GALGOTIAS UNIVERSITY

(Established under Galgotias University Uttar Pradesh Act No. 14 of 2011)

School of Computing Science and Engineering

Program: M.Tech Computer Science and Engineering

Scheme: 2018 – 2020

Curriculum

Semester 1

Sl. No	Course Code	Name of the Course					Assessment Pattern		
			L	T	P	C	IA	CAT I/II	ETE
1	CENG5001	Professional Communication Skills	0	0	2	1	50	-	50
2	MATH5001	Advanced Numerical and Statistical Methods	3	1	0	4	20	50	100
3	MCSE1110	Advanced Design and Analysis of Algorithms	3	0	0	3	20	50	100
4	MCSE1120	Advanced Computer Networks	3	0	0	3	20	50	100
5	MCSE1130	Advanced Operating Systems	3	0	0	3	20	50	100
6	MCSE1140	Big Data Technologies	3	0	0	3	20	50	100
7	MCSE1111	Advanced Design and Analysis of Algorithms Lab	0	0	2	1	50	-	50
8	MCSE1121	Advanced Computer Networks Lab	0	0	2	1	50	-	50
9	MCSE1141	Big Data Technologies Lab	0	0	2	1	50	-	50
		Total	**15**	**1**	**8**	**20**			

Semester II

Sl No	Course Code	Name of the Course					Assessment Pattern		
			L	T	P	C	IA	CAT I/II	ETE
1	MCSE1210	Network Security	3	0	0	3	20	50	100
2	MCSE1220	Advanced Computer Graphics	3	0	0	3	20	50	100
3	MCSE1230	Cloud Computing Technologies	3	0	0	3	20	50	100
4	MCSE91*	Elective-1	3	0	0	3	20	50	100
5	MCSE92*	Elective-2	3	0	0	3	20	50	100
6	MCSE1211	Network Security Lab	0	0	2	1	50	-	50
7	MCSE1221	Advanced Computer Graphics Lab	0	0	2	1	50	-	50
		Total	**15**	**0**	**4**	**17**			

Semester III

Sl No	Course Code	Name of the Course					Assessment Pattern		
			L	T	P	C	IA	MTE	ETE
1	SLMT5001	Quantitative and Communication Proficiency	0	0	4	2	50	-	100
2	MCSE2310	Software Requirements Engineering	3	0	0	3	20	50	100
3	MCSE93*	Elective-3	3	0	0	3	20	50	100
4	MCSE94*	Elective-4	3	0	0	3	20	50	100
5	MCSE2311	Software Requirements Engineering Lab	0	0	2	1	50	-	50
6	MCSE2381	M. Tech Dissertation Part-1	0	0	0	5	50	-	50
		Total	**12**	**0**	**6**	**17**			

Semester IV									
Sl No	**Course Code**	**Name of the Course**					**Assessment Pattern**		
			L	**T**	**P**	**C**	**IA**	**MTE**	**ETE**
1	MCSE2481	M. Tech Dissertation-Final	0	0	30	15	**50**	**-**	**50**
		Total	**0**	**0**	**30**	**15**			

List of Electives

Basket-1

Sl No		**Course Code**	**Name of the Electives**				
				L	**T**	**P**	**C**
1	**Elective-1**	MCSE9110	IoT Technology and Applications	3	0	0	3
2		MCSE9120	IoT on Cloud	3	0	0	3
3		MCSE9130	Big Data Mining and Analytics	3	0	0	3
4		MCSE9140	Data Science and Big Data Analytics	3	0	0	3

Basket-2

Sl No		**Course Code**	**Name of the Electives**				
				L	**T**	**P**	**C**
1	**Elective-2**	MCSE9210	Real Time Systems	3	0	0	3
2		MCSE9220	Mobile and Pervasive Computing	3	0	0	3
3		MCSE9230	Parallel Programming Paradigms	3	0	0	3
4		MCSE9240	Information Retrieval Techniques	3	0	0	3

Basket-3

Sl No		**Course Code**	**Name of the Electives**				
				L	**T**	**P**	**C**
1	**Elective-3**	MCSE9310	Formal models of software systems	3	0	0	3
2		MCSE9320	Embedded Software Development	3	0	0	3
3		MCSE9330	Social Network Analysis	3	0	0	3
4		MCSE9340	Bio-inspired Computing	3	0	0	3

Basket-4

Sl No		**Course Code**	**Name of the Electives**				
				L	**T**	**P**	**C**
1	**Elective-4**	MCSE9410	Data Visualization Techniques	3	0	0	3
2		MCSE9420	Reconfigurable Computing	3	0	0	3
3		MCSE9430	Mobile Application Development	3	0	0	3
4		MCSE9440	Information Storage Management	3	0	0	3

Detailed Syllabus

Name of The Course	Professional and Communication Skills			
Course Code	CENG 5001			
Prerequisite				
Corequisite				
Antirequisite				
	L	T	P	C
	0	0	2	1

Course Objective:

1. To develop the professional and communicational skills of learners in a technical environment.
2. To enable students acquire functional and technical writing skills.
3. To enable students acquire presentation skills to technical and non-technical audience.

Course Outcomes:

CO1	Improve their reading fluency skills through extensive reading
CO2	Use and assess information from academic sources, distinguishing between main ideas and details
CO3	Compare and use a range official support through formal and informal writings
CO4	The students will be able to exhibit language proficiency in comprehending, describing, and investigating.

Text Books

1. Rajendra Pal and J.S.Korlahalli. Essentials of Business Communication. Sultan Chand & Sons. New Delhi.

Reference Books

1. Kaul. Asha. Effective Business Communication.PHI Learning Pvt. Ltd. New Delhi.2011.
2. Murphy, Essential English Grammar, CUP.
3. J S Nesfield, English Grammar: Composition and Usage
4. Muralikrishna and S. Mishra, Communication Skills for Engineers.

UNIT 1:

Aspects of Communication; Sounds of syllables; Past tense and plural endings; Organizational techniques in Technical Writing; Paragraph Writing, Note taking, Techniques of presentation

UNIT 2:

Tense, Voice, conditionals, Techno-words; Basic concepts of pronunciation; word stress; Business letters, email, Techniques for Power Point Presentations; Dos and don'ts of Group Discussion

UNIT 3:

An introduction to Modal and Phrasal verbs; Expansion; Word formation; Technical Resume; Company Profile Presentation; Interview Skills

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
50	-	50	100

Name of The Course	Advanced Numerical and Statistical Methods			
Course Code	MATH5001			
Prerequisite				
Corequisite				
Antirequisite				
	L	T	P	C
	3	1	0	4

Course Objective:

With ever growing demand of computational techniques, scope of numerical methods is penetrating aggressively into major and important fields including Science, Engineering &Technology, Medical, Space Science, Economics, Business and Environment. The objective is to achieve knowledge and understanding of numerical methods and to apply appropriate methods to model and solve problems where ordinary analytical methods fail. Statistical methods are used in manufacturing, development of food product, computer software, energy sources, pharmaceuticals and many other areas. The objective of statistics and probability is to analyze data to make scientific judgments in the face of uncertainty and variation for the improvement of the desired quality.

Course Outcomes:
At the end of the course, students will be able to:

CO1	Apply various numerical methods to solve system of linear and non-linear equations.
CO2	Apply standard interpolation methods to interpolate required/ missing value.
CO3	Apply appropriate methods of numerical differentiation /integration to solve related problems.
CO4	Solve ordinary differential equations and partial differential equations using appropriate numerical methods.
CO5	Identify the type of distributions and apply a suitable test to draw the conclusion.

Text Books:

1. Numerical Methods for Scientific and Engineering Computation (6^{th} edition) by Jain, Iyengar & Jain, New Age International publishers.
2. Probability & Statistics for Engineers & Scientists (9^{th} edition) by R.E.Walpole, R,H,Myers & K.Ye.

Reference Books:

1. Numerical Methods by E Balagurusamy, Tata McGraw Hill
2. Curtis F. Gerald and Patrick O Wheatley, Applied Numerical Analysis, Pearson Education Ltd.
3. Introductory Methods of Numerical Analysis by S.S. Sastry, PHI learning Pvt Ltd.
4. Numerical methods for Engineers (6^{th} edition), Steven C. Chapra and Raymond P. Caynale.
5. Numerical Methods in Engineering & Science (9^{th} edition), by B.S.Grewal
6. Statistical Methods by S.P. Gupta, Sultan Chand and Sons
7. Probability and Statistics by Schaum's series (3^{rd} edition)

Unit –I **8 Hours**

System of Linear Equations: Direct Methods- Gauss elimination – Pivoting, Partial and Total Pivoting, Triangular factorization method using Crout LU decomposition, Cholesky method, Iterative Method- Gauss- Seidel and Jacobi method, ill conditioned matrix System of Non-linear equation- Newton Raphson and Modified Newton Raphson Method. Iterative methods

Unit -II **8 Hours**

Interpolation and Approximation: Lagrange, Spline and Hermite interpolation, Approximations, Error of approximation, Norms for discrete and continuous data, Least square approximation.

Unit -III **8 Hours**

Numerical Integration: Newton Cotes closed Quadrature, Gauss Legendre Quadrature, Multiple Integration An introduction to Modal and Phrasal verbs; Expansion; Word formation; Technical Resume; Company Profile Presentation; Interview Skills

Unit -IV **9 Hours**

Numerical Solution of Differential Equations: Finite Difference Schemes, Numerical solution of Ordinary differential equation using Modified Euler's method, Runge-Kutta method of 2nd, 3rd and 4th orders, Predictor-Corrector method, Solution of Laplace's and Poisson's equations by Liebman's method, Solution of one dimensional time dependent heat flow.

Unit -V **9 Hours**

Probability and statistics: Review of concept of probability, Random Variables, Continuous and discrete distribution function, moments and moments generating functions, Binomial, Poisson, Negative Binomial, Geometric and Hyper-geometric Distributions, Uniform, Normal, Exponential, Gamma and Beta distributions. Point and Interval estimation, Testing of Hypothesis (t-test and chi square test), Analysis of variance and Introduction of Design of experiments

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Advanced Design and Analysis of Algorithms			
Course Code	MCSE1110			
Prerequisite				
Corequisite				
Antirequisite				
	L	T	P	C
	3	0	0	3

Course Objectives

1. To know the importance of the complexity of a given algorithm.
2. To study various algorithmic design techniques.
3. To utilize data structures and/or algorithmic design techniques in solving new problems.
4. To know and understand basic computability concepts and the complexity classes P, NP, and NP-Complete.

Course Outcomes

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

CO1	Analyze the complexity of the algorithms and use technique divide and conquer to solve the problems
CO2	Identify feasible solutions for different problems through greedy method and minimize the solutions space and to solve the problems through dynamic programming.
CO3	Solve the problems through graph algorithms.
CO4	Justify that a certain problem is NP-Complete
CO5	Understand and apply linear programming concepts to real time applications.

Text Books

1. Cormen, Leiserson, Rivest and Stein, "Introduction to Algorithms", 2nd Edition, by, McGraw-Hill, 2000.
2. E. Horowitz, and S. Sahni, "Fundamentals of Computer Algorithms", Computer Science Press (1978).

Reference Books

1. Jon Kleinberg and Eva Tardos. Algorithm Design. Pearson Education, 2007.
2. Sanjoy Das Gupta, Christos Papadimitriou, Umesh Vazirani, Algorithms 1st Edition, Mcgraw Higher Ed, 2006.
3. Alfred V. Aho, John E. Hopcroft, Jeffery D.Ulman, Data Structures and Algorithms, Pearson; 1st edition, 2001.

Course Content

Unit I: Introduction **9 Hours**

Overview of algorithmic design, asymptotic notation and its properties, Growth of Functions, Time complexity and Analysis of algorithms, Recurrence Relations.

Unit II: Sorting and Searching Algorithms **9 Hours**

Brute Force Method - Sorting in Quadratic time, insertion , selection and Bubble sort; Divide and conquer method- Sorting in Logarithmic time – Quick Sort , merge Sort , Shell Sort , Heap sort; Non-comparison sorts - Sorting in Linear Time - Counting Sort , Radix Sort , Bucket Sort; Worst Case and best case analysis of all sorting algorithms; Linear Search, Binary Search, Hashing, Randomized select , randomized quick sort.

Unit III: Algorithms for Trees **9 hours**

Binary Tree - Binary Tree traversals, Binary Search Tree, heap, priority Queues, Red Black Trees, B-Trees.

Unit IV : Graph Algorithms **8 hours**

Graph Searching- Breadth-First Search, Depth-First Search, DAGs and topological sorting, minimum spanning

tree, shortest path, backtracking, Network flow algorithms.
Unit V: Greedy Algorithms, Amortized Analysis and Dynamic Programming 10 hours Longest common subsequence, Greedy Algorithms - Knapsack problem; Huffman codes, Algorithms for String Matching, Theory of NP-completeness; Turing machines and the halting problem, Applications of Algorithms in Databases, Information Retrieval and Web Searching, Data Mining

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	**30**	**50**	**100**

Name of The Course	Advanced Computer Networks			
Course Code	MCSE1120			
Prerequisite				
Corequisite				
Antirequisite				
	L	T	P	C
	3	0	0	3

Course Objectives

The objective of this course is to:

1. An ability to understand the basic concept of data communications and computer networks (e.g., different network types, applications, protocols, OSI layered architecture model, switching methodologies)
2. Provide the skills needed for algorithms in computer networks for various situations that one may encounter in a career in Computer Science.
3. Learn different algorithmic methodologies to design efficient algorithms and protocols in network field.

Course Outcomes

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

CO1	To develop knowledge about physical structure of computer network
CO2	To understand the fundamental concepts in routing and addressing
CO3	To analysis the problem in different layer during the communication in network
CO4	To understand the congestion control and transport protocols
CO5	To became expert to use of Internet and public network
CO6	To able to understand the connection management in network at transport layer

Text Books

1. Behrouz A. Forouzan, TCP/IP Protocol Suite, Third Edition, Tata McGraw-Hill, 2005.
2. W. Richard Stevens, TCP/IP Illustrated, The Protocols, Pearson Education, 2004.
3. D. E. Comer, Internetworking with TCP/IP Principles, Protocols and Architecture Vol - I, Pearson Education, 2001.

Reference Books

1. Internetworking with TCP/IP: Design, Implementation, and Internals by Douglas E. Comer, Stevens.Prentice Hall. Hardcover- 30 April, 2004.
2. Networks Fundamental Video 3 - the Transmission Control Protocol/internet Protocol (Tcp/ip) Stack by Delmar.Delmar. Unknown Binding- 1 December, 2002.
3. Advanced IP Routing in Cisco Networks (McGraw-Hill Technical Expert) by Terry Slattery, Bill Burton. Osborne McGraw-Hill. Paperback- 1 October, 2000.

Course Content

Unit I: Networking Standards and Specification **8 hours** Networking standards and specifications, Need for standardization, ISO and the IEEE standards, The IEEE 802 Project
Unit II: Addressing and Routing **8 hours** Network names and addresses, Physical layer addressing: the MAC address, Network layer addressing: The IP address, Network layer address: The IPX address.
Unit III: Overview of OSI and TCP/IP Protocol Suite **8 hours** Converting network names to IP addresses, Resolving IP addresses to physical addresses, Addressing and routing.

Unit IV : TCP/IP Protocol Suite **8 hours** TCP/IP Protocol Suite, TCP/IP Protocol Suite advantages, Internet Protocol (IP), Transport Layer Protocols -TCP and UDP, File Transfer protocols - FTP and TFTP, Mail and news protocols - SMTP, POP3, NNTP and IMAP, Other Protocols Suite – ICMP and ARP.
Unit V: Other Networking Protocols **8 hours** The IPX/SPX Protocol Suite, NetBEUI, AppleTalk Protocol, File sharing protocols - SMB, NCP, and NFS, Routing protocols - RIP, OSPF and BGP, Network Management Protocol – SNMP and CIMP, Convergent Protocols – H.323 and SIP

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	**30**	**50**	**100**

Name of The Course	Advanced Operating Systems			
Course Code	MCSE1130			
Prerequisite				
Corequisite				
Antirequisite				
	L	T	P	C
	3	0	0	3

Course Objectives

1. To learn the fundamentals of Operating Systems.
2. To gain knowledge on Distributed operating system concepts that includes architecture, Mutual exclusion algorithms, Deadlock detection algorithms and agreement protocols.
3. To gain insight on to the distributed resource management components viz. the algorithms for implementation of distributed shared memory, recovery and commit protocols.
4. To know the components and management aspects of Real time, Mobile operating systems.

Course Outcomes

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

CO1	Discuss the various synchronization, scheduling and memory management issues.
CO2	Demonstrate the Mutual exclusion, Deadlock detection and agreement protocols of Distributed operating system.
CO3	Discuss the various resource management techniques for distributed systems.
CO4	Identify the different features of real time and mobile operating systems.
CO5	Install and use available open source kernel.
CO6	Modify existing open source kernels in terms of functionality or features used.

Text Books

1. Mukesh Singhal and Niranjan, "Advanced Concepts in Operating Systems", TMH, 1st Edition, 2001
2. Andrew S. Tanenbaum, "Modern Operating Systems", Pearson Education, 2nd Edition, 2006
3. Andrew S. Tanenbaum, "Distributed Operating Systems", Pearson Education, 2nd Edition, 2001.
4. Pradeep K. Sinha, "Distributed Operating Systems and concepts", PHI, First Edition, 2002

Reference Books

1. Mukesh Singhal and Niranjan G. Shivaratri, "Advanced Concepts in Operating Systems – Distributed, Database, and Multiprocessor Operating Systems", Tata McGraw-Hill, 2001.
2. Abraham Silberschatz; Peter Baer Galvin; Greg Gagne, "Operating System Concepts", Seventh Edition, John Wiley & Sons, 2004.
3. Daniel P Bovet and Marco Cesati, "Understanding the Linux kernel", 3rd edition, O'Reilly, 2005.

Course Content

Unit I: Introduction **8 hours** Operating system concept - processes and threads, process model, process creation, process termination, process hierarchies, and process states, Implementation of processes, Threads- Thread model, thread usage, Implementation of threads in user space and kernel, Hybrid implementations.
Unit II: Inter Process Communication **8 hours**

Race conditions, critical regions, Mutual Exclusion with busy waiting, sleep and wakeup, Semaphores, Mutexes, Monitors, Message passing; Scheduling- scheduling in batch systems, Interactive systems, Real time systems, Thread scheduling.
Unit III: Deadlocks **8 hours** Deadlocks-Introduction, Deadlock Detection and Recovery – Deadlock Detection with one resource of each type, with multiple resource of each type, recovery from deadlock; Deadlock Avoidance, Deadlock Prevention
Unit IV : Memory and Device Management **8 hours** Introduction, Swapping, Paging, Virtual memory – Demand paging, page replacement Algorithms; File System Management- Organization of File System, File Permissions, MS DOS and UNIX file system case studies, NTFS; Device Management- I/O Channels, Interrupts and Interrupt Handling, Types of device allocation.
Unit V: Distributed Operating Systems **8 hours** Distributed operating system concept – Architectures of Distributed Systems, Distributed Mutual Exclusion, Distributed Deadlock detection, Agreement protocols, Threads, processor Allocation, Allocation algorithms, Distributed File system design; Real Time Operating Systems: Introduction to Real Time Operating Systems, Concepts of scheduling , Real time Memory Management.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Big Data Technologies				
Course Code	MCSE1140				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To understand the competitive advantages of big data analytics.
2. To understand the big data frameworks.
3. To learn data analysis methods.
4. To learn stream computing.
5. To gain knowledge on Hadoop related tools such as HBase, Cassandra, Pig, and Hive for big data analytics.

Course Outcomes

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

CO1	Understand how to leverage the insights from big data analytics.
CO2	Analyze data by utilizing various statistical and data mining approaches
CO3	Perform analytics on real-time streaming data.
CO4	Understand the various NoSql alternative database models.

Text Books

1. Bill Franks, ―Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics‖, Wiley and SAS Business Series, 2012.

2. David Loshin, "Big Data Analytics: From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph", 2013.

3. Michael Berthold, David J. Hand, ―Intelligent Data Analysis‖, Springer, Second Edition, 2007.

4. Michael Minelli, Michelle Chambers, and Ambiga Dhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses", Wiley, 2013.

Reference Books

1. P. J. Sadalage and M. Fowler, "NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence", Addison-Wesley Professional, 2012.

2. Richard Cotton, "Learning R – A Step-by-step Function Guide to Data Analysis, O‘Reilly Media, 2013.

Course Content

Unit I: INTRODUCTION TO BIG DATA **8 hours**

Big Data – Definition, Characteristic Features – Big Data Applications - Big Data vs Traditional Data - Risks of Big Data - Structure of Big Data - Challenges of Conventional Systems - Web Data – Evolution of Analytic Scalability - Evolution of Analytic Processes, Tools and methods - Analysis vs Reporting - Modern Data Analytic Tools.

Unit II: HADOOP FRAMEWORK **9 hours**

Distributed File Systems - Large-Scale FileSystem Organization – HDFS concepts - MapReduce Execution,

Algorithms using MapReduce, Matrix-Vector Multiplication – Hadoop YARN

Unit III: DATA ANALYSIS **13 hours**

Statistical Methods:Regression modelling, Multivariate Analysis - Classification: SVM & Kernel Methods - Rule Mining - Cluster Analysis, Types of Data in Cluster Analysis, Partitioning Methods, Hierarchical Methods, Density Based Methods, Grid Based Methods, Model Based Clustering Methods, Clustering High Dimensional Data - Predictive Analytics – Data analysis using R.

Unit IV : MINING DATA STREAMS **8 hours**

Streams: Concepts – Stream Data Model and Architecture - Sampling data in a stream - Mining Data Streams and Mining Time-series data - Real Time Analytics Platform (RTAP) Applications - Case Studies - Real Time Sentiment Analysis, Stock Market Predictions.

Unit V: BIG DATA FRAMEWORKS **9 hours**

Introduction to NoSQL – Aggregate Data Models – Hbase: Data Model and Implementations – Hbase Clients – Examples – .Cassandra: Data Model – Examples – Cassandra Clients – Hadoop Integration. Pig – Grunt – Pig Data Model – Pig Latin – developing and testing Pig Latin scripts. Hive – Data Types and File Formats – HiveQL Data Definition – HiveQL Data Manipulation – HiveQL Queries.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Advanced Design and Analysis of Algorithms Lab				
Course Code	MCSE1111				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		0	0	2	1

List of Experiments:

1. Write C++ programs to implement the following: a) Prim's algorithm. b) Kruskal's algorithm.
2. Write a C++ program to find optimal ordering of matrix multiplication. (Note: Use Dynamic programming method).
3. Consider the problem of eight queens on an (8x8) chessboard. Two queens are said to attack each other if they are on the same row, column, or diagonal. Write a C++ program that implements backtracking algorithm to solve the problem i.e. place eight non-attacking queens on the board.
4. Write a C++ program to find the strongly connected components in a digraph.
5. Write a C++ program to implement file compression (and un-compression) using Huffman's algorithm. .
6. Write a C++ program to implement dynamic programming algorithm to solve all pairs shortest path problem.
7. Write a C++ program to solve 0/1 knapsack problem using the following: a) Greedy algorithm. b) Dynamic programming algorithm. c) Backtracking algorithm. d) Branch and bound algorithm.
8. Write a C++ program that uses dynamic programming algorithm to solve the optimal binary search tree problem.
9. Write a C++ program for solving traveling sales persons problem using the following: a) Dynamic programming algorithm. b) The back tracking algorithm.

Continuous Assessment Pattern

Internal Assessment (IA)	End Term Exam (ETE)	Total Marks
50	50	100

Name of The Course	Advanced Computer Networks Lab				
Course Code	MCSE1121				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		0	0	2	1

List of Experiments:

1. Configuration and logging to a CISCO Router and introduction to the basic user Interfaces. Introduction to the basic router configuration and basic commands.
2. Configuration of IP addressing for a given scenario for a given set of topologies.
3. Configure a DHCP Server to serve contiguous IP addresses to a pool of four IP devices with a default gateway and a default DNS address. Integrate the DHCP server with a BOOTP demon to automatically serve Windows and Linux OS Binaries based on client MAC address.
4. Configure, implement and debug the following: Use open source tools for debugging and diagnostics. a. ARP/RARP protocols b. RIP routing protocols c. BGP routing d. OSPF routing protocols e. Static routes (check using netstat)
5. Configure DNS: Make a caching DNS client, and a DNS Proxy; implement reverse DNS and forward DNS, using TCP dump/Wireshark characterise traffic when the DNS server is up and when it is down.
6. Configure FTP Server on a Linux/Windows machine using a FTP client/SFTP client characterise file transfer rate for a cluster of small files 100k each and a video file of 700mb.Use a TFTP client and repeat the experiment.
7. Configure a mail server for IMAP/POP protocols and write a simple SMTP client in C/C++/Java client to send and receive mails
8. Implement Open NMS+ SNMPD for checking Device status of devices in community MIB of a linux PC. Using yellow pages and NIS/NFS protocols implement Network Attached Storage Controller (NAS). Extend this to serve a windows client using SMB. Characterise the NAS traffic using wireshark.

Continuous Assessment Pattern

Internal Assessment (IA)	End Term Exam (ETE)	Total Marks
50	50	100

Name of The Course	Big Data Technologies Lab			
Course Code	MCSE1141			
Prerequisite				
Corequisite				
Antirequisite				
	L	T	P	C
	0	0	2	1

LIST OF EXPERIMENTS:

Hadoop

1. Install, configure and run Hadoop and HDFS
2. Implement word count / frequency programs using MapReduce
3. Implement an MR program that processes a weather dataset R
4. Implement Linear and logistic Regression
5. Implement SVM / Decision tree classification techniques
6. Implement clustering techniques
7. Visualize data using any plotting framework
8. Implement an application that stores big data in Hbase / MongoDB / Pig using Hadoop / R.

Continuous Assessment Pattern

Internal Assessment (IA)	End Term Exam (ETE)	Total Marks
50	50	100

Name of The Course	Network Security				
Course Code	MCSE1210				
Prerequisite					
Corequisite					
Antirequisite					
	L	T	P	C	
	3	0	0	3	

Course Objectives

1. To understand the fundamentals of network security.
2. To acquire knowledge on standard algorithms used to provide confidentiality, integrity and authenticity.
3. To understand the various key distribution and management schemes.
4. To understand how to deploy encryption techniques to secure data in transit across data networks.
5. To design security applications in the field of Information technology.

Course Outcomes

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

CO1	Compare various Security Techniques Design Secure applications Inject secure coding in the developed applications
CO2	Implement basic security algorithms required by any computing system.
CO3	Analyze the vulnerabilities in any computing system and hence be able to design a security solution
CO4	Analyze the possible security attacks in complex real time systems and their effective countermeasures.
CO5	Identify the security issues in the network and resolve it.
CO6	Evaluate security mechanisms using rigorous approaches, including theoretical derivation, modeling, and simulations.

Text Books

1. Behrouz A. Ferouzan, ―Cryptography & Network Security‖, Tata Mc Graw Hill, 2007.
2. Bruce Schneier and Neils Ferguson, ―Practical Cryptography‖, First Edition, Wiley Dreamtech India Pvt Ltd, 2003.
3. Charles Pfleeger, ―Security in Computing‖, 4th Edition, Prentice Hall of India, 2006.
4. Charlie Kaufman and Radia Perlman, Mike Speciner, ―Network Security, Second Edition, Private Communication in Public World‖, PHI 2002.

Reference Books

1. Douglas R Simson ―Cryptography – Theory and practice, First Edition, CRC Press, 1995.
2. Man Young Rhee, ―Internet Security: Cryptographic Principles‖, ―Algorithms and Protocols‖, Wiley Publications, 2003.
3. Ulysess Black, ―Internet Security Protocols‖, Pearson Education Asia, 2000.
4. William Stallings, Cryptography and Network Security, 6th Edition, Pearson Education, March 2013.

Course Content

Unit I: INTRODUCTION **10 hours**

Services, Mechanisms and attacks-Classical Encryption techniques (Symmetric cipher model, substitution

techniques, transposition techniques, steganography).FINITE FIELDS AND NUMBER THEORY: Groups, Rings, Fields-Modular arithmetic-Euclid's algorithm Finite fields- Polynomial Arithmetic –Prime numbers-Fermat's and Euler's theorem-Testing for primality -The Chinese remainder theorem- Discrete logarithms

Unit II: BLOCK CIPHERS & PUBLIC KEY ENCRYPTION 10 hours

Data Encryption Standard-Block cipher design principles-block cipher modes of operation Advanced Encryption Standard (AES)-Triple DES-Blowfish-RC5 algorithm. Public key encryption: Principles of public key cryptosystems-The RSA algorithm – Key Management - Diffie Hellman Key exchange-Elliptic curve arithmetic-Elliptic curve cryptography.

Unit III: HASH FUNCTIONS AND DIGITAL SIGNATURES 13 hours

Authentication requirement – Authentication function – MAC – Hash function – Security of hash function and MAC –MD5 - SHA - HMAC – CMAC - Digital signature and authentication protocols – DSS – EI Gamal – Schnorr.

Unit IV : E-MAIL, IP & WEB SECURITY 8 hours

E-mail Security: Pretty Good Privacy-S/MIME. IPSecurity: Overview of IPSec - IP security policy-Encapsulation Security Payload (ESP)-Combining Security Associations-Internet Key Exchange. Web Security: Web Security Considerations-Secure Socket Layer(SSL)- Transport Layer Security(TLS)- -Secure Electronic Transaction (SET).

Unit V: SYSTEM SECURITY 9 hours

Authentication applications – Kerberos – X.509 Authentication services - Firewalls – Types of Firewalls-Firewall design principles- Trusted System. Intruders – Intrusion detection – Viruses and related threats – Virus Countermeasures.

.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Advanced Computer Graphics				
Course Code	MCSE1220				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To study the graphics techniques, packages and algorithms.
2. To enable the Students to understand the Graphics rendering and hardware.
3. To enable the Students to learn visualization techniques.

Course Outcomes

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

CO1	Create interactive graphics applications using one or more graphics application programming interfaces.
CO2	Use illumination models.
CO3	Explain graphics hardware.
CO4	Apply surface rendering and visualization techniques.

Text Books

1. Watt A. and M. Watt, Advanced, Animation and Rendering Techniques, Addison Wesley, 1992.
2. Hearn D. and P. Baker, Computer Graphics C Version, Pearson Education India; 2 edition, 2002.

Reference Books

1. Neider, J., T. Davis, and M. Woo, OpenGL Programming Guide, Addison-Wesley, 1993.
2. Luebke D., M. Reddy, J. Cohen, A. Varshney, B. Watson, R. Huebner, Level of Detail for 3D Graphics, 2003.
3. James D. Foley, Andries van Dam, Steven K. Feiner and John Hughes, Computer Graphics: Principles and Practice, Second Edition in C, Addison-Wesley, 1995.
4. Dan Ginsburg, Budi Purnomo, Dave Shreiner and Aatab Munshi, OpenGL ES 3.0 Programming Guide 2nd Edition, Kindle Edition, 2014.

Course Content

Unit I: INTRODUCTION **8 hours**

Overview, Modeling, Procedural Models, Fractal Models, and Grammar based models, particle systems, and viewing, Rasterization and Ray tracing

Unit II: Illumination **8 hours**

Vertex/Geometry/Pixel programming, Illumination mode, specular reflection model, shading models for curve surfaces, Radiosity method, Rendering, Recursive ray tracing, Texture mapping.

Unit III: Graphics Hardware **8 hours**

Graphics hardware architecture, Object representation and levels of detail.

Unit IV : Surface Rendering **8 hours**

Parametric and implicit surfaces, Meshing, Visibility and shadow computation, Global illumination.

Unit V: Visualization Techniques **9 hours**

Introduction to volume visualization, Introduction to animation, Image based rendering, Filler.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Cloud Computing Technologies				
Course Code	MCSE1230				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To understand the concepts of cloud and utility computing.
2. To understand the various issues in cloud computing.
3. To familiarize themselves with the lead players in cloud.
4. To appreciate the emergence of cloud as the next generation computing paradigm.
5. To be able to set up a private cloud.

Course Outcomes

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

CO1	Articulate the main concepts, key technologies, strengths and limitations of cloud computing.
CO2	Identify the architecture, infrastructure and delivery models of cloud computing.
CO3	Explain the core issues of cloud computing such as security, privacy and interoperability.
CO4	Choose the appropriate technologies, algorithms and approaches for the related issues.

Text Books

1. Kai Hwang, Geoffrey C Fox, Jack G Dongarra, "Distributed and Cloud Computing, From Parallel Processing to the Internet of Things", Morgan Kaufmann Publishers, 2012.
2. John W.Rittinghouse and James F.Ransome, "Cloud Computing: Implementation, Management, and Security", CRC Press, 2010.
3. Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing, A Practical Approach", McGraw-Hill Osborne Media, 2009.

Reference Books

1. Jim Smith, Ravi Nair, "Virtual Machines: Versatile Platforms for Systems and Processes", Elsevier/Morgan Kaufmann, 2005.
2. Danielle Ruest, Nelson Ruest, “Virtualization: A Beginner‟s Guide”, McGraw-Hill Osborne Media, 2009.
3. Tom White, "Hadoop: The Definitive Guide", Yahoo Press, 2012. 7. Rajkumar Buyya, Christian Vecchiola, and Thamarai Selvi, “Mastering Cloud Computing”, Tata McGraw Hill, 2013.

Course Content

Unit I: INTRODUCTION **9 hours**

Evolution of Cloud Computing -System Models for Distributed and Cloud Computing - NIST Cloud Computing Reference Architecture -IaaS - On-demand Provisioning - Elasticity in Cloud - Examples of IaaS Providers - PaaS - Examples of PaaS Providers - SaaS - Examples of SaaS Providers - Public , Private and Hybrid Clouds – Google App Engine, Amazon AWS - Cloud Software Environments -Eucalyptus, Open Nebula, Open Stack, Nimbus

Unit II: VIRTUALIZATION **9 hours**

Basics of Virtual Machines - Process Virtual Machines – System Virtual Machines – Emulation – Interpretation – Binary Translation - Taxonomy of Virtual Machines. Virtualization –Management Virtualization — Hardware Maximization – Architectures – Virtualization Management – Storage Virtualization – Network Virtualization

Unit III: VIRTUALIZATION INFRASTRUCTURE **9 hours**

Comprehensive Analysis – Resource Pool – Testing Environment –Server Virtualization – Virtual Workloads – Provision Virtual Machines –Desktop Virtualization – Application Virtualization – Work with AppV – Mobile OS for smart phones – Mobile Platform Virtualization – Collaborative Applications for Mobile platforms

Unit IV : PROGRAMMING MODEL **9 hours**

Map Reduce Hadoop Distributed File Systems – Hadoop I/O – Developing Map Reduce Applications – Working of Map Reduce – Types and Formats – Setting up Hadoop Cluster

Unit V: CLOUD INFRASTRUCTURE AND SECURITY **9 hours**

Architectural Design of Compute and Storage Clouds - Inter Cloud Resource Management - Resource Provisioning and Platform Deployment - Global Exchange of Cloud Resources - Security Overview – Cloud Security Challenges – Software as a Service Security – Security Governance – Risk Management – Security Monitoring – Security Architecture Design – Data Security – Application Security – Virtual Machine Security.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Network Security Lab				
Course Code	MCSE1211				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		0	0	2	1

LIST OF EXPERIMENTS:

1. Develop a C program that demonstrates inter process communication
2. Develop a TCP client/server application
3. Develop a UDP client/server application
4. Develop an Iterative UDP server with 2 or 3 clients
5. Develop a concurrent TCP server with 2 or 3 clients
6. Develop a multiprotocol server with TCP and UDP and 2 clients
7. Develop simple Python programs that use frequently used syntactic constructs
8. Develop a Socket based application in Python
9. Build client applications for major APIs (Amazon S3, Twitter etc) in Python
10. Develop an application that interacts with e-mail servers in python
11. Develop applications that work with remote servers using SSH, FTP etc in Python.

Continuous Assessment Pattern

Internal Assessment (IA)	End Term Exam (ETE)	Total Marks
50	50	100

Name of The Course	Advanced Computer Graphics Lab				
Course Code	MCSE1221				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		0	0	2	1

List of Experiments:

1. Implementation of Algorithms for drawing 2D Primitives – Line (DDA, Bresenham) – all slopes Circle (Midpoint)
2. 2D Geometric transformations – Translation Rotation Scaling Reflection Shear Window-Viewport
3. Composite 2D Transformations
4. 3D Transformations - Translation, Rotation, Scaling.
5. 3D Projections – Parallel, Perspective.
6. Creating 3D Scenes.
7. Image Editing and Manipulation - Basic Operations on image using any image editing software, Creating gif animated images, Image optimization.
8. 2D Animation – To create Interactive animation using any authoring tool.

Continuous Assessment Pattern

Internal Assessment (IA)	End Term Exam (ETE)	Total Marks
50	50	100

Name of The Course	Software Requirements Engineering				
Course Code	MCSE2310				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. Understand the basics of requirements engineering.
2. Learn different techniques used for requirements elicitation.
3. Know the role played by requirements analysis in requirement integration.
4. Appreciate the use of various methodologies for requirements development.
5. Study the current trends in requirements prioritization and validation.

Course Outcomes

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

CO1	Prepare SRS including the details of requirements engineering
CO2	Describe the stages of requirements elicitation.
CO3	Analyze software requirements gathering.

Text Books

1. Ian Sommerville, Pete Sawyer, ―Requirements Engineering: A Good Practice Guide‖, Sixth Edition, Pearson Education, 2004.
2. Dean Leffingwe, Don Widrig, ―Managing Software Requirements A Use Case Approach‖, Second Addition, Addison Wesley, 2003.

Reference Books

1. Karl Eugene Wiegers, ―Software Requirements‖, Word Power Publishers, 2000.
2. Ian Graham, ―Requirements Engineering and Rapid Development‖, Addison Wesley, 1998.
3. Wiegers, Karl, Joy Beatty, ‖Software requirements‖, Pearson Education, 2013.

Course Content

Unit I: REQUIREMENTS ENGINEERING OVERVIEW 9 hours

Software Requirement Overview – Software Development Roles –Software Development Process Kernels – Commercial Life Cycle Model – Vision Development – Stakeholders Needs & Analysis – Stakeholder needs – Stakeholder activities.

Unit II: REQUIREMENTS ELICITATION 9 hours

The Process of Requirements Elicitation – Requirements Elicitation Problems – Problems of Scope – Problems of Understanding – Problems of Volatility – Current Elicitation Techniques – Information Gathering – Requirements Expression and Analysis – Validation – An Elicitation Methodology Framework – A Requirements Elicitation Process Model – Methodology over Method – Integration of Techniques – Fact-Finding – Requirements Gathering – Evaluation and Rationalization – Prioritization – Integration and Validation.

Unit III: REQUIREMENTS ANALYSIS 9 hours

Identification of Functional and Non Functional Requirements – Identification of Performance Requirements –

Identification of safety Requirements – Analysis – Feasibility and Internal Compatibility of System Requirements – Definition of Human Requirements Baseline.

Unit IV: REQUIREMENTS DEVELOPMENT **9 hours**

Requirements analysis – Requirements Documentation – Requirements Development Workflow – Fundamentals of Requirements Development – Requirements Attributes Guidelines Document – Supplementary Specification Document – Use Case Specification Document – Methods for Software Prototyping – Evolutionary prototyping – Throwaway prototyping.

Unit V: REQUIREMENTS VALIDATION **9 hours**

Validation objectives – Analysis of requirements validation – Activities – Properties – Requirement reviews – Requirements testing – Case tools for requirements engineering.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Software Requirements Engineering Lab				
Course Code	MCSE2311				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		0	0	2	1

List of Exercises:

Choose any one application for performing the following phases

1. Program Analysis and Project Planning. Thorough study of the problem – Identify project scope, Objectives, Infrastructure. – PROJECT PLAN DOCUMENTATION
2. Software requirement Analysis Describe the individual Phases / Modules of the project, Identify deliverables. – SRS DOCUMENTATION
3. Data Modeling Use work products – Data dictionary, Use case diagrams and activity diagrams, build and test class diagrams, Sequence diagrams , add interface to class diagrams. – DESIGN DOCUMENTATION
4. Software Development and Debugging Use technology of your choice to develop and debug the application– CODE DOCUMENTATION
5. Software Testing Perform validation testing, Coverage analysis, memory leaks, develop test case hierarchy, Site check and Site monitor. – TEST CASE DOCUMENTATION

SUGGESTED LIST OF APPLICATIONS:

1. Student Marks Analyzing System.
2. Quiz System.
3. Online Ticket Reservation System
4. Payroll System
5. Course Registration System
6. Stock Maintenance.
7. Any real time applications can be taken.

Continuous Assessment Pattern

Internal Assessment (IA)	End Term Exam (ETE)	Total Marks
50	50	100

List of Electives

Name of The Course	IoT Technology and Applications				
Course Code	MCSE9110				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To understand the fundamentals of Internet of Things.
2. To learn about the basics of IOT protocols.
3. To build a small low cost embedded system using Raspberry Pi.
4. To apply the concept of Internet of Things in the real world scenario.

Course Outcomes

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

CO1	Analyze various protocols for IoT Develop web services to access/control IoT devices.
CO2	Design a portable IoT using Rasperry Pi.
CO3	Deploy an IoT application and connect to the cloud.
CO4	Analyze applications of IoT in real time scenario.

Text Books

1. Arshdeep Bahga, Vijay Madisetti, ―Internet of Things – A hands-on approach‖, Universities Press, 2015.
2. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), ―Architecting the Internet of Things‖, Springer, 2011.
3. Honbo Zhou, ―The Internet of Things in the Cloud: A Middleware Perspective‖, CRC Press, 2012.

Reference Books

1. Jan Ho¨ ller, Vlasios Tsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence", Elsevier, 2014.
2. Olivier Hersent, David Boswarthick, Omar Elloumi , ―The Internet of Things – Key applications and Protocols‖, Wiley, 2012

Course Content

Unit I: INTRODUCTION TO IoT **9 hours**

Internet of Things - Physical Design- Logical Design- IoT Enabling Technologies - IoT Levels & Deployment Templates - Domain Specific IoTs - IoT and M2M - IoT System Management with NETCONF-YANG- IoT Platforms Design Methodology

Unit II: IoT ARCHITECTURE **9 hours**

M2M high-level ETSI architecture - IETF architecture for IoT - OGC architecture - IoT reference model - Domain model - information model - functional model - communication model - IoT reference architecture.

Unit III: IoT PROTOCOLS **9 hours**

Protocol Standardization for IoT – Efforts – M2M and WSN Protocols – SCADA and RFID Protocols – Unified Data Standards – Protocols – IEEE 802.15.4 – BACNet Protocol – Modbus– Zigbee Architecture – Network layer – 6LowPAN - CoAP - Security

Unit IV : BUILDING IoT WITH RASPBERRY PI & ARDUINO **9 hours**

Building IOT with RASPERRY PI- IoT Systems - Logical Design using Python – IoT Physical Devices & Endpoints - IoT Device -Building blocks -Raspberry Pi -Board - Linux on Raspberry Pi - Raspberry Pi Interfaces - Programming Raspberry Pi with Python - Other IoT Platforms - Arduino.

Unit V: CASE STUDIES AND REAL-WORLD APPLICATIONS **9 hours**

Real world design constraints - Applications - Asset management, Industrial automation, smart grid, Commercial building automation, Smart cities - participatory sensing - Data Analytics for IoT – Software & Management Tools for IoT Cloud Storage Models & Communication APIs - Cloud for IoT - Amazon Web Services for IoT.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	IoT on Cloud				
Course Code	MCSE9120				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To understand the basics of Internet of Things.
2. To get an idea of some of the application areas where Internet of Things can be applied.
3. To understand the middleware for Internet of Things.
4. To understand the concepts of Web of Things.
5. To understand the concepts of Cloud of Things with emphasis on Mobile cloud computing.
6. To understand the IOT protocols.

Course Outcomes

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

CO1	Identify and design the new models for market strategic interaction.
CO2	Design business intelligence and information security for WoB
CO3	Analyze various protocols for IoT.
CO4	Design a middleware for IoT.
CO5	Analyze and design different models for network dynamics.

Text Books

1. The Internet of Things in the Cloud: A Middleware Perspective - Honbo Zhou – CRC Press – 2012.
2. Architecting the Internet of Things - Dieter Uckelmann; Mark Harrison; Florian Michahelles(Eds.) – Springer – 2011
3. Networks, Crowds, and Markets: Reasoning About a Highly Connected World - David Easley and Jon Kleinberg, Cambridge University Press - 2010
4. The Internet of Things: Applications to the Smart Grid and Building Automation by -Olivier Hersent, Omar Elloumi and David Boswarthick - Wiley -2012
5. Olivier Hersent, David Boswarthick, Omar Elloumi , "The Internet of Things – Key applications and Protocols", Wiley, 2012

Reference Books

1. Jan Ho¨ ller, Vlasios Tsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence", Elsevier, 2014.
2. Olivier Hersent, David Boswarthick, Omar Elloumi , ―The Internet of Things – Key applications and Protocols‖, Wiley, 2012

Course Content

Unit I: INTRODUCTION **10 hours**

Definitions and Functional Requirements –Motivation – Architecture - Web 3.0 View of IoT– Ubiquitous IoT Applications – Four Pillars of IoT – DNA of IoT - The Toolkit Approach for End-user Participation in the Internet of Things. Middleware for IoT: Overview – Communication middleware for IoT –IoT Information Security

Unit II: IOT PROTOCOLS **8 hours**

Protocol Standardization for IoT – Efforts – M2M and WSN Protocols – SCADA and RFID Protocols – Issues with IoT Standardization – Unified Data Standards – Protocols – IEEE 802.15.4 – BACNet Protocol – Modbus – KNX – Zigbee Architecture – Network layer – APS layer – Security

Unit III: WEB OF THINGS **10 hours**

Web of Things versus Internet of Things – Two Pillars of the Web – Architecture Standardization for WoT– Platform Middleware for WoT – Unified Multitier WoT Architecture – WoT Portals and Business Intelligence. Cloud of Things: Grid/SOA and Cloud Computing – Cloud Middleware – Cloud Standards – Cloud Providers and Systems – Mobile Cloud Computing – The Cloud of Things Architecture.

Unit IV : INTEGRATED **9 hours**

Integrated Billing Solutions in the Internet of Things Business Models for the Internet of Things - Network Dynamics: Population Models – Information Cascades - Network Effects - Network Dynamics: Structural Models - Cascading Behavior in Networks - The Small-World Phenomenon.

Unit V: APPLICATIONS **8 hours**

The Role of the Internet of Things for Increased Autonomy and Agility in Collaborative Production Environments - Resource Management in the Internet of Things: Clustering, Synchronisation and Software Agents. Applications - Smart Grid – Electrical Vehicle Charging.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Big Data Mining and Analytics				
Course Code	MCSE9130				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To understand the computational approaches to Modeling, Feature Extraction.
2. To understand the need and application of Map Reduce.
3. To understand the various search algorithms applicable to Big Data.
4. To analyse and interpret streaming data.
5. To learn how to handle large data sets in main memory.
6. To learn the various clustering techniques applicable to Big Data.

Course Outcomes

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

CO1	Design algorithms by employing Map Reduce technique for solving Big Data problems.
CO2	Design algorithms for Big Data by deciding on the apt Features set.
CO3	Design algorithms for handling petabytes of datasets.
CO4	Design algorithms and propose solutions for Big Data by optimizing main memory consumption
CO5	Design solutions for problems in Big Data by suggesting appropriate clustering techniques.

Text Books

1. Jure Leskovec, AnandRajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, Second Edition, 2014.
2. Jiawei Han, MichelineKamber, Jian Pei, “Data Mining Concepts and Techniques”, Morgan Kaufman Publications, Third Edition, 2011.
3. Ian H.Witten, Eibe Frank “Data Mining – Practical Machine Learning Tools and Techniques”, Morgan Kaufman Publications, Third Edition, 2011.
4. David Hand, HeikkiMannila and Padhraic Smyth, “Principles of Data Mining”, MIT PRESS, 2001

Reference Books

1. Jan Ho¨ ller, Vlasios Tsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence", Elsevier, 2014.
2. Olivier Hersent, David Boswarthick, Omar Elloumi , ―The Internet of Things – Key applications and Protocols‖, Wiley, 2012

Course Content

Unit I: DATA MINING AND LARGE SCALE FILES **9 hours**

Introduction to Statistical modeling – Machine Learning – Computational approaches to modeling – Summarization – Feature Extraction – Statistical Limits on Data Mining - Distributed File Systems – Map-reduce – Algorithms using Map Reduce – Efficiency of Cluster Computing Techniques

Unit II: SIMILAR ITEMS **9 hours**

M2M high-level ETSI architecture - IETF architecture for IoT - OGC architecture - IoT reference model - Domain model - information model - functional model - communication model - IoT reference architecture.

Unit III: MINING DATA STREAMS **9 hours**

Stream Data Model – Sampling Data in the Stream – Filtering Streams – Counting Distance Elements in a Stream – Estimating Moments – Counting Ones in Window – Decaying Windows.

Unit IV : LINK ANALYSIS AND FREQUENT ITEMSETS **9 hours**

Page Rank –Efficient Computation - Topic Sensitive Page Rank – Link Spam – Market Basket Model – A-priori algorithm – Handling Larger Datasets in Main Memory – Limited Pass Algorithm – Counting Frequent Item sets.

Unit V: CLUSTERING **9 hours**

Introduction to Clustering Techniques – Hierarchical Clustering –Algorithms – K-Means – CURE – Clustering in Non – Euclidean Spaces – Streams and Parallelism – Case Study: Advertising on the Web – Recommendation Systems.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Data Science & Big Data Analytics				
Course Code	MCSE9140				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. Gain a foundation level understanding on big data and the state of the practice of analytics.
2. Introduces Data Analytics Lifecycle to address industry challenges that leverage big data.
3. Provides grounding in basic and advanced analytic methods and an introduction to big data analytics technology and tools, including MapReduce and Hadoop.
4. Provide a practical opportunity to apply methods and tools to help investigate a big data analytics real world problem.

Course Outcomes

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

CO1	Explain the phases and activities of the data analytics lifecycle and identify the main activities and deliverables.
CO2	Select and execute appropriate advanced analytic methods for candidate selection, categorization, and predictive modeling.
CO3	Explore and make an initial analysis of the data, using R and help in creation of initial hypotheses regarding potential relationships within the data that can then be explored using more advanced analytic methods.
CO4	Students will have the knowledge and practical experience to immediately participate effectively in big data and other analytics projects

Text Books

1. Analytics in Practice, by Soumendra Mohanty, Tata Mcgraw hill Education(2011), IsBn-13:-9780070707061.
2. Agile Analytics: A value Driven approach to Business intelligence and Data Warehousing, by Ken w. Collier, Pearson Education (2012), ISBN-13:- 9788131786826.
3. MapReduce Design Patterns**,** by Donald Miner, O'Reilly (2012), ISBN- 13:-9789350239810.
4. David Hand, HeikkiMannila and Padhraic Smyth, "Principles of Data Mining", MIT PRESS, 2001

Reference Books

1. Jan Ho¨ ller, Vlasios Tsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence", Elsevier, 2014.
2. Olivier Hersent, David Boswarthick, Omar Elloumi , ―The Internet of Things – Key applications and Protocols‖, Wiley, 2012

Course Content

Unit I: Introduction to Big Data Analytics 9 hours Overview of big data, the state of practice of analytics, the Data Scientist role, and big data analytics in industry verticals.
Unit II: Overview of Data Analytics Lifecycle 9 hours Phases of a typical analytics lifecycle – discovery, data preparation, model planning, model building, communicating results and findings, and operationalizing, Critical activities in each phase of the lifecycle.
Unit III: Initial Analysis of the Data 9 hours Introduction to R programming, initial exploration and analysis of the data using R, and basic visualization using R.
Unit IV : Advanced Analytics and Statistical Modeling for Big Data Theory and Methods 9 hours Core methods used by a Data Scientist, including candidate selection using the Naïve Bayesian Classifier, categorization using K-means clustering and association rules, predictive modeling using decision trees, linear and logistic regression, and time-series analysis, and text analysis.
Unit V: Advanced Analytics and Statistical Modeling for Big Data – Technology and Tools 9 hours Analytic tools for unstructured data, including MapReduce and the Hadoop ecosystem. It also details in-database analytics with SQL extensions and other advanced SQL techniques and MADlib functions for in-database analytics.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Real Time Systems				
Course Code	MCSE9210				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To learn real time operating system concepts, the associated issues & Techniques.
2. To understand design and synchronization problems in Real Time System.
3. To explore the concepts of real time databases.
4. To understand the evaluation techniques present in Real Time System.

Course Outcomes

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

CO1	Apply principles of real time system design techniques to develop real time applications.
CO2	Make use of database in real time applications.
CO3	Make use of architectures and behaviour of real time operating systems.
CO4	Apply evaluation techniques in application.

Text Books

1. C.M. Krishna, Kang G. Shin, ―Real-Time Systems‖, McGraw-Hill International Editions, 1997
2. Philip.A.Laplante, ―Real Time System Design and Analysis‖, Prentice Hall of India, 3rd Edition, 2004.
3. Rajib Mall, ―Real-time systems: theory and practice‖, Pearson Education, 2009.

Reference Books

1. R.J.A Buhur, D.L Bailey, ―An Introduction to Real-Time Systems‖, Prentice Hall International, 1999.
2. Stuart Bennett, ―Real Time Computer Control-An Introduction‖, Prentice Hall of India, 1998.
3. Allen Burns, Andy Wellings, ―Real Time Systems and Programming Languages‖, Pearson Education, 2003

Course Content

Unit I: REAL TIME SYSTEM AND SCHEDULING 9 hours

Introduction– Structure of a Real Time System –Task classes – Performance Measures for Real Time Systems – Estimating Program Run Times – Issues in Real Time Computing – Task Assignment and Scheduling – Classical uniprocessor scheduling algorithms –Fault Tolerant Scheduling..

Unit II: SOFTWARE REQUIREMENTS ENGINEERING 9 hours

Requirements engineering process – types of requirements – requirements specification for real time systems – Formal methods in software specification – structured Analysis and Design – object oriented analysis and design and unified modelling language – organizing the requirements document – organizing and writing documents – requirements validation and revision.

Unit III: INTERTASK COMMUNICATION AND MEMORY MANAGEMENT 9 hours

Buffering data – Time relative Buffering- Ring Buffers – Mailboxes – Queues – Critical regions – Semaphores – other Synchronization mechanisms – deadlock – priority inversion – process stack management – run time ring

buffer – maximum stack size – multiple stack arrangement – memory management in task control block - swapping – overlays – Block page management – replacement algorithms – memory locking – working sets – real time garbage collection – contiguous file systems.

Unit IV: REAL TIME DATABASES **9 hours**

Real time Databases – Basic Definition, Real time Vs General Purpose Databases, Main Memory Databases, Transaction priorities, Transaction Aborts, Concurrency control issues, Disk Scheduling Algorithms, Two– phase Approach to improve Predictability – Maintaining Serialization Consistency – Databases for Hard Real Time Systems.

Unit V: EVALUATION TECHNIQUES AND CLOCK SYNCHRONIZATION **9 hours**

Reliability Evaluation Techniques – Obtaining parameter values, Reliability models for Hardware Redundancy– Software error models. Clock Synchronization–Clock, A Nonfault– Tolerant Synchronization Algorithm – Impact of faults – Fault Tolerant Synchronization in Hardware – Fault Tolerant Synchronization in software.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Mobile and Pervasive Computing				
Course Code	MCSE9220				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To learn the basic architecture and concepts till Third Generation Communication systems.
2. To understand the latest 4G Telecommunication System Principles.
3. To introduce the broad perspective of pervasive concepts and management.
4. To explore the HCI in Pervasive environment.
5. To apply the pervasive concepts in mobile environment.

Course Outcomes

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

CO1	Obtain a thorough understanding of Basic architecture and concepts of till Third Generation Communication systems.
CO2	Explain the latest 4G Telecommunication System Principles.
CO3	Incorporate the pervasive concepts.
CO4	Implement the HCI in Pervasive environment.
CO5	Work on the pervasive concepts in mobile environment.

Text Books

1. Alan Colman, Jun Han, and Muhammad Ashad Kabir, Pervasive Social Computing Socially-Aware Pervasive Systems and Mobile Applications, Springer, 2016.

2. J.Schiller, ―Mobile Communication‖, Addison Wesley, 2000.

3. Juha Korhonen, ―Introduction to 4G Mobile Communications‖ , Artech House Publishers, 2014.

Reference Books

1. Kolomvatsos, Kostas, Intelligent Technologies and Techniques for Pervasive computing, IGI Global, 2013.
2. M. Bala Krishna, Jaime Lloret Mauri, ―Advances in Mobile Computing and Communications: Perspectives and Emerging Trends in 5G Networks‖, CRC 2016.
3. Minyi Guo, Jingyu Zhou, Feilong Tang, Yao Shen, ― Pervasive Computing: Concepts, Technologies and Applications ‖ CRC Press, 2016.

Course Content

Unit I: INTRODUCTION **9 hours**

History – Wireless communications: GSM – DECT – TETRA – UMTS – IMT – 2000 – Blue tooth, WiFi, WiMAX, 3G ,WATM.- Mobile IP protocols -WAP push architecture-Wml scripts and applications. Data networks – SMS – GPRS – EDGE – Hybrid Wireless100 Networks – ATM – Wireless ATM.

Unit II: OVERVIEW OF A MODERN 4G TELECOMMUNICATIONS SYSTEM **9 hours**

Introduction. LTE-A System Architecture. LTE RAN. OFDM Air Interface. Evolved Packet Core. LTE

Requirements. LTE-Advanced. LTE-A in Release. OFDMA – Introduction. OFDM Principles. LTE Uplink—SC-FDMA. Summary of OFDMA.

Unit III: PERVASIVE CONCEPTS AND ELEMENTS 9 hours

Technology Trend Overview - Pervasive Computing: Concepts - Challenges - Middleware - Context Awareness - Resource Management - Human–Computer Interaction - Pervasive Transaction Processing - Infrastructure and Devices - Wireless Networks - Middleware for Pervasive Computing Systems - Resource Management - User Tracking- Context Management -Service Management - Data Management - Security Management - Pervasive Computing Environments - Smart Car Space - Intelligent Campus.

Unit IV : HCI IN PERVASIVE COMPUTING 9 hours

Prototype for Application Migration - Prototype for Multimodalities - Human–Computer Interface in Pervasive Environments - HCI Service and Interaction Migration – Context Driven HCI Service Selection - Interaction Service Selection Overview - User Devices - Service-Oriented Middleware Support - User History and Preference - Context Manager - Local Service Matching - Global Combination - Effective Region - User Active Scope - Service Combination Selection Algorithm

Unit V: PERVASIVE MOBILE TRANSACTIONS 9 hours

Pervasive Mobile Transactions - Introduction to Pervasive Transactions - Mobile Transaction Framework - Unavailable Transaction Service - Pervasive Transaction Processing Framework - Context-Aware Pervasive Transaction Model - Context Model for Pervasive Transaction Processing - Context-Aware Pervasive Transaction Model - A Case of Pervasive Transactions - Dynamic Transaction Management - Context-Aware Transaction Coordination Mechanism - Coordination Algorithm for Pervasive Transactions - Participant Discovery - Formal Transaction Verification - Petri Net with Selective Transition.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Parallel Programmig Paradigms				
Course Code	MCSE9230				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To familiarize the issues in parallel computing.
2. To describe distributed memory programming using MPI.
3. To understand shared memory paradigm with Pthreads and with OpenMP.
4. To learn the GPU based parallel programming using OpenCL.

Course Outcomes

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

CO1	Identify issues in parallel programming.
CO2	Develop distributed memory programs using MPI framework
CO3	Design and develop shared memory parallel programs using Pthreads and using OpenMP
CO4	Implement Graphical Processing OpenCL programs.

Text Books

1. Munshi, B. Gaster, T. G. Mattson, J. Fung, and D. Ginsburg, ―OpenCL programming guide‖, Addison Wesley, 2011
2. M. J. Quinn, ―Parallel programming in C with MPI and OpenMP‖, Tata McGraw Hill, 2003.
3. Peter S. Pacheco, ―An introduction to parallel programming‖, Morgan Kaufmann, 2011.

Reference Books

1. Rob Farber, ―CUDA application design and development‖, Morgan Haufmann, 2011.
2. W. Gropp, E. Lusk, and A. Skjellum, ―Using MPI: Portable parallel programming with the message passing interface‖, Second Edition, MIT Press, 1999

Course Content

Unit I: FOUNDATIONS OF PARALLEL PROGRAMMING **9 hours**

Motivation for parallel programming – Need-Concurrency in computing – Basics of processes, multitasking and threads – cache – cache mappings – caches and programs – virtual memory – Instruction level parallelism – hardware multi-threading – Parallel Hardware-SIMD – MIMD – Interconnection networks – cache coherence – Issues in shared memory model and distributed memory model –Parallel Software- Caveats- coordinating processes/ threads- hybrid model – shared memory model and distributed memory model - I/O – performance of parallel programs-– parallel program design.

Unit II: DISTRIBUTED MEMORY PROGRAMMING WITH MPI **9 hours**

Basic MPI programming – MPI_Init and MPI_Finalize – MPI communicators – SPMDprograms– MPI_Send and MPI_Recv – message matching – MPI- I/O – parallel I/O – collective communication – Tree-structured

communication -MPI_Reduce – MPI_Allreduce, broadcast, scatter, gather, allgather – MPI derived types – dynamic process management – performance evaluation of MPI programs- A Parallel Sorting Algorithm.

Unit III: SHARED MEMORY PARADIGM WITH PTHREADS 9 hours

Basics of threads, Pthreads – thread synchronization – critical sections – busy waiting – mutex – semaphores – barriers and condition variables – read write locks with examples - Caches, cache coherence and false sharing – Thread safety-Pthreads case study.

Unit IV : SHARED MEMORY PARADIGM: OPENMP 9 hours

Basics OpenMP – Trapezoidal Rule-scope of variables – reduction clause – parallel for directive – loops in OpenMP – scheduling loops –Producer Consumer problem – cache issues – threads safety in OpenMP – Two-body solvers- Tree Search.

Unit V: GRAPHICAL PROCESSING PARADIGMS: OPENCL AND INTRODUCTION TO CUDA 9 hours

Introduction to OpenCL – Example-OpenCL Platforms- Devices-Contexts - OpenCL programming – Built-In Functions-Programs Object and Kernel Object – Memory Objects - Buffers and Images – Event model – Command-Queue - Event Object - case study. Introduction to CUDA programming.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Information Retrieval Techniques				
Course Code	MCSE9240				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To understand the basics of information retrieval with pertinence to modeling, query operations and indexing.
2. To get an understanding of machine learning techniques for text classification and clustering.
3. To understand the various applications of information retrieval giving emphasis to multimedia IR, web search.
4. To understand the concepts of digital libraries.

Course Outcomes

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

CO1	Build an Information Retrieval system using the available tools.
CO2	Identify and design the various components of an Information Retrieval system.
CO3	Apply machine learning techniques to text classification and clustering which is used for efficient Information Retrieval.
CO4	Design an efficient search engine and analyze the Web content structure.

Text Books

1. Christopher D. Manning, Prabhakar Raghavan, Hinrich Schutze, ―Introduction to Information Retrieval‖, Cambridge University Press, First South Asian Edition, 2008.
2. Implementing and Evaluating Search Engines‖, The MIT Press, Cambridge, Massachusetts London, England, 2010

Reference Books

3. Ricardo Baeza – Yates, Berthier Ribeiro – Neto, ―Modern Information Retrieval: The concepts and Technology behind Search‖ (ACM Press Books), Second Edition, 2011.
4. Stefan Buttcher, Charles L. A. Clarke, Gordon V. Cormack, ―Information Retrieval

Course Content

Unit I: INTRODUCTION: MOTIVATION 9 hours Basic Concepts – Practical Issues - Retrieval Process – Architecture - Boolean Retrieval – Retrieval Evaluation – Open Source IR Systems–History of Web Search – Web Characteristics– The impact of the web on IR ––IR Versus Web Search–Components of a Search engine.
Unit II: MODELING 9 hours Taxonomy and Characterization of IR Models – Boolean Model – Vector Model - Term Weighting – Scoring and Ranking –Language Models – Set Theoretic Models - Probabilistic Models – Algebraic Models – Structured Text Retrieval Models – Models for Browsing

Unit III: **INDEXING** **9 hours** Static and Dynamic Inverted Indices – Index Construction and Index Compression. Searching - Sequential Searching and Pattern Matching. Query Operations -Query Languages – Query Processing - Relevance Feedback and Query Expansion - Automatic Local and Global Analysis – Measuring Effectiveness and Efficiency.
Unit IV : CLASSIFICATION AND CLUSTERING **9 hours** Text Classification and Naïve Bayes – Vector Space Classification – Support vector machines and Machine learning on documents. Flat Clustering – Hierarchical Clustering –Matrix decompositions and latent semantic indexing – Fusion and Meta learning.
Unit V: SEARCHING THE WEB **9 hours** Searching the Web –Structure of the Web –IR and web search – Static and Dynamic Ranking – Web Crawling and Indexing – Link Analysis - XML Retrieval Multimedia IR: Models and Languages – Indexing and Searching Parallel and Distributed IR – Digital Libraries.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Formal Models of Software Systems				
Course Code	MCSE9310				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To understand the goals, complexity of software systems, the role of Specification activities and qualities to control complexity.
2. To understand the fundamentals of abstraction and formal systems.
3. To learn fundamentals of logic reasoning- Propositional Logic, temporal logic and apply to models systems.
4. To understand formal specification models based on set theory, calculus and algebra and apply to a case study.
5. To learn Z, Object Z and B Specification languages with case studies.

Course Outcomes

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

CO1	Understand the complexity of software systems, the need for formal specifications activities and qualities to control complexity.
CO2	Gain knowledge on fundamentals of abstraction and formal systems.
CO3	Learn the fundamentals of logic reasoning- Propositional Logic, temporal logic and apply to models systems.
CO4	Develop formal specification models based on set theory, calculus and algebra and apply to a typical case study.
CO5	Have working knowledge on Z, Object Z and B Specification languages with case studies.

Text Books

1. Mathematical Logic for computer science, second edition, M.Ben-Ari, Springer,2003.
2. Logic in Computer Science- modeling and reasoning about systems, 2nd Edition, Cambridge University Press, 2004.
3. Specification of Software Systems, V.S. Alagar, K. Periyasamy, David Grises and Fred B Schneider, Springer –Verlag London, 2011.

Reference Books

1. The ways Z: Practical programming with formal methods, Jonathan Jacky, Cambridge University Press,1996.
2. Using Z-Specification Refinement and Proof,Jim Woodcock and Jim Devies Prentice Hall, 1996
3. Z: An introduction to formal methods, Second Edition, Antoi Diller, Wiley, 1994

Course Content

Unit I: SPECIFICATION FUNDAMENTALS **9 hours**

Role of Specification- Software Complexity - Size, Structural, Environmental, Application, domain, Communication Complexity, How to Control Complexity. Software specification, Specification Activities-Integrating Formal Methods into the Software Life-Cycle. Specification Qualities- Process Quality Attributes of Formal Specification Languages, Model of Process Quality, Product Quality and

Utility, Conformance to Stated Goals Quality Dimensions and Quality Model.

Unit II: FORMAL METHODS **9 hours**

Abstraction- Fundamental Abstractions in Computing. Abstractions for Software Construction. Formalism Fundamentals - Formal Systems, Formalization Process in Software Engineering Components of a Formal System- Syntax, Semantics, and Inference Mechanism. Properties of Formal Systems - Consistency. Automata-Deterministic Finite Accepters, State Machine Modeling Nondeterministic Finite Accepters, Finite State Transducers Extended Finite State Machine. Case Study—Elevator Control. Classification of C Methods-Property-Oriented Specification Methods, Model-Based Specification Techniques.

Unit III: **LOGIC** **9 hours**

Propositional Logic - Reasoning Based on Adopting a Premise, Inference Based on Natural Deduction. Predicate Logic - Syntax and Semantics, Policy Language Specification, knowledge Representation Axiomatic Specification. Temporal Logic -.Temporal Logic for Specification and Verification, Temporal Abstraction Propositional Temporal Logic (PTL), First Order Temporal Logic (FOTL).Formal Verification, Verification of Simple FOTL, Model Checking, Program Graphs, Transition Systems.

Unit IV : SPECIFICATION MODELS **9 hours**

Mathematical Abstractions for Model-Based Specifications-Formal Specification Based on Set Theory, Relations and Functions. Property-Oriented Specifications- Algebraic Specification, Properties of Algebraic Specifications, Reasoning, Structured Specifications. Case Study—A Multiple Window Environment: requirements, Modeling Formal Specifications. Calculus of Communicating Systems: Specific Calculus for Concurrency. Operational Semantics of Agents, Simulation and Equivalence, Derivation Trees, Labeled Transition Systems.

Unit V: FORMAL LANGUAGES **9hours**

The Z Notation, abstractions in Z, Representational Abstraction, Types, Relations and Functions, Sequences, Bags. Free Types-Schemas, Operational Abstraction -Operations Schema Decorators, Generic Functions, Proving Properties from Z specifications, Consistency of Operations. Additional Features in Z. Case Study: An Automated Billing System. The Object-Z Specification Language- Basic Structure of an Object-Z, Specification. Parameterized Class, Object-Orientation, composition of Operations-Parallel Communication Operator, Nondeterministic Choice Operator, and Environment Enrichment. The B-Method -Abstract Machine Notation (AMN), Structure of a B Specification, arrays, statements. Structured Specifications, Case Study- A Ticketing System in a Parking.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Embedded Software Development				
Course Code	MCSE9320				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To understand the architecture of embedded processor, microcontroller and peripheral devices.
2. To interface memory and peripherals with embedded systems.
3. To study the embedded network environment.
4. To understand challenges in Real time operating systems.
5. To study, analyze and design applications on embedded systems.

Course Outcomes

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

CO1	Understand different architectures of embedded processor, microcontroller and peripheral devices.
CO2	Interface memory and peripherals with embedded systems.
CO3	Work with embedded network environment.
CO4	Understand challenges in Real time operating systems.
CO5	Design and analyze applications on embedded systems.

Text Books

1. Adrian McEwen, Hakim Cassimally, "Designing the Internet of Things" Wiley Publication, First edition, 2013.
2. Andrew N Sloss, D. Symes, C. Wright, ‖ Arm system developers guide‖, Morgan Kauffman/Elsevier, 2006.
3. ArshdeepBahga, Vijay Madisetti, " Internet of Things: A Hands-on-Approach" VPT First Edition, 2014.
4. C. M. Krishna and K. G. Shin, ―Real-Time Systems‖ , McGraw-Hill, 1997.

Reference Books

1. Frank Vahid and Tony Givargis, ―Embedded System Design: A Unified Hardware/Software Introduction‖, John Wiley & Sons.
2. Jane.W.S. Liu, ―Real-Time systems‖, Pearson Education Asia.
3. Michael J. Pont, ―Embedded C‖, Pearson Education , 2007.
4. Muhammad Ali Mazidi , SarmadNaimi , SepehrNaimi, "The AVR Microcontroller and Embedded Systems: Using Assembly and C" Pearson Education, First edition, 2014.
5. Steve Heath, ―Embedded SystemDesign‖ , Elsevier, 2005.
6. Wayne Wolf, ―Computers as Components:Principles of Embedded Computer System Design‖, Elsevier, 2006.

Course Content

Unit I: EMBEDDED PROCESSORS **9 hours**

Embedded Computers - Characteristics of Embedded Computing Applications - Challenges in Embedded Computing System Design - Embedded System Design Process- Formalism for System Design - Structural Description - Behavioural Description - ARM Processor - Intel ATOM Processor.

Unit II: EMBEDDED COMPUTING PLATFORM **9 hours**

CPU Bus Configuration - Memory Devices and Interfacing - Input/Output Devices and Interfacing - System Design - Development and Debugging – Emulator – Simulator - JTAG Design Example – Alarm Clock - Analysis and Optimization of Performance - Power and Program Size.

Unit III: **EMBEDDED NETWORK ENIVIRONMENT** **9 hours**

Distributed Embedded Architecture - Hardware And Software Architectures - Networks for Embedded Systems - I2C - CAN Bus - SHARC Link Supports – Ethernet – Myrinet – Internet - Network-based Design - Communication Analysis - System Performance Analysis - Hardware Platform Design - Allocation and Scheduling - Design Example - Elevator Controller.

Unit IV : REAL-TIME CHARACTERISTICS **9 hours**

Clock Driven Approach - Weighted Round Robin Approach - Priority Driven Approach - Dynamic versus Static Systems - Effective Release Times and Deadlines - Optimality of the Earliest Deadline First (EDF) Algorithm - Challenges in Validating Timing Constraints in Priority Driven Systems - Off-Line versus On-Line Scheduling.

Unit V: SYSTEM DESIGN TECHNIQUES **9 hours**

Design Methodologies - Requirement Analysis – Specification - System Analysis and Architecture Design - Quality Assurance - Design Examples - Telephone PBX - Ink jet printer - Personal Digital Assistants - Set-Top Boxes.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Social Network Analysis				
Course Code	MCSE9330				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To understand the components of the social network.
2. To model and visualize the social network.
3. To mine the users in the social network.
4. To understand the evolution of the social network.
5. To know the applications in real time systems.

Course Outcomes

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

CO1	Work on the internals components of the social network.
CO2	Model and visualize the social network.
CO3	Mine the behavior of the users in the social network
CO4	Predict the possible next outcome of the social network.
CO5	Apply social network in real time applications.

Text Books

1. Ajith Abraham, Aboul Ella Hassanien, Václav Snášel, ―Computational Social Network Analysis: Trends, Tools and Research Advances‖, Springer, 2012
2. Borko Furht, ―Handbook of Social Network Technologies and Applications‖, Springer, 1st edition, 2011.
3. Charu C. Aggarwal, ―Social Network Data Analytics‖, Springer; 2014.

Reference Books

1. Giles, Mark Smith, John Yen, ―Advances in Social Network Mining and Analysis‖, Springer, 2010.
2. Guandong Xu , Yanchun Zhang and Lin Li, ―Web Mining and Social Networking – Techniques and applications‖, Springer, 1st edition, 2012.
3. Peter Mika, ―Social Networks and the Semantic Web‖, Springer, 1st edition, 2007.
4. Przemyslaw Kazienko, Nitesh Chawla,‖Applications of Social Media and Social Network Analysis‖, Springer,2015.

Course Content

Unit I: INTRODUCTION **9 hours**

Introduction to Web - Limitations of current Web – Development of Semantic Web – Emergence of the Social Web – Statistical Properties of Social Networks -Network analysis - Development of Social Network Analysis - Key concepts and measures in network analysis - Discussion networks - Blogs and online communities - Web-based networks.

Unit II: MODELING AND VISUALIZATION **9 hours**

Visualizing Online Social Networks - A Taxonomy of Visualizations - Graph Representation - Centrality- Clustering - Node-Edge Diagrams - Visualizing Social Networks with Matrix Based Representations- Node-Link Diagrams - Hybrid Representations - Modelling and aggregating social network data – Random Walks and their Applications –Use of Hadoop and Map Reduce - Ontological representation of social individuals and relationships.

Unit III: **MINING COMMUNITIES** **9 hours**

Aggregating and reasoning with social network data, Advanced Representations – Extracting evolution of Web Community from a Series of Web Archive - Detecting Communities in Social Networks - Evaluating Communities – Core Methods for Community Detection & Mining - Applications of Community Mining Algorithms - Node Classification in Social Networks.

Unit IV : EVOLUTION **9 hours**

Evolution in Social Networks – Framework - Tracing Smoothly Evolving Communities - Models and Algorithms for Social Influence Analysis - Influence Related Statistics - Social Similarity and Influence - Influence Maximization in Viral Marketing - Algorithms and Systems for Expert Location in Social Networks - Expert Location without Graph Constraints - with Score Propagation – Expert Team Formation - Link Prediction in Social Networks - Feature based Link Prediction – Bayesian Probabilistic Models - Probabilistic Relational Models.

Unit V: APPLICATIONS **9 hours**

A Learning Based Approach for Real Time Emotion Classification of Tweets, A New Linguistic Approach to Assess the Opinion of Users in Social Network Environments, Explaining Scientific and Technical Emergence Forecasting, Social Network Analysis for Biometric Template Protection.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Bio Inspired Computing				
Course Code	MCSE9340				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To Learn bio-inspired theorem and algorithms.
2. To Understand random walk and simulated annealing.
3. To Learn genetic algorithm and differential evolution.
4. To Learn swarm optimization and ant colony for feature selection.
5. To understand bio-inspired application in image processing.

Course Outcomes

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

CO1	Implement and apply bio-inspired algorithms.
CO2	Explain random walk and simulated annealing.
CO3	Implement and apply genetic algorithms.
CO4	Explain swarm intelligence and ant colony for feature selection.
CO5	Apply bio-inspired techniques in image processing.

Text Books

1. Eiben,A.E.,Smith,James E, "Introduction to Evolutionary Computing", Springer 2015.
2. Helio J.C. Barbosa, "Ant Colony Optimization - Techniques and Applications", Intech 2013.
3. Xin-She Yang , Jaao Paulo papa, "Bio-Inspired Computing and Applications in Image Processing",Elsevier 2016.

Reference Books

1. Xin-She Yang, "Nature Ispired Optimization Algorithm,Elsevier First Edition 2014.
2. Yang ,Cui,XIao,Gandomi,Karamanoglu ,"Swarm Intelligence and Bio-Inspired Computing", Elsevier First Edition 2013.

Course Content

Unit I: INTRODUCTION **9 hours**

Introduction to algorithm - Newton' s method - optimization algorithm - No-Free-Lunch Theorems - Nature-Inspired Mataheuristics -Analysis of Algorithms -Nature Inspires Algorithms -Parameter tuning and parameter control.

Unit II: RANDOM WALK AND ANEALING **9 hours**

Random variables - Isotropic random walks - Levy distribution and flights - Markov chains - step sizes and search efficiency - Modality and intermittent search strategy - importance of randomization- Eagle strategy-Annealing and Boltzmann Distribution - parameters -SA algorithm - Stochastic Tunneling.

Unit III: **GENETIC ALOGORITHMS AND DIFFERENTIAL EVOLUTION** **9 hours**

Introduction to genetic algorithms and - role of genetic operators - choice of parameters - GA varients - schema

theorem - convergence analysis - introduction to differential evolution - varients - choice of parameters - convergence analysis - implementation.

Unit IV : SWARM OPTIMIZATION AND FIREFLY ALGORITHM 9 hours

Swarm intelligence - PSO algorithm - accelerated PSO - implementation - convergence analysis - binary PSO - The Firefly algorithm - algorithm analysis - implementation - varientsAnt colony optimization toward feature selection

Unit V: APPLICATION IN IMAGE PROCESSING 9 hours

Bio-Inspired Computation and its Applications in Image Processing: An Overview – Fine Tuning Enhanced Probabilistic Neural Networks Using Meta-heuristic-driven Optimization - Fine-Tuning Deep Belief Networks using Cuckoo Search - Improved Weighted Thresholded Histogram Equalization Algorithm for Digital Image Contrast Enhancement Using Bat Algorithm - Ground Glass Opacity Nodules Detection and Segmentation using Snake Model - Mobile Object Tracking Using Cuckoo Search.

.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Data Visualization Techniques				
Course Code	MCSE9410				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To develop skills to both design and critique visualizations.
2. To introduce visual perception and core skills for visual analysis.
3. To understand visualization for time-series analysis.
4. To understand visualization for ranking analysis.
5. To understand visualization for deviation analysis.
6. To understand visualization for distribution analysis.
7. To understand visualization for correlation analysis.
8. To understand visualization for multivariate analysis.
9. To understand issues and best practices in information dashboard design.

Course Outcomes

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

CO1	Explain principles of visual perception.
CO2	Apply core skills for visual analysis.
CO3	Apply visualization techniques for various data analysis tasks.
CO4	Design information dashboard.

Text Books

1. Ben Fry, "Visualizing data: Exploring and explaining data with the processing environment", O'Reilly, 2008.
2. Edward R. Tufte, "The visual display of quantitative information", Second Edition, Graphics Press, 2001.
3. Evan Stubbs, "The value of business analytics: Identifying the path to profitability", Wiley, 2011.
4. Gert H. N. Laursen and Jesper Thorlund, "Business Analytics for Managers: Taking business intelligence beyond reporting", Wiley, 2010.

Reference Books

1. Nathan Yau, "Data Points: Visualization that means something", Wiley, 2013.
2. Stephen Few, "Information dashboard design: Displaying data for at-a-glance monitoring", second edition, Analytics Press, 2013.
3. Stephen Few, "Now you see it: Simple Visualization techniques for quantitative analysis", Analytics Press, 2009.
4. Tamara Munzner, Visualization Analysis and Design, AK Peters Visualization Series, CRC Press, Nov. 2014.

Course Content

Unit I: CORE SKILLS FOR VISUAL ANALYSIS 9 hours Information visualization – effective data analysis – traits of meaningful data – visual perception –making abstract data visible – building blocks of information visualization – analytical interaction – analytical navigation – optimal quantitative scales – reference lines and regions – trellises and crosstabs – multiple concurrent views – focus and context – details on demand – over-plotting reduction – analytical patterns – pattern examples.
Unit II: TIME-SERIES, RANKING, AND DEVIATION ANALYSIS 9 hours Time-series analysis – time-series patterns – time-series displays – time-series best practices – part-to-whole and ranking patterns – part-to-whole and ranking displays – best practices – deviation analysis – deviation analysis displays – deviation analysis best practices.
Unit III: **DISTRIBUTION, CORRELATION, AND MULTIVARIATE ANALYSIS 9 hours** Distribution analysis – describing distributions – distribution patterns – distribution displays – distribution analysis best practices – correlation analysis – describing correlations – correlation patterns – correlation displays – correlation analysis techniques and best practices – multivariate analysis – multivariate patterns – multivariate displays – multivariate analysis techniques and best practices.
Unit IV : INFORMATION DASHBOARD DESIGN 9 hours Information dashboard – Introduction– dashboard design issues and assessment of needs – Considerations for designing dashboard-visual perception – Achieving eloquence.
Unit V: INFORMATION DASHBOARD DESIGN 9 hours Advantages of Graphics _Library of Graphs – Designing Bullet Graphs – Designing Sparklines – Dashboard Display Media –Critical Design Practices – Putting it all together Unveiling the dashboard.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Reconfigurable Computing				
Course Code	MCSE9420				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To understand the need for reconfigurable computing.
2. To expose the students to various device architectures.
3. To examine the various reconfigurable computing systems.
4. To understand the different types of compute models for programming reconfigurable architectures.
5. To expose the students to HDL programming and familiarize with the development environment.
6. To expose the students to the various placement and routing protocols.
7. To develop applications with FPGAs.

Course Outcomes

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

CO1	Identify the need for reconfigurable architectures.
CO2	Discuss the architecture of FPGAs.
CO3	Point out the salient features of different reconfigurable architectures
CO4	Build basic modules using any HDL.
CO5	Develop applications using any HDL and appropriate tools.
CO6	Design and build an SoPC for a particular application.

Text Books

1. Christophe Bobda, ―Introduction to Reconfigurable Computing – Architectures, Algorithms and Applications‖, Springer, 2010.
2. Maya B. Gokhale and Paul S. Graham, ―Reconfigurable Computing: Accelerating Computation with Field-Programmable Gate Arrays‖, Springer, 2005.
3. FPGA Frontiers: New Applications in Reconfigurable Computing, 2017, Nicole Hemsoth, Timothy Prickett Morgan, Next Platform.

Reference Books

1. Reconfigurable Computing: From FPGAs to Hardware/Software Codesign 2011 Edition by Joao Cardoso (Editor), Michael Hübne, Springer.
2. Scott Hauck and Andre Dehon (Eds.), ―Reconfigurable Computing – The Theory and Practice of FPGA-Based Computation‖, Elsevier / Morgan Kaufmann, 2008.

Course Content

Unit I: DEVICE ARCHITECTURE **9 hours** General Purpose Computing Vs Reconfigurable Computing – Simple Programmable Logic Devices – Complex Programmable Logic Devices – FPGAs – Device Architecture - Case Studies.
Unit II: RECONFIGURABLE COMPUTING ARCHITECTURES AND SYSTEMS 9 hours Reconfigurable Processing Fabric Architectures – RPF Integration into Traditional Computing Systems – Reconfigurable Computing Systems – Case Studies – Reconfiguration Management.
Unit III: **PROGRAMMING RECONFIGURABLE SYSTEMS** **9 hours** Compute Models - Programming FPGA Applications in HDL – Compiling C for Spatial Computing – Operating System Support for Reconfigurable Computing.
Unit IV : MAPPING DESIGNS TO RECONFIGURABLE PLATFORMS 9 hours The Design Flow - Technology Mapping – FPGA Placement and Routing – Configuration Bitstream Generation – Case Studies with Appropriate Tools.
Unit V: APPLICATION DEVELOPMENT WITH FPGAS **9 hours** Case Studies of FPGA Applications – System on a Programmable Chip (SoPC) Designs.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Mobile Application Development				
Course Code	MCSE9430				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. Understand system requirements for mobile applications.
2. Generate suitable design using specific mobile development frameworks.
3. Generate mobile application design.
4. Implement the design using specific mobile development frameworks.
5. Deploy the mobile applications in marketplace for distribution.

Course Outcomes

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

CO1	Describe the requirements for mobile applications.
CO2	Explain the challenges in mobile application design and development.
CO3	Develop design for mobile applications for specific requirements.
CO4	Implement the design using Android SDK.
CO5	Implement the design using Objective C and iOS.
CO6	Deploy mobile applications in Android and iPhone marketplace for distribution

Text Books

1. Charlie Collins, Michael Galpin and Matthias Kappler, ―Android in Practice‖, DreamTech, 2012.
2. David Mark, Jack Nutting, Jeff LaMarche and Frederic Olsson, ―Beginning iOS 6 Development: Exploring the iOS SDK‖, Apress, 2013.
3. http://developer.android.com/develop/index.html.

Reference Books

1. James Dovey and Ash Furrow, ―Beginning Objective C‖, Apress, 2012.
2. Jeff McWherter and Scott Gowell, "Professional Mobile Application Development", Wrox,2012.
3. Reto Meier, ―Professional android Development‖, Wiley-India Edition, 2012

Course Content

Unit I: INTRODUCTION **9 hours** Introduction to mobile applications – Embedded systems - Market and business drivers for mobile applications – Publishing and delivery of mobile applications – Requirements gathering and validation for mobile applications.
Unit II: BASIC DESIGN **9 hours** Introduction – Basics of embedded systems design – Embedded OS - Design constraints for mobile applications, both hardware and software related – Architecting mobile applications – User interfaces for mobile applications – touch events and gestures – Achieving quality constraints – performance, usability, security, availability and modifiability.
Unit III: **ADVANCED DESIGN** **9 hours** Designing applications with multimedia and web access capabilities – Integration with GPS and social media networking applications – Accessing applications hosted in a cloud computing environment – Design patterns for mobile applications.
Unit IV : ANDROID **9 hours** Introduction – Establishing the development environment – Android architecture – Activities and views – Interacting with UI – Persisting data using SQLite – Packaging and deployment – Interaction with server side applications – Using Google Maps, GPS and Wifi – Integration with social media applications.
Unit V: IOS **9 hours** Introduction to Objective C – iOS features – UI implementation – Touch frameworks – Data persistence using Core Data and SQLite – Location aware applications using Core Location and Map Kit – Integrating calendar and address book with social media application – Using Wifi - iPhone marketplace.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100

Name of The Course	Information Storage Management				
Course Code	MCSE9440				
Prerequisite					
Corequisite					
Antirequisite					
		L	T	P	C
		3	0	0	3

Course Objectives

1. To understand the storage architecture and available technologies.
2. To learn to establish & manage data center.
3. To learn security aspects of storage & data center.

Course Outcomes

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

CO1	Select from various storage technologies to suit for required application.
CO2	Apply security measures to safeguard storage & farm.
CO3	Analyse QoS on Storage.

Text Books

1. EMC Corporation, "Information Storage and Management: Storing, Managing, and Protecting Digital Information", Wiley, India, 2010.
2. Marc Farley, ―Building Storage Networks‖, Tata McGraw Hill ,Osborne, 2001.

Reference Books

1. Robert Spalding, ―Storage Networks: The Complete Reference―, Tata McGraw Hill , Osborne, 2003.

Course Content

Unit I: STORAGE TECHNOLOGY **9 hours**

Review data creation and the amount of data being created and understand the value of data to a business, challenges in data storage and data management, Solutions available for data storage, Core elements of a data center infrastructure, role of each element in supporting business activities.

Unit II: STORAGE SYSTEMS ARCHITECTURE **9 hours**

Hardware and software components of the host environment, Key protocols and concepts used by each component ,Physical and logical components of a connectivity environment ,Major physical components of a disk drive and their function, logical constructs of a physical disk, access characteristics, and performance Implications, Concept of RAID and its components, Different RAID levels and their suitability for different application environments: RAID 0, RAID 1, RAID 3, RAID 4, RAID 5, RAID 0+1, RAID 1+0, RAID 6, Compare and contrast integrated and modular storage systems ,Iligh-level architecture and working of an intelligent storage system.

Unit III: **INTRODUCTION TO NETWORKED STORAGE** **9 hours**

Evolution of networked storage, Architecture, components, and topologies of FC-SAN, NAS, and IP-SAN, Benefits of the different networked storage options, understand the need for long-term archiving solutions and

describe how CAS full fill the need, understand the appropriateness of the different networked storage options for different application environments.

Unit IV: INFORMATION AVAILABILITY, MONITORING & MANAGING DATACENTERS **9 hours**

List reasons for planned/unplanned outages and the impact of downtime, Impact of downtime -Business continuity (BC) and disaster recovery (DR) ,RTO and RPO, Identify single points of failure in a storage infrastructure and list solutions to mitigate these failures, architecture of backup/recovery and the different backup/ recovery topologies, replication technologies and their role in ensuring information availability and business continuity, Remote replication technologies and their role in providing disaster recovery and business continuity capabilities. Identify key areas to monitor in a data center, Industry standards for data center monitoring and management, Key metrics to monitor for different components in a storage infrastructure, Key management tasks in a data center.

Unit V: SECURING STORAGE AND STORAGE VIRTUALIZATION **9 hours**

Information security, Critical security attributes for information systems, Storage security domains, List and analyzes the common threats in each domain, Virtualization technologies, block-level and file-level virtualization technologies and processes.

Continuous Assessment Pattern

Internal Assessment (IA)	Mid Term Exam (MTE)	End Term Exam (ETE)	Total Marks
20	30	50	100