer Ozsu Patrick Valduriez.
- Raakrishnan and Gehrke, Database Management Systems, References Books.

REFERENCE BOOKS

- Korth, Silberschatz, Sudarshan, Database System Concepts.
- Rob and Coronel, Database Systems: Design, Implementation and Management.
- Date and Longman, Introduction to Database Systems.

LIVE PROJECT-I	
Course Code: 21MBDA203	Continuous Evaluation: 60 Marks
Credits: 3	End Semester Examination: 40 Marks
L T P : 0 0 6	
Prerequisite: Basics of Programming	

COURSE OBJECTIVE

- To work on real world practical Big Data projects that you are passionate about.
- To develop a strong foundation in Big Data, math - this includes linear algebra, calculus, statistics and probability.
- To become a good developer with solid Big Data Analytics and computer science abilities.
- To read scientific papers and apply them or redo the Big Data Analytics experiments on your own.
- To deploy models with elegant and reusable Hadoop code, IBM and COGNOS software.

COURSE LEARNING OUTCOMES (CLO)

The Live Project has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand the vision of Big Data from a global context.
- Understand and apply Hadoop in Market perspective of Big Data.
- Implement, Apply and analyze architecture and APIs with use of Devices, Gateways and Data Management in Big data.
- Evaluate the application of Big Data in Industrial and Commercial Building Automation, evaluating Big Data performance using MapReduce and Real-World Design Constraints.
- Build and create state of the art architecture in Big Data with IBM COGNOS software

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5					✓

BIG DATA ANALYTICS LIVE PROJECT

Welcome to the Live Project for Big Data Analytics! In this culminating project, you will build a big data ecosystem using tools and methods form the earlier courses in this specialization. You will analyze a data set simulating big data generated from a large number of users who are playing our imaginary game "Catch the Pink Flamingo". During the Live Project, you will walk through the typical big data science steps for acquiring,

exploring, preparing, analyzing, and reporting. In the first two weeks, we will introduce you to the data set and guide you through some exploratory analysis using tools such as Splunk and Open Office. Then we will move into more challenging big data problems requiring the more advanced tools you have learned including KNIME, Spark's MLLib and Gephi. As a result of our collaboration with IBM, a software company focus on analyzing machine-generated big data, learners with the top projects will be eligible to present to IBM and meet IBM recruiters and engineering leadership.

Activity	DESIRED PROGRESS– SEMESTER II
Task 1	Students should be able to understand and implement the Big data concepts studied in Semester 1
Task 2	Students should apply the gained knowledge in implementing real time and live projects.
Task 3	Students should regularly report to their project mentors and show the project progress.
Task 4	Students should incorporate real time Big data problem domains in their live projects.
Task 5	Students should show seventy percent project progress by the end of the semester.

IBM COGNOS LAB	
Course Code: 21MBDA221	Continuous Evaluation: 40 Marks
Credits: 1	End Semester Examination: 60 Marks
L T P : 0 0 2	
Prerequisite: Knowledge of Machine Learning	

COURSE OBJECTIVES

- To identify the basics of IBM Cognos Analytics - Reporting
- To create and generate a report
- To work with dimensionally-modeled relational and dimensional data sources
- To aggregate data in list reports
- To add repeated information to list reports

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students will have:

- Ability to represent data graphically.
- Ability to Create chart reports
- Ability to Work with gauge charts and pie charts
- Ability to Customize charts
- Ability to Focus reports using filters

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓	✓	
CO4				✓	
CO5					✓

LIST OF PROGRAMS

1. What is IBM Cognos Analytics - Reporting?
2. Dimensionally modeled relational data
3. Use personal data sources and data modules
4. Examine list reports
5. Aggregate fact data

6. Multiple facts and repeated information
7. Add repeated information to reports
8. Create crosstab reports
9. Customize reports with conditional formatting
10. Drill-through definitions
11. Work with crosstab data
12. Create discontinuous crosstab reports
13. Create visualization reports
14. Focus reports using filters
15. Focus reports using prompts
16. Use calculations
17. Enhance report layout
18. Use additional report-building techniques

TEXT BOOKS

- Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
- Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009.

REFERENCE BOOKS

- Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.
- Pattern Recognition and Machine Learning, Book by Christopher Bishop.

SEMINAR	
Course Code: 21MBDA222	Continuous Evaluation: 40 Marks
Credits: 1	End Semester Examination: 60 Marks
L T P : 0 0 2	
Prerequisite: NIL	

COURSE OBJECTIVES

- To learn how to carry out literature search.
- To learn the art of technical report writing.
- To learn the art of verbal communication with the help of modern presentation techniques.
- To learn the ability to ask disciplinarily appropriate questions of the material
- To learn the ability to evaluate sources.

COURSE LEARNING OUTCOMES

The syllabus adhere to all Bloom's Taxonomy Levels and has been prepared in accordance with National Education Policy (NEP). After completion of course

- Students will demonstrate the ability to perform close and critical readings.
- Students will demonstrate the ability to consider critically the motives and methods of scholarship and the relationship between them.
- Students will demonstrate the ability to distinguish opinions and beliefs from researched claims and evidence and recognize that kinds of evidence will vary from subject to subject. For instance, some fields call for quantitative support while others work more commonly with quoted, textual evidence.
- Students will demonstrate the ability to ask disciplinarily appropriate questions of the material and recognize when lines of inquiry fall outside of disciplinary boundaries.
- Students will demonstrate the ability to evaluate, credit, and synthesize sources.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓	✓		
CO3			✓		
CO4				✓	
CO5					✓

LIST OF PROGRAMS

1. A student will select a topic in emerging areas of Engineering & Technology and will carry out the task under the supervision of a teacher assigned by the department.

2. He/ She will give a seminar talk on the same before a committee constituted by the chairperson the department. The committee should comprise of 2 or 3 faculty members from different specializations. The teacher(s) associated in the committee will each be assigned 2 hours teaching load per week.
3. However, supervision of seminar topic will be in addition to the regular teaching load.

SEMESTER-III

DATA ANALYSIS AND REGRESSION	
Course Code: 21MBDA301	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: UG level course in Data Analysis	

COURSE OBJECTIVE
• To develop the students ability to deal with numerical and quantitative issues in business
• To enable the use of statistical, graphical and algebraic techniques wherever relevant.
• To familiarize students with basic paradigms and solve advanced algorithmic problems.
• To have a proper understanding of Statistical applications in Economics and Management.
• To come up with analysis of efficiency and proofs of correctness.

COURSE LEARNING OUTCOMES
The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:
• Describe and discuss the key terminology, concepts tools and techniques used in business statistical analysis.
• Critically evaluate the underlying assumptions of analysis tools.
• Understand and critically discuss the issues surrounding sampling and significance.
• Discuss critically the uses and limitations of statistical analysis.
• Solve a range of problems using the techniques covered.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	**CLO2**	**CLO3**	**CLO4**	**CLO5**
CO1	✓				
CO2		✓			
CO3			✓	✓	
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	Descriptive Statistics, Introduction to the course Descriptive Statistics, Probability Distributions.
UNIT-II	Inferential Statistics, Inferential Statistics through hypothesis tests Permutation & Randomization Test.
UNIT-III	Regression & ANOVA, Regression ANOVA(Analysis of Variance), Prescriptive analytics, Creating data for analytics through designed experiments Creating data for analytics through Active learning Creating data for analytics through Reinforcement learning.
UNIT-IV	Machine Learning: Introduction and Concepts, Differentiating algorithmic and model based frameworks, Regression : Ordinary Least Squares, Ridge Regression, Lasso Regression, K Nearest Neighbours Regression & Classification
UNIT-V	Unsupervised Learning and Challenges for Big Data Analytics Clustering, Associative Rule Mining Challenges for big data analytics.

TEXT BOOKS
• Regression Analysis Microsoft Excel, Conrad Carlberg, 2016
• Biostatistics by Example Using SAS® Studio, Ron Cody EdD,2016
• Multiple Regression Approaches, Chetan Patel, K. S. Kushwaha,2019

REFERENCE BOOKS
• Notes on the theory of multiple regression analysis,J. J Thomas, 2012
• Research Methods and Statistics in Psychology, Hugh Coolican, 2018

LIVE PROJECT-II	
Course Code: 21MBDA302	Continuous Evaluation: 60 Marks
Credits: 4	End Semester Examination: 40 Marks
L T P : 0 0 8	
Prerequisite: Knowledge of Programming	

COURSE OBJECTIVES
• To work on real world practical Big Data projects that you are passionate about.
• To develop a strong foundation in Big Data, math - this includes linear algebra, calculus, statistics and probability.
• To become a good developer with solid Big Data Analytics and computer science abilities.
• To read scientific papers and apply them or redo the Big Data Analytics experiments on your own.
• To deploy models with elegant and reusable Hadoop code.

COURSE LEARNING OUTCOMES (PLO)
The Live Project has been prepared in accordance with National Education Policy (NEP). After completion of course, students will learn the art of:
• Understanding the vision of Big Data from a global context.
• Understand and apply Hadoop in Market perspective of Big Data.
• Implement, Apply and analyze architecture and APIs with use of Devices, Gateways and Data Management in Big data.
• Evaluate the application of Big Data in Industrial and Commercial Building Automation, evaluate Big Data performance using MapReduce and Real-World Design Constraints.
• Build and create state of the art architecture in Big Data. Creating projects and research activities based on Pig, Hive, Pig Latin.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	**CLO2**	**CLO3**	**CLO4**	**CLO5**
CO1	✓				
CO2		✓	✓		
CO3			✓		
CO4				✓	
CO5					✓

BIG DATA ANALYTICS LIVE PROJECT

Welcome to the Live Project for Big Data Analytics! In this culminating project, you will build a big data ecosystem using tools and methods form the earlier courses in this specialization. You will analyze a data set simulating big data generated from a large number of users who are playing our imaginary game "Catch the Pink Flamingo". During the Live Project, you will walk through the typical big data science steps for acquiring, exploring, preparing, analyzing, and reporting. In the first two weeks, we will introduce you to the data set and guide you through some exploratory analysis using tools such as Splunk and Open Office. Then we will move into more challenging big data problems requiring the more advanced tools you have learned including KNIME, Spark's MLLib and Gephi. As a result of our collaboration with IBM, a software company focus on analyzing machine-generated big data, learners with the top projects will be eligible to present to IBM and meet IBM recruiters and engineering leadership.

Activity	DESIRED PROGRESS– SEMESTER III
Task 1	Students should be able to understand convert the progress made in earlier semester into tangible project.
Task 2	Students should transform the live project into research paper or patent.
Task 3	Students should show the deliverable outcome to their mentor
Task 4	Students should present ideas to implement the project in their Dissertation.
Task 5	Students should extend the novelty of the project to form new and more interactive live projects.

DISSERTATION PART-I	
Course Code: 21MBDA311	Continuous Evaluation (Internal): 60 Marks
Credits: 4	End Semester Examination: 40 Marks
L T P : 0 0 8	
Pre-Requisites:	

The primary objective of this course is to develop in student the capacity for analysis & judgment and the ability to carry out independent investigation in design /development through a dissertation work involving creativity, innovation and ingenuity. The work must start with comprehensive literature search and critical appreciation thereof so as to select research problem the student wishes to work on.

Each student will carry out independent dissertation under the supervision of some teacher(s) who will be called Supervisor(s). In no case more than two supervisors can be associated with one dissertation work.

The dissertation involving design / testing/ computer simulation/ case studies etc. which commences in the III Semester will be completed in IV Semester. The evaluation of the dissertation phase –I besides approval of the dissertation topic of the students will be done by:

Head of Department: HoD

M Tech Coordinator / Senior Faculty: Member Secretary

Respective dissertation supervisor: Member

The student will be required to submit two copies of his/her report to the department for record (one copy each for the department and participating teacher).

SEMESTER-IV

DISSERTATION PART-II	
Course Code: 21MBDA401	Continuous Evaluation (Internal): 60 Marks
Credits: 12	End Semester Examination: 40 Marks
L T P : 0 0 24	
Pre-Requisites:	

The dissertation started in III Semester will be completed in IV Semester and will be evaluated in the following manner.

Internal Assessment

Internal Assessment (class work evaluation) will be effected as per ordinance through interim report, presentation and discussion thereon by:

HoD of Department: Chairperson

M Tech Coordinator/ Senior Faculty: Member Secretary

Respective dissertation supervisor: Member

External Assessment

Final dissertation will be assessed by a panel of examiners consisting of the following:

Chairperson of Department: Chairperson

Respective Supervisor(s): Member(s)

External expert: To be appointed by the University

Note: The External Expert must be from the respective area of specialization. The chairperson & M Tech Coordinator with mutual consultation will divide the submitted dissertations into groups depending upon the area of specialization and will recommend the list of experts for each group separately to the Dean (Engineering) for selecting the examiners with the note that an external expert should be assigned a maximum of FIVE dissertations for evaluation. The student will be required to submit THREE copies of his/her report to the M Tech Coordinator for record and processing.

SYLLABUS OF PROFESSIONAL ELECTIVE COURSES

ADVANCED EVOLUTIONARY ALGORITHMS	
Course Code: 21MBDA111	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: NIL	

COURSE OBJECTIVE

- To gain understanding of various evolutionary computation techniques.
- To identify algorithms suitable for solving certain evolutionary-computation problems.
- To learn to apply evolutionary computation techniques to optimization, learning, and design.
- To learn to implement at least one algorithm from each of the following groups: generic algorithms, representations, selections, and search operators.
- To learn about various biological systems to exploit natural processes such as ACO, PSO and artificial neural system and related learning algorithms.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand notion of evolutionary algorithms and their importance to modelling, optimization, classification and data analyses.
- Identify of algorithms suitable for solving certain evolutionary-computation problems.
- Apply evolutionary computation techniques to optimization, learning, and design.
- Implement at least one algorithm from each of the following groups: generic algorithms, representations, selections, and search operators.
- Develop evolutionary algorithms for real-world applications.

COURSE LEARNING OUTCOME (CLO)- COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5				✓	✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**INTRODUCTION:**

	A brief history of evolutionary computation, Elements of Genetic Algorithms, A simple genetic algorithm, Applications of genetic algorithms. Evolving computer programs, data analysis and prediction, evolving neural networks, Modelling interaction between learning and evolution, modelling sexual selection, measuring evolutionary activity.
UNIT-II	**THEORETICAL FOUNDATION OF GENETIC ALGORITHM:** Schemas and Two-Armed and k-armed problem, royal roads, exact mathematical models of simple genetic algorithms, Statistical- Mechanics Approaches. Computer Implementation of Genetic Algorithm: Data structures, Reproduction, crossover and mutation, mapping objective functions to fitness form, fitness scaling, coding, a multiparameter, mapped, fixed point coding, discretization and constraints.
UNIT-III	**APPLICATIONS OF GENETIC ALGORITHMS:** The risk of genetic algorithms, De Jong and function optimization, Improvement in basic techniques, current application of genetic algorithms.
UNIT-IV	**NEURAL NETWORKS:** Neural Networks: Neuron Models, Neuron Architecture, Mathematical Model of Neural Networks, , Artificial Neural Network Learning Methods and Learning Strategies, Supervised Learning, Unsupervised Learning, Reinforcement Learning, Activation Functions, Pattern Classification and Linear Separability, Single and Multilayer Perceptron Network, Self-Organizing Map (Kohonen network), Hopfield Network, Back Propagation Network, Radial Basis function Network.
UNIT-V	**COLLECTIVE SYSTEMS:** Collective Behavior and Swarm Intelligence, Particle Swarm Optimization and Ant Colony Optimization, Artificial evolution of Competing Systems, Artificial Evolution of cooperation and competition.

TEXT BOOKS

- Genetic algorithms in search, optimization and Machine Learning by David E. Goldberg, Pearson Education
- The simple genetic algorithm foundations and theory by Michael D. Vose, PHI.
- Eberhart, E. and Y. Shi., Coputational Intelligence: Concepts and Implementations, Morgan Kauffmann, San Diego, 2007.

REFERENCE BOOKS

- An introduction to genetic algorithms by Melanle Mitchell, PHI.
- Simon O. Haykin, "Neural Networks and Learning Machines", Third Edition, Prentice Hall, 2008.
- A.E. Elben and J. E. Smith, "Introduction to Evolutionary Computing", Springer, 2010.

ARTIFICIAL INTELLIGENCE & NEURAL NETWORKS	
Course Code: 21MBDA112	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: UG level course in Artificial Intelligence & Neural Network	

COURSE OBJECTIVE

- To become familiar with basic principles of AI toward problem solving, inference, perception, knowledge representation, and learning.
- To elucidate the basic knowledge representation, problem solving, and learning methods of Artificial Intelligence.
- To assess the applicability, strengths, and weaknesses of the basic knowledge representation, problem solving, and learning methods in solving particular engineering problems
- To have an understanding of the basic issues of knowledge representation and blind and heuristic search .
- To understand other topics such as minimax, resolution, etc. that play an important role in AI programs.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand the various searching techniques, constraint satisfaction problem and example problems- game playing techniques.
- Acquire the knowledge of real world knowledge representation.
- Apply these techniques in applications which involve perception, reasoning and learning..
- Explain the role of agents and how it is related to environment and the way of evaluating it and how agents can act by establishing goals.
- Analyse and design a real world problem for implementation and understand the dynamic behavior of a system.
- Use different machine learning techniques to design AI machine and enveloping applications for real world problems.

COURSE LEARNING OUTCOME (CLO)- COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
CO1	✓					
CO2		✓				
CO3			✓			
CO4				✓	✓	
CO5					✓	✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**INTRODUCTION TO AI:** Introduction: AI problems, foundation of AI and history of AI intelligent agents: Agents and Environments, the concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation.
UNIT-II	**SEARCHING:** Searching for solutions, uniformed search strategies – Breadth first search, depth first Search. Search with partial information (Heuristic search) Hill climbing, A* ,AO* Algorithms, Problem reduction, Game Playing-Adversial search, Games, mini-max algorithm, optimal decisions in multiplayer games, Problem in Game playing, Alpha-Beta pruning, Evaluation functions.
UNIT-III	**KNOWLEDGE REPRESENTATION:** Knowledge representation issues, predicate logic- logic programming, semantic nets-frames and inheritance, constraint propagation, representing knowledge using rules, rules based deduction systems. Reasoning under uncertainty, review of probability, Baye's probabilistic interferences and dempster shafer theory.
UNIT-IV	**NEURAL NETWORKS:** Characteristics of Neural Networks, Historical Development of Neural Networks Principles, Artificial Neural Networks: Terminology, Models of Neuron, Topology, Basic Learning Laws, Pattern Recognition Problem, Basic Functional Units, Pattern Recognition Tasks by the Functional Units. Feedforward Neural Networks: Introduction, Analysis of pattern Association Networks, Analysis of Pattern Classification Networks, Analysis of pattern storage Networks, Analysis of Pattern Mapping Networks. Feedback Neural Networks, Introduction, Analysis of Linear Auto associative FF Networks.
UNIT-V	**COMPETITIVE LEARNING NEURAL NETWORKS & COMPLEX PATTERN RECOGNITION:** Competitive Learning Neural Networks & Complex pattern Recognition Introduction, Analysis of Pattern Clustering Networks, Analysis of Feature Mapping Networks, Associative Memory.

TEXT BOOKS

- Artificial Intelligence – A Modern Approach. Second Edition, Stuart Russel, Peter Norvig, PHI/ Pearson Education.
- Artificial Neural Networks B. Yagna Narayana, PHI
- Artificial Intelligence, 2nd Edition, E. Rich and K. Knight(TMH).
- Artificial Intelligence and Expert Systems – Patterson PHI.
- Expert Systems: Principles and Programming- Fourth Edn, Giarrantana/ Riley, Thomson.

REFERENCE BOOKS

- Neural Networks Simon Haykin PHI.
- Artificial Intelligence, 3rd Edition, Patrick Henry Winston., Pearson Edition.

DISTRIBUTED SYSTEMS	
Course Code: 21MBDA113	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: Database Management Systems Concepts	

COURSE OBJECTIVES
• To understand distributed systems from system perspective.
• To understand distributed systems from algorithmic perspective.
• To understand, design and analyse distributed systems.

COURSE LEARNING OUTCOMES
The syllabus has been prepared in accordance with National Education Policy (NEP). After the completion of course, students would be able to:
• Understand the concepts of communication, coordination.
• Understand the concepts of synchronization and uncertainty to the lower bounds techniques.
• Build the spanning trees from flooding and leader election algorithms.
• Understand the applications and design of various distributed systems.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	**CLO2**	**CLO3**	**CLO4**
CO1	✓	✓		
CO2			✓	
CO3				✓

COURSE CONTENTS

UNIT NUMBER	**COURSE CONTENTS**
UNIT-I	Introduction to DS, Message Passing, Leader Election, Distributed Models, Causality and Logical Time. Logical Time, Global State & Snapshot and Distributed Mutual Exclusion-Non-Token and Quorum based approaches
UNIT-II	Distributed Mutual Exclusion-Token based approaches, Consensus & Agreement, Check pointing & Rollback Recovery
UNIT-III	Deadlock Detection, DSM and Distributed MST.

	Termination Detection, Message Ordering & Group Communication, Fault Tolerance and Self-Stabilization
UNIT-IV	Distributed Randomized Algorithms, DHT and P2P Computing
UNIT-V	Case Studies: GFS, HDFS, Map Reduce and Spark, Sensor Networks, Authentication & Security in DS

TEXTBOOKS

- Kshemkalyani, A. D., & Singhal, M. (2011). *Distributed computing: principles, algorithms, and systems*. Cambridge University Press.
- Attiya, H., & Welch, J. (2004). *Distributed computing: fundamentals, simulations, and advanced topics* (Vol. 19). John Wiley & Sons.

REFERENCE BOOKS

- Lynch, N. A. (1996). *Distributed algorithms*. Elsevier.

DATA SCIENCE	
Course Code: 21MBDA211	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: Basic knowledge of Data Science	

COURSE OBJECTIVE

- To provide you with the knowledge and expertise to become a proficient data scientist.
- To develop fundamental knowledge of concepts underlying data science projects.
- To demonstrate an understanding of statistics and machine learning concepts that are vital for data science.
- To evaluate data visualizations based on their design and use for communicating stories from data.
- To understand various machine learning models.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would 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.
- Demonstrate proficiency with statistical analysis of data.
- Execute statistical analyses with professional statistical software.
- Develop the ability to build and assess data-based models.
- Demonstrate skill in data management.

COURSE LEARNING OUTCOME (CLO)- COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
CO1	✓					
CO2		✓				
CO3			✓	✓		
CO4				✓		
CO5					✓	✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**INTRODUCTION TO DATA SCIENCE:** Big Data and Data Science Hype, Statistical Inference, Exploratory Data Analysis and Data Science Process, Data Science Toolkit, Types of data, Example applications of Data Science.

UNIT NUMBER	COURSE CONTENTS
UNIT-II	**DATA COLLECTION AND MANAGEMENT**: Introduction, Sources of data, Data collection and APIs, Exploring and fixing data. Mining Data Stream: The Stream Data Model, Sampling data is a stream, Filtering Streams, Counting distinct elements in a stream.
UNIT-III	**MAP REDUCE:** Introduction – distributed file system – algorithms using map reduce, Matrix-Vector Multiplication by Map Reduce – Hadoop - Understanding the Map Reduce architecture - Writing Hadoop MapReduce Programs - Loading data into HDFS - Executing the Map phase - Shuffling and sorting - Reducing phase execution.
UNIT-IV	**MACHINE LEARNING:** Introduction to machine learning models, Training sets, Approaches to machine learning. Machine learning architecture.
UNIT-V	**DATA VISUALIZATION:** Introduction, Types of data visualization, Data for visualization: Data types, Data encodings, Retinal variables, Techniques for Data Visualization. Introduction and implementation to SQL and Python.

TEXT BOOKS

- Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk From The Frontline. O'Reilly.

REFERENCE BOOKS

- Jure Leskovek, Anand Rajaraman and Jeffrey Ullman. Mining of Massive Datasets. v2.1, Cambridge University Press.

ARCHITECTURE OF HIGH PERFORMANCE COMPUTER SYSTEMS	
Course Code: 21MBDA212	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: Computer Architecture and Organization, Data Structure	

COURSE OBJECTIVE

- To introduce parallel architectures and different shared and distributed memory architectures. MPI and OpenMP are discussed along with their applications.
- To provide systematic and comprehensive treatment of the hardware and the software high performance techniques involved in current day computing.
- To introduce the fundamentals of high performance computing with the graphics processing units and many integrated cores using their architectures and corresponding programming environments.
- To illustrate the architecture of multiprocessors.
- To provide systematic and comprehensive treatment of the components in the pipeline that extract instruction level parallelism.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students will learn the art of:

- Write parallel algorithms for high performance systems and learn problem decomposition and load balancing using MPI and OpenMP.
- Administration, scheduling, code portability and data management in an HPC environment.
- Administration with particular reference to Grid Computing.
- Administration loosely coupled and tightly coupled multiprocessor.
- Provide a strong foundation on memory hierarchy design and trade-offs in both uniprocessor and multiprocessors.
- Administration SIMD matrix multiplication.

COURSE LEARNING OUTCOME (CLO)- COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
CO1	✓					
CO2		✓				
CO3			✓			
CO4				✓	✓	
CO5						✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**INTRODUCTION TO PARALLEL PROCESSING:** Parallelism in uniprocessor system, basic uniprocessor architecture, parallel processing mechanism, balancing of sub system bandwidth, multiprogramming and time sharing, parallel computer structures, pipeline computers, array computers, multiprocessor systems, dataflow computer concept, architectural classification scheme: multiplicity of instruction-data streams, serial versus parallel processing, parallelism versus pipelining, parallel processing applications, productive modelling simulation, engineering design and automation MPI programming, OpenMP programming.
UNIT-II	**PRINCIPLES OF PIPELINING AND VECTOR PROCESSING:** Pipelining- an overlapped parallelism, principles of linear pipelining, clock period, efficiency, throughput, classification of pipeline processors, general pipeline and reservation tables.
UNIT-III	**PRINCIPLES OF DESIGNING PIPELINE PROCESSORS:** Effect of branching, data buffering and bussing structures, internal forwarding and register tagging, hazard detection and resolution, job sequencing and collision prevention, reservation and latency analysis, collision free scheduling, state diagram, greedy cycle, pipeline schedule optimization, pipeline throughput, pipeline efficiency.
UNIT-IV	**STRUCTURE AND ALGORITHM FOR ARRAY PROCESSORS**: SIMD array processor, SIMD computer organization, inter –PE communication, SIMD interconnection network, static versus dynamic networks, cube interconnection network, shuffle-exchange omega networks, parallel algorithms and SIMD matrix multiplication.
UNIT-V	**MULTIPROCESSOR ARCHITECTURE AND SCHEDULING:** Functional structure, loosely coupled and tightly coupled multiprocessor, deterministic scheduling strategy, deterministic scheduling model, control flow versus data flow computer, data flow graphs and languages.

TEXT BOOKS

- Kai Hwang, "Advanced Computer Architecture", Tata McGraw Hill Edition
- Kai Hwang and Faye A. Briggs, "Computer Architecture and Parallel Processing", McGraw-Hill International Edition
- Richard Y. Kain, "Advanced Computer Architecture: a Systems Design", Prentice Hall.

REFERENCE BOOKS

- James M. Feldman, Charles T. Retter, "Computer architecture: a designer's Text Based on a generic RISC", McGraw-Hill
- Parallel Programming for Multicore and Cluster Systems by Thomas Rauber and Gudula Runger.

DATA WAREHOUSING & DATA MINING	
Course Code: 21MBDA213	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: Databases, Probability	

COURSE OBJECTIVE
• To introduce data warehousing and mining techniques. • To understand data warehouse concepts, architecture, business analysis and tools. • To study application of data mining in web mining. • To learn pattern matching and cluster analysis is included to aware students of broad data mining areas. • To describe the data mining tasks and study their well-known techniques.

COURSE LEARNING OUTCOMES
The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:
• Provide a brief introduction to general issues of Data Warehouse and Data Mining. • Provide students with a clear understanding of the different architectures and mining techniques. • Understand the role and function of Data Warehouse and Data Mining. • Explain the stages and process different data mining techniques. • Learn mining and warehouse techniques through the use of different tools.

COURSE LEARNING OUTCOME (CLO)- COURSE OBJECTIVE (CO) MAPPING

	CLO1	**CLO2**	**CLO3**	**CLO4**	**CLO5**
CO1	✓	✓			
CO2		✓			
CO3			✓		
CO4				✓	
CO5				✓	✓

COURSE CONTENTS

UNIT NUMBER	**COURSE CONTENTS**
UNIT-I	**DATA WAREHOUSE:** Concept of Data warehouse, usage and trends. DBMS vs data warehouse, Data marts, Metadata, Multidimensional data mode, Data cubes, Schemas for Multidimensional Database: stars, snowflakes and fact constellations. Data warehouse process & architecture,

UNIT NUMBER	COURSE CONTENTS
	OLTP vs OLAP, ROLAP vs MOLAP, types of OLAP, servers, 3-Tier data warehouse architecture, distributed and virtual data warehouses, data warehouse manager.
UNIT-II	**OLAP TOOLS:** Need for OLAP, Multidimensional Versus Multi relational OLAP, Categorization of OLAP tools, OLAP operations, Identifying Facts and Dimensions, Designing Fact Tables, Designing Dimension Tables Building a Data Warehouse: Data Warehouse Schemas. Steps for the Design and Construction of Data Warehouses. Business consideration, Design consideration, Technical consideration, Integrated Solutions.
UNIT-III	**INTRODUCTION TO DATA MINING:** Introduction to Data mining, KDD versus data mining, data mining techniques, tools and applications. Data mining query languages, data specification, specifying knowledge, hierarchy specification, pattern presentation & visualisation specification, data mining languages and standardisation of data mining.
UNIT-IV	**MINING FREQUENT PATTERNS, ASSOCIATIONS AND CORRELATIONS:** Market Basket Analysis, Frequent Item sets, Closed Item sets and Association Rules, Frequent Item set Mining Methods, Pattern Evaluation Decision Tree: Basics, Building a Decision Tree, Classifying by using Decision Trees, Building Multiple Decision Trees, Obtaining Prules from Decision Trees.
UNIT-V	**CLUSTERING:** Clustering in Grouping, Agglomerative Hierarchical Clustering, K- means clustering. Multilayer Neural Nets: Neurodes, Modelling an AND Gate, Or Gate and XOR Gate. Commonly used Neunet Architecture. Nearest Neighbour Classification: Performance of Nearest Neighbour classifier, Modification of Nearest Neighbor Classifier.

TEXT BOOKS

- Rajjan Singhal, "Pattern Recognition Techniques and Applications", Oxford University Press.
- Zhao Y., Cen Y., "Data mining Applications with R", Elsevier India.

REFERENCE BOOKS

- A. Berson, S.J. Smith, "Data Warehousing, Data Mining & OLAP", TataMcGraw-Hill.
- J Han, M. Kamber and J. Pei, "Data Mining Concepts and Techniques", Elsevier India.

SOFTWARE RELIABILITY & FAULT TOLERANT SYSTEM	
Course Code: 21MBDA214	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: Software Engineering	

COURSE OBJECTIVE
• To understand the risk of computer failures and their peculiarities compared with other equipment failures. • To know the different advantages and limits of fault avoidance and fault tolerance techniques. • To be aware of the threat from software defects and human operator error as well as from hardware failures. • To understand the basics of redundant design. • To know the different forms of redundancy and their applicability to different classes of dependability requirements.

COURSE LEARNING OUTCOMES
The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:
• Create understanding of the fundamental concepts of fault-tolerance. • Learn basic techniques for achieving fault-tolerance in electronic, communication and software Systems. • Develop skills in modelling and evaluating fault-tolerant architectures in terms of reliability, availability and safety. • Gain knowledge in sources of faults and means for their prevention and forecasting. • Understand merits and limitations of fault-tolerant design.

COURSE LEARNING OUTCOME (CLO)- COURSE OBJECTIVE (CO) MAPPING

	CLO1	**CLO2**	**CLO3**	**CLO4**	**CLO5**
CO1	✓	✓			
CO2		✓			
CO3			✓		
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**SOFTWARE RELIABILITY:** Measures of software reliability, Mean Time To Failure (MTTF), Mean Time Between Failure (MTBF), Mean Time To Recovery (MTTR), availability, maintainability, Musa's operational profiles and type-1 uncertainty, defect removal and type-2 uncertainty, reliability stability and reliability growth, hardware reliability vs. software reliability, failure probability density function and reliability function, Reliability prediction , reliability metrics.
UNIT-II	**DEVELOPMENT OF RELIABLE SOFTWARE:** Reliable software, defect prevention, detection and removal, design for robustness, verification & validation, stabilization of requirements, design, code and test artifacts, active and passive fault detection, fault handling and correction, exceptions, survivability, reliability models, software availability model.
UNIT-III	**FAULT TOLERANT DESIGN:** Basic concepts: Reliability concepts, Failures & faults, Reliability and Failure rate, Relation between reliability and mean time between failure, maintainability and availability, reliability of series, parallel and parallel-series combinational circuits. Fault Tolerant Design: Basic concepts-static, dynamic, hybrid, triple modular redundant system (TMR), 5MR reconfiguration techniques, Data redundancy, Time redundancy and software Redundancy concepts. fault tolerant software systems.
UNIT-IV	**SOFTWARE AND HARDWARE FAULT TOLERANCE:** Software and hardware faults, failure intensity function, characterization of fault injection, detection and correction, techniques for prediction of remaining faults and fault injection, classification tree analysis, code coverage, coding technique, fault tolerant & self-checking, fail safe circuits, synchronous and asynchronous fail safe circuits.
UNIT-V	**FAULT TOLERANT SOFTWARE:** Concept of N-version programming (NVP) and methods, recovery block, acceptance tests, fault trees, validation of fault tolerant systems, security, fault tolerance in wireless/mobile networks and Internet.

TEXT BOOKS

- Software Reliability Engineering, John D. Musa, Tata McGraw Hill,2005.
- Fault-Tolerant Computer System Design, D.K. Pradhan,2003.
- Design and Analysis of Fault-Tolerant Digital Systems, B. W. Johnson, Addison-Wesley,1989.
- Fault-Tolerant Computing, Theory & Techniques, D.K. Pradhan, Prentice Hall,1986.
- Reliable Computer Systems: Design and Evaluation, D. P. Siewiorek and R. S. Swartz, Digital Press, 1992.

REFERENCE BOOKS

- Probability and Statistics with Reliability, Queueing and Computer Science application, K. S. Trivedi, Prentice Hall,1982.
- Fault Tolerant Principles and Practice, Anderson and Lee, PHI, 1989.

ADHOC & SENSOR NETWORK	
Course Code: 21MBDA231	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: Computer Networks	

COURSE OBJECTIVE
• To impart the comprehensive knowledge of various techniques in mobile networks/Ad Hoc networks and sensor based networks. • To facilitate the understanding of Infrastructure less networks and their importance in the future directions for wireless communications. • To learn Ad Hoc network and Sensor Network fundamentals. • To understand the different routing protocols. • To understand the transport layer and security issues possible in Ad Hoc and Sensor networks.

COURSE LEARNING OUTCOMES
The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:
• Describe an Ad Hoc network and analyse various technologies associated with it. • Explain the concepts, network architectures and applications of wireless sensor networks. • Analyse Ad Hoc & sensor based networks and compute various parameters associated with it. • Discuss the challenges in designing routing and transport protocols for wireless Ad-Hoc/sensor networks. • Comprehend the various sensor network Platforms, tools and applications.

COURSE LEARNING OUTCOME (CLO) - COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5				✓	✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**MAC & ROUTING IN AD HOC NETWORKS:** Introduction, Issues and challenges in Ad Hoc networks, MAC Layer Protocols for wireless Ad Hoc networks, Contention-Based MAC protocols, MAC Protocols Using Directional Antennas, Multiple Channel MAC Protocols, Power-Aware MAC Protocols, Routing in Ad Hoc Networks, Design Issues, Proactive, Reactive and Hybrid Routing Protocols.

UNIT NUMBER	COURSE CONTENTS
UNIT-II	**TRANSPORT & QOS IN ADHOC NETWORKS TCP's:** Challenges and Design Issues in Ad Hoc Networks, Transport protocols for ad hoc networks, Issues and Challenges in providing QoS, MAC Layer QoS solutions, Network Layer QoS solutions, QoS Model.
UNIT-III	**MAC & ROUTING IN WIRELESS SENSOR NETWORKS:** Introduction, Applications, Challenges, Sensor network architecture, MAC Protocols for wireless sensor networks, Low duty cycle protocols and wakeup concepts, Contention-Based protocols, Schedule-Based protocols, IEEE 802.15.4 Zig bee, Topology Control, Routing Protocols.
UNIT-IV	**TRANSPORT & QOS IN WIRELESS SENSOR NETWORKS:** Data Centric and Contention-Based Networking, Transport Layer and QoS in Wireless Sensor Networks, Congestion Control, In-network processing , Operating systems for wireless sensor networks, Examples.
UNIT-V	**SECURITY IN AD HOC AND SENSOR NETWORKS:** Security Attacks, Key Distribution and Management, Intrusion Detection, Software based Antitamper techniques, Water marking techniques, Defence against routing attacks - Secure AdHoc routing protocols, Broadcast authentication WSN protocols, TESLA, Biba , Sensor Network Security Protocols, SPINS

TEXT BOOKS

- Subir Kumar Sarkar, T G Basavaraju, C Puttamadappa, "Ad Hoc Mobile Wireless Networks", Auerbach Publications, 2008.
- Holger Karl, Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley & Sons, Inc., 2005.
- ErdalÇayırcı ,Chunming Rong, "Security in Wireless Ad Hoc and Sensor Networks", John Wiley and Sons, 2009.
- C. Siva Ram Murthy and B. S. Manoj, "Ad Hoc Wireless Networks – Architectures and Protocols", Pearson Education, 2004.
- Carlos De Morais Cordeiro, Dharma Prakash Agrawal, "Ad Hoc and Sensor Networks: Theory and Applications (2nd Edition)", World Scientific Publishing, 2011.

REFERENCE BOOKS

- Waltenegus Dargie, Christian Poellabauer, "Fundamentals of Wireless Sensor Networks Theory and Practice", John Wiley and Sons, 2010.
- Adrian Perrig, J. D. Tygar, "Secure Broadcast Communication: In Wired and Wireless Networks", Springer, 2006.

COMPILER FOR HPC	
Course Code: 21MBDA232	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: Data Structure, Compiler Design, Theory of Computation	

COURSE OBJECTIVE
• To introduce structure of compilers and high performance compiler design for students. • To understand the concepts of data dependence. • To understand the concepts of cache coherence and parallel loops in compilers. • To study concurrency analysis and vector analysis. • To study SIMD, MIMD machines and their characteristics.

COURSE LEARNING OUTCOMES
The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:
• Familiarize with the structure of compiler. • Understand parallel loops, data dependency and exception handling and debugging in compiler. • Acquainted with the fundamental programming techniques for high performance computer architectures. • Design, implement and benchmark parallel programs on shared-memory and distributed-memory systems. • Familiar with Message-Passing Machines.

COURSE LEARNING OUTCOME (CLO) - COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5				✓	✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**INTRODUCTION:** High Performance Systems, Structure of a Compiler, Programming Language Features, and Languages for High Performance.
UNIT-II	**DATA DEPENDENCE:** Data Dependence in Loops, Data Dependence in Conditionals, Data Dependence in Parallel Loops, Programme Dependence Graph. Scalar Analysis with Factored Use-Def Chains: Constructing Factored UseDef Chains, FUD Chains for Arrays, Induction Variables Using FUD Chains, Constant Propagation with FUD Chains, Data Dependence for Scalars. Data

UNIT NUMBER	COURSE CONTENTS
	Dependence Analysis for Arrays. Array Region Analysis, Pointer Analysis, I/O Dependence, Procedure Calls, Inter-procedural Analysis.
UNIT-III	**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.
UNIT-IV	**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.
UNIT-V	**MESSAGE-PASSING MACHINES:** SIMD Machines, MIMD Machines, Data Layout, Parallel Code for Array Assignment, Remote Data Access, Automatic Data Layout, Multiple Array Assignments, Scalable Shared- Memory Machines: Global Cache Coherence, Local Cache Coherence, Latency Tolerant Machines.

TEXT BOOKS

- Michael Wolfe, High-Performance Compilers for Parallel Computing, Pearson
- Define program-data independence, data models for database systems, database schema and database instances.

REFERENCE BOOKS

- Recall Relational Algebra concepts, and use it to translate queries to Relational Algebra statements and vice versa.

ADVANCED MACHINE LEARNING	
Course Code: 21MBDA233	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: Machine Learning	

COURSE OBJECTIVE

- To provide introduction to machine learning design and concept of optimization
- To introduce students to the basic concepts and techniques of Machine Learning.
- To develop skills of using recent machine learning software for solving practical problems.
- To gain experience of doing independent study and research.
- To understand popular machine learning approaches.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students will be able to:

- Extract features that can be used for machine learning approach in various IOT applications.
- Get an insight of when to apply a particular machine learning approach.
- Mathematically analyze various machine learning approaches and paradigms.
- Have a good understanding of the fundamental issues and challenges of machine learning: data, model selection, model complexity, etc.
- Have an understanding of the strengths and weaknesses of many popular machine learning approaches.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**SUPERVISED LEARNING (REGRESSION/CLASSIFICATION) BASIC METHODS:**

UNIT NUMBER	COURSE CONTENTS
	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.
UNIT-II	**UNSUPERVISED LEARNING (CLUSTERING):** K-means/Kernel K-means, Dimensionality Reduction: PCA and kernel PCA, Introduction to ICA, Evaluating Machine Learning algorithms and Model Selection.
UNIT-III	**DIFFERENT METHODS:** Ensemble Methods (Boosting, Bagging and Random Forest), Modelling Sequence Problems, Time-Series Data, Deep Learning and Feature Representation Learning Forests.
UNIT-IV	**AN INTRODUCTION TO SOME OTHER ADVANCED TOPIC:** Semi-supervised Learning, Active Learning.
UNIT-V	**REINFORCEMENT LEARNING:** Reinforcement Learning, Inference in Graphical Models, Bayesian Learning and Inference.

TEXTBOOKS

- Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
- Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009.

REFERENCE BOOKS

- Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.
- Pattern Recognition and Machine Learning, Book by Christopher Bishop.

MATHEMATICAL FOUNDATIONS OF COMPUTER SCIENCE	
Course Code: 21MBDA234	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: Discrete Mathematics	

COURSE OBJECTIVE
• To provide the foundations of probabilistic and statistical analysis that can be helpful in modelling applications. • To study various sampling and classification problems. • To have the basic statistical methodology of data analysis including; graphs, descriptive statistics. • To understand probability, sampling and graph theory that serve as an essential tool for applications of computer and information sciences. • To have the analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning.

COURSE LEARNING OUTCOMES
The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:
• Understand the basic notions of discrete and continuous probability. • Understand the role that sampling distributions play in those methods. • Perform correct and meaningful statistical analyses of simple to moderate complexity. • Understand various graphs in different geometries related to edges. • Analysis the different computer science applications in different areas like data mining, bioinformatics.

COURSE LEARNING OUTCOME (CLO) - COURSE OBJECTIVE (CO) MAPPING

	CLO1	**CLO2**	**CLO3**	**CLO4**	**CLO5**
CO1	✓				
CO2		✓			
CO3			✓	✓	
CO4				✓	✓
CO5				✓	✓

COURSE CONTENTS

UNIT NUMBER	**COURSE CONTENTS**
UNIT-I	**DISTRIBUTION FUNCTION:** Probability mass, density, and cumulative distribution functions, Conditional Probability, Expected value, Applications of the Univariate and Multivariate problems. Probabilistic

UNIT NUMBER	COURSE CONTENTS
	inequalities, Random samples, sampling distributions of estimators and Maximum Likelihood.
UNIT-II	**SAMPLING:** Random samples, sampling distributions of estimators, Methods of Moments and Maximum Likelihood.
UNIT-III	**STATISTICAL INFERENCE:** Descriptive Statistics, Introduction to multivariate statistical models, Multivariate Regression, Multinominal regression and classification problems, principal components analysis, The problem of overfitting model assessment.
UNIT-IV	**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
UNIT-V	**COMPUTER SCIENCE AND ENGINEERING APPLICATIONS WITH ANY OF FOLLOWING AREA:** Data mining, Computer security, Software engineering, Computer architecture, Bioinformatics, Machine learning. Recent Trends in various distribution functions in mathematical field of computer science for varying fields like, soft computing, and computer vision.

TEXT BOOKS

- Tremblay J.P. and Manohar R., "Discrete Mathematical Structures with applications to Computer Science", McGraw Hill International Edition, 1987Kenneth H. Rosen, Discrete Mathematics and Its Applications, 4th Edition, Tata McGraw Hill, 2002
- Venkataraman M.K. et al., "Discrete Mathematics", National Publishing Co.,2000
- Prof. V. Sundaresan, K.S. Ganapathy Subramanian and K. Ganesan, Discrete Mathematics, New Revised Edition,2001.
- Alan Doerr and Kenneth Levasseur, "Applied Discrete Structures for Computer Science", Galgotia Publications (P)Ltd.,1992

REFERENCE BOOKS

- C.L. Liu, Elements of Discrete Mathematics, 2nd Edition, McGraw Hill Publications,1985.
- Gersting. J.L. Mathematical Structures for Computer Science, 3rd Edition, W.H. Freeman and Co.,1993.
- Lidl and Pitz, Applied abstract Algebra, Springer – Verlag, New York,1984.

OPTIMIZATION TECHNIQUES	
Course Code: 21MBDA311	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: Linear Algebra and Numerical Methods	

COURSE OBJECTIVE

- To understand the Concept of optimization and classification of optimization problems.
- To introduce various optimization techniques i.e. classical, linear programming, transportation problem, simplex algorithm, dynamic programming.
- To optimize these mathematical problems using nature based algorithms.
- Constrained and unconstrained optimization techniques for solving and optimizing the problems in real world situations.
- To explain the concept of Dynamic programming and its applications to project implementation.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Explain the need of optimization of engineering systems
- Apply classical optimization techniques, linear programming, simplex algorithm, transportation problem
- Apply the methods of optimization in real life situation.
- Apply unconstrained optimization and constrained non-linear programming and dynamic programming
- Apply Genetic Optimization.

COURSE LEARNING OUTCOME (CLO) - COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5				✓	✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**INTRODUCTION:** Statement of an Optimization problem – design vector – design constraints – constraint surface – objective function – objective function surfaces – classification of Optimization problems.

UNIT NUMBER	COURSE CONTENTS
UNIT-II	**CLASSICAL OPTIMIZATION TECHNIQUES**: Classical Optimization Techniques: Single variable Optimization – multi variable Optimization without constraints – necessary and sufficient conditions for minimum/maximum – multivariable Optimization with equality constraints. Solution by method of Lagrange multipliers – Multivariable Optimization with inequality constraints – Kuhn – Tucker conditions.
UNIT-III	**LINEAR PROGRAMMING:** Standard form of a linear programming problem – geometry of linear programming problems – definitions and theorems – solution of a system of linear simultaneous equations – pivotal reduction of a general system of equations – motivation to the simplex method – simplex algorithm. Transportation Problem: Finding initial basic feasible solution by north – west corner rule, least cost method and Vogel's approximation method – testing for optimality of balanced transportation problems.
UNIT-IV	**UNCONSTRAINED NONLINEAR PROGRAMMING:** One dimensional minimization methods, Classification, Fibonacci method and Quadratic interpolation method Unconstrained Optimization Techniques: Univariant method, Powell's method and steepest descent method.
UNIT-V	**MODERN METHODS OF OPTIMIZATION:** Genetic Optimization, Simulated Annealing, Particle Swarm Optimization, Ant Colony Optimization.

TEXT BOOKS

- Laurence A. Wolsey (1998). Integer programming. Wiley. ISBN978-0-471-28366-9.
- Practical Optimization Algorithms and Engineering Applications Andreas Antoniou.
- An Introduction to Optimization Edwin K., P. Chong & Stanislaw h. Zak.

REFERENCE BOOKS

- Dimitris Bertsimas; Robert Weismantel (2005). Optimization over integers. Dynamic Ideas. ISBN 978-0-9759146-2-5.
- John K. Karl of (2006). Integer programming: theory and practice. Press. ISBN 978-0-8493- 1914-3.
- H. Paul Williams (2009). Logic and Integer Programming. Springer. ISBN978-0-387-92279-9.

CLOUD COMPUTING	
Course Code: 21MBDA312	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: Basics of Networking, Security & Privacy	

COURSE OBJECTIVE

- To learn the basic Cloud types and delivery models.
- To study architecture, challenges for each Cloud type and service delivery model.
- To provide an overview to the concepts, processes, and best practices needed to successfully secure information within Cloud infrastructures.
- To understand trust-based security model to real-world security problems.
- To develop an understanding of the risk and compliance responsibilities.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Articulate the main concepts, key technologies, strengths, and limitations of cloud computing and the possible applications for state-of-the-art cloud computing.
- Identify the architecture and infrastructure of cloud computing, including SaaS, PaaS, IaaS, public cloud, private cloud, hybrid cloud, etc.
- Identify security aspects of each cloud model.
- Develop a risk-management strategy for moving to the Cloud.
- Apply trust-based security model to different layer.
- Implement Cloud Security Alliance.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5	CLO6
CO1	✓					
CO2		✓				
CO3			✓			
CO4				✓	✓	
CO5						✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**INTRODUCTION TO CLOUD COMPUTING:** Cloud Computing: Definition, roots of clouds, characteristics, Cloud Architecture – public, private, hybrid, community, advantages & disadvantages of Cloud Computing. Migrating into a Cloud: broad approaches, seven-step model to migrate

UNIT NUMBER	COURSE CONTENTS
	Virtualization: benefits & drawbacks of virtualization, virtualization types – operating system virtualization, platform virtualization, storage virtualization, network virtualization, application virtualization, virtualization technologies.
UNIT-II	**CLOUD SERVICES & PLATFORMS:** Compute services, Storage services Database services, Application Services, Queuing services, E-mail services, Notification services, Media services, Content delivery services, Analytics services, Deployment & management services, Identity & access management services. Case studies of these services. Federated & Multimedia Cloud Computing: architecture, features of federation types, federation scenarios, layers enhancement of federation; Multimedia Cloud.
UNIT-III	**SECURITY ISSUES IN CLOUD COMPUTING:** Infrastructure Security, Infrastructure Security: The Network Level, The Host Level, The Application Level, Data Security and Storage, Aspects of Data Security, Data Security Mitigation Provider Data and Its Security Identity and Access Management Trust Boundaries and IAM, IAM Challenges, Relevant IAM Standards and Protocols for Cloud Services,IAM Practices in the Cloud, Cloud Authorization Management
UNIT-IV	**SECURITY MANAGEMENT IN THE CLOUD SECURITY:** Management Standards, Security Management in the Cloud, Availability Management: SaaS, PaaS, IaaS Privacy Issues, Data Life Cycle, Key Privacy Concerns in the Cloud, Protecting Privacy, Changes to Privacy Risk Management and Compliance in Relation to Cloud Computing, Legal and Regulatory Implications, U.S. Laws and Regulations, International Laws and Regulations.
UNIT-V	**AUDIT AND COMPLIANCE:** Internal Policy Compliance, Governance, Risk, and Compliance (GRC),Regulatory/External Compliance, Cloud Security Alliance, Auditing the Cloud for Compliance, Security-as-a-Cloud.

TEXT BOOKS

- Cloud Computing Explained: Implementation Handbook for Enterprises, John Rhoton, Publication November 2,2009.
- Buyya, Rajkumar, James Broberg, and Andrzej M. Goscinski, eds. Cloud computing: Principles and paradigms. Vol. 87. John Wiley & Sons, 2010.

REFERENCE BOOKS

- Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance (Theory in Practice), Tim Mather, ISBN-10: 0596802765,O'Reilly Media, September2009
- Chandrasekaran, K. Essentials of cloud computing. CrC Press, 2014.

COMPUTER NETWORK AND DISTRIBUTED SYSTEMS	
Course Code: 21MBDA313	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: Database Management Systems, Computer Network	

COURSE OBJECTIVE

- To introduce the fundamental concepts of networking.
- To study wireless networking technologies.
- To study infrastructure and various issues of managing the network.
- To understand foundations of Distributed Systems.
- To study various protocols and threats related to distributed systems.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Demonstrate in-depth knowledge in the area of Computer Networking.
- To demonstrate scholarship of knowledge through performing in a group to identify, formulate and solve a problem related to Computer Networks
- Conduct experiments to analyse the identified research work in building Computer Networks.
- Apply Peer to peer systems.
- Apply RDF, XML, RESTful.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓	✓		
CO3			✓		
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**INTRODUCTION TO NETWORK:** Data Communication, Transmission Methodologies, Data Link Layer, Multiple Access & Local Area Networks, Connecting Devices and Backbone Networks, Network Layer and Transport Layer, Application Layer. Internet architecture, The TCP/IP layered model,

UNIT NUMBER	COURSE CONTENTS
	Protocols, design principles, standardization, IETF, Link-layer, Transmission theory and protocols, Ethernet networks, switches.
UNIT-II	**WIRELESS NETWORKING:** wireless LANS & PANS, ad-hoc wireless networks & security, wireless sensor networks, Cellular Mobile Wireless Networks, Evolution of Modern Mobile Wireless Communication System.
UNIT-III	**NETWORK MANAGEMENT:** What Is Network Management?, The Infrastructure for Network Management, The Internet-Standard Management Framework, Structure of Management Information: SMI, Management Information Base: MIB, SNMP Protocol Operations and Transport Mappings, Security and Administration, ASN.
UNIT-IV	**DISTRIBUTRED SYSTEMS:** Introduction to distributed systems, Issues, challenges, Distributed system models (architectural, interaction, failure, security), Time in distributed systems, Clock synchronization, logical clocks, Distributed objects, Distributed algorithms, Mutual exclusion, Leader election, Client-server programming, Application of reliable/ordered multicast, Consensus, Indirect communication, Group communication, Publish- subscribe, Message queues.
UNIT-V	**WEB PROTOCOLS:** Web protocols, the classic web service model; WSDL, SOAP, UDDI, RDF, XML, RESTful web services; HTTP methods, JSON, (Linked) open data, Peer to peer systems, Design principles, Bit Torrent, Distributed hash tables, Network security, Authentication and encryption, PKI, (Distributed) denial of service attacks,

TEXT BOOKS

- S. Tanenbaum, Computer Networks, 4th edition, Prentice Hall,2008.
- W. Stallings," Data and Computer Communications, 8th edition, Prentice Hall,2007.
- Forouzan,",Data Communications and Networking," 4th edition, McGraw Hill,2007.
- B.A. Forouzan," TCP/IP Protocol Suite", TMH, 3rd edition, 2006.

REFERENCE BOOKS

- Jochen H. Schiller, "Mobile Communications," Pearson Education,2003.
- JieWu"Distributed System Design" 1st Edition, ISBN-13:978-0849331787
- Principles of Distributed Database Systems, M.T. Ozsu and P. Valduriez, Prentice-Hall,1991.

APPLIED WIRELESS SENSOR NETWORKS	
Course Code: 21MBDA321	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: Computer Networks	

COURSE OBJECTIVE

- To understand Architect sensor networks for various application setups.
- To devise appropriate data dissemination protocols and model links cost.
- To understanding of the fundamental concepts of wireless sensor networks and have a basic knowledge of the various protocols at various layers.
- To understand Architect sensor networks for various application setups.
- To devise appropriate data dissemination protocols and model links cost.
- To understand of the fundamental concepts of wireless sensor networks and have a basic knowledge of the various protocols at various layers.

COURSE LEARNING OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). 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.
- Analyse the protocol design issues of wireless sensor networks
- Evaluate the QoS related performance measurements of Ad hoc and sensor networks.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5				✓	✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**AD HOC WIRELESS NETWORKS:**

	What is an Ad Hoc Network? Heterogeneity in Mobile Devices – Wireless Sensor Networks – Traffic Profiles – Types of Ad hoc Mobile Communication – Types of Mobile Host Movements – Challenges Facing Ad hoc Mobile Networks – Ad hoc wireless Internet . Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks – Classifications of Routing Protocols. Wireless Internet: Wireless Internet, Mobile IP, TCP in Wireless Domain, WAP, Optimizing Web Over Wireless.
UNIT-II	**MAC PROTOCOLS FOR AD HOC WIRELESS NETWORKS:** Issues in Designing a MAC protocol for Ad Hoc Wireless Networks, Design goals of a MAC Protocol for Ad Hoc Wireless Networks, Classifications of MAC Protocols, Contention – Based Protocols, Contention – Based Protocols with reservation Mechanisms, Contention – Based MAC Protocols with Scheduling Mechanisms, MAC Protocols that use Directional Antennas, Other MAC Protocols.
UNIT-III	**SECURITY:** Possible attacks, countermeasures, SPINS, Static and dynamic key Distribution, LEAP, INSENS Evolving Standards: Energy-Efficient Design, Synchronization, Transport Layer Issues.
UNIT-IV	**ROUTING PROTOCOLS FOR WSN:** Resource-aware routing, Location- based protocols, Data-centric protocols, Hierarchical protocols, Mobility-based and Heterogeneity based protocols, Geographic Routing, Broadcast, Multicast; Data Dissemination, Data Gathering; Quality of Sensor Network: Coverage, Exposure analysis.
UNIT-V	**QUALITY OF SERVICE:** Introduction, Issues and Challenges in Providing QoS in Ad Hoc Wireless Networks, Classification of QoS Solutions, MAC Layer Solutions, Network Layer Solutions, QoS Frameworks for Ad Hoc Wireless Networks.

TEXT BOOKS

- W. Dargie and C. Poellabauer, "Fundamentals of Wireless Sensor Networks –Theory and Practice", Wiley 2010
- KazemSohraby, Daniel Minoli and TaiebZnati, "wireless sensor networks -Technology, Protocols, and Applications", Wiley Interscience 2007

REFERENCE BOOKS

- Takahiro Hara,Vladimir I. Zadorozhny, and Erik Buchmann, "Wireless Sensor Network Technologies for the Information Explosion Era", springer 2010
- K.Akkaya and M.Younis, " A Survey of routing protocols in wireless sensor networks", Elsevier Adhoc Network Journal, Vol.3, no.3,pp. 325-349, 2005

SOFT COMPUTING	
Course Code: 21MBDA322	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: Basic knowledge of mathematics	

COURSE OBJECTIVE

- To introduce soft computing concepts.
- To understand 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 students the hands-on experience on MATLAB to implement various strategies of neural network.

COURSE OUTCOMES

The syllabus has been prepared in accordance with National Education Policy (NEP). 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.
- Analyze and implement neural network on realistic problems.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓	✓			
CO2		✓			
CO3			✓		
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**INTRODUCTION TO SOFT COMPUTING AND NEURAL NETWORKS:** Evolution of Computing: Soft Computing Constituents, From Conventional AI to Computational Intelligence: Machine Learning Basics.
UNIT-II	**FUZZY LOGIC :** Introduction to fuzzy Logic, Classical and Fuzzy Sets, Overview of Classical Sets, Membership Function, Fuzzy Rule generation. Operations on Fuzzy Sets: Compliment, Intersection, Union, Combination of Operations, Aggregation Operation
UNIT-III	**NEURAL NETWORKS:** Neural Networks : History, Overview of Biological Neuro-System, Mathematical Models of Neurons, ANN architecture, Learning rules, Gradient Descent Algorithm, Learning Paradigms-Supervised, Unsupervised and Reinforcement Learning, ANN Training Algorithms- Perceptrons, Training Rules, Delta, Back Propagation Algorithm, Multilayer Perceptron Model, Hopfield Networks, Associative Memories, Applications of Artificial Neural Networks. Adaptive Resonance architectures, Advances in Neural networks.
UNIT-IV	**GENETIC ALGORITHMS:** Introduction to Genetic Algorithms (GA), Applications of GA in Machine Learning: Machine Learning Approach to Knowledge Acquisition.
UNIT-V	**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.

TEXTBOOKS

- Jyh:Shing Roger Jang, Chuen:Tsai Sun, EijiMizutani, Neuro:Fuzzy and Soft Computing, Prentice:HallofIndia,2003.
- George J. Klirand Bo Yuan, Fuzzy Sets and Fuzzy Logic:Theory and Applications, Prentice Hall, 1995
- Sivanandam, S. N., and S. N. Deepa. Principles of soft computing (with CD). John Wiley & Sons, 2007.

REFERENCE BOOKS

- MATLAB ToolkitManuaL
- OglyAliev, Rafik Aziz, and Rashad Rafik Aliev. Soft computing and its applications. World Scientific, 2001.

COMPUTER VISION	
Course Code: 21MBDA323	Continuous Evaluation (Internal): 40 Marks
Credits: 4	End Semester Examination: 60 Marks
L T P : 4 0 0	
Pre-Requisites: Linear algebra, vector calculus, Data structures and Programming	

COURSE OBJECTIVES
• 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. • To study various image analysis techniques.

COURSE LEARNING OUTCOMES
The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:
• Develop the practical skills necessary to build computer vision applications. • To gain exposure to object and scene recognition and categorization from images. • To Develop Clustering: K-Means, K-Medoids. • Able to attempt solutions to current computer vision problems. • Having an understanding of commonly prevalent computer vision techniques with an awareness of research challenges available therein.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	**CLO2**	**CLO3**	**CLO4**	**CLO5**
CO1	✓				
CO2		✓			
CO3			✓	✓	
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT NUMBER	**COURSE CONTENTS**
UNIT-I	**INTRODUCTION:** Motivation, Image Representation and Image Analysis Tasks, Image Representations, a Few Concepts - Image Digitization, Sampling, Quantization, Digital Image Properties, Metric and Topological Properties of Digital Images, Histograms, Entropy, Image Quality, Noise in Images, Color Images, Color Spaces, Cameras: An Overview
UNIT-II	**EDGE DETECTION:**

	Introduction, Edge detection techniques, Edge detection performance, Hough transform, corner detection.
UNIT-III	**SEGMENTATION:** Watershed Segmentation , Region Growing Post-Processing, Evaluation Issues in Segmentation , Supervised Evaluation , Unsupervised Evaluation, Mean Shift Segmentation , Active Contour Models - Snakes Traditional Snakes and Balloons , Extensions , Gradient Vector Flow Snakes , Geometric Deformable Models - Level Sets and Geodesic Active Contours , Towards 3D Graph-Based Image Segmentation , Simultaneous Detection of Border Pairs , Sub-optimal Surface Detection , Graph Cut Segmentation , Optimal Single and Multiple Surface Segmentation
UNIT-IV	**FEATURE EXTRACTION:** Feature extraction, shape, histogram, color, spectral, texture, using CVIP tools, Feature analysis, feature vectors, distance/similarity measures, data preprocessing.
UNIT-V	**PATTERN ANALYSIS:** Clustering: K-Means, K-Medoids, Mixture of Gaussians Classification: Discriminant Function, Supervised, Unsupervised, Semi supervised Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA, and Non-parametric methods.

TEXT BOOKS

- Szeliski, Richard. Computer vision: algorithms and applications. Springer Science & Business Media, 2010.
- Chen, Chi Hau, ed. Handbook of pattern recognition and computer vision. World Scientific, 2015.

REFERENCE BOOKS

- Hassaballah, Mahmoud, and Ali Ismail Awad, eds. Deep learning in computer vision: principles and applications. CRC Press, 2020.
- Krig, Scott. Computer vision metrics: Survey, taxonomy, and analysis. Springer Nature, 2014.

SYLLABUS OF OPEN ELECTIVES

QUANTITATIVE TECHNIQUES	
Course Code: 21MBDA222	Continuous Evaluation (Internal): 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	
Prerequisites: Statistics, Mathematics	

COURSE OBJECTIVE

- To appreciate the uses and importance of quantitative methods in decision making.
- To formulate and solve decision problems in quantitative terms.
- To discuss business forecasts based on past data.
- To study about different multi-criteria decision making tools.
- To improve decision making with the help of PERT and CPM techniques.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand the concept of quantitative techniques.
- Identify different types of decision-making environments and choose the appropriate decision making approaches for each.
- Identify, formulate and solve Linear Programming Problems graphically, mathematically.
- Study about different multi-criteria decision making tools.
- Develop critical thinking and use PERT and CPM techniques to improve decision making.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓	✓	
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**AN OVERVIEW TO QUANTITATIVE TECHNIQUES:**

UNIT NUMBER	COURSE CONTENTS
	An analytical scientific approach to Problem solving, quantitative analysis, Operational research models & modeling process for Managerial Decision Making. Collection and analysis of Data Statistics for Management: Measures of Central Tendency & Dispersion, Probability concepts, Bayes Theorem & Applications, Probability Distributions-Binomial, Poisson, Normal & Exponential, Sampling & Sampling Distributions, Testing of Hypothesis.
UNIT-II	**DECISION MAKING AND QUANTITATIVE TECHNIQUES DECISION ANALYSIS:** Decision Trees & Utility Theory, Decision Making under uncertainty, under risk, under certainty & under conflict. Game Theory.
UNIT-III	**LINEAR PROGRAMMING FORMULATION AND SOLUTION:** Linear Programming; graphical, simplex method, dual simplex, Sensitivity Analysis & Duality. Integer Programming. Transportation, Transhipment& Assignment Models.
UNIT-IV	**MULTI-CRITERIA DECISION MAKING TOOLS MULTICRITERIA DECISION MAKING:** Linear Goal Programming, Scoring Models, Fuzzy outranking, Introduction to concepts of AHP (Analytic Hierarchy Process} & ANP (Analytic Network Process).
UNIT-V	**ADVANCE QUANTITATIVE METHODS AND APPLICATION:** Glimpses of Metaheuristics (Tabu, Simulated Annealing & Genetic algorithm), Markov chains & Decision Processes, Sequencing, Dynamic Programming & Nonlinear Programming (Quadratic & Geometric Programming) . Network models; shortest route, maximal flow problem . PERT, CPM, Case studies & applications.

TEXT BOOKS

- Anderson, Sweeney, Williams, 2002, Quantitative Methods for Business, Thomson South Western.
- Hamdy A Taha, 2006, Operations Research-An Introduction, Prentice Hall of India.
- Vohra N.D, 2007, Quantitative Techniques in Management, Tata McGraw- Hill.
- KantiSwarup, P.K.Gupta, Man Mohan, 2008, Operation Research, Sultan Chand and sons.

REFERENCE BOOKS

- Barry Render, RalphMStairJr, Michael E Hanna, 2005, Quantitative analysis for management, Pearson Education.

INTRODUCTION TO BIOINFORMATICS	
Course Code: 21MBDA224	Continuous Evaluation (Internal): 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	
Prerequisites: Chemistry	

COURSE OBJECTIVE
• To impart knowledge on basic techniques of Bioinformatics and on analysis of biological data using computational methods • To solve given biological problems by using appropriate bioinformatic methods and databases. • To investigate problems in molecular and biology from a computational perspective • To extract information from different types of bioinformatics data. • To study representation of patterns and applying their relationships in bioinformatics.

COURSE LEARNING OUTCOMES (CLO)
The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:
• Extract information from different types of bioinformatics data (gene, protein, disease, etc.), including their biological characteristics and relationships. • Account for and use methods in structural bioinformatics such as classification of protein structures, structure prediction, simulations and structure based drug design. • Solve given biological problems by using appropriate bioinformatic methods and databases. • Apply the different approaches used for data integration and data management, including data warehouse and wrapper approaches. . • Employ different data representation models and formats used for bioinformatics data representation, including markup languages such as SBML and CellML, and ontologies such as GO ontology.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**INTRODUCTION:** objectives and overviews, Interdisciplinary nature of Bioinformatics, Data integration, Data analysis, Major Bioinformatics databases and tools. Metadata: Summary & reference systems, finding new type of data online. Molecular Biology and Bioinformatics: Systems approach in biology, Central dogma of molecular biology, problems in molecular approach and the bioinformatics approach, overview of the bioinformatics applications.
UNIT-II	**DNA:** Basic chemistry of nucleic acids, Structure of DNA, Structure of RNA, DNA Replication, -Transcription, -Translation, Genes- the functional elements in DNA, Analysing DNA, DNA sequencing. Proteins: Amino acids, Protein structure, Secondary, Tertiary and Quaternary structure, Protein folding and function, Nucleic acid-Protein interaction.
UNIT-III	**APPLICATIONS FOR BIOINFORMATICS:** Perl Basics, Perl applications for bioinformatics- Bioperl, Linux Operating System, mounting/ unmounting files, tar, gzip / gunzip, telnet, ftp, developing applications on Linux OS, Understanding and Using Biological Databases, Overview of Java, CORBA, XML, Web deployment concepts.
UNIT-IV	**BIOLOGICAL DATA STORAGE TECHNIQUES:** Genome, Genomic sequencing, expressed sequence tags, gene expression, transcription factor binding sites and single nucleotide polymorphism. Computational representations of molecular biological data storage techniques: databases (flat, relational and object oriented), and controlled vocabularies, general data retrieval techniques: indices, Boolean search, fuzzy search and neighbouring, application to biological data warehouses.
UNIT-V	**REPRESENTATION OF PATTERNS AND RELATIONSHIPS IN BIOINFORMATICS:** Macromolecular structures, chemical compounds, generic variability and its connection to clinical data. Representation of patterns and relationships: sequence alignment algorithms, regular expressions, hierarchies and graphical models, Phylogenetic BLAST.

TEXT BOOKS

- Krane, Dan E. Fundamental concepts of bioinformatics. Pearson Education India, 2002.
- Rastogi, S. C., Parag Rastogi, and Namita Mendiratta. Bioinformatics Methods And Applications: Genomics Proteomics And Drug Discovery 3Rd Ed. PHI Learning Pvt. Ltd., 2008.

REFERENCE BOOKS

- Zvelebil, Marketa J., and Jeremy O. Baum. Understanding bioinformatics. Garland Science, 2007.
- Baxevanis, Andreas D., Gary D. Bader, and David S. Wishart, eds. Bioinformatics. John Wiley & Sons, 2020.
- Jones, Neil C., Pavel A. Pevzner, and Pavel Pevzner. An introduction to bioinformatics algorithms. MIT press, 2004.

BUSINESS ANALYTICS	
Course Code: 21MBDA225	Continuous Evaluation (Internal): 40 Marks
Credits: 3	End Semester Examination: 60 Marks
L T P : 3 0 0	
Prerequisites: Statistics, Mathematics	

COURSE OBJECTIVE

- To understand the role of business analytics within an organization.
- To familiarize the students with the concept of Data Analytics (Big Data) and its applicability in a business environment.
- To analyse data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
- To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
- To become familiar with processes needed to develop, report, and analyze business data.

COURSE LEARNING OUTCOMES (CLO)

The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:

- Understand the concepts and methods of business analytics.
- Ability to critically analyse, synthesize and solve complex unstructured business problems.
- Able to apply organization structures of Business analytics.
- Analyze the theories and methods and be able to choose the correct business analytics methods and use them in practice to draw logical conclusions and make recommendations in strategic decision-making situation.
- Understand the various forecasting techniques on real applications.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	CLO2	CLO3	CLO4	CLO5
CO1	✓				
CO2		✓			
CO3			✓		
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT NUMBER	COURSE CONTENTS
UNIT-I	**BUSINESS ANALYTICS:**

UNIT NUMBER	COURSE CONTENTS
	Overview of Business analytics, Scope of Business, analytics, Business Analytics Process, Relationship of Business Analytics, Process and organisation, competitive advantages of Business Analytics. Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.
UNIT-II	**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.
UNIT-III	**ORGANIZATION STRUCTURES:** 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.
UNIT-IV	**DECISION ANALYSIS:** Formulating Decision Problems, Decision Strategies, with the without Outcome Probabilities, Decision Trees, the Value of Information, Utility and Decision Making.
UNIT-V	**FORECASTING TECHNIQUES:** Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time.

TEXT BOOKS

- Larson, Erik W., and Clifford F. Gray. Project Management: The Managerial Process (Special Indian Edition). Tata McGraw-Hill Education, 2006.
- Cadle, James. Business analysis. Edited by Debra Paul, and Donald Yeates. BCS, The Chartered Institute for IT, 2014.

REFERENCE BOOKS

- Siegel, Eric. Predictive analytics: The power to predict who will click, buy, lie, or die. Vol. 10. Hoboken: Wiley, 2013.
- Gordon, Jonathan, Jesko Perrey, and Dennis Spillecke. "Big data, analytics and the future of marketing and sales." McKinsey: Digital Advantage (2013).
- Bajpai, Naval. Business statistics. Pearson Education India, 2009.
- Whigham, David. Business data analysis using Excel. Oxford University Press, 2007.

DESIGN OF EMBEDDED SYSTEMS	
Course Code: 21MBDA226	Continuous Evaluation (Internal): 40 Marks
Credits: 3	External/ Examination: 60
L T P : 3 0 0	
Pre-Requisites: Linear algebra, vector calculus, Data structures and Programming	

COURSE OBJECTIVE
• To have knowledge about the basic working of a microcontroller system and its programming in assembly language • To provide experience to integrate hardware and software for microcontroller applications systems • To grasp the principles of state-of-the-art Embedded Systems • To study various Embedded Systems techniques. • To understand the design concept of embedded systems.

COURSE LEARNING OUTCOMES (CLO)
The syllabus has been prepared in accordance with National Education Policy (NEP). After completion of course, students would be able to:
• Acquire knowledge about microcontrollers embedded processors and their applications. • Foster ability to understand the internal architecture and interfacing of different peripheral devices with Microcontrollers. • Foster ability to write the programs for microcontroller. • Foster ability to understand the design concept of embedded . • Foster ability to understand the role of embedded systems in industry.

COURSE LEARNING OUTCOME (CLO)-COURSE OBJECTIVE (CO) MAPPING

	CLO1	**CLO2**	**CLO3**	**CLO4**	**CLO5**
CO1	✓				
CO2	✓	✓			
CO3			✓	✓	
CO4				✓	
CO5					✓

COURSE CONTENTS

UNIT NUMBER	**COURSE CONTENTS**
UNIT-I	**MICROPROCESSOR AND MICROCONTROLLER:** Microprocessor and Microcontroller, Different types of Microcontrollers, 4 bit, 8 bit, 16 bit, and 32 bit Microcontrollers, Processor Architectures: Harvard & Princeton, CISC & RISC, Microcontrollers memory types, Microcontrollers features, Criteria for choosing a microcontroller, Applications of microcontrollers.
UNIT-II	**EMBEDDED SYSTEM:**

UNIT NUMBER	COURSE CONTENTS
	Embedded System, Embedded Processors, Hardware units, Devices and Software in a system, Embedded system on chip, Complex Systems design and processors, Design examples. Introduction to Embedded C, Difference between C & Embedded C.
UNIT-III	**IMPLEMENTATION :** Types of Operators, Bitwise Operators explained, control structures & loops, Decision making with if statement, If….else statement, Switch statement, and GOTO statement, The While and Do – While statements, For statement
UNIT-IV	**REGISTERS, EEPROM PROGRAMMING :** Power Input and Decoupling , Reset, Watchdog Timer, System Clock/Oscillators, Configuration Registers, Sleep , Hardware and File Registers, Parallel Input Output, Interrupts, Prescaler , The OPTION Register , Mid-Range Built-In EEPROM Flash Access,TMR1 and TMR2 Serial I/0, Analog I/0, Parallel Slave Port (PSP), External Memory Connections ,In-Circuit Serial Programming (ISCP).
UNIT-V	**LED & LCD:** Introduction of LED's, Interfacing Circuit Description of LED's. Programming of LED's Interfacing, Introduction to Switches & Keyboard Matrix, Interfacing Circuit of Switches & Keyboard Matrix, Programming of Keyboard Matrix & Switches, Controlling of LED's by using Switches, Key board Matrix & LCD Interfacing Program

TEXT BOOKS

- Heath, Steve. Embedded systems design. Elsevier, 2002.
- Wilmshurst, Tim. Designing embedded systems with PIC microcontrollers: principles and applications. Elsevier, 2006.

REFERENCE BOOKS

- Kaelbling, Leslie Pack. Learning in embedded systems. MIT press, 1993.
- Zurawski, Richard, ed. Embedded systems handbook. CRC press, 2005.