SCHEME & SYLLABUS OF UNDERGRADUATE DEGREE COURSE

B. TECH.
INTERNET OF THINGS

III YEAR
(V & VI Semester)

Effective for the students admitted in year 2021-22 and onwards
Approved by ……. academic council meeting held on …….

Teaching & Examination Scheme
B. Tech. (Internet of Things)
3rd Year – V Semester
(Effective for the students admitted in year 2021-22 and onwards)

S. No.	Category	Course Code	Course Title	Hours			Exam Hours	Marks			Credit
				L	T	P		IA	ETE	Total	
	THEORY										
1	DC	5IO4-01	Operating Systems	3	-	-	3	30	70	100	**3**
2		5IO4-02	Computer Organization and Architecture	3	-	-	3	30	70	100	**3**
3		5IO4-03	Computer Networks	3	-	-	3	30	70	100	**3**
4		5IO4-04	RFID and Wireless Sensor Networks	3	-	-	3	30	70	100	**3**
5		5IO4-05	Privacy and Security in IoT	3	-	-	3	30	70	100	**3**
6	DE	5IO5-11	Smart Systems	2	-	-	3	30	70	100	**2**
		5IO5-12	Human Computer Interaction								
		5IO5-13	Distributed Systems								
7		5IO5-14	Information Theory & Coding	2	-	-	3	30	70	100	**2**
		5IO5-15	Information Security Systems								
		5IO5-16	Cloud Computing								
Sub Total				**19**	**00**	**00**	**-**	**210**	**490**	**700**	**19**
PRACTICAL & SESSIONAL											
8	DC	5IO4-21	Network Protocols Lab	-	-	2	-	60	40	100	**1**
9		5IO4-22	IoT Lab	-	-	2	-	60	40	100	**1**
10		5IO4-23	Mobile Application Development Lab	-	-	2	-	60	40	100	**1**
11	UI	5IO7-30	Industrial Training	-	-	1	-	60	40	100	**3**
12	CCA	5IO8-00	SODECA / Co-Curricular Activity	-	-	-	-	-	100	100	**1**
Sub Total				**00**	**00**	**07**	**-**	**240**	**260**	**500**	**7**
Total				**19**	**00**	**07**	**-**	**450**	**750**	**1200**	**26**

L = Lecture, **T** = Tutorial, **P** = Practical, **IA** = Internal Assessment, **ETE** = End Term Exam, **Cr** = Credits

Teaching & Examination Scheme
B. Tech. (Internet of Things)
3rd Year – VI Semester
(Effective for the students admitted in year 2021-22 and onwards)

S. No.	Category	Course Code	Course Title	Hours			Exam Hours	Marks			Credit
				L	T	P		IA	ETE	Total	
	THEORY										
1	DC	6IO4-01	Compiler Design	3	-	-	3	30	70	100	**3**
2		6IO4-02	Design and Analysis of Algorithms	3	-	-	3	30	70	100	**3**
3		6IO4-03	IoT Architecture and its Protocols	3	-	-	3	30	70	100	**3**
4		6IO4-04	Machine Learning	3	-	-	3	30	70	100	**3**
5		6IO4-05	Data Analytics and Applications	3	-	-	3	30	70	100	**3**
6	DE	6IO5-11	Computer Vision	2	-	-	3	30	70	100	**2**
		6IO5-12	Soft Computing and Evolutionary Algorithms								
		6IO5-13	Introduction to Blockchain								
Sub Total				**17**	**00**	**00**		**180**	**420**	**600**	**17**
	PRACTICAL & SESSIONAL										
7	DC	6IO4-21	Compiler Design Lab	-	-	2	-	60	40	100	**1**
8		6IO4-22	Advanced IoT Lab	-	-	2	-	60	40	100	**1**
9		6IO4-23	Design and Analysis of Algorithms Lab	-	-	2	-	60	40	100	**1**
10	UI	6IO7-50	Innovation and Design Thinking Hands-on Project	-	-	3	-	60	40	100	**2**
11	CCA	6IO8-00	SODECA / Co-Curricular Activity	-	-	-	-	-	100	100	**2**
Sub Total				**00**	**00**	**09**	**-**	**240**	**260**	**500**	**7**
Total				**17**	**00**	**09**	**-**	**420**	**680**	**1100**	**24**

L = Lecture, **T** = Tutorial, **P** = Practical, **IA**=Internal Assessment**, ETE**=End Term Exam, **Cr**=Credits

V Semester
B. Tech. (Internet of Things)
5IO4-01: Operating Systems

Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives: As a result of successfully completing this course, students will:

- Learn about how Operating System is Important for Computer System.
- Learn about different types of Operating Systems and their services.
- Learn different process scheduling algorithms and synchronization techniques to achieve better performance of a computer system.
- Learn about device and device management.
- Learn about the concept of memory management and virtual memory.
- Learn about the concept of file system.

Course Outcomes: Upon successful completion of the course the students will be able to

CO-1: Analyze basic concepts of operating systems and their structures.
CO-2: Analyze various issues related to inter-process communication like process synchronization and critical section.
CO-3: Synthesize the concepts of I/O management, file system implementation, scheduling, resource management and deadlocks.
CO-4: Interpret the issues and challenges of memory management.
CO-5: Understand protection and security issues related to the operating system.

S. No.	Contents	Hours
1	**Introduction to OS and Process Management:** Introduction to operating systems, operating system structure, system calls, Process concept, Operations on processes, cooperating processes, inter process communication, mutual exclusion, critical section problem, Synchronization hardware, wait and signal procedures, Semaphores, Classic problems of synchronization, critical regions, Monitors, process scheduling and algorithms, threads, multithreading. **CPU Scheduling**: Scheduling criteria, Scheduling algorithms, Multiple processor scheduling, Real time scheduling	**9**
2	**Memory Management:** Background, Swapping, Contiguous memory allocation, Paging, Segmentation, Segmentation with paging. Virtual Memory, Demand paging, Page replacement policies, Allocation of frames, Thrashing, case study.	**8**
3	**Deadlock and Device Management:** ***Deadlock:*** System model, Deadlock characterization, Methods for handling deadlocks, Deadlock prevention, Deadlock avoidance, Deadlock detection, Recovery from deadlock. ***Device management***: devices and their characteristics, device drivers, device handling, disk scheduling algorithms, Swap space management.	**9**
4	**File Systems and Its Implementation**: File System Interface, File concepts, Access methods, Directory structure, File system mounting, Directory implementation, Allocation methods, Free space management – efficiency and performance, recovery, log structured file systems	**7**
5	**Protection and Case Studies:** ***Protection***: Goals of protection, Principles of protection, Domain of protection, Access matrix, Implementation of access matrix, Access control, Revocation of access rights, file	**7**

	security, user authentication ***Case Study***: Linux Operating System Linux history; Design principles; Kernel modules; Process management; Scheduling; Memory management; File systems, Input and output; Inter-process communication, Case studies of Real Time and Mobile OS.	
Total		**40**

Suggested Books:

1. Silberschatz, Galvin, and Gagne, "Operating System Concepts", Wiley India Pvt Ltd.
2. Modern Operating Systems, Andrew S. Tanenbaum, Herbert Bos, Pearson Education India; Fourth edition 2016. ISBN-13:978- 9332575776
3. Operating Systems: Internals and Design Principles William Stallings, Pearson Education India; 7 edition (2013). ISBN-13: 978-9332518803
4. Gary Nutt, "Operating Systems", Third Edition, Pearson Education
5. Operating Systems: A Design-Oriented Approach, Charles Crowley, International edition, McGraw-Hill Education (ISE Editions). ISBN-13 978 0071144629

V Semester B. Tech. (Internet of Things)	
5IO4-02: Computer Organization and Architecture	
Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:

As a result of successfully completing this course, students will:

- Learn the principles of computer organization and basic architectural concepts.
- Understand the basics of instructions sets and their impact on processor design.
- Demonstrate an understanding of the design of the functional units of a digital computer system.
- Evaluate cost performance and design trade-offs in designing and constructing a computer processor including memory.
- Design a pipeline for consistent execution of instructions with minimum hazards.
- Recognize and manipulate representations of numbers stored in digital computers.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Study of the basic structure and operation of a digital computer system.

CO-2: Analysis of the design of arithmetic & logic unit and understanding of the fixed point and floating point arithmetic operations.

CO-3: Implementation of control unit techniques and the concept of Pipelining.

CO-4: Understanding the hierarchical memory system, cache memories and virtual memory.

CO-5: Understanding the different ways of communicating with I/O devices and standard I/O interfaces.

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	**Register Transfer and Micro-operations**: Register Transfer Language (RTL), Bus and Memory Transfers, Arithmetic Micro-Operations, Logic Micro-Operations, Shift Micro-Operations, Arithmetic Logic Shift Unit (ALU).	**9**
3	**Basic Computer Organization and Design**: Instruction Codes, Computer Registers, Computer Instructions, Timing and Control, Instruction Cycle, Register-Reference and Memory- Reference Instructions, Input-Output and Interrupt, Design of Basic Computer.	**8**
4	**Central Processing Unit:** General Register Organization, Stack Organization, Instruction Format, Addressing Modes, Data Transfer and Manipulation, Program Control, Reduced Instruction Set Computer (RISC) and Complex Instruction Set Computer (CISC).	**8**
5	**Pipeline and Vector Processing**: Flynn's Taxonomy, Parallel Processing, Pipelining, Arithmetic Pipeline, Instruction Pipeline. **Computer Arithmetic**: Signed Magnitude Binary Numbers - Addition and Subtraction, Multiplication- Booth Multiplication Algorithm, Array Multiplier, Division Algorithm.	**8**
6	**Input-Output Organization**: Input-output Interface Modes of Transfer, Daisy Chaining Priority, Direct Memory Access (DMA), Input-Output Processor (IOP)- CPU-IOP Communication. **Memory Organization**: Memory Hierarchy, Main Memory, Auxiliary Memory, Associative Memory, Cache Memory, Virtual Memory.	**8**
Total		**42**

Suggested Books:

1. M. Morris Mano, Computer System Architecture, Pearson
2. Carl Hamacher, Zvonko Vranesic, Safwat Zaky Computer Organization, McGraw-Hill, Fifth Edition, Reprint 2012
3. John P. Hayes, Computer Architecture and Organization, Tata McGraw Hill, Third Edition, 1998.

Reference books

4. William Stallings, Computer Organization and Architecture-Designing for Performance, Pearson Education, Seventh edition, 2006.
5. Behrooz Parahami, "Computer Architecture", Oxford University Press, Eighth Impression, 2011.
6. David A. Patterson and John L. Hennessy, "Computer Architecture-A Quantitative Approach", Elsevier, a division of reed India Private Limited, Fifth edition, 2012
7. Structured Computer Organization, Tannenbaum(PHI)

V Semester B. Tech. (Internet of Things)	
5IO4-03: Computer Networks	
Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:

As a result of successfully completing this course, students will:

- Become familiar with layered communication architectures (OSI and TCP/IP models).
- Understand different services offered by various OSI and TCP/IP model layers.
- Understand the client/server model and key application layer protocols.
- Understand the concept of unreliable data transfer and its role in communication.
- Understand the concepts of reliable data transfer and how TCP implements these concepts.
- Know the principles of congestion control and trade-offs in fairness and efficiency.
- Understand the role and concept of routing in communication.
- Understand the basics of error detection, including parity, checksums, and CRC.
- Familiarize the student with current topics such as security, network management, sensor networks, and/or other topics.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Understand basic computer network technology.

CO-2: Understand OSI and TCP/IP reference model and working of each layer of these reference models.

CO-3: Obtain the skills of subnetting and routing mechanisms.

CO-4: Address design and implementation aspects of various essential network protocols and its integration into network-based applications.

S. No.	Contents	Hours
1	**Introduction:** history and development of computer networks, networks topologies. Layering and protocols. OSI and TCP/IP Protocol Stacks, Basics of packet, circuit and virtual circuit switching. **Physical Layer:** Guided Transmission media: twisted pairs, coaxial cable, fiber optics, Wireless transmission.	**6**
2	**Data link layer:** Design issues, framing, Error detection and correction. Elementary data link protocols: simplex protocol, A simplex stop and wait protocol for an error-free channel, A simplex stop and wait protocol for noisy channel. Sliding Window protocols: A one-bit sliding window protocol, A protocol using Go-Back-N, A protocol using Selective Repeat, Example data link protocols. Medium Access sub layer: The channel allocation problem, Multiple access protocols: ALOHA, Carrier sense multiple access protocols, collision free protocols. Wireless LANs, Data link layer switching, Ethernet bridging.	**8**
3	**Network Layer:** Design issues, Routing algorithms, shortest path routing, Flooding, Hierarchical routing, Broadcast, Multicast, distance vector routing, link state routing, Congestion Control Algorithms, Quality of Service, Internetworking, Fragmentation, The Network layer in the internet, IP addressing, IPv4, IPv6. CIDR, NAT, Basics of IP support protocols (ARP, DHCP, ICMP)	**8**
4	**Transport Layer:** Transport Services, Elements of Transport protocols, Connection management, Error and Flow Control, Congestion Control, TCP and UDP protocols, Sockets.	**7**

5	**Application Layer**: Domain name system, Electronic Mail; the World Wide Web, HTTP, FTP, Streaming audio and video.	**7**
6.	**Current Topics Related to Computer Network**: Basic overview of the role and working of topic such as Software-defined Networks, Wireless Sensor Networks and Internet of Things, Cyber-physical systems	**6**
Total		**42**

Suggested Books:

1. Computer Networks, Andrew S. Tanenbaum and David J Wetherall, 5th Edition. Pearson publication.
2. Computer Networking: A Top-Down Approach Featuring the Internet, James F Kurose and Keith W Ross. Pearson publication.
3. Computer Networking: A Top-Down Approach, Behrouz A. Forouzan, Firouz Mosharraf, TMH.
4. Data Communications and Networking – Behrouz A. Forouzan. 4th Edition TMH.
5. Computer Networks: A Systems Approach, 5th Ed., LL Peterson, BS Davie, Morgan-Kauffman, 2011.
6. Cryptography and Network Security, Principles and Practice, 5th Ed., W Stallings, Prentice-Hall, 2010
7. Internet of Things: A Hands-on Approach , by Arshdeep Bagha and Vijay Madisetti, Universities Press, 2015, ISBN: 9788173719547
8. Fundamentals of Cyber-Physical Systems - https://eprints.whiterose.ac.uk/173235/1/Chapter%201 .%20 Fundamentals%20of%20 Cyber-Physical %20Systems.pdf
9. Cyber-Physical Systems and Internet of Things - https://nvlpubs.nist.gov/nistpubs/SpecialPublications /NIST.SP.1900-202.pdf

V Semester B. Tech. (Internet of Things)	
5IO4-04: RFID and Wireless Sensor Networks	
Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- Learn and understand RFID Technology
- Learn and understand wireless sensor network

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Describe the overview of RFID and it's enabling technologies.

CO-2: Apply the concept of radio frequency and its application in RFID enabled technologies.

CO-3: Describe the overview of wireless sensor networks and it's enabling technologies.

CO-4: Apply various concepts for assignment of MAC addresses.

CO-5: Apply the design principles of WSN architectures and operating systems for simulating environment situations.

S. No.	Contents	Hours
1	Introduction of RFID, Automatic Identification Systems, A Comparison of Different ID Systems, Components of an RFID System, Differentiation Features of RFID Systems, Transponder Construction Formats, Frequency, Range and Coupling, Active and Passive Transponders, Information Processing in the Transponder , Selection Criteria for RFID Systems, Fundamental Operating Principles.	**8**
2	Frequency Ranges and Radio Licensing Regulations, Coding and Modulation, Data Integrity, Multi-Access Procedures – Anticollision, Security of RFID Systems, Attacks on RFID Systems.	**8**
3	Wireless Sensor Networks- Introduction, Challenges and Constraints, Applications, Node Architecture, Operating Systems, Physical Layer.	**7**
4	Medium Access Control: Characteristics of MAC Protocols in Sensor Networks, Contention Free MAC Protocols, Contention-Based MAC Protocols, Network Layer: Various Routing Protocols.	**9**
5	Security in WSN: Challenges of Security in Wireless Sensor Networks, Security Attacks in Sensor Networks, Protocols and Mechanisms for Security, IEEE 802.15.4 and ZigBee Security	**8**
	Total	**40**

Suggested Books:

1. Klaus Finkenzeller, RFID Handbook, WILEY & SONS
2. Fundamentals of Wireless Sensor Networks: theory and practice by Waltenegus Dargie, Christian Poellabauer
3. RFID and Sensor Networks Architecture, Protocols, Security and integration by Yan Zhang, Laurence T. Yang, Jining.
4. Ian F. Akyildiz, and Mehmet Can Vuran, Wireless Sensor Networks, 2010, Wiley, USA.
5. Wireless Sensor Networks Technology, protocols and applications by Kazem Sohraby, Daniel Minoli Taieb Znati, John Wiley & Sons, Inc Publication.

V Semester B. Tech. (Internet of Things)	
5IO4-05: Privacy and Security in IoT	
Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:

As a result of successfully completing this course, students will:

- Know about the security issues, threat and vulnerabilities in IoT system.
- Understand the way to secure the sensor network data.
- Understand cryptography and its implementation.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Ability to understand the Security requirements in IoT.

CO-2: Understand the cryptographic fundamentals for IoT

CO-3: Ability to understand the authentication credentials and access control.

CO-4: Understand the various types Trust models and Cloud Security.

S. No.	Contents	Hours
1	Introduction **to Securing the Internet of Things**: Security Requirements in IoT Architecture - Security in Enabling Technologies -Security Concerns in IoT Applications. Security Architecture in the Internet of Things -Security Requirements in IoT - Insufficient Authentication/Authorization – Insecure Access Control - Threats to Access Control, Privacy, and Availability - Attacks Specific to IoT. Vulnerabilities – Secrecy and Secret-Key Capacity - Authentication/Authorization for Smart Devices - Transport Encryption – Attack & Fault trees	**8**
2	**Cryptographic Fundamentals for IoT**: Cryptographic primitives and its role in IoT – Encryption and Decryption – Hashes –Digital Signatures – Random number generation – Cipher suites – key management fundamentals – cryptographic controls built into IoT messaging and communication protocols – IoT Node Authentication	**8**
3	**Identity & Access Management Solutions for IoT**: Identity lifecycle – authentication credentials – IoT IAM infrastructure – Authorization with Publish / Subscribe schemes – access control	**8**
4	**Privacy Preservation and Trust Models for IoT**: Concerns in data dissemination – Lightweight and robust schemes for Privacy protection – Trust and Trust models for IoT – self-organizing Things - Preventing unauthorized access	**8**
5	**Cloud Security for IoT**: Cloud services and IoT – offerings related to IoT from cloud service providers – Cloud IoT security controls – An enterprise IoT cloud security architecture – New directions in cloud enabled IoT computing	**8**
	Total	**40**

Suggested Books:

1. Practical Internet of Things Security (Kindle Edition) by Brian Russell, Drew Van Duren
2. Securing the Internet of Things Elsevier
3. Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations

V Semester B. Tech. (Internet of Things)	
5IO5-11: Smart Systems	
Credit: 2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:

As a result of successfully completing this course, students will:

- To introduce the fundamental concepts of MEMS based sensors and actuators.
- To acquaint the students with various materials and material properties for Microsystem designing.
- To provide comprehensive understanding of various micromachining techniques and expose the students to design, simulation and analysis software.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Identify and understand the fundamental concepts and background of MEMS and Microsystems.

CO-2: Familiar with the basics of various sensors and actuators.

CO-3: Recognize and interpret various micromachining techniques and design, analysis and applications of various MEMS devices micromachining tools and techniques

CO-4: Incorporate simulation and micro-fabrication knowledge for developing various MEMS devices.

S. No.	Contents	Hours
1	Introduction to Sensor Devices, Piezoresistive pressure sensor, Piezoresistive Accelerometer, Capacitive Sensing, Accelerometer and Microphone, Resonant Sensor and Vibratory Gyroscope, Low-Power, Low Voltage Sensors Micro Electro Mechanical Systems Analysis and Design of MEMS Devices- Nano Sensors.	**5**
2	Interfacing Sensor Information and MCU Amplification and Signal Conditioning, Integrated Signal Conditioning, Digital conversion, MCU Control MCUs for Sensor Interface, Techniques and System Consideration, Sensor Integration.	**6**
3	Control Techniques and Standards Control of Sensors using - State Machines, Fuzzy Logic, Neural Networks, Adaptive Control. Control Application using - CISC, RISC, DSP Control and IEEE 1451 Standards.	**6**
4	Communication For Smart Sensors Wireless Data Communications- RF Sensing, Telemetry, Automotive Protocols, Industrial Networks Home Automation, MCU Protocols.	**6**
5	Packaging, Testing and Reliability Implications of Smart Sensors Semiconductor Packaging- Hybrid Packaging- Packaging for Monolithic Sensors- Reliability Implications Testing Smart Sensors- HVAC Sensor Chip	**5**
	Total	**28**

Suggested Books:

1. G. K. Ananthasuresh, K J Vinoy, S Gopalakrishnan, KN Bhatt, V K Aatre," Micro and Smart Systems: Technology and Modeling ", 2012, 1st ed., Wiley, New York.
2. Tai-Ran Hsu, “MEMS & Microsystem, Design and Manufacture”, 2017, 1st ed., McGraw Hill India, New Delhi.
3. Wolfgang Menz, Jürgen Mohr, Oliver Paul, "Microsystem Technology", 2011, 2nd ed., Wiley, New York.
4. Banks H.T. Smith R.C. and Wang Y. Smart, ‘Material Structures – Modeling, Estimation and Control’, 2011, 1st ed., John Wiley & Sons, NewYork.
5. Artificial Intelligence: A Modern Approach by S. Russell and P. Norvig, Prentice Hall.

V Semester B. Tech. (Internet of Things)	
5IO5-12: Human Computer Interaction	
Credit: 2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- Historical Evaluation of Field, Interactive System Design
- Understand model based design case studies
- Empirical design and data analysis in HCI

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Understand Interactive system design, concept of usability, HCI and GUI

CO-2: Understand model based design and evaluation

CO-3: Understand various guidelines in HCI

CO-4: Analyze empirical research methods in HCI

CO-5: Understand task modeling and its analysis

S. No.	Contents	Hours
1	Introduction: Objective, scope and outcome of the course.	**1**
2	Historical evolution of the field, Interactive system design, Concept of usability -definition and elaboration, HCI and software Engineering, GUI design and Aesthetics, Prototyping techniques.	**2**
3	Model-based Design and evaluation: Basic idea, introduction to different types of models, GOMS family of models (KLM and CMNGOMS), Fitts' law and Hick-Hyman's law, Model-based design case studies	**3**
4	Guidelines in HCI: Shneiderman's eight, golden rules, Norman's seven principles, Norman's model of interaction, Nielsen's ten heuristics with example of its use Heuristic evaluation, Contextual inquiry, Cognitive walkthrough	**5**
5	Empirical research methods in HCI: Introduction (motivation, issues, research question formulation techniques), Experiment design and data analysis (with explanation of one-way ANOVA)	**6**
6	Task modelling and analysis: Hierarchical task analysis (HTA), Engineering task models and Concur Task Tree (CTT),Introduction to formalism in dialog design, design using FSM (finite state machines) State charts and (classical) Petri Nets in dialog design	**6**
7	Introduction to CA, CA types, relevance of CA in IS design Model Human Processor (MHP), OOP- Introduction OOM- Object Oriented Modeling of User Interface Design	**5**
Total		**28**

Suggested Books:

6. Human–Computer Interaction, Third Edition Alan Dix, Janet Finlay, Gregory D. Abowd, Pearson Education Limited

V Semester B. Tech. (Internet of Things)	
5IO5-13: Distributed Systems	
Credit: 2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:

As a result of successfully completing this course, students will:

- To Understand hardware and software issues in modern distributed systems.
- To get knowledge in distributed architecture, naming, synchronization, consistency and replication, fault tolerance, security, and distributed file systems.
- To analyze the current popular distributed systems such as peer-to-peer (P2P) systems will also be analyzed.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: To understand the foundations of distributed systems.

CO-2: To learn issues related to clock Synchronization and the need for global state in distributed systems.

CO-3: To learn distributed mutual exclusion and deadlock detection algorithms.

CO-4: To understand the significance of agreement, fault tolerance and recovery protocols in Distributed Systems.

CO-5: To learn the characteristics of peer-to-peer and distributed shared memory systems

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	**Distributed Systems:** Features of distributed systems, nodes of a distributed system, Distributed computation paradigms, Model of distributed systems, Types of Operating systems: Centralized Operating System, Network Operating Systems, Distributed Operating Systems and Cooperative Autonomous Systems, design issues in distributed operating systems. Systems Concepts and Architectures: Goals, Transparency, Services, Architecture Models, Distributed Computing Environment (DCE).	**5**
3	**Theoretical issues in distributed systems:** Notions of time and state, states and events in a distributed system, time, clocks and event precedence, recording the state of distributed systems. **Concurrent Processes and Programming:** Processes and Threads, Graph Models for Process Representation, Client/Server Model, Time Services, Language Mechanisms for Synchronization.	**5**
4	**Distributed Process Scheduling:** A System Performance Model, Static Process Scheduling with Communication, Dynamic Load Sharing and Balancing, Distributed Process Implementation. Distributed File Systems: Transparencies and Characteristics of DFS, DFS Design and implementation, Transaction Service and Concurrency Control	**5**
5	**Distributed Shared Memory**: Non-Uniform Memory Access Architectures, Memory Consistency Models, Multiprocessor Cache Systems, Distributed Shared Memory, Implementation of DSM systems.	**6**
6	**Distributed Agreement:** Concept of Faults, failure and recovery, Replicated Data Management: concepts and issues, Database Techniques, Atomic Multicast, and Update	**6**

	Propagation. CORBA case study: Introduction, Architecture, CORBA RMI, CORBA Services.	
Total		**28**

Suggested Books:

1. Distributed Systems, Principles and Paradigms, 2nd edition by Andrew S. Tanenbaum and Maarteen Van Steen, Pearson Education, (ISBN-13: 978- 0132392273), 2013 IT-89
2. Distributed System: Concepts and Design, 5th edition by Coulouris, Dollimore, Kindberg,Pearson Ed, (ISBN-13: 978-0132143011), 2013
3. Distributed Algorithms: Principles, Algorithms, and Systems by A. D. Kshemkalyani and M. Singhal, (ISBN-13: 978-0521189842) , 2013

V Semester B. Tech. (Internet of Things)	
5IO5-14: Information Theory & Coding	
Credit: 2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives: As a result of successfully completing this course, students will:

- To understand information theoretic behavior of a communication system.
- To understand various source coding techniques for data compression.
- To understand various channel coding techniques and their capability.
- To Build and understanding of fundamental concepts of data communication and networking

Course Outcomes: Upon successful completion of the course, students will be able to

CO-1: Perform information theoretic analysis of communication system.

CO-2: Design a data compression scheme using suitable source coding technique.

CO-3: Design a channel coding scheme for a communication system.

CO-4: Understand and apply fundamental principles of data communication and networking.

CO-5: Apply flow and error control techniques in communication networks.

S. No.	Contents	Hours
1	Introduction: Objective, scope and outcome of the course	**1**
2	Introduction to information theory Uncertainty, Information and Entropy, Information measures for continuous random variables, source coding theorem. Discrete Memory less channels, Mutual information, Conditional entropy.	**5**
3	Source coding schemes for data compaction Prefix code, Huffman code, Shanon-Fane code &Hempel-Ziv coding channel capacity. Channel coding theorem. Shannon limit.	**5**
4	Linear Block Code Introduction to error connecting codes, coding & decoding of linear block code, minimum distance consideration, conversion of non-systematic form of matrices into systematic form.	**5**
5	Cyclic Code Code Algebra, Basic properties of Galois fields (GF) polynomial operations over Galois fields, generating cyclic code by generating polynomial, parity check polynomial. Encoder & decoder for cyclic codes.	**6**
6	Convolutional Code Convolutional encoders of different rates. Code Tree, Trllis and state diagram. Maximum likelihood decoding of convolutional code: The viterbi Algorithm fee distance of a convolutional code	**6**
	Total	**28**

Suggested Books:

1. J. A. Thomas and T. M. Cover: Elements of information theory, Wiley, 2006.
2. J. H. van Lint: Introduction to Coding Theory, Third Edition, Springer, 1998.
3. F. J. MacWilliams and N.J. Sloane: Theory of Error Correcting Codes, Parts I and II, North-Holland, Amsterdam, 1977.
4. D. Stinson: Combinatorial Designs: Constructions and Analysis, Springer, 2003
5. P. J. Cameron and J. H. van Lint: Designs, Graphs, Codes and their Links, Cambridge Univ.Press, 2010.
6. C. Fragouli and E. Soljanin: Network Coding Fundamentals, Now Publisher, 2007.
7. M. Medard and A. Sprintson, (editors): Network Coding – Fundamentals and Applications, Acadamic Press, 2012.
8. C. Fragouli, J. Le Boudec, J. Widmer: Network coding: An instant primer

V Semester B. Tech. (Internet of Things)	
5IO5-15: Information Security Systems	
Credit: 2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:

As a result of successfully completing this course, students will:

- Understand security attacks in a digital system.
- Understand basic concept of cryptography
- Understand how to protect information.
- Use theoretical and practical knowledge in securing data transfer and authentication.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Identify the security attacks and type of malicious programs

CO-2: Analyze the vulnerabilities in any computing system and hence be able to design a security solution.

CO-3: Evaluate security mechanisms using cryptography methods.

CO-4: To understand various network security applications, IPSec, Firewall, IDS, Web Security, Email Security and Malicious software

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	**Security Attacks,** Security Services, Security Mechanisms and Principles, Security goals, Malicious software, Worms, Viruses, Trojans, Spyware, Botnets, Classical encryption techniques- substitution ciphers and transposition ciphers, cryptanalysis, stream and block ciphers.	**7**
3	**Basic of Cryptography:** Symmetric and asymmetric cryptography, Data Encryption standard (DES) with example, strength of DES, Design principles of block cipher, AES with structure, its transformation functions, key expansion, example and implementation. RSA cryptosystem,	**7**
4	**Internet Security:** TCP/IP Security, Secure Sockets Layer (SSL), Transport Layer Security (TLS), HTTPS, Secure Shell (SSH), IPsec, Email Security, DNS Security, Authentication Protocols	**7**
5	**Web Security:** Phishing attack, SQL Injection, Securing databases and database access, Cross Site Scripting Attacks, Cookies, Session Hijacking, E-commerce security **System Security:** Firewalls, Types: Packet filter (stateless, stateful), Application layer proxies, Firewall Location and Configurations, Intruders, Intrusion Detection System.	**6**
	Total	**28**

Suggested Books:

1. Cryptography and Network Security - Principles and Practice: William Stallings, Pearson Education, 6th Edition
2. Cryptography and Network Security: Atul Kahate, Mc Graw Hill, 3rd Edition
3. Network Security and Cryptography: Bernard Menezes, CENGAGE Learning.
4. Cryptography and Network Security: Forouzan Mukhopadhyay, Mc Graw Hill, 3rd Edition.
5. Principles of Computer Security: WM. Arthur Conklin, Greg White, TMH.

V Semester B. Tech. (Internet of Things)	
5IO5-16: Cloud Computing	
Credit: 2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:

As a result of successfully completing this course, students will:

- The fundamental ideas behind Cloud Computing, the evolution of the paradigm, its applicability; benefits
- The basic ideas and principles in data center design; cloud management techniques and cloud software deployment considerations;
- Different CPU, memory and I/O virtualization techniques in cloud

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Explain the core concepts of the cloud computing paradigm

CO-2: Discuss system, network and storage virtualization and outline their role in enabling the cloud computing system model.

CO-3: Understanding security architecture of cloud infrastructure

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	**Cloud Computing:** Nutshell of cloud computing, Enabling Technology, Historical development, Vision, feature Characteristics and components of Cloud Computing. Challenges, Risks and Approaches of Migration into Cloud. Ethical Issue in Cloud Computing, Evaluating the Cloud's Business Impact and economics, Future of the cloud. Networking Support for Cloud Computing.	**5**
3	**Cloud Computing Architecture:** Cloud Reference Model, Layer and Types of Clouds, Services models, Data centre Design and interconnection Network, Architectural design of Compute and Storage Clouds. Cloud Programming and Software: Fractures of cloud programming, Parallel and distributed programming paradigms-Map Reduce, Hadoop, High level Language for Cloud. Programming of Google App engine	**6**
4	**Virtualization Technology:** Definition, Understanding and Benefits of Virtualization. Implementation Level of Virtualization, Virtualization Structure/Tools and Mechanisms, Hypervisor VMware, KVM, Xen. Virtualization of CPU, Memory, I/O Devices, Virtual Cluster and Resources Management, Virtualization of Server, Desktop, Network, and Virtualization of data-centre	**5**
5	**Securing the Cloud:** Cloud Information security fundamentals, Cloud security services, Design principles, Policy Implementation, Cloud Computing Security Challenges, Cloud Computing Security Architecture . Legal issues in cloud Computing.	**5**
6	**Data Security in Cloud:** Business Continuity and Disaster Recovery , Risk Mitigation , Understanding and Identification of Threats in Cloud, SLA-Service Level Agreements, Trust Management	**6**
	Total	**28**

Suggested Books:

1. Rajkumar Buyya, James Broberg, Andrzej M. Goscinski: "Cloud Computing: Principles and Paradigms", Wiley, 2011
2. Rajkumar Buyya, Christian Vecchiola, S Thamarai Selvi, Mastering Cloud Computing, Tata McGraw

Hill, 2013
3. Barrie Sosinsky: "Cloud Computing Bible", Wiley-India, 2010
4. Ronald L. Krutz, Russell Dean Vines: "Cloud Security: A Comprehensive Guide to Secure Cloud Computing", Wiley-India, 2010
5. Tim Mather, Subra Kumara swamy, Shahed Latif, Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance, O'Reilly Media, 2009.

V Semester B. Tech. (Internet of Things)	
5IO4-21: Network Protocols Lab	
Credit: 1	**Max. Marks: 100 (IA:60, ETE:40)**
0L+0T+ 2P	**End Term Exams: 2 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- Able to understand basic working principle of UDP Network Protocol.
- Able to understand basic working principle of TCP Network Protocol.
- Able to install various Network simulation and perform Network Simulation.

Course Outcomes:
Upon successful completion of the course, students will be able to

CO-1: Simulate different network topologies.
CO-2: Implement various framing methods of Data Link Layer.
CO-3: Implement various Error and flow control techniques.
CO-4: Implement network routing and addressing techniques.
CO-5: Implement transport and security mechanisms

List of Experiments

1. Implementation of Stop and Wait Protocol and Sliding Window Protocol.
2. Study of Socket Programming and Client – Server model
3. Write a code simulating ARP /RARP protocols.
4. Write a code simulating PING and TRACEROUTE commands
5. Create a socket for HTTP for web page upload and download.
6. Write a program to implement RPC (Remote Procedure Call)
7. Implementation of Subnetting.
8. Applications using TCP Sockets like ***a. Echo client and echo server b. Chat c. File Transfer***
9. Applications using TCP and UDP Sockets like ***d. DNS e. SNMP f. File Transfer***
10. Study of Network simulator (NS).and Simulation of Congestion Control Algorithms using NS
11. Perform a case study about the different routing algorithms to select the network path with its optimum and economical during data transfer. i. Link State routing ii. Flooding iii. Distance vector
12. To learn handling and configuration of networking hardware like RJ-45 connector, CAT-6 cable, crimping tool, etc.
13. Configuration of router, hub, switch etc. (using real devices or simulators)
14. Running and using services/commands like ping, traceroute, nslookup, arp, telnet, ftp, etc.
15. Network packet analysis using tools like Wireshark, tcpdump, etc.
16. Network simulation using tools like Cisco Packet Tracer, NetSim, OMNeT++, NS2, NS3, etc.
17. Socket programming using UDP and TCP (e.g., simple DNS, data & time client/server, echo client/server, iterative & concurrent servers)

Note: The Instructor may add/delete/modify/tune experiments, wherever he/she feels in a justified manner It is also suggested that open source tools should be preferred to conduct the lab (C , C++ , Java , NS3, Mininet, Opnet, TCP Dump, Wireshark etc.

V Semester B. Tech. (Internet of Things)	
5IO4-22: IoT Lab	
Credit: 1	**Max. Marks: 100 (IA:60, ETE:40)**
0L+0T+ 2P	**End Term Exams: 2 Hours**

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Understand the concept of Internet of Things

CO-2: Implement interfacing of various sensors with Arduino/Raspberry Pi

CO-3: Demonstrate the ability to transmit data wirelessly between different devices.

CO-4: Show an ability to upload/download sensor data on cloud and server

CO-5: Examine various SQL queries from MySQL database

List of Experiments

The student should have hands on experience in using various sensors like temperature, humidity, smoke, light, etc. and should be able to use control web camera, network, and relays connected to the Pi.

1. Start Raspberry Pi and try various Linix commands in command terminal window: ls, cd, touch, mv, rm, man, mkdir, rmdir, tar, gzip, cat, more, less, ps, sudo, cron, chown, chgrp, ping etc.
2. Run some python programs on Pi like: a) Read your name and print Hello message with name b) Read two numbers and print their sum, difference, product and division. c) Word and character count of a given string. d) Area of a given shape (rectangle, triangle and circle) reading shape and appropriate values from standard input.
3. Run some python programs on Pi like: a) Print a name 'n' times, where name and n are read from standard input, using for and while loops. b) Handle Divided by Zero Exception. c) Print current time for 10 times with an interval of 10 seconds. d) Read a file line by line and print the word count of each line.
4. a) Light an LED through Python program b) Get input from two switches and switch on corresponding LEDs c) Flash an LED at a given on time and off time cycle, where the two times are taken from a file.
5. a) Flash an LED based on cron output (acts as an alarm) b) Switch on a relay at a given time using cron, where the relay's contact terminals are connected to a load. c) Get the status of a bulb at a remote place (on the LAN) through web.

V Semester B. Tech. (Internet of Things)	
5IO4-23: Mobile Application Development Lab	
Credit: 1	**Max. Marks: 100 (IA:60, ETE:40)**
0L+0T+ 2P	**End Term Exams: 2 Hours**

Course Objectives:

As a result of successfully completing this course, students will:

- To introduce the concepts of app development and basic concepts like activity, intents, broadcasts, to be used in app development.
- To familiarize students with GUI widgets and their usage
- To develop ability to design Android applications

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: To be able to install IDE, SDK, NDK required for development of Apps

CO-2: To be able to design basic GUI based applications

CO-3: To be able to design applications interacting with database

CO-4: To be able to learn communication between applications

S. No.	List of Experiments
1	To study Android Studio and android studio installation. Create "Hello World" application.
2	Design an application to display IMEI, IMSI, Location, Version, and other basic information of device
3	To understand Activity, Intent, Create sample application with login module.(Check username and password).
4	Design simple GUI application with activity and intents e.g. calculator.
5	Write an application that draws basic graphical primitives on the screen
6	Create an android app for database creation using SQLite Database
7	Develop a application that takes phone number and message as input from user and send the message to given number
8	Design simple GUI application to display all sensors available in device
9	Implement an menu driven application that writes data to the SD card file and read data from sdcard file.
10	Design a location tracking application using GPS

VI Semester B. Tech. (Internet of Things)	
6IO4-01: Compiler Design	
Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:

As a result of successfully completing this course, students will:

- Familiar with basic ideas and the working of the compiler.
- Learn about syntax analysis.
- Learn about representation in the form of DAG.
- Learn about theory knowledge of Parsing, Code generation, and optimization.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Acquire knowledge of different phases and passes of the compiler and use compiler tools like LEX and YACC.

CO-2: Understand the Top-Down and Bottom-up parsers and construction of LL, SLR, CLR, and LALR parsing tables.

CO-3: Acquire knowledge about runtime data structure, like symbol table organization and different techniques.

CO-4: Understand the target machine's run time environment, its instruction set for code generation, and techniques for code optimization.

S. No.	Contents	Hours
1	**Introduction:** Objective, scope, and outcome of the course. Compiler, Translator, Interpreter definition, Phase of compiler, Bootstrapping, Review of Finite automata lexical analyzer, Input, Recognition of tokens, Idea about LEX: A lexical analyzer generator, Error handling.	**6**
2	**Review of CFG Ambiguity of grammars:** Introduction to parsing. Top-down parsing, LL grammars & passers error handling of LL parser, Recursive descent parsing predictive parsers, Bottom-up parsing, Shift reduce parsing, LR parsers, Construction of SLR, Conical LR & LALR parsing tables, parsing with ambiguous grammar. Operator precedence parsing, Introduction of automatic parser generator: YACC error handling in LR parsers.	**10**
3	**Syntax-directed translation:** Construction of syntax trees, S-Attributed Definition, L-attributed definitions, Top-down translation. Intermediate code forms using postfix notation, DAG, Three address code, TAC for various control structures, Representing TAC using triples and quadruples, Boolean expression, and control structures.	**10**
4	**Runtime environments:** Storage allocation, Strategies, heap management, Activation records, Accessing local and non-local names in a block structured language, Parameters passing, Symbol table organization, Data structures used in symbol tables.	**8**
5	**Definition of basic block control flow graphs:** DAG representation of basic block, Advantages of DAG, Sources of optimization, Loop optimization, Loop invariant computation, Peephole optimization, Issues in the design of code generator, A simple code generator, Code generation from DAG. Machine Independent Optimization: Idea about global data flow analysis, constant propagation, liveness analysis, and common subexpression elimination.	**6**
Total		**40**

Suggested Books:

1. Compilers: Principles, Techniques, and Tools, Second Edition, Alfred Aho, Monica Lam, Ravi Sethi, Jeffrey D. Ullman, January 2013. ISBN-978-9332518667.
2. Modern Compiler Implementation in Java. Andrew W Appel, Jens Paisberg. Cambridge University Press, January 2002. ISBN-978-0521820608
3. Modern Compiler Implementation in ML, Andrew W Appel, Cambridge University Press, December 1997. ISBN-0 521 58274 1
4. Modern Compiler Implementation in C, Andrew W Appel, Cambridge University Press, December 1997. ISBN 0-521-60765-5
5. Compiler Construction: Principles and Practice, 1st Edition, Kenneth C. Louden, Cengage Learning; 1 edition (January 24, 1997), ISBN-13: 978-0534939724
6. V Raghvan, " Principles of Compiler Design," McGraw-Hill, ISBN:9780070144712

VI Semester
B. Tech. (Internet of Things)

6IO4-02: Design and Analysis of Algorithms

Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- Able to analyze asymptotic runtime complexity of algorithms including formulating recurrence relations.
- Able to understand and design algorithms using greedy strategy, divide and conquer approach, dynamic programming.
- Demonstrate a familiarity with major algorithms and data structures and Synthesize efficient algorithms in common engineering design situations

Course Outcomes:
Upon successful completion of the course the students will be able to
CO-1: The ability of how to design an algorithm which solves the current problem in hand.
CO-2: To Write efficient algorithms for given problems.
CO-3: To focus on Deriving the complexities of any given algorithm.
CO-4: Learning the programming of various algorithms through assignments

S. No.	Contents	Hours
1	**Introduction**: Concept of algorithmic efficiency, run time analysis of algorithms, Asymptotic Notations. Growth of Functions, Master's Theorem,	**5**
2	**Searching and Sorting:** Structure of divide-and-conquer algorithms; examples: binary search, quick sort, Strassen Matrix Multiplication; merge sort, heap sort and Analysis of divide and conquer run time, recurrence relations.	**7**
3	**Greedy Method:** Overview of the greedy paradigm examples of exact optimization solution: minimum cost spanning tree, approximate solutions: Knapsack problem, Kruskal's algorithm and Prim's algorithm for finding Minimum cost Spanning Trees, Dijkstra's and Bellman Ford Algorithm for finding Single source shortest paths, Huffman coding, Activity Selection Problem.	**8**
4	**Dynamic programming:** Principles of dynamic programming. Applications: Rod cutting problem, Floyd-Warshall algorithm for all pair shortest paths. Matrix multiplication, travelling salesman Problem, Longest Common sequence, Back tracking: Overview, 8-queen problem, and Knapsack problem, Traveling Salesman problem.	**7**
5	**Branch and bound:** LC searching Bounding, FIFO branch and bound, LC branch and bound application: 0/1 Knapsack problem	**6**
6	**Computational Complexity:** Polynomial Vs non-polynomial time complexity; NP-hard and NP-complete classes, examples: Circuit Satisfiablity, Vertex cover, Subset Sum problem, Randomized Algorithms, String Matching, NP-Hard and NP Completeness, Introduction to Approximation Algorithms,	**7**
	Total	**40**

Suggested Books:

1. T .H .Cormen, C .E .Leiserson, R .L . Rivest "Introduction to Algorithms", 3rd Ed.,PHI, 2011 (reprint)
2. E. Horowitz, S. Sahni, and S. Rajsekaran, "Fundamentals of Computer Algorithms,"Galgotia Publication
3. Sara Basse, A. V. Gelder, " Computer Algorithms," Addison Wesley
4. Aho ,Ullman "Principles of Algorithms "
5. S.K Basu- Design Methods and Analysis of Algorithms, 2nd Ed., PHI

VI Semester B. Tech. (Internet of Things)	
6IO4-03: IoT Architecture and its Protocols	
Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:

To introduce to the student the popular IoT reference models.

- To acquaint the student with the challenges in and solutions for IoT network access.
- To enable the student to examine the feasibility of IP for IoT, leading to a study of optimization of IP for IoT.
- To expose the student to the popular application protocols for IoT with application development in view.
- To familiarize the student with the basics of data and analytics for IoT.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Distinguish between different IoT network architectures.

CO-2: Experiment with various access technologies for IoT.

CO-3: Analyze the difference between protocol design at the network, transport and application layers for IoT and that for the Internet.

CO-4: Select the appropriate IoT protocol at the network and application layers for a given application.

CO-5: Build end-to-end IoT applications that may include IoT data analysis.

S. No.	Contents	Hours
1	Introduction to IoT, IoT Network Architecture Architectures: What is IoT?: Genesis of IoT, IoT and digitization, IoT impact, IoT challenges. IoT Network Architecture and Design: Drivers behind new network architectures, Comparing IoT architectures, A simplified IoT architecture. OneM2M and IoTWF architectures.	**7**
2	Smart Objects and Connecting Smart Objects: Smart Objects: The things in IoT: Sensors, actuators and smart objects, Sensor networks. Connecting Smart Objects: Communications Criteria, IEEE 802.15.4 - Standardization and Alliances, Physical Layer, MAC Layer, Topology, Security. IEEE 802.15.4g and 802.15.4e - Topology, IEEE 1901.2a - Topology, IEEE 802.11ah - Topology. LoRAWAN - Topology. NB-IoT and other LTE variations.	**8**
3	IP as the IoT Network Layer: The business case for IP: The key advantages of IP, Adoption or Adaptation of IP. The need for optimization: Constrained nodes, Constrained Networks, IP versions. Optimizing IP for IoT: From 6LoWPAN to 6Lo, Header compression, Fragmentation, Mesh addressing, Mesh-under vs Mesh-over routing. 6TiSCH RPL: Objective Function, Rank, RPL Headers, Metrics,	**8**
4	The Transport Layer IoT Application Transport Methods: Application layer protocol not present, SCADA, Adapting SCADA for IP, Tunneling legacy SCADA over IP networks. Generic Web-based protocols. IoT Application Layer Protocols, CoAP, MQTT.	**8**
5	An introduction to data analytics for IoT: Structured vs Unstructured Data, Data in motion vs data at rest, IoT data analytics overview, IoT data analytics challenges. Machine Learning: Machine Learning overview, Supervised Learning, Unsupervised learning, Neural Networks, Machine Learning and getting intelligence from Big Data. Predictive analytics. Big data analytics tools and technology: Massively parallel processing databases, NoSQL databases, HADOOP. Edge streaming analytics: Comparing Big Data and Edge Analytics, Edge	**9**

	Analytics Core Functions, Distributed Analytics Systems.	
	Total	**40**

Suggested Books:

1. IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry, Cisco Press, 2017
2. Hersent, Olivier, David Boswarthick, and Omar Elloumi. The internet of things: Key applications and protocols. John Wiley & Sons, 2011.
3. Buyya, Rajkumar, and Amir Vahid Dastjerdi, eds. Internet of Things: Principles and paradigms. Elsevier, 2016.
4. RPL: IPv6 routing protocol for low-power and lossy networks. (Accessed on 20/11/2019). [Online] Available: https://tools.ietf.org/html/rfc6550.
5. https://www.ietf.org/proceedings/94/slides/slides-94-rtgarea-2.pdf
6. https://www.thethingsnetwork.org/docs/lorawan/architecture/

VI Semester B. Tech. (Internet of Things)	
6IO4-04: Machine Learning	
Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:

As a result of successfully completing this course, students will:

- To develop a foundation in machine learning techniques.
- To learn basic concepts and process for machine learning.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Understand the important steps of machine learning algorithms and related concepts.

CO-2: Explain various Machine learning algorithms and their concepts.

CO-3: Apply various machine learning algorithms on a given data set.

CO-4: Compare variants of machine learning algorithms on the basis of their merits, demerits, performance

CO-5: Understand the concept of Reinforcement learning and Recommended system

S. No.	Contents	Hours
1	Introduction: Objective, scope and outcome of the course.	**1**
2	**Supervised learning algorithm:** Introduction, types of learning, application, Supervised learning: Linear Regression Model, Naive Bayes classifier Decision Tree, K nearest neighbor, Logistic Regression, Support Vector Machine, Random forest algorithm	**9**
3	**Unsupervised learning algorithm:** Grouping unlabeled items using k-means clustering, Hierarchical Clustering, Probabilistic clustering, Association rule mining, Apriori Algorithm, f-p growth algorithm, Gaussian mixture model.	**8**
4	**Introduction to Statistical Learning Theory:** Feature extraction - Principal component analysis, Singular value decomposition. Feature selection – feature ranking and subset selection, filter, wrapper and embedded methods, Evaluating Machine Learning algorithms and Model Selection.	**8**
5	**Semi supervised learning, Reinforcement learning:** Markov decision process (MDP), Bellman equations, policy evaluation using Monte Carlo, Policy iteration and Value iteration, Q-Learning, StateAction-Reward-State-Action (SARSA), Model-based Reinforcement Learning.	**8**
6	**Recommended system:** Collaborative filtering, Content-based filtering Artificial neural network, Perceptron, Multilayer network, Backpropagation, Introduction to Deep learning.	**8**
Total		**42**

Suggested Books:

1. Mitchell M., T., Machine Learning, McGraw Hill (1997) 1stEdition.
2. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012
3. Ethem Alpaydin, Introduction to Machine Learning, MIT Press, 2004
4. Tom Mitchell, Machine Learning, McGraw Hill, 1997.
5. Pat Langley , Elements of Machine Learning, Morgan Kaufmann Publishers, Inc. 1995
6. Bishop M., C., Pattern Recognition and Machine Learning, Springer-Verlag (2011) 2ndEdition.
7. Michie D., Spiegelhalter J. D., Taylor C. C., Campbell, J., Machine Learning, Neural and Statistical Classification. Overseas Press (1994).

VI Semester
B. Tech. (Internet of Things)

6IO4-05: Data Analytics and Applications

Credit: 3	**Max. Marks: 100 (IA:30, ETE:70)**
3L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- To understand EDA, inference and regression techniques.
- Apply Matrix decomposition techniques to perform data analysis.
- Understand concepts and importance of data pre-processing techniques.
- Importance and application of Machine Learning Algorithms.
- Knowledge of acquiring data through web-scraping and data APIs

Course Outcomes:
Upon successful completion of the course, students will be able to
CO-1: Utilize EDA, inference and regression techniques.
CO-2: Utilize Matrix decomposition techniques to perform data analysis.
CO-3: Apply data pre-processing techniques.
CO-4: Apply Basic Machine Learning Algorithms.
CO-5: Acquire data through web-scraping and data APIs.

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	Introduction to data analysis: Introduction and importance of data science. Big Data Analytics, Business intelligence vs Big data, Current landscape of analytics, Exploratory Data Analysis (EDA), statistical measures, Basic tools (plots, graphs and summary statistics) of EDA, Data Analytics Lifecycle, Discovery, Data Visualization Principles of Data Visualization	**7**
3	Introductory hypothesis testing and statistical inference: Introduction to Hypothesis Testing, Central Limit Theorem, A/B testing. Identifying Potential Data Sources Linear regression - Introduction to simple linear regression, multiple linear regression, least squares principle, exploratory vs. inferential viewpoints, Model generalizability, cross validation, and using categorical variables in regression, logistic regression, Multiple correlation, Partial correlation	**6**
4	Linear Algebra Basics- Matrices to represent relations between data, Linear algebraic operations on matrices – Matrix decomposition: Singular Value Decomposition (SVD) and Principal Component Analysis (PCA).	**7**
5	Data Pre-processing and Feature Selection - Data cleaning - Data integration - Data Reduction - Data Transformation and Data Discretization, Feature Generation and Feature Selection, Feature Selection algorithms: Filters- Wrappers - Decision Trees - Random Forests	**7**
6	Basic Machine Learning Algorithms - Classifiers - Decision tree - Naive Bayes - k-Nearest Neighbors (k-NN), k-means – SVM Association Rule mining – Ensemble methods	**8**
	Total	**36**

Suggested Books:

1. Mining of Massive Datasets. v2.1, Jure Leskovek, Anand Rajaraman and Jefrey Ullman., Cambridge University Press. (2019)
2. Doing Data Science, Straight Talk From The Frontline, Cathy O'Neil and Rachel Schutt, O'Reilly
3. Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython Wes McKinney, O'Reilly Media
4. Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Aurélien Géron, O'Reilly Media

VI Semester
B. Tech. (Internet of Things)

6IO5-11: Computer Vision

Credit: 2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives: To introduce the fundamentals of image formation
To provide understanding of segmentation techniques in vision-based applications
To impart knowledge on advanced concepts in image representation techniques
To provide insights on implementation of computer vision algorithms for biomedical applications

Course Outcomes: Upon successful completion of the course, students will be able to
CO1: Ability to understand the fundamental concepts in computer vision
CO2: Ability to understand different image formation model
CO3: Ability to apply segmentation techniques and descriptors
CO4: Ability to analyze medical problems using computer vision techniques
CO5: Ability to evaluate performance of computer vision algorithms in biomedical applications

S. No.	Contents	Hours
1	**What is Computer Vision** - Low-level, Mid-level, High-level, Overview of Diverse Computer Vision Applications: Document Image, Analysis, Bio-metrics, Object Recognition, Tracking, Medical Image Analysis, Content-Based Image Retrieval, Video Data Processing, Multimedia, Virtual Reality and Augmented Reality.	**6**
2	**Image Formation Models**: Monocular imaging system, Orthographic & Perspective Projection, Camera model and Camera calibration, Binocular imaging systems, Multiple views geometry, Structure determination, shape from shading, Photometric Stereo, Depth from Defocus, Construction of the 3D model from images.	**6**
3	**Image Processing, Feature Extraction, and Motion Estimation**: Image pre-processing, Image representations (continuous and discrete), Edge detection, Regularization theory, Optical computation, Stereo Vision, Motion estimation, Structure from motion.	**4**
4	**Shape Representation and Segmentation**: Contour-based representation, Region-based representation, De-formable curves and surfaces, Snakes and active contours, Level set representations, Fourier, and wavelet descriptors, Medial representations, Multi-resolution analysis, Object recognition.	**6**
5	**Image Understanding and Computer Vision Applications**: Pattern recognition methods, Face detection, Face detection, Face recognition, 3D shape models of faces Application: Surveillance-foreground-background separation–human gait analysis Application: In-vehicle **vision system**: locating roadway–road markings–identifying road signs-locating pedestrians.	**6**
	Total	**28**

Suggested Books:

1. D. Forsyth and J. Ponce, Computer Vision - A modern approach, Prentice Hall
2. Richard Szeliski, Computer Vision: Algorithms and Applications (CVAA), Springer, 2010
3. E. R. Davies, Computer & Machine Vision, Academic Press, 2012
4. Dana H. Ballard, Christopher M. Brown, Computer Vision, Prentice Hall 1st Edition (May 1, 1982), ISBN-978-0131653160

VI Semester B. Tech. (Internet of Things)	
6IO5-12: Soft Computing and Evolutionary Algorithms	
Credit:2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- Able to understand basics of Fuzzy Set
- Able to understand the concepts of the genetic algorithms.
- Able to understand the ide of the evolutionary algorithms.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Comprehend the fuzzy logic and the concept of fuzziness involved in various systems and fuzzy set theory.

CO-2: Understand the concepts of fuzzy sets, knowledge representation using fuzzy rules, approximate reasoning, fuzzy inference systems, and fuzzy logic

CO-3: Describe with genetic algorithms and other random search procedures useful while seeking global optimum in selflearning situations.

CO-4: Develop some familiarity with current research problems and research methods in Soft Computing Techniques

S. No.	Contents	Hours
1	**Introduction to Soft Computing**: Aims of Soft Computing-Foundations of Fuzzy Sets Theory-Basic Concepts and Properties of Fuzzy Sets- Elements of Fuzzy Mathematics-Fuzzy Relations-Fuzzy Logic	**5**
2	**Application of Fuzzy Sets**: Applications of Fuzzy Sets-Fuzzy Modeling – Fuzzy Decision Making-Pattern Analysis and Classification-Fuzzy Control Systems-Fuzzy Information Processing- Fuzzy Robotics.	**6**
3	**Genetic Algorithms**: Main Operators- Genetic Algorithm Based Optimization-Principle of Genetic Algorithm- Genetic Algorithm with Directed Mutation- Comparison of Conventional and Genetic Search Algorithms Issues of GA in practical implementation. Introduction to Particle swarm optimization-PSO operators-GA and PSO in engineering applications	**6**
4	**Neuro-Fuzzy Technology**: Fuzzy Neural Networks and their learning-Architecture of Neuro- Fuzzy Systems- Generation of Fuzzy Rules and membership functions - Fuzzification and Defuzzyfication in Neuro-Fuzzy Systems- Neuro-Fuzzy Identification - Neuro Fuzzy Control- Combination of Genetic Algorithm with Neural Networks- Combination of Genetic Algorithms and Fuzzy Logic-Neuro-Fuzzy and Genetic Approach in engineering applications.	**6**
5	**Basic Evolutionary Processes, EV**: A Simple Evolutionary System, Evolutionary Systems as Problem Solvers, A Historical Perspective, Canonical Evolutionary Algorithms - Evolutionary Programming, Evolution Strategies, A Unified View of Simple EAs- A Common Framework, Population Size	**5**
Total		**28**

Suggested Books:

1.An Introduction to Genetic Algorithm Melanic Mitchell (MIT Press)

2.Evolutionary Algorithm for Solving Multi-objective, Optimization Problems (2nd Edition), Collelo, Lament, Veldhnizer (Springer)
3.Fuzzy Logic with Engineering Applications Timothy J. Ross (Wiley)
4.Sivanandam, Deepa, " Principles of Soft Computing", Wiley
5.Jang J.S.R, Sun C.T. and Mizutani E, "Neuro-Fuzzy and Soft computing", Prentice Hall
6.Timothy J. Ross, "Fuzzy Logic with Engineering Applications", McGraw Hill

VI Semester B. Tech. (Internet of Things)	
6IO5-13: Introduction to Blockchain	
Credit: 2	**Max. Marks: 100 (IA:30, ETE:70)**
2L+0T+ 0P	**End Term Exams: 3 Hours**

Course Objectives:

As a result of successfully completing this course, students will:

- The students should be able to understand a broad overview of the essential concepts of blockchain technology.
- To familiarize students with Bitcoin protocol followed by the Ethereum protocol – to lay the foundation necessary for developing applications and programming.
- Students should be able to learn about different types of blockchain and consensus algorithms.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: To explain the basic notion of distributed systems.

CO-2: To use the working of an immutable distributed ledger and trust model that defines blockchain.

CO-3: To illustrate the essential components of a blockchain platform.

S. No.	Contents	Hours
1	**Introduction:** Objective, scope and outcome of the course.	**1**
2	Basics: The Double-Spend Problem, Byzantine Generals' Computing Problems, Public-Key Cryptography, Hashing, Distributed Systems, Distributed Consensus.	**5**
3	Technology Stack: Blockchain, Protocol, Currency. Bitcoin Blockchain: Structure, Operations, Features, Consensus Model, Incentive Model	**5**
4	Ethereum Blockchain: Smart Contracts, Ethereum Structure, Operations, Consensus Model, Incentive Model.	**5**
5	Tiers of Blockchain Technology: Blockchain 1.0, Blockchain 2.0, Blockchain 3.0, Types of Blockchain: Public Blockchain, Private Blockchain, Semi-Private Blockchain, Sidechains.	**6**
6	Types of Consensus Algorithms: Proof of Stake, Proof of Work, Delegated Proof of Stake, Proof Elapsed Time, Deposite-Based Consensus, Proof of Importance, Federated Consensus or Federated Byzantine Consensus, Practical Byzantine Fault Tolerance. Blockchain Use Case: Supply Chain Management.	**6**
	Total	**28**

Suggested Books:

1. Kirankalyan Kulkarni, Essentials of Bitcoin and Blockchain, Packt Publishing.
2. Anshul Kaushik, Block Chain & Crypto Currencies, Khanna Publishing House.
3. Tiana Laurence, Blockchain for Dummies, 2nd Edition 2019, John Wiley & Sons.
4. Mastering Blockchain: Deeper insights into decentralization, cryptography, Bitcoin, and popular Blockchain frameworks by Imran Bashir, Packt Publishing (2017).
5. Blockchain: Blueprint for a New Economy by Melanie Swan, Shroff Publisher O'Reilly Publisher Media; 1st edition (2015).

VI Semester B. Tech. (Internet of Things)	
6IO4-21: Compiler Design Lab	
Credit: 1	**Max. Marks: 100 (IA:60, ETE:40)**
0L+0T+ 2P	**End Term Exams: 2 Hours**

Course Objectives:
As a result of successfully completing this course, students will:

- To implement Lexical Analyzer using Lex tool & Syntax Analyzer or parser using YACC Tool
- Write programs related to various grammars

Course Outcomes:
Upon successful completion of the course, students will be able to

CO-1: Design Lexical analyzer for given language using C and LEX tools.

CO-2: Implement Symbol table

CO-3: Write parser for given strings using C and YACC tools.

S. No.	List of Experiments
1	Introduction: Objective, scope and outcome of the course.
2	To identify whether given string is keyword or not.
3	Count total no. of keywords in a file. [Taking file from user]
4	Count total no of operators in a file. [Taking file from user]
5	Count total occurrence of each character in a given file. [Taking file from user]
6	Write a C program to insert, delete and display the entries in Symbol Table.
7	Write a LEX program to identify following: 1. Valid mobile number 2. Valid url 3. Valid identifier 4. Valid date (dd/mm/yyyy) 5. Valid time (hh:mm:ss)
8	Write a lex program to count blank spaces,words,lines in a given file
9	Write a lex program to count the no. of vowels and consonants in a C file.
10	Write a YACC program to recognize strings aaab,abbb using a^nb^n, where b>=0.
11	Write a YACC program to evaluate an arithmetic expression involving operators +,-,* and /.
12	Write a YACC program to check validity of a strings abcd,aabbcd using grammar a^nb^nc^md^m, where n , m>0
13	Write a C program to find first of any grammar.

VI Semester B. Tech. (Internet of Things)	
6IO4-22: Advanced IoT Lab	
Credit: 1	**Max. Marks: 100 (IA:60, ETE:40)**
0L+0T+ 2P	**End Term Exams: 2 Hours**

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: Solving Societal problems with the help of IOT

CO-2: Problem Analysis and Designing a Solution

CO-3: Understanding the importance of Technology in the life of common men.

List of Experiments

A students should implement two case studies from the IOT Projects List (Individually or in small group)

1. Wearable Computer With Temperature Distance Sensors
2. Weather Imaging CubeSat with Telemetry Transmission
3. IOT Water Pollution Monitor RC Boat
4. Mountain Climber Health & GPS Tracker
5. Contactless IOT Doorbell
6. IOT Smart Parking Using RFID
7. IOT Contactless Covid Testing Booth Automation
8. IOT Social Distancing & Monitoring Robot For Queue
9. IOT Covid Patient Health Monitor in Quarantine
10. IOT based Manhole Detection and Monitoring System
11. IOT based Smart Energy Meter Monitoring with Theft Detection
12. IOT Weather Station Airship
13. IOT based Three Phase Power Failure Monitoring with SMS Alerts
14. IOT based Intelligent Gas Leakage Detector Using Arduino
15. 360° Aerial Surveillance UAV With IOT Camera
16. IOT Garbage Segregator & Bin Level Indicator
17. IOT Temperature & Mask Scan Entry System
18. IOT based Smart Agriculture Monitoring System Project
19. IOT Based Automatic Vehicle Accident Detection and Rescue System
20. Greenhouse Monitoring and Control System using IOT Project

These are suggested projects. Instructor/teacher may change/add projects as per his/her discretion.

VI Semester B. Tech. (Internet of Things)	
6IO4-23: Design and Analysis of Algorithms Lab	
Credit: 1	**Max. Marks: 100 (IA:60, ETE:40)**
0L+0T+ 2P	**End Term Exams: 2 Hours**

Course Objectives: As a result of successfully completing this course, students will:

- Able to understand a solid background in the design and analysis of the major classes of algorithms
- Able to develop their own versions for a given computational task and to compare and contrast their performance

Course Outcomes: Upon successful completion of the course, students will be able to

CO-1: Design algorithms using divide and conquer, greedy and dynamic programming.

CO-2: Execute sorting algorithms such as sorting, graph related and combinatorial algorithm in a high level language.

CO-3: Analyze the performance of merge sort and quick sort algorithms using divide and conquer technique.

CO-4: Apply the dynamic programming technique to solve real world problems such as knapsack and TSP

S. No.	List of Experiments
1	Sort a given set of elements using the Quicksort method and determine the time required to sort the elements. Repeat the experiment for different values of n, the number of elements in the list to be sorted and plot a graph of the time taken versus n. The elements can be read from a file or can be generated using the random number generator.
2	Implement a parallelized Merge Sort algorithm to sort a given set of elements and determine the time required to sort the elements. Repeat the experiment for different values of n, the number of elements in the list to be sorted and plot a graph of the time taken versus n. The elements can be read from a file or can be generated using the random number generator.
3	a. Obtain the Topological ordering of vertices in a given digraph. b. Compute the transitive closure of a given directed graph using Warshall's algorithm.
4	Implement 0/1 Knapsack problem using Dynamic Programming.
5	From a given vertex in a weighted connected graph, find shortest paths to other vertices using Dijkstra's algorithm.
6	Find Minimum Cost Spanning Tree of a given undirected graph using Kruskal's algorithm.
7	a. Print all the nodes reachable from a given starting node in a digraph using BFS method. b. Check whether a given graph is connected or not using DFS method.
8	Find Minimum Cost Spanning Tree of a given undirected graph using Prim's algorithm.

Suggested Books:

1. T .H .Cormen, C .E .Leiserson, R .L . Rivest "Introduction to Algorithms", 3rd Ed.,PHI, 2011 (reprint)
2. E. Horowitz, S. Sahni, and S. Rajsekaran, "Fundamentals of Computer Algorithms,"Galgotia Publication
3. Sara Basse, A. V. Gelder, " Computer Algorithms," Addison Wesley
4. Aho ,Ullman "Principles of Algorithms "
5. S.K Basu- Design Methods and Analysis of Algorithms, 2nd Ed., PHI

VI Semester B. Tech. (Internet of Things)	
6IO7-50: Innovation and Design Thinking Hands-on Project	
Credit: 2	**Max. Marks: 100 (IA:60, ETE:40)**
0L+0T+3P	**Mode of evaluation: Report and presentation**

Course Objectives:

As a result of successfully completing this course, students will:

- Learn about the National Innovation and Startup Policy (NISP)of Govt. of India.
- Learn how to ideate, prototype and Iterate solutions.
- Learn about applying Design Thinking Tools and Approaches for Right Problem Identification and Solution Development.
- Learn about Business Plan Development.
- Learn about Legal Structures and Ethical Steps in Establishing Startups.
- Able to design and develop a Prototype.
- Students will be able to pitch their idea.
- Will be able to demonstrate their innovative and design thinking capabilities using mock-up models.

Course Outcomes:

Upon successful completion of the course, students will be able to

CO-1: learn about opportunities and challenges for startup and incubation.

CO-2: Students will be able to identify an Opportunity from a Problem using design thinking.

CO-3: Students will be able to frame Product and service ideas.

CO-4: Learn and implement Design Thinking Process.

CO-5: Students will be able to design and develop a Prototype.

CO-6: Students will be able to prepare documentation and pitch their idea.

exp. No.	Contents
1	National Innovation and Startup Policy (NISP) and Legal Structures and Ethical Steps in Establishing Startups, Generation and Management of IP at the Early Stage of Innovation and Startup Development, IPR and IPR policies.
2	Design Thinking, Process of Design Thinking, Empathy, Define, Ideate, Prototype, Testing.
3	Understanding Technology Readiness Level (TRL), Manufacturing Readiness Level (MRL) and Investment Readiness Level (IRL) Stages & Implications in Innovation Development
4	Capstone Project: Students in groups of 3 to 5 students must prepare a project idea using the design thinking process under the mentorship of the faculty members. Students must submit a capstone project report containing various ideas learned in experiments numbers 1-3 and their implementation or usage in the capstone project to the Institute Innovation Council (IIC) cell or Head of Department along with a presentation.

Assessment or Evaluation:

Students need to submit a capstone project report to the Institute Innovation Council (For the Institute having IIC cells) or the head of the department (For the Institute not having IIC cells) containing step by step approach to the project based on design thinking methodology along with the final presentation to IIC Cell (For the Institute having IIC cells) or Head of department (For the Institute not having IIC cells).

Suggested Books:

1. Idris Mootee, “Design Thinking for Strategic Innovation: What They Can't Teach You at Business or Design School”, John Wiley & Sons (2013).

2. Tim Brown, "Change by design", Harper Collins, 2009
3. "Design Thinking- The Guide Book" – Facilitated by the Royal Civil service Commission, Bhutan
4. The Lean Startup: How Constant Innovation Creates Radically Successful Businesses
5. Start With Why: How Great Leaders Inspire Every
6. National Innovation and Startup Policy 2019 for students and faculty of Higher Education Institutions (HEIs) https://mic.gov.in/assets/doc/startup_policy_2019.pdf
7. Tom Kelley, The Art of Innovation: Lessons in Creativity from IDEO, America's Leading Design Firm
8. Roger L. Martin , Design of Business: Why Design Thinking is the Next Competitive Advantage, Harvard Business Review Press
9. Online resource