VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE
(VJTI) MATUNGA, MUMBAI 400 019
(Autonomous Institute affiliated to University of Mumbai)

Curriculum
(Scheme of Instruction & Evaluation and Course contents)
For
Post Graduate Programme Leading to

Masters of Engineering Degree
in
Computer Engineering
(Specialization in Network Infrastructure and Management Systems)

Department of Computer Engineering and Information Technology,

Implemented from the batch admitted in Academic Year 2022-23

2023

M Tech Computer Engineering
(Specialization in Network Infrastructure and Management Systems)
Programme Outcomes

LIST OF PROGRAM OUTCOMES	
PO1	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the field of computer engineering and specialized topics in various domains of computer engineering.
PO4	An ability to apply mathematical modeling, algorithms and techniques in respective areas of computer engineering to solve complex engineering problems.
PO5	An ability to design and develop robust, reliable, scalable tools and techniques for knowledge-based systems to enhance lifelong learning.

MTech Computer Engineering
(Specialization in Network Infrastructure and Management Systems)
Scheme of Instruction and Evaluation
SEMESTER I

Scheme of Instruction					Scheme of Evaluation			
S.No	Course Code	Course Title	L-T-P	Credits	TA	MST	ESE	ESE hours
1	CONM5001S	Computational Methods (PSM)	3-0-0	3	20	20	60	3
2	CONM5011S	Advanced Algorithms (Core-1)	3-0-0	3	20	20	60	3
3	CONM5012S	Computer Network Design (Core-2)	3-0-0	3	20	20	60	3
4	CONM502XT	Program Elective -1	3-1-0	4	20	20	60	3
5	CONM503XS	Program Elective - 2	3-0-0	3	20	20	60	3
6	CONM506XT	Open Elective - 1	3-1-0	4	20	20	60	3
7	CONM5071L	Computer Network Design (Laboratory-1)	0-0-2	1	60%CIE		40	-
8	CONM5072L	Cloud Computing (Laboratory-2)	0-0-2	1	60%CIE		40	-
9	CONM5073L	Cross-platform App Development (Laboratory-3)	0-0-2	1	60%CIE		40	-
10	MTEC081L	Liberal Learning-1	0-0-2	1	60%CIE		40	-
			28	24				

Abbreviations: **S**: Standalone, **T**: Standalone with Tutorial, **L**: Laboratory **TA**: Teachers Assessment / Term work Assessment, **MST**: Mid Semester Test, **ESE**: End Semester written Examination, **CIE**: Continuous in-Semester Evaluation, **PSM**: Program Specific Mathematics, **MNC**: Mandatory Non Credit Course

Program Elective -1			Program Elective - 2		
S.No	Course Code	Course Title	S.No	Course Code	Course Title
1.	CONM5021T	Software Engineering	1.	CONM5031S	Cloud Computing
2.	CONM5022T	Distributed Systems	2.	CONM5032S	Internet of Things
3.	CONM5023T	Computer Systems Performance Analysis	3.	CONM5033S	GPU Architecture and programming
4.	CONM5024T	Social Network Analysis	4.	CONM5033S	Software Defined Network

Open Elective - 1		
S.No	Course Code	Course Title
1.	CONM5061T	Database Management Systems

MTech Computer Engineering
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Scheme of Instruction and Evaluation
SEMESTER II

Scheme of Instruction					Scheme of Evaluation			
S.No	Course Code	Course Title	L-T-P	Credits	TA	IST	ESE	ESE hours
1	CONM5002S	Research Methodology and IPR (Mandatory Learning)	3-0-0	3	20	20	60	3
2	CONM5012S	Network Administration (Core-3)	3-0-0	3	20	20	60	3
3	CONM5014S	Network Security (Core-4)	3-0-0	3	20	20	60	3
4	CONM504XT	Program Elective -3	3-1-0	4	20	20	60	3
5	CONM505XS	Program Elective - 4	3-0-0	3	20	20	60	3
6	CONM506XT	Open Elective - 2	3-1-0	4	20	20	60	3
7	CONM5074L	Network Administration (Laboratory-4)	0-0-2	1	60%CIE		40	-
8	CONM5075L	DevOps (Laboratory-5)	0-0-2	1	60%CIE		40	-
9	CONM5076L	Deep Learning (Laboratory -6)	0-0-2	1	60%CIE		40	-
10	MTEC082L	Liberal Learning-2	0-0-2	1	60%CIE		40	-
			28	24				

Program Elective -3			Program Elective - 4		
S.No	Course Code	Course Title	S.No	Course Code	Course Title
1.	CONM5041T	Information Security	1.	CONM5051S	Ad-hoc Network
2.	CONM5042T	Soft Computing	2.	CONM5052S	Blockchain Technology
3.	CONM5043T	Software Project Management	3.	CONM5053S	Parallel Algorithms
4.	CONM5044T	Software Architecture	4.	CONM5054S	Big Data Analytics

Open Elective - 2		
S.No	Course Code	Course Title
1.	CONM5065T	Human Computer Interaction
2.	CONM5066T	Machine Learning

MTech Computer Engineering (Specialization in Network Infrastructure and Management Systems) Scheme of Instruction and Evaluation
SEMESTER III

Scheme of Instruction					Scheme of Evaluation
S.No	Course Code	Course Title	L-T-P	Credits	
1	CONM091D	Skill Based Course (Project Stage -I)	—	5	100%CIE
2	CONM092D	Skill Based Course (Project Stage -II)	—	5	100%CIE
3	CONM101S	Self-Learning Course -1	—	1	100% ESE of 3 hours or credit transfer
4	CONM201S	Self-Learning Course -2	—	1	100% ESE of 3 hours or credit transfer
5	CONM201MNC	Mandatory Non-Credit Course	—	0	100% ESE of 3 hours or credit transfer
				12	

Scheme of Instruction and Evaluation
SEMESTER IV

Scheme of Instruction					Scheme of Evaluation
S.No	Course Code	Course Title	L-T-P	Credits	
1	CONM093D	Skill Based Course (Project Stage -III)	—	5	100%CIE
2	CONM093D	Skill Based Course (Project Stage -IV)	—	7	100%CIE
				12	

Programme Name	M. Tech. Computer Engineering (Specialization in Network Infrastructure and Management Systems)
Course Code	CONM5001S
Course Title	Computational Methods
Course Type	Program Specific Mathematics
Prerequisites: Fundamental of computer science, discrete mathematics and probability theory and statistics.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Analyze mathematical models and methods using proofs. **CO2.** Apply number theory principles for real world problems. **CO3.** Demonstrate counting usage in computer applications. **CO4.** Illustrate probability principles for addressing randomness in the applications. **CO5.** Practice recurrence in real life problems. **CO6.** Design advanced graph theoretic algorithms.	

	Course Contents	Hrs.	CO
1.	**Introduction to proofs:** Propositions, Predicates, Axiomatic Method, Proof by Cases, Proof by Contradiction, Well Ordering Proofs, Propositional Logic, Equivalence and Validity, Algebra of Propositions, Proof by Induction	8	CO1
2.	**Number Theory:** Divisibility, Modular Arithmetic, Multiplicative Inverses, Euler's Theorem, RSA Public Key Encryption	6	CO2
3.	**Counting:** Sums and Asymptotics, Counting Sequences, Counting Subsets, Pigeonhole Principle, Inclusion-Exclusion, Combinatorial Proofs, Generating Functions	6	CO3
4.	**Probability:** Events and Probability Spaces, Conditional Probability, Random Variables, Random Walks	8	CO4
5.	**Recurrences:** Linear Recurrences, Divide-and-Conquer Recurrences	6	CO5
6.	**Directed graphs and Partial Orders:** Vertex Degrees, Walks and Paths, Directed Acyclic Graphs and Scheduling, Partial Orders, Equivalence Relations	6	CO6

Text Books	
1.	Kolman, Bernard, Robert C. Busby, and Sharon Ross. Discrete mathematical structures. Prentice-Hall, Inc., 1995.
2.	Cormen, Thomas H., Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. Introduction to algorithms. MIT press, 2022.
Reference Books	
1.	Lehman, Eric, Tom Leighton, and Albert R. Meyer. Mathematics for computer science. Technical report, 2006. Lecture notes, 2010.

Programme Name	M. Tech. Computer Engineering (Specialization in Network Infrastructure and Management Systems)
Course Code	CONM5011S
Course Title	Advanced Algorithms
Course Type	Core Subject
Prerequisites: Fundamental of computer science, discrete mathematics and probability theory and statistics.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Analyze algorithms and determine efficiency of algorithm. **CO2.** Design analysis algorithms using the greedy, dynamic programming, and divide and conquer techniques. **CO3.** Design and build solutions for a real world problem using graphs. **CO4.** Prove problems of P, NP, or NP-Complete. **CO5.** Demonstrate geometric algorithms usage in real life problems. **CO6.** Illustrate advanced algorithms techniques for NP Complete problems.	

	Course Contents	Hrs.	CO
1.	**Introduction:** Asymptotic notation, recurrences, amortized analysis	6	CO1
2.	**Algorithm design techniques:** Greedy algorithms, divide-and-conquer algorithms, dynamic programming	8	CO2
3.	**Graph algorithms:** Traversal, topological sort, minimum spanning trees, shortest path,biconnected components, strongly connected components in directed graphs, network flow	8	CO3
4.	**NP-completeness:** Classes P, NP and space complexity, reduction, NP-completeness, examples of NP-complete problems	6	CO4
5.	**Geometric algorithms:** Convex hulls, sweep paradigm, Voronoi diagrams, closest pair, nearest neighbour search.	6	CO5
6.	**Approximation Algorithms:** Approximation algorithms for known NP complete problems	6	CO6

Text Books	
1.	Kleinberg, Jon, and Eva Tardos. Algorithm design. Pearson Education India, 2006.
2.	Cormen, Thomas H., Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. Introduction to algorithms. MIT press, 2022.
Reference Books	
1.	Aho, A., J. Hopcroft, and J. Ullman. "The Design and Analysis of Algorithms. Addison and Wesley." Reading, MA (1974).

Programme Name	M. Tech. Computer Engineering (Specialization in Network Infrastructure and Management Systems)
Course Code	CONM5012S
Course Title	Computer Network Design
Course Type	Core Subject
Prerequisites: Nil.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Apply networking tools and techniques to design computer network. **CO2.** Evaluate Transport Layer protocols for Quality of Service (QoS). **CO3.** Examine Network Layer services and Protocols. **CO4.** Recommend Application Protocols as per need of application. **CO5.** Categorize various network security flaws. **CO6.** Design and deploy computer network as per customer requirement.	

	Course Contents	Hrs.	CO
1.	**Computer Network Design Foundation:** Introduction to Networking: Comparison between OSI and TCP/IP Protocol Suite, IP addressing, Cables, Repeaters, Bridges, Routers, Switches, Hubs, Gateway, VLANS, Network Design Case studies.	6	CO1, CO6
2.	**Transport Layer:** Introduction, Transport Layer Protocols, Congestion Control and Quality of Service User Datagram Protocol (UDP), Transmission Control Protocol (TCP), Stream Control Transmission Protocol (SCTP)	10	CO2, CO6
3.	**Network Layer:** Introduction, packet format, IPV4 addresses, Internet protocol Version 4(IPV4), IPV6, Address resolution protocol (ARP), Reverse address resolution protocol (RARP), Internet control Message protocol (ICMP), Real time transport protocol (RTP), RTP control protocol (RTCP), VOICE OVER IP etc	7	CO3, CO6
4.	**Routing Protocols:** Unicast Routing Protocols (RIP, OSPF, and BGP), Multicasting and Multicast Routing Protocols, RIP (Routing information protocol), OSPF (Open shortest path first), BGP (Border gateway protocol), Internet group management protocol (IGMP)	7	CO3, CO6
5.	**Application Layer Protocols:** Introduction, Host Configuration: BOOTP and DHCP, Domain Name System (DNS), TELNET and SSH, File Transfer: FTP and TFTP, SNMP	5	CO4, CO6
6.	**Applications of Secure Computer Network:** Internet Security: Security aspects in Network Layer, Transport Layer, and Application Layer, working of Firewalls, Advances in the domain	4	CO5

Text Books	
1.	Behrouz A. Forouzan, "TCP/IP Protocol Suite", III Edition, Tata McGraw Hill, 2005
2.	Behrouz A. Forouzan, "Data Communications and Networking", Tata McGraw-Hill, Fourth Edition
Reference Books	
1.	W. Richard Stevens, "TCP/IP Illustrated, Volume 1", Addison-Wesley, Second Edition
2.	Internetworking with TCP-IP: Design, Implementation, and Internals, by D. E. Comer and D. L. Stevens Vol II, Prentice Hall.

Programme Name	M. Tech. Computer Engineering (Specialization in Network Infrastructure and Management Systems)
Course Code	CONM5061T
Course Title	Database Management Systems
Course Type	Open Elective
Prerequisites: Nil.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Differentiate various database architectures. **CO2.** Design and implement relational databases. **CO3.** Execute MongoDB commands to manipulate data. **CO4.** Use advanced XML queries on database. **CO5.** Apply practices of implementing database security. **CO6.** Perform transaction processing and achieve concurrency control.	

	Course Contents	Hrs.	CO
1.	**Introduction to Database Management Systems and Enhanced Data Models for Advanced Applications:** Characteristics of database, Database users, Advantages of DBMS, Data Models, Schema and Instances, Three schema Architecture and Data Independence, Database Languages and Interfaces, The Database System Environment, Centralized and Client / Server Architecture for DBMS. Introduction to Temporal Database and Multimedia Databases.	4	CO1
2.	**Relational-Database Design and SQL:** Functional dependencies, Normalisation forms, Decomposition, Overall database design process. SQL: DDL: Create, Modify, Alter, Drop, View definition, etc.DML: SELECT, INSERT, DELETE, Update, Nested Query, SQL with SET operations: Union, Intersect, Except, etc, Aggregate Functions: Group By, Having, SUM, etc, SQL with Logical operations, Nested and Complex Queries, Join Queries. DCL : GRANT, REVOKE, etc DBA level query. Cursors and Triggers, Procedures and Functions, Partitions, SQL Backup and Recovery.	8	CO2
3.	**Introduction to NoSQL Databases:** Introduction, Design of parallel systems, Parallel query processing. Avenues for parallelism, Array and vector processors. Multiprocessor architecture: taxonomy of parallel architectures, Parallel Query Evaluation. Advanced Transaction Processing Non-relational DBMS: consistency and availability trade-offs, NoSQL DBMS (key-value, document, and graph), MongoDB: CRUD operations.	8	CO3
4.	**XML Databases:** Introduction to XML Documents and Databases, XML schemas, tree structure, and DOM, XML Query.	6	CO4
5.	**Database Security:** Introduction to major database attacks: SQL Injection, DoS/DDoS etc. Encryption and Public Key Infrastructures.	4	CO5

6.	**Transaction Processing and Concurrency Control:** Schedules and serializability, Lock management, Compensation and Databases, Deadlock Handling, Multiple granularity, validation protocols, multi-version protocols, snap shot isolation, predicate locking, Weak Levels of Consistency in Practice.	8	CO6

Text Books	
1.	Elmasri, Navathe. Fundamentals of Database Management systems, Pearson Education, 2008.
2.	Avi Silberschatz, Henry F. Korth, S. Sudarshan. Database System Concepts, Seventh Edition, McGraw-Hill, 2010.
3.	P. Sadalage and M. Fowler, NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence, Addison Wesley, 2012.
Reference Books	
1.	Thomas Connolly and Carolyn Begg, "Database Systems" 3rd Edition, Addison-Wesley, 2005.
2.	V.S. Subrahmanian, "Multimedia database systems", Springer, 1996.

Programme Name	M. Tech. Computer Engineering
Course Code	MTEC081L
Course Title	Indian Knowledge Systems
Course Type	Liberal Learning

Prerequisites: Nil.

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

CO1. Understand Indic knowledge systems.

CO2. Classify Indian vedas and puranas.

CO3. Justify Indian Science.

	Course Contents	Hrs.	CO
1.	**Introduction:** Introduction to Indic knowledge systems, Introduction to Sanskrit alphabet, root words, structure	2	CO1
2.	**Chaturdasha Vidyasthana:** Introduction to Chaturdasha Vidyasthana – Overview, Veda, Vedangas, Shad Darshana, Smriti Itihasa, Purana	4	CO2
3.	**Indian sciences:** Overview, Mathematics, Astronomy, Engineering, Metals and Mining, Medicine and Surgery, Psychology- mind sciences, Town planning, Ship building, etc	4	CO3
4.	**Leadership:** Leadership lessons from Mahabharata, Ramayana, Lessons from Ramayana, Importance and relevance of Mahabharata and Ramayana	4	CO2
5.	**Evolution of Indian education system:** Overview of Indian education system - Gurukul, Universities, Subjects	4	CO2, CO3
6.	**Revision:** Revision - open discussion - paper work, Revision - wrap up - open discussion - paper work	2	CO1, CO2, CO3

Text Books	
1.	Introduction to Indian knowledge Systems - Concepts and Applications
2.	Mahabharata Unravelled: Lesser Known facets of a well-known history, Ami Ganatra.
Reference Books	
1.	4. Educational Heritage of India, Sahana Singh.
2.	A beautiful tree, Dharmapal.

Programme Name	M. Tech. Computer Engineering (Specialization in Network Infrastructure and Management Systems)
Course Code	CONM5021T
Course Title	Software Engineering
Course Type	Program Elective
Prerequisites: Programming, basics of software engineering	
Course Outcomes: At the end of the course student will be able to: **CO1.** Illustrate software development process and best practice for software development. **CO2.** Demonstrate agile development principles and techniques to manage agile software developments. **CO3.** Investigate requirements to generate software requirement document. **CO4.** Apply component based design to real life applications. **CO5.** Illustrate skills of software testing to projects. **CO6.** Estimate cost of the project.	

	Course Contents	Hrs.	CO
1.	**Fundamentals of Software Engineering:** software life-cycle process models, industry-standard software engineering tools.	3	CO1
2.	**Agile Methods for Software Development Method:** Extreme Programming (XP), Scrum, Lean, Crystal, Dynamic Systems Development Method and Feature-Driven Development.	8	CO2
3.	**Software Requirements Analysis and Engineering:** Identification of stakeholders, the elicitation and verification of requirements from them, and translation into detailed requirements	6	CO3
4.	**Software Architecture and Component-Based Design:** software design process and it's models; software architectures and design plans; design methods; design state assessment; design quality assurance; and design verification.	8	CO4
5.	**Software Testing and Quality Assurance:** systematic testing of software systems, software verification, symbolic execution, software debugging, quality assurance, measurement and prediction of software reliability.	8	CO5
6.	**Cost Estimation and Measurement:** industry-standard software sizing metrics as Function, Feature, and Object Points and their relationship to the lines-of-code metric.	6	CO6

Text Books	
1.	Roger Pressman. Software Engineering: A Practitioner's Approach (7th. ed.). McGraw-Hill, Inc., USA. 2009.
Reference Books	
1.	Jalote, Pankaj. An integrated approach to software engineering. Springer Science & Business Media, 2012.
2.	Sommerville, Ian. Software Engineering, 9/E. Pearson Education India, 2011.

Programme Name	M. Tech. Computer Engineering (Specialization in Network Infrastructure and Management Systems)
Course Code	CONM5022T
Course Title	Distributed Systems
Course Type	Program Elective
Prerequisites: Operating Systems, Computer Networks.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Illustrate fundamental concepts of distributed systems. **CO2.** Demonstrate synchronization principles for real world problems in distributed systems. **CO3.** Distinguish different middle-ware technologies in computer distributed applications. **CO4.** Examine shared data operations and replication in the distributed applications. **CO5.** Inspect distributed systems with case studies. **CO6.** Design advanced graph theoretic algorithms.	

	Course Contents	Hrs.	CO
1.	**Foundations:** Examples of distributed systems, Architectural models, Network principles, Multi-cast communication, Network virtualization, Message passing interface (MPI), Request-reply protocols, Remote procedure call (RPC), Remote method invocation (RMI), group communication, publish-subscribe systems, message queue systems, shared memory–based approaches.	9	CO1
2.	**Synchronization and Coordination of Distributed Systems:** Clocks, events and process states, Synchronizing physical clocks, Logical time and logical clocks, Global states, Distributed mutual exclusion, Elections, Coordination and agreement in group communication, Consensus and related problems	8	CO2
3.	**Middle-ware Components:** Distributed objects, CORBA, Distributed components, Enterprise JavaBeans and Fractal, Web services, Coordination of web services, Peer-to-peer middleware, Routing overlays, Overlay case studies: Pastry, Tapestry	6	CO3
4.	**Distributed Shared Data:** Distributed mutual exclusion, Elections, Coordination and agreement in group communication, Consensus, Transactions, Nested transactions, Locks, Optimistic concurrency control, Timestamp ordering, Flat and nested distributed transactions, Atomic commit protocols, Concurrency control in distributed transactions, Distributed deadlocks, Transaction recovery, System model and the role of group communication, Fault-tolerant services, Case studies of highly available services: The gossip architecture, Bayou and Coda, Transactions with replicated data	9	CO4

5.	**Distributed Systems:** Overview of security techniques, Case studies: Needham–Schroeder, Kerberos, TLS, 802.11 WiFi, File service architecture, Case study: Sun Network File System, Case study: The Andrew File System, Name services and the Domain Name System, Directory services, Case study: The Global Name Service, Case study: The X.500 Directory Service	6	CO5
6.	**Designing Distribute Systems:** Introducing the case study: Google, Overall architecture and design philosophy, Underlying communication paradigms, Data storage and coordination services, Distributed computation services	3	CO6

Text Books	
1.	George Coulouris, Jean Dollimore, and Tim Kindberg, " Distributed Systems Concepts and Design", 5th ed., Pearson Education, 2011.
2.	Ghosh, Sukumar. Distributed systems: an algorithmic approach. Chapman and Hall/CRC; 2nd edition 2014.
Reference Books	
1.	Van Steen, Maarten, and Andrew S. Tanenbaum. Distributed systems. Leiden, The Netherlands: Maarten van Steen, 2017.

Programme Name	M. Tech. Computer Engineering (Specialization in Network Infrastructure and Management Systems)
Course Code	CONM5023T
Course Title	Computer Systems Performance Analysis
Course Type	Program Elective

Prerequisites: Operating Systems, Computer Networks, and Probability and Statistics.

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

CO1. Evaluate the performance of the various computer systems and networks, mistakes commonly observed in performance evaluation projects and a proper methodology to avoid them.

CO2. Illustrate performance metrics and analyze them mathematically, analytically or through simulation.

CO3. Illustrate the application of probability functions and distributions for computer systems.

CO4. Design mathematical models using Queuing Networks models and use programming languages to simulate and evaluate the performance of various computer systems within or outside the network.

CO5. Evaluate the performance of network systems by using various queuing models.

CO6. Analyze the performance evaluation of various protocols, algorithm in an network environment.

	Course Contents	Hrs.	CO
1.	**Overview of Performance Evaluation:** Introduction, common mistakes and how to avoid them, selection of techniques and metrics.	10	CO1
2.	**Measurement Techniques and Tools:** Types of workloads, the art of workload selection, workload characterization and techniques, monitors, program-execution monitors and accounting logs, capacity planning and bench-marking, the art of data presentation.	10	CO2
3.	**Probability Theory and use for Evaluation:** Introduction to probability refresher, conditional probability, total probability, discrete and continuous random variables, common distributions, probability generating functions(pgf) and Laplace transforms (lst), numerous examples from computer networking, Commonly used distributions.	6	CO3
4.	**Queuing Theory :** Queuing models, little theorem application, stochastic processes, Markov chain formulation, discrete time and continuous time markov chains (dtmc, ctmc), MMD, Operational laws.	4	CO4

5.	**Queuing System Models and Application:** Queuing system m/m/1, m/m/1/k, m/m/s/, m/m/y queue analysis m-server case. Multidimensional markov chain application in circuit switching/g/1 queue, generalization of m/g/1 theory application to atm, embedding instants in the m/g/1 theory m/g/1 with geometrically distributed messages. chain embedded to cell transmission, message transmission completion. queue balance equation, finite buffer case, mean value analysis.	6	CO5
6.	**Network Analysis:** Local area Network analysis, standard comment based analysis, contention based protocols, demand assignment protocols, nodes in packet switches networks, performance analysis of data link layer, Network layer. Traffic control and congestion in ATM networks, TCP/IP Traffic control.	3	CO6

Text Books	
1.	Raj Jain, "The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation, and Modeling", Wiley-Interscience, 1991.
Reference Books	
1.	K.S. Trivedi, "Probability and Statistics with Reliability, Queueing and Computer Science Applications", John Wiley and Sons, 2001.
2.	Ross, Sheldon M. Introduction to probability models. Academic press, 2014.

Programme Name	M. Tech. Computer Engineering (Specialization in Network Infrastructure and Management Systems)
Course Code	CONM5024T
Course Title	Social Network Analysis
Course Type	Program Elective

Prerequisites: Analysis of Algorithm, Computer Networks, Data Mining.

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

CO1. Illustrate sociology and anthropology used the ideas of culture and cultural formation concepts of Social Network Analysis.

CO2. Demonstrate statistical properties for real world problems in Social Network Analysis.

CO3. Distinguish different edge classification techniques and use in the application.

CO4. Examine shared data operations and replication in the distributed applications.

CO5. Inspect data mining in Social Network Analysis with case studies.

CO6. Design advanced graph theoretic algorithms.

	Course Contents	Hrs.	CO
1.	**Foundations:** Introduction to new science of networks; Networks examples; Sociometry, small groups, and communities; Cliques, roles, and matrices; Space and distance; Dynamics and social change	6	CO1
2.	**Statistical Properties of Social Network:** Graph concepts and properties; static and dynamic properties of social graphs; RandomWalk based Proximity Measures; other proximity measures; Graph-theoretic Measures for Semi-supervised Learning; Algorithms for computing the proximity measures; Applications using random walks approach.	8	CO2
3.	**Community Discovery in Social Networks:** Defining communities; Core Methods: Quality Functions, Kernighan-Lin(KL) algorithm, Agglomerative/Divisive Algorithms, Spectral Algorithms, Multi-level Graph Partitioning, Markov Clustering; Community Discovery in Dynamic Networks, Heterogeneous Networks, Directed Networks.	6	CO3
4.	**Node Classification in Social Networks:** The Node Classification Problem; Problem Formulation; Local Classifiers, Random Walk based classifier, Node Classification to Large Social Networks, Basic Methods, Second-order Methods, Map-Reduce, Dissimilarity in Labels, Edge Labeling, Label Summarization.	6	CO4
5.	**Data Mining in Social Media:** Data Representation, Event Maps, Social Networking Sites: Illustrative Examples, Blogosphere: Illustrative Examples.	6	CO5
6.	**Visualizing Social Network:** Visual Images, MDS and SVD to explore data, Exploratory Research, Validating a Model, Structural Visualization, Semantic and Temporal Visualization, Statistical Visualization	6	CO6

Text Books

1. Charu C. Aggarwal, "Social Network Data Analytics" Springer New York, NY, 2011.
2. Carrington, P., Scott, J., Wasserman, S. (Eds.). Models and Methods in Social Network Analysis (Structural Analysis in the Social Sciences). Cambridge: Cambridge University Press, 2005.

Reference Books

1. Xiaoming Fu, Jar-Der Luo, Margarete Boos. Social Network Analysis Interdisciplinary Approaches and Case Studies.CRC Press, 2020.
2. Carrington, Peter J., John Scott, and Stanley Wasserman, eds. Models and methods in social network analysis. Vol. 28. Cambridge university press, 2005.

Programme Name	M. Tech. Computer Engineering (Specialization in Network Infrastructure and Management Systems)
Course Code	CONM5031S
Course Title	Cloud Computing
Course Type	Program Elective
Prerequisites: Operating system	
Course Outcomes: At the end of the course student will be able to: **CO1.** Describe cloud computing concepts, architecture, deployment model and other cloud terminologies **CO2.** Use various aspects of SLA, workout cloud economics. **CO3.** Apply security features of cloud. **CO4.** Distinguish various special purpose cloud. **CO5.** Use and Create private cloud. **CO6.** Design solution using cloud services.	

	Course Contents	Hrs.	CO
1.	**Introduction:** Cloud Computing – Overview, Cloud Computing – Introduction, Evolution of Cloud Computing, Cloud Computing Architecture, Cloud Architecture - Deployment Models, , Virtualization, XML Basics, Web Services, Service Oriented Architecture	6	CO1
2.	**Service Level Agreement (SLA):** SLA – Tutorial (problems), Economics, Economics Tutorial (problems), Managing Data, Introduction to Map Reduce, Map Reduce – Tutorial (problem), Resource Management in cloud	8	CO2
3.	**Openstack Cloud:** Detail Study of openstack cloud, Deployment/ implementation of Openstack cloud as private cloud, OpenStack Major Components, Architecture of Openstack, Openstack Work Flow, Nova scheduler filtering, OpenStack Storage Concepts Study of other services	8	CO5
4.	**Cloud Types:** Broker for Cloud Marketplace, Fog Computing, Use Case Geospatial Cloud, Green Cloud, Sensor Cloud Computing, IoT Cloud	4	CO4
5.	**Cloud Security:** Security - Basic Components, Security Attacks, Classes of Threats, Policies and Mechanisms, Goals of Security, Trust and Assumptions, Types of Mechanisms, Assurance, Operational Issues, Passive and Active Attacks, Security Services.	8	CO3
6.	**Cloud Platforms study:** Case study of public cloud like AWS, Microsoft Azure, Google cloud GCP, Study and use of various services. Cloud Migration, Docker container, Serverless Computing, Dew computing	6	CO6

Text Books	
1.	Arshdeep Bahga , Vijay Madisetti, Cloud Computing: A Hands-On Approach. Universities Press.
Reference Books	
1.	Buyya, Rajkumar, Christian Vecchiola, and S. Thamarai Selvi. Mastering cloud computing: foundations and applications programming. Newnes, 2013.

Programme Name	M. Tech. Computer Engineering (Specialization in Network Infrastructure and Management Systems)
Course Code	CONM5032S
Course Title	Internet of Things
Course Type	Program Elective
Prerequisites:	
Course Outcomes: At the end of the course student will be able to: **CO1.** Analyze the importance of various aspects of IoT. **CO2.** Apply different tools for interoperability for IoT. **CO3.** Design different SDN for IoT. **CO4.** Analyze Data Handling and Analytics in IoT. **CO5.** Design and develop different application in IoT. **CO6.** Create different case studies in IoT.	

	Course Contents	Hrs.	CO
1.	**Fundamentals of Internet of Things:** Introduction to IoT, Sensing, Actuation, Basics of Networking, Communication Protocols, Sensor Networks, Machine-to-Machine Communications.	4	CO1
2.	**Interoperability in IoT:** Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino, Introduction to Python programming, Introduction to Raspberry Pi.	6	CO2
3.	**Implementation of IoT:** Implementation of IoT with Raspberry Pi, Introduction to SDN, SDN for IoT.	8	CO3
4.	**Data Handling in IOT:** Data Handling and Analytics, Cloud Computing, Cloud Computing, Sensor-Cloud, Fog Computing.	8	CO4
5.	**Application of IOT:** Connected Vehicles, Smart Grid, Industrial IoT. Challenges in Design and Development		CO5
6.	**Case Study:** Agriculture, Healthcare, Activity Monitoring.		CO6

Text Books	
1.	S. Misra, A. Mukherjee, and A. Roy, 2020. Introduction to IoT. Cambridge University Press.
2.	S. Misra, C. Roy, and A. Mukherjee, 2020. Introduction to Industrial Internet of Things and Industry 4.0. CRC Press.
Reference Books	
1.	Research Papers

Programme Name	M. Tech. Computer Engineering (Specialization in Network Infrastructure and Management Systems)
Course Code	CONM5033S
Course Title	GPU Architecture and Programming
Course Type	Program Elective
Prerequisites: Nil.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Describe concepts of the GPU architecture. **CO2.** Justify memory hierarchy and usage in parallel programming. **CO3.** Apply synchronization primitives in parallel programming. **CO4.** Justify data transfer through streams for parallel programs. **CO5.** Infer kernel functions for the real time systems. **CO6.** Illustrate case studies.	

	Course Contents	Hrs.	CO
1.	**Introduction:** Streaming Multi Processors, Cache Hierarchy,The Graphics Pipeline History, Graphics processors, graphics processing units, Clock speeds, CPU/GPU comparisons, heterogeneity, Accelerators, Parallel programming, CUDA / OpenCL / OpenACC	8	CO1
2.	**Memory** Memory hierarchy, DRAM / global, local / shared, private/local, textures, constant memory, Pointers, parameter passing, arrays and dynamic memory, multi-dimensional arrays, Memory allocation, memory copying across devices, Programs with matrices, performance evaluation with different memories.	6	CO2
3.	**Synchronization** Memory consistency. Barriers (local versus global), atomics, memory fence. Prefix sum, reduction. Programs for concurrent data structures such as worklists, linked-lists. Synchronization across CPU and GPU. Warp Scheduling, Divergence	8	CO3
4.	**Streams:** Asynchronous processing, tasks, task-dependence. Overlapped data transfers, default stream, synchronization with streams. Events, event-based-synchronization- overlapping data transfer and kernel execution, pitfalls.	6	CO4
5.	**Functions:** Device functions, host functions, kernels, functors, Optimization examples : optimizing Reduction Kernels Optimization examples : Kernel Fusion, Thread and Block OpenCL basics and OpenCL for Heterogeneous Computing Support: Debugging GPU programs. Profiling, profile tools, performance aspects	8	CO5
6.	**Advanced topics:** Case studies, Dynamic Parallelism, Unified virtual memory, Multi-GPU processing, Peer access, Heterogeneous processing	6	CO6

Text Books	
1.	Programming Massively Parallel Processors: A Hands-on Approach; David Kirk, Wen-mei Hwu; Morgan Kaufman; 2016
Reference Books	
1.	CUDA Programming: A Developer's Guide to Parallel Computing with GPUs; Shane Cook; Morgan Kaufman; 2012
2.	Heterogeneous Computing with OpenCL" – Benedict Gaster,Lee Howes, David R. Kaeli

Programme Name	M. Tech. Computer Engineering
Course Code	COCE5054S
Course Title	Software Defined Network
Course Type	Program Elective

Prerequisites: Computer Network.

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

CO1. Demonstrate the working of SDN.
CO2. Emulate SDN using openflow.
CO3. Programme the SDN.
CO4. Apply SDN in data center.
CO5. Study SDN security and its applications.

	Course Contents	Hrs.	CO
1.	**Computer Network Design Foundation:** Introduction to SDN: History of Software Defined Networking (SDN), Modern Data Center, Traditional Switch Architecture, Why SDN, Evolution of SDN, How SDN Works – Centralized and Distributed Control and Date Planes, The Genesis of SDN	06	CO1
2.	**Open Flow and SDN Controllers:** Open Flow Specification, SDN via APIs, SDN via Hypervisor- Based Overlays – SDN via Opening up the Device, General Concepts, OpenFlow Protocol, SDN Controllers: Introduction, VMware - Nicira - VMware/Nicira - OpenFlow-Related - Mininet - NOX/POX - Trema - Ryu - Big Switch Networks/Floodlight Layer 3 Centric - Plexxi - Cisco OnePK	06	CO2
3.	**SDN Programming:** Northbound Application Programming Interface, Current Languages and Tools, Composition of SDNs – Network Functions Virtualization (NFV) and Software Defined Networks: Concepts, Implementation and Applications, NetApp Development, Network Slicing	06	CO3
4.	**SDN in Data Center:** SDN in the Data Center - SDN in Other Environments - SDN Applications - SDN Use Cases - The Open Network Operating System 3, Multitenant and Virtualized Multitenant Data Center – SDN Solutions for the Data Center Network – VLANs – EVPN – VxLAN – NVGRE	08	CO4
5.	**SDN Security:** Security Characteristics of SDN, Security Analysis and Potential attacks in SDN,Security Principles of SDN, Solutions to the security issues in SDN, Network Security enhancement using the SDN Framework – Issues and Challenges, Threats to SDN -Networks, Controllers, Applications	06	CO5

6.	**SDN Applications and SDN Future:** SDN applications-Reactive versus Proactive Applications, Analysing Simple SDN Applications, A Simple Reactive Java Application, Using the Floodlight Controller, Using the Open Daylight Controller, Access Control for the Campus, Traffic Engineering for Service Providers, Applications of SDN to Real Networks. SDN Future -Potential Novel Applications of Open SDN-Managing Non-traditional Physical Layer Links, Applying Programming Techniques to Networks, Security Applications, Roaming in Mobile Networks, Traffic Engineering in Mobile Networks, SDN Open Source - SDN Futures - Final Thoughts and Conclusions	08	CO5

Text Books	
1.	Paul Goransson and Chuck Black, "Software Defined Networks: A Comprehensive Approach", Morgan Kaufmann, 2014, ISBN: 9780124166752, 9780124166844.
2.	SiamakAzodolmolky, "Software Defined Networking with Open Flow, Packt Publishing, 2013, ISBN: 9781849698726.
3.	Thomas D. Nadeau, Ken Gray, "SDN: Software Defined Networks, An Authoritative Review"
Reference Books	
1.	1. Vivek Tiwari, "SDN and OpenFlow for Beginners", Digital Services, 2013, ISBN: 10: 1-940686-00-8, 13: 978-1-940686-00-4.
2.	Fei Hu, "Network Innovation through OpenFlow and SDN: Principles and Design", CRC Press, 2014, ISBN: 10: 1466572094.
3.	Open Networking Foundation (ONF) Documents, https://www.opennetworking.org, 2015

Programme Name	M. Tech. Computer Engineering (Specialization in Network Infrastructure and Management Systems)
Course Code	CONM5002S
Course Title	Research Methodology and IPR
Course Type	Program Core (Mandatory Learning)
Prerequisites: Nil.	
Course Outcomes: At the end of the course student will be able to: **CO1.** To Explore research and describe the research process and research methods. **CO2.** Model and visualize the processes and requirements for conducting successful research. **CO3.** Identify the requirement of report writing and apply over it. **CO4.** To investigate and apply the basic aspects of the scientific conduct and publication ethics in order to demonstrate through software approach. **CO5.** To apply knowledge in publication ethics and investigate misconduct for the exploration of required IT Acts in research project. **CO6.** To be able to present, review and publish on scientific paper work.	

	Course Contents	Hrs.	CO
1.	**Research Methods:** Objectives of Research, Various Steps in Scientific Research, Types of Research; Research Problem , Research Design , Survey Research , Case Study Research and hypothesis,Sampling , Measurement and Scaling techniques , Methods of data collection, Design of Survey and Experiments , Hypothesis design	6	CO1
2.	**Computer Application in Research Methodology:** C Data Processing and Modeling :Data processing and Measures Mathematical model formulation for queries using relational algebra, Design of software Architecture ,Database design, Algorithm Design ,GUI design ,Model building and decision making , Probability Distributions, Fundamentals of Statistical Analysis and Inference, Correlation and Regression ,Classification ,Clustering	5	CO2
3.	**Report writing:** Structure and Components of Research Report, Types of Report, Layout of Research Report, Writing research proposal ,Mechanism of writing a research report, Performance evaluation and curve fitting, Result declaration by various graphs and charts	4	CO3

4.	**Scientific conduct and publication ethics:** Ethics with respect to science and research,Intellectual honesty and research integrity, falsification, fabrication and plagiarism., duplicate and overlapping publication, salami slicing,Selective reporting and misinterpretation of data,Best practices/standards setting initiatives and guidelines: COPE, WAME, etc,Publication misconducts: definition, concept, problems that lead to unethical behavior and vice versa, types,Violation of publications ethic, authorship and contribution ship, Identification of publication misconduct, complaints and appeals,Software tools: Use of plagiarism tool like Turnitin, Urkund, and other open-source software tool	6	CO4
5.	**Publication ethics and misconduct:** Subject specific ethical issues, FFP, authorship,Conflict of interest,Complaints and appeals: examples and fraud from India and abroad,IT Acts for handling misconduct.	5	CO5
6.	**Application Of Results and Ethics:** Ethical issues , ethical committees , Commercialization , Code of Research Ethics Intellectual property Trademark rights ,Copyright,Patent ,Plagiarism ,royalty Databases Indexing databases, Citation databases: Web of science, Scopus etc. Research Metrics:Impact factor of journal as per citation report, SNIP, SJR, IPP, Cite score ,Metrics: h-index, i10-index, g-index, altmetrics	6	CO6

Text Books	
1.	Research Methodology by G.C.Ramamurthy Dreamtech Publications
2.	C.R. Kothari, Research Methodology Methods and Techniques, 2/e, VishwaPrakashan, 2006
3.	MacIntyre, A., 2003. A Short History of Ethics. a history of moral philosophy from the Homeric age to the 20th century. Routle
4.	Bhaskar, D.,2019. Ethics in Science Education, Research and Governance. Current Science, 117(10), pp.1736-1737.
Reference Books	
1.	Engineering Optimization methods and applications A.ravindran ,Wiley publication
2.	Donald R. Cooper, Pamela S. Schindler, Business Research Methods, 8/e, Tata McGraw-Hill Co. Ltd., 2006.

Programme Name	M. Tech. Computer Engineering
Course Code	COCE5041S
Course Title	Network Administration
Course Type	Program Core

Prerequisites: Computer Networks

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

CO1. Analyze different network architectures and their features.
CO2. Perform various network operations and maintenance activities.
CO3. Identify the requirements of a data center network.
CO4. Examine and analyze the network effectively.
CO5. Design a secure network and resolve the issues.

	Course Contents	Hrs.	CO
1.	**Network Architecture Overview:** Physical Infrastructure, Logical Design, ISO/OSI Model, Network Topologies, Data Communication and Routing, Network Addressing and Security Features..	6	CO1
2.	**Network Operations and Processes:** Monitoring, Management: Access and Audit Trail, Life Cycle, Configuration Management, Deployment Process, Documentation: Network Design and Implementation, DNS, Labeling, Support: Tools, Organizational Structure, Network Services.	7	CO2, CO4
3.	**Datacenter Networks:** Build/Rent/Outsource, Requirements, Capacity Management, Life-Cycle Management, Patch Cables, Labeling, Console Access, Workbench, Tools and Supplies, Security Aspects.	7	CO1, CO3
4.	**Network Monitoring:** Overview, Monitoring Platforms, Data Collection and Performance Analysis, Systems and Service Monitoring, SNMP, Namespaces and Nameservices, Time Management, Customer Support, Incident Report.	8	CO2, CO4
5.	**Network Maintenance:** Change Management, Scaling and Expansion, Server Upgrades, Maintenance Windows, Software Repositories and Licencing, Data Storage, Backup and Restore, Disaster Recovery.	8	CO2, CO4
6.	**Network Security:** Basic Security Measures, The OSI Security Architecture, Security Attacks, Security Services and Mechanisms, Fundamental Security Design Principles, Attack Surfaces and Attack Trees, A Model for Network Security, Standards, Legal and Ethical Issues.	6	CO1, CO5

Text Books

1. Thomas Limoncelli, Christina Hogan, Strata Chalup "The Practice of System and Network Administration, Volume 1", 3ed, Addison-Wesley (2017)
2. Evi Nemeth, Garth Snyder, Trent Hein, Ben Whaley, Dan Mackin, "UNIX and Linux System Administration Handbook", 5ed, Addison-Wesley (2018)

Reference Books

1. Mark Burgess, "Principles of Network and System Administration", 2ed, John Wiley (2004)
2. William Stallings, "Network Security Essentials", 6ed, Pearson (2017)

Programme Name	M. Tech. Computer Engineering (Specialization in Network Infrastructure and Management Systems)
Course Code	CONM5014S
Course Title	Network Security
Course Type	Program Core
Prerequisites: Nil.	
Course Outcomes: At the end of the course student will be able to: **CO1.** Demonstrate the concept of cryptography, Network security ,Layered Architecture. **CO2.** Evaluate network Stack Vulnerabilities, threats and counter measures **CO3.** Analyze the network and web attacks at different layers of TCP/IP stack. **CO4.** Explore a better understanding of Network Security Protocols. **CO5.** Apply the fundamentals of security in programs, operating systems and databases.	

	Course Contents	Hrs.	CO
1.	**Overview of Security:** Motivation, Terminology/Background, Cryptography Overview, Confidentiality, Integrity, Authentication: Foundations,Symmetric key encryption, Block modes, Asymmetric key encryption, Hashes, MACs, Digital Signatures, key distribution, one way/mutual/mediated authentication,Protocols Overview,Introduction to Network security ,Layered architecture, Client Server architecture, Peer-to-Peer Architecture.	4	CO1
2.	**Vulnerabilities and Threat in Network Stack:** Basic services used and provided by TCP/IP Stack,Types of devices constituting a network. Concept of Internet Service Providers (ISPs)and overall conceptual view of the Internet. Routing fundamentals. Different types of networks such as LAN, WAN, VPN, etc, TCP/IP Protocol and its Vulnerabilities, Hyper Text Transfer Protocol (HTTP) and corresponding cyber security vulnerabilities.TCP/UDP/IP Vulnerabilities,Data link layer protocol vulnerability, Routing attacks.	7	CO2
3.	**Network and Web Attacks:** Attacks at link/network/transport/application layer,Denial of Service (DOS) attacks, Firewalls, Intrusion Detection,Malware and its types, The OWASP top 10-attacks,Client side and Server side attacks: Injection, Vulnerability, SQL injection, Cross Site Scripting (XSS) . Session Hijacking,Phishing, Click jacking, scripting, Broken Authentication and Session Management, Insecure Direct Object References, Cross Site Request Forgery (CSRF) Vulnerability, Failure to Restrict URL Access, Invalidated Redirects and Forwards.	7	CO3

4.	**Network Security protocols:** Application Layer: SSH.PGP,MIME,Transport Layer: TLS/SSL, Network Layer: IPSec, Link Layer: WPA, WEP, Open source tools for defense mechanism, Network Security controls, How to use network analysis tool: Wireshark and NMAP, ESAPI structure: security mechanism to mitigate the top 10 threats of OWASP, Defenses against the same.	7	CO4
5.	**System Security:** Introduction to System Security, Server Security, OS Security,Database Security, Various concepts of system and server security,overview of program security.	7	CO5
6.	**Advances in network security:** Cyber Security and Recent Technologies ,Security aspects in IoT, Cloud Computing and Image/video data. Bio-metrics, Mobile Computing and Hardening on android and ios, IOT Security, Android Malware Analysis, Experimentation using open source tools	7	CO5, CO1

Text Books	
1.	William Stallings, "Cryptography and Network Security", Pearson Education/PHI, 2006
2.	Network Security Bible second edition by eric cole
Reference Books	
1.	
2.	

Programme Name	M. Tech. Computer Engineering
Course Code	CONM5041T
Course Title	Soft Computing
Course Type	Program Elective

Prerequisites: Neural network

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

CO1. Construct intelligent systems leveraging the archetype of soft computing techniques.

CO2. Provide the mathematical background for carrying out the optimization associated with intelligent learning algorithms.

CO3. Design hybrid system to revise the principles of soft computing in various applications.

CO4. Develop familiarity with current research problems and research methods in soft computing.

	Course Contents	Hrs.	CO
1.	**Fuzzy Logic:** Introduction to fuzzy logic, Fuzzy membership functions, Operations on fuzzy sets, Fuzzy relations, Fuzzy propositions, Fuzzy implications, Fuzzy inferences, Defuzzification Techniques, Fuzzy logic controller, Advances in fuzzy logic	12	CO1, CO4
2.	**Genetic Algorithm (GA):** Concept of GA, GA Operators: Encoding, Selection, Crossover, Mutation, Advances in GA	8	CO1, CO2, CO4
3.	**Multi-Objective Optimization:** Introduction to MOO problem, Non-Pareto based approach for MOO problem, Pareto based approach for MOO problem, Advances in MOO	8	CO1, CO2, CO4
4.	**Artificial Neural Network:** Introduction to ANN, Various architectures of ANN, Learning algorithms of ANN, Advances in ANN	8	CO1, CO4
5.	**Hybrid Systems:** Integration of Neural Networks, Fuzzy Logic and Genetic Algorithms, Research orientation of soft computing techniques	4	CO1, CO3, CO4

Text Books

1. S.N. Sivanandam and S.N. Deepa, "Principles of Soft Computing", Wiley India, 2007.
2. S. Rajasekaran and G. A. Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic, and Genetic Algorithms (Synthesis and Applications)", PHI Education, 2003.

Reference Books

1. Fakhreddine O. Karray and Clarence De Silva, "Soft Computing and Intelligent Systems Design (Theory, Tools and Applications)", Pearson education, 2009.
2. Timothy J. Ross, "Fuzzy Logic with engineering applications", John Wiley; Sons, 2016.
3. Melanic Mitchell, "An Introduction to Genetic Algorithm", MIT Press, 1998.
4. Carlos A. Coello Coello, Gary B. Lamont and David A. Van Veldhuizen, "Evolutionary Algorithms for Solving Multi-Objective Problems", 2 nd Edition, Springer, 2007.
5. Simon Haykin, "Neural Networks and Learning Machines", 3 rd Edition, Pearson, 2009.

Programme Name	M. Tech. Computer Engineering
Course Code	CONM5042T
Course Title	Ethical Hacking
Course Type	Program Elective

Prerequisites: Cryptography and Network Security

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

CO1. Apply ethical hacking phases to present to perform attacks.
CO2. Analyse system hacking.
CO3. Analyse web application vulnerabilities.
CO4. Illustrate the design of wireless hacking
CO5. Evaluate algorithms and framework for penetration testing.
CO6. Develop solutions and tools for OS vulnerabilities

	Course Contents	Hrs.	CO
1.	**Introduction to Ethical Hacking:** Introduction-Ethical hacking Terminology-types of hacking technologies-phases of ethical hacking-Foot printing-Social Engineering-Scanning and enumeration.	6	CO1
2.	**System Hacking:** Understanding the password hacking techniques-Rootkits-Trojans-Backdoors-Viruses and worms-sniffers-denial of service-Session hijacking.	6	CO2
3.	**Web Server Hacking:** Hacking web servers-web application vulnerabilities –Buffer overflow-Wireless hacking-Physical Security.	6	CO3
4.	**Wireless Hacking:** WEP, WPA Authentication mechanism-wireless sniffers-Physical Security-factors affecting physical security-honeypots-Firewall types.	6	CO4
5.	**Penetration Testing:** Cryptography-overview of MD5, SHA, RC4-penetration testing methodologies- steps- pentest legal framework-penetration testing tools.	6	CO5
6.	**Desktop and Server OS Vulnerabilities and Embedded OS:** Windows OS Vulnerabilities, Tools and Best practices, Linux OS Vulnerabilities and Tools, Introduction to Embedded OS and its vulnerabilities.	9	CO6

Text Books

1. Michael T. Simpson, Kent Backman, James Corley, Hands-On Ethical Hacking and Network Defense, Cengage Learning India Pvt. Ltd, 2016.
2. Patrick Engebretson, The Basics of Hacking and Penetration Testing: Ethical Hacking and Penetration Testing Made Easy, Syngress Basics Series

Reference Books

1. CEH v10: EC-Council Certified Ethical Hacker Complete Training Guide with Practice Labs

Programme Name	M. Tech. Computer Engineering
Course Code	CONM5043T
Course Title	Software Architecture
Course Type	Program Elective
Prerequisites: Object Oriented Software Engineering, Programming language.	
Course Outcomes: At the end of the course student will be able to: **CO1.** To build knowledge on software architecture **CO2.** To develop architectural approaches from requirements and manage traceability between architecture and requirements. **CO3.** To teach students the basic skills in reasoning about and expressing software designs **CO4.** To learn Analysis, Implementation and Deployment **CO5.** Practice human resource management and communications management techniques for software projects. **CO6.** Practice risk management and procurement management techniques for software projects.	

	Course Contents	Hrs.	CO
1.	**Fundamental of Software Architecture:** Prescriptive vs Descriptive Architecture, Architectural Design- DSSA, Architectural Pattern, Architectural Styles: Layered styles, Dataflow styles, Shared memory, interpreter Style, Implicit Invocation Styles, Peer to Peer Styles. Complex Architectural Style: C2 and CORBA Connectors: Roles, Types of Connector, Data Distribution connector: Event based, Grid-based, Client-server based, P2P based.	9	CO1
2.	**Architectural Modelling::** Connector Roles, Connector Types and Their Variation Dimensions, Example Connectors, Modeling Concepts, Ambiguity, Accuracy, and Precision, Description Language: Darwin, Rapide, Wright. Domain and Style-Specific ADLs: Koala, Weaves AADL . Visualization Techniques: Textual, Informal Graphical Editor, UML, LTSA, xADL 2.0, MTAT	8	CO2
3.	**Architectural Analysis:** Analysis Goal, Scope of Analysis, Types of Analysis Analysis Techniques: Inspection and Review Based: ATAM, Model based: Wright, Reliability Analysis	6	CO3
4.	**Applied Architectures and Styles, Designing for Non-Functional Properties:** Distributed and Networked Architectures, Architectures for Network-Based Applications, Decentralized Architectures, Service-Oriented Architectures and Web Services, Efficiency, Complexity, Scalability and Heterogeneity, Adaptability, Dependability.	9	CO4
5.	**Role of architecture in Software engineering:** Enterprise Architectures, Zachman's Framework; Architectural Styles, Design Patterns; Architecture Description Languages; Product-line architectures; Component based development	6	CO5

6.	**Design Patterns:** Basic patterns: facade, adapter, flyweight ; delegates: visitors, command, memento; grammars: composite, decorator, interpreter; frameworks: template method, factory, abstract factory; separation of concerns: observer, mediator, model-view-controller.	9	CO6

Text Books	
1.	Richard N. Taylor, Nenad Medvidovic, Eric M. Dashofy, Software Architecture: Foundation, Theory and Practice, Wiley, India , 2009
Reference Books	
1.	Frank Buschmann, Regine Meunier, Hans Rohnert, Peter Sommerlad, Miachel Stal, Douglas Schmidt.Pattern Oriented Sofware Architecture, Volumes 1 and 2
2.	M. Shaw and D.Garlan, Software Architecture: Perspectives on an Emerging Discipline, Pearson , 2006
3.	Len Bass, Paul Clements, Rick Katzman, Ken Bass. Software Architecture in Practice

Programme Name	M. Tech. Computer Engineering
Course Code	CONM5051S
Course Title	Ad hoc Network
Course Type	Program Elective

Prerequisites: Nil.

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

CO1. 1. Justify the wireless technology requirements.

CO2. 2. Apply the MAC protocols for the design of wireless network.

CO3. 3. Inspect the behaviour of Mobile IP and routing protocols.

CO4. 4. Examine the impact of transport layer protocols over wireless and wired medium.

CO5. 5. Evaluate resource optimization techniques for better performance.

CO6. 6. Design and deploy different wireless networks.

	Course Contents	Hrs.	CO
1.	**Fundamentals of Ad hoc Network:** Wireless technology: Signals, Antennas, Spectrum, Radio Propagation Mechanism, Characteristics of wireless Channel, Issues in Ad Hoc Wireless Networks, Multiplexing, Modulation.	4	CO1
2.	**MAC Protocols for Ad Hoc Wireless Networks:** Introduction, Issues in Designing a MAC Protocol for Ad Hoc Wireless Networks, Motivation for a specialized MAC, Design Goals of a MAC Protocol for Ad Hoc Wireless Networks, Classifications of MAC Protocols.	6	CO2
3.	**Wireless LAN and PAN:** Fundamentals of WLAN, IEEE 802.11 standards, HIPERLAN, Bluetooth. Wireless Internet: Introduction, Mobile IP, WAP.	8	CO1, CO2
4.	**Routing Protocols for Ad Hoc Wireless Networks:** Introduction, Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks, Classifications of Routing Protocols: Table-Driven Routing Protocols, On-Demand Routing Protocols, Hybrid Routing Protocols, Routing protocols with efficient flooding mechanisms (OLSR), power-aware routing protocols, Multicast routing: zonal routing etc.	8	CO3
5.	**Transport Layer and Security Protocols for Ad Hoc Wireless Networks:** Introduction, Traditional TCP, indirect TCP, Snooping TCP, Fast retransmit/fast recovery, transmission/time out freezing, selective retransmission, transaction-oriented TCP. Network Security Attacks: Network Layer, Transport Layer, Application Layer, Key Management, Secure Routing in Ad Hoc Wireless Networks.	6	CO4

6.	**Applications of Ad hoc Network:** Quality of Service in Ad Hoc Wireless Networks: Introduction, Issues and Challenges in Providing QoS in Ad Hoc Wireless Networks, Classifications of QoS Solutions, QoS Frameworks for Ad Hoc Wireless Networks. Energy Management in Ad Hoc Wireless Networks: Introduction, Need for Energy Management in Ad Hoc Wireless Networks, Classification of Energy Management Schemes, Battery Management Schemes, Transmission Power Management Schemes, System Power Management Schemes. Case study: Cellular network, 802.15.4, 802.16 Recent Advances in the domain.	10	CO5, CO6

Text Books	
1.	Jochen Schiller, "Mobile communications", 2nd Edition, Pearson Education, 2008.
2.	C. Siva Ram Murthy and B.S. Manoj, "Ad Hoc Wireless Networks: Architectures and Protocols", third Edition, Pearson education, 2008.
Reference Books	
1.	Wiiliam Stallings, "Wireless Communications and Networks" Prentice Hall, 2nd edition, 2005.
2.	C K Toh, "Ad Hoc Mobile Wireless Networks: Protocols and Systems", 1st Edition, Pearson education, 2002.
3.	Rappaport, "Wireless Communications Principals and Practices", 2nd Edition, Pearson Education Pvt. Ltd, 2003.

Programme Name	M. Tech. Computer Engineering
Course Code	CONM5052S
Course Title	Blockchain Technology
Course Type	Program Elective

Prerequisites: Data Structures, Algorithms, Operating System, Computer Networks.

Course Outcomes: At the end of the course student will be able to:
CO1. Identify Blockchain structure and its importance.
CO2. Differentiate Blockchain Platforms and their working.
CO3. Classify consensus algorithms for different case studies.
CO4. Design smart contract for real world applications.
CO5. Asses security issues of blockchain and smart contracts.
CO6. Demonstrate skills to build cryptocurrency applications based on Blockchain Technology.

	Course Contents	Hrs.	CO
1.	**Introduction:** Concepts of cryptocurrency and Blockchain, Advantages over Traditional Databases, Block in a Blockchain, Concept of Blockchain parameters- Header, Miners, Difficulty, Nonce, Stakes, Forking, Double- Spending Problem; Types of Blockchain: Public, Private, Consortium.	4	CO1
2.	**Blockchain Platforms:** Bitcoin Network and Architecture, Transaction in Bitcoin Network, Mining, Creation of Coins, Consensus Mechanisms and Validation: Proof of Work (PoW), Proof of Stake (PoS), Practical Byzantine Fault Tolerance (PBFT), Bitcoin Security issues. Ethereum vs. Bitcoin, Transactions, Ethereum Blocks, Mining Algorithm, Gas, Fees, Eth 2.0 GHOST Protocol.	8	CO2
3.	**Consensus Algorithms::** Study and comparison of different consensus algorithms: Algorand, Ouroboros, Ethereum's consensus, Ripple Protocol Consensus Algorithm (RPCA), etc	4	CO3
4.	**Smart Contracts Fundamentals:** Introduction to Smart Contracts, Framework of smart contract, Life cycle of smart contract, Solidity, Writing and Deploying Smart Contracts in Solidity, Vulnerabilities in Smart Contracts, Attacks, Prevention of Attacks.	6	CO4
5.	**Security:** Wallets and Keys, User Addresses and Privacy Security issues in Blockchain: Anonymity, Sybil Attacks, Selfish Mining, 51/49 ratio Attacks	4	CO5
6.	**Case Studies:** Application based: e-Governance, e-Commerce, Database Applications where third party is involved Use Cases: Cryptocurrency and Other Sectors like Finance, Voting System, and Healthcare, etc. Block chain in Social Networking, block chain in 5G	9	CO6

Text Books	
1.	Andreas M. Antonopoulos, Gavin Wood, Dr. Gavin Wood. Mastering Ethereum: Building Smart Contracts and DApps. O'Reilly Media, Incorporated, 2018.
2.	A. Narayanan, J. Bonneau, E. Felten, A. Miller, and S Goldfeder, "Bitcoin and Cryptocurrency Technologies", Princeton University Press, 2016
3.	Andreas M. Antonopoulos. Mastering Bitcoin Programming the Open Blockchain. O'Reilly Media 2017.
Reference Books	
1.	M. Swan, "Blockchain: Blueprint for a New Economy", OReilly, 2015

Programme Name	M. Tech. Computer Engineering
Course Code	CONM5053S
Course Title	Parallel Algorithms
Course Type	Program Elective

Prerequisites: Data Structures, Algorithms, Operating System, Computer Networks.

Course Outcomes: At the end of the course student will be able to:
CO1. classify parallel Computers, pipeline processing methods, interconnection networks, and multi-core/ many-core.
CO2. Differentiate multi-core/many-core for parallel architecture.
CO3. Practice different parallel Programming environments.
CO4. Design different parallel algorithm techniques.
CO5. Compare different parallel algorithms.
CO6. Design a parallel algorithm to solve real-time applications.

	Course Contents	Hrs.	CO
1.	**Introduction, Pipeline Processing and Interconnection network:** Parallel Computing, Parallel Architecture, Architectural Classification Scheme, Performance of Parallel Computers, Performance Metrics for Processors, Parallel Programming Models, Parallel Algorithms, Many core GPGPU architectures, Distributed processing, Pipeline, Hazards, Branch Prediction, Interconnection network.	6	CO1
2.	**Multi-core/many-core Architecture:** Basics of parallel architecture. Inter-process communication, Synchronization, Mutual exclusion, Introduction to multi-core/many core architecture Introduction to multi core/many-core programming, AMD/ATI GPU architectures, GPU Hardware: Streaming Multiprocessors, Kernel, Thread Blocks, Threads, GPU Memory Model: Synchronization, Barrier, Memory access, Coalesce, Atomics	6	CO2
3.	**Parallel programming Model:** Concurrency platforms: Cilk++, OpenMP,MPI, OpenCL, OpenACC, Open GL – Adhoc techniques for parallel algorithms: Independent loop scheduling, dependent loops, loop spreading, loop unrolling, problem partitioning, Divide and Conquer strategies, pipelining – Non-serial Parallel algorithms, GPU architectures and the programming model for GPGPU (CUDA).Communication Patterns: Map, Gather, Scatter, Stencil, Transpose, Strategies for efficient CUDA programming.	6	CO3
4.	**Parallel Algorithm Design:** Principles of Parallel Algorithm Design: Preliminaries, Decomposition Techniques, Characteristics of Tasks and Interactions, Mapping Techniques for Load Balancing, Methods for Containing Interaction Overheads, Parallel Algorithm Models.	6	CO4

5.	**Analysis of Parallel Algorithm:** Basic performance measures, measures of data communication, Multiplication factors, effect of software, cognitive system, benchmarking, defining and measuring cost, scalability of parallel system, Z-Transform analysis, Dependence Graph analysis, Computational Geometry analysis, Numerical and Non-numerical algorithms: Sorting, graphs, dynamic programming, dense matrix algorithms, sparse matrix algorithms.	6	CO5
6.	**Supercomputing and Parallel Algorithms:** Introduction to Grid, Cluster, GPGPUs architectures, Job Management Systems, File Systems: Shared File Systems (e.g. NFS), Parallel File Systems (e.g. GPFS, PVFS, Lustre), interconnection networks for supercomputers. Case studies: supercomputer etc.	9	CO6

Text Books	
1.	Fayez Gebali, "Algorithms and Parallel Computing", Wiley publications, 2011.
2.	AnanthGrama, Anshul Gupta, George Karypis, Vipin Kumar, Introduction to Parallel Computing, Pearson Education, Second Edition, 2007.
3.	Selim G. Akl, "Design and analysis of parallel algorithms", Prentice Hall.
Reference Books	
1.	Michael J. Quinn, —Parallel Programming in C with MPI and OpenMP‖, McGraw-Hill International Editions, Computer Science Series, 2008.
2.	Hawang Kai and Briggs F. A., "Computer Architecture and Parallel Processing", McGraw Hill, 1984.
3.	Barbara Chapman, Using OpenMP. Portable Shared Memory Parallel Programming, The MIT Press Cambridge, Massachusetts London, England 2008

Programme Name	M. Tech. Computer Engineering
Course Code	CONM5054S
Course Title	Big Data Analytics
Course Type	Program Core

Prerequisites: Database Management System, Java, Python, AI, Machine Learning.

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

CO1. To analyse the important components of big data.

CO2. Illustrate different components in Hadoop and MapReduce.

CO3. Develop problem solving skills like Collect, manage, store, query, and analyze various forms of Big Data using NoSQL.

CO4. Solve different problems using data streaming in big data analytics.

CO5. To apply adequate perspectives of big data analytics in various applications like recommender systems, social media applications, etc.

CO6. To analyse spark framework of big data analytic.

	Course Contents	Hrs.	CO
1.	**Introduction to Big Data and Hadoop:** Introduction to Big Data, Big Data characteristics, types of Big Data, Traditional vs. Big Data business approach, Case Study of Big Data Solutions,Concept of Hadoop Core Hadoop Components; Hadoop Ecosystem	4	CO1
2.	**Hadoop HDFS and MapReduce:** Distributed File Systems: Physical Organization of Compute Nodes, Large-Scale File-System Organization. MapReduce: The Map Tasks, Grouping by Key, The Reduce Tasks, Combiners, Details of MapReduce Execution, Coping with Node Failures. Algorithms Using MapReduce: Matrix-Vector Multiplication by MapReduce, Relational-Algebra Operations, Computing Selections by MapReduce, Computing Projections by MapReduce, Union, Intersection, and Difference by MapReduce Hadoop Limitations	4	CO2
3.	**NoSQL:** Introduction to NoSQL, NoSQL Business Drivers, NoSQL Data Architecture Patterns: Key-value stores, Graph stores, Column family (Bigtable)stores, Document stores, Variations of NoSQL architectural patterns, NoSQL Case Study NoSQL solution for big data, Understanding the types of big data problems; Analyzing big data with a shared-nothing architecture Choosing distribution models: master-slave versus peer-to-peer; NoSQL systems to handle big data problems	6	CO3

4.	**Mining Data Streams:** The Stream Data Model: A Data-Stream-Management System, Examples of Stream Sources, Stream Queries, Issues in Stream Processing. Sampling Data techniques in a Stream Filtering Streams: Bloom Filter with Analysis,Counting Distinct Elements in a Stream, Count-Distinct problem, Flajolet-Martin Algorithm, Combining Estimates, Space Requirements Counting Frequent Items in a Stream, Sampling Methods for Streams, Frequent Item sets in Decaying Window,Counting Ones in a Window: The Cost of Exact Counts, The Datar-Gionis-Indyk-Motwani Algorithm, Query Answering in the DGIM Algorithm, Decaying Windows.	6	CO4
5.	**Finding Similar Items, Clustering, and Real-Time Big Data Models:** Distance Measures: Definition of a Distance Measure, Euclidean Distances, Jaccard Distance, Cosine Distance, Edit Distance, Hamming Distance. CURE Algorithm, Stream-Computing, A Stream-Clustering Algorithm, Initializing and Merging Buckets, Answering Queries PageRank Overview, Efficient computation of PageRank: PageRank Iteration Using MapReduce, Use of Combiners to Consolidate the Result Vector. A Model for Recommendation Systems, Content-Based Recommendations, Collaborative Filtering. Social Networks as Graphs, Clustering of Social-Network Graphs, Direct Discovery of Communities in a social graph.	6	CO5
6.	**Big Data Analytics Frameworks:** Spark Framework: Introduction to GPU Computing, CUDA Programming Model, CUDA API, Simple Matrix, Multiplication in CUDA, CUDA Memory Model, Shared Memory Matrix Multiplication, Additional CUDA API Features,Spark SQL and GraphX: SQL Context, Importing and Saving data, Data frames – using SQL, GraphX overview, Creating Graph, Graph Algorithms, Spark Streaming: Overview, Errors and Recovery, Streaming Source, Streaming live data with spark.	7	CO6

Text Books	
1.	CreAnand Rajaraman and Jeff Ullman —Mining of Massive Datasets, Cambridge University Press, 2014
2.	Alex Holmes —Hadoop in Practice, Manning Press, Dreamtech Press.
3.	Dan Mcary and Ann Kelly — Making Sense of NoSQL – A guide for managers and the rest of us, Manning Press
Reference Books	
1.	Bill Franks , Taming The Big Data Tidal Wave: Finding Opportunities In Huge Data Streams With Advanced Analytics, Wiley
2.	Chuck Lam, Hadoop in Action, Dreamtech Press
3.	Jared Dean, Big Data, Data Mining, and Machine Learning: Value Creation for Business Leaders and Practitioners, Wiley India Private Limited, 2014.
4.	Jiawei Han and Micheline Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann Publishers, 3rd ed, 2010.

Programme Name	M. Tech. Computer Engineering
Course Code	CONM5065T
Course Title	Human Computer Interaction
Course Type	Open Elective

Prerequisites: Nil.

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

CO1. Analyze the importance of various aspects of HCI.
CO2. Apply different tools for interactive system design for HCI
CO3. Design different web interfaces of HCI.
CO4. Create interaction using different interactive style.
CO5. Design and develop different usability aspects of software system.
CO6. Create software system using UX and UI. s

	Course Contents	Hrs.	CO
1.	**Introduction to Human-Computer Interaction:** Objective, Overview and historical evolution of HCI, Ergonomics, Interaction styles, Elements of the WIMP (windows, icons, pointers, menus) interface, interactivity, the context of the interaction, paradigms for interaction, Cognitive walkthrough.	4	CO1
2.	**Design process:** Human interaction with computers, importance of human characteristics human consideration, Human interaction speeds, understanding business junctions. Screen Designing, Interaction Design, Interactive Design, Interface Design, GUI Design, Software Tools, Dialog Design.	8	CO2
3.	**Web Interfaces:** Designing Web Interfaces – Drag and Drop, Direct Selection, Contextual Tools, Overlays, Inlays and Virtual Pages, Process Flow	4	CO3
4.	**Interaction Styles:** Concept of combined reality, virtual reality, technologies, existing scientific and commercial projects. Sensing and tracking. Sensors for sensing of fingers, hands and touching. Interactive digital surfaces, manipulation of digital objects, displays with rear projection.	6	CO4
5.	**Usability Testing and Analytic Evaluation:** Involves usability testing through examples, the basics of experimental design, the methods used in usability testing, the role of field studies in evaluation, the important concepts associated with inspection methods, how heuristic evaluation can be adapted to evaluate different types of interactive products, what is involved in doing heuristic evaluation and various kinds of walkthrough, how to perform predictive technique, and when to use them, the advantages and disadvantages of using analytical evaluation.	8	CO5
6.	**Design Case Studies:** 1] Multikey press Hindi Text Input Method on a Mobile Phone, 2] GUI design for a mobile phone based Matrimonial application. 3] Employment Information System for unorganized construction workers on a Mobile Phone	6	CO6

Text Books	
1.	Interaction design: Beyond Human-Computer Interaction, 4/e by J. Preece, Y. Rogers and H. Sharp and Published by John Wiley and Sons
2.	Designing the User Interface, 5/e (Pub. Pearson) - Shneiderman B., Plaisant C., Coen M., Jacobs S
3.	Bill Scott and Theresa Neil, —Designing Web Interfaces, First Edition, O 'Reilly.
Reference Books	
1.	Human – Computer Interaction. Alan Dix, Janet Fincay, Gre Goryd, Abowd, Russell Bealg, Pearson Education.
2.	Interaction Design Prece, Rogers, Sharps. Wiley Dreamtech.
3.	User Interface Design, Soren Lauesen, Pearson Education.

Programme Name	M. Tech. Computer Engineering
Course Code	CONM5066T
Course Title	Machine Learning
Course Type	Open Elective

Prerequisites: Basic understanding of probability and statistics, linear algebra and calculus.

Course Outcomes: At the end of the course student will be able to:
CO1. . Gain knowledge about basic concepts of Machine Learning
CO2. Identify machine learning tools and techniques solving real time problems
CO3. Solve the problems using various machine learning techniques
CO4. Optimise and test the model for best performance.
CO5. Exploring the advances in machine learning future to solve real time case studies

	Course Contents	Hrs.	CO
1.	**Introduction:** Introduction and Basic Concepts of ML, Taxonomy of ML, Types of machine learning: Supervised Learning, Regression Vs Classification, Unsupervised Learning, Clustering, Classification, Rules mining, Prediction, Issues in machine learning.	6	CO1
2.	**Machine learning Tools:** R, Python, Scikit Learn, BigML , WEKA, or. any one platform to make machine learning in practice with case studies.Data and Data understanding, Data preprocessing. Learning Association Rules: Mining Frequent Patterns, Apriori algorithm, and other varients of Association rules mining algorithms.	8	CO2, CO3
3.	**Supervised Learning:** Decision Trees: ID3, Classification and Regression Trees, Regression. Neural Networks, Support vector machines, Generalized Linear Models (GLM), Probabilistic Learning: Bayesian Learning, Bayes Optimal Classifier, Naıve Bayes Classifier, Markov Decision Process (MDP). Ensemble Learning: Model Combination Schemes, Bagging: Random Forest Trees, Boosting: Adaboost, Stacking	08	CO1, CO3
4.	**Unsupervised learning:** Clustering, Instance-based learning, K-nearest Neighbour, Dimensionality Reduction, K-Mode Clustering, Expectation Maximization, Gaussian Mixture Models.	6	CO3

5.	**Balanced Machine Learning Model and Model Evaluation:** What Are Evaluation Metrics? Types of Predictive Models, Confusion Matrix, F-Score, Accuracy, Precision, Recall, Gain and Lift Charts , Kolmogorov-Smirnov Chart , Area Under the ROC Curve, Log Loss, Gini Coefficient, Concordant – Discordant Ratio, Root Mean Squared Error (RMSE), Root Mean Squared Logarithmic Error, R-Squared/Adjusted R-Squared, Cross Validation, Bias-Variance and Error Analysis, Bias/variance trade-off, Error Analysis, Normal Equations, Variance, Gradient Descent, Model Balancing: Overfitting, underfitting, Variance, Bias and Model Complexity in Machine Learning.	8	CO4
6.	**Introduction to Advanced topics in Machine Learning:** Deep Neural Networks, Vectorization, Backpropagation, Forward propagation, multi-label classification, Conditional Random Fields (CRFs), Reinforcement Learning, Spectral clustering-Semi-supervised learning. Deep Learning Models: Introduction to NN, important terms in NN, DNN, CNN, RNN, Model Training and testing, Pretrain models, parameter tuning and customized models, Deep learning in images processing, video processing, text processing.	6	CO5

Text Books	
1.	Ethem Alpaydin, "Introduction to Machine Learning", MIT Press, Prentice Hall of India, Third Edition, 2014.
2.	Miroslav Kubat, "An Introduction to Machine Learning", Springer, 2015.
Reference Books	
1.	Tom Mitchell, "Machine Learning", McGraw-Hill, 2017
2.	Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems", Third Edition, OReilly Publication, 2022
3.	John D. Kelleher, Deep Learning, The MIT Press Essential Knowledge series, 2019
4.	Jerome Friedman, Robert Tibshirani, Trevor Hastie, "The Elements of Statistical Learning" Springer, 2017.