JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
B.Tech. in CSE (INTERNET OF THINGS)
III & IV YEAR COURSE STRUCTURE & TENTATIVE SYLLABUS (R18)

Applicable From 2020-21 Admitted Batch

III YEAR I SEMESTER

S. No.	Course Code	Course Title	L	T	P	Credits
1		Finite Automata and Compiler Design	3	0	0	3
2		Microprocessors & Microcontrollers	3	0	0	3
3		Computer Networks	3	0	0	3
4		Database Management Systems	3	0	0	3
5		Professional Elective - I	3	0	0	3
6		Professional Elective - II	3	0	0	3
7		Database Management Systems Lab	0	0	3	1.5
8		Microprocessors & Microcontrollers Lab	0	0	3	1.5
9		Advanced Communication Skills Lab	0	0	2	1
10		Intellectual Property Rights	3	0	0	0
		Total Credits	**21**	**0**	**8**	**22**

III YEAR II SEMESTER

S. No.	Course Code	Course Title	L	T	P	Credits
1		IoT Communication Protocols	3	1	0	4
2		Computer Vision and Robotics	3	1	0	4
3		Programming Languages for IoT	3	1	0	4
4		Professional Elective – III	3	0	0	3
5		Open Elective - I	3	0	0	3
6		IoT lab	0	0	3	1.5
7		Professional Elective - III Lab	0	0	3	1.5
8		Computer Vision Lab	0	0	2	1
9		Environmental Science	3	0	0	0
		Total Credits	**18**	**3**	**8**	**22**

IV YEAR I SEMESTER

S. No.	Course Code	Course Title	L	T	P	Credits
1		IoT Cloud Processing and Analytics	3	0	0	3
2		IoT Security	2	0	0	2
3		Professional Elective - IV	3	0	0	3
4		Professional Elective - V	3	0	0	3
5		Open Elective - II	3	0	0	3
6		IoT Security & Cloud Computing Lab	0	0	2	1
7		Industrial Oriented Mini Project/ Summer Internship	0	0	0	2*
8		Seminar	0	0	2	1
9		Project Stage – I	0	0	6	3
		Total Credits	**14**	**0**	**10**	**21**

IV YEAR II SEMESTER

S. No.	Course Code	Course Title	L	T	P	Credits
1		Organizational Behaviour	3	0	0	3
2		Professional Elective – VI	3	0	0	3
3		Open Elective – III	3	0	0	3
4		Project Stage – II	0	0	14	7
		Total Credits	**9**	**0**	**14**	**16**

*Note: Industrial Oriented Mini Project/ Summer Internship is to be carried out during the summer vacation between 6th and 7th semesters. Students should submit report of Industrial Oriented Mini Project/ Summer Internship for evaluation.

MC – Environmental Science – Should be Registered by Lateral Entry Students Only.
MC – Satisfactory/Unsatisfactory.

Professional Elective – I

	Architecting Smart IoT Devices
	Data Analytics for IoT
	IoT System Architectures
	Operating Systems for IoT
	Design and Analysis of Algorithms

Professional Elective – II

	Machine Learning
	Real Time Systems
	Embedded Hardware Design
	Energy Sources and Power Management
	Software Engineering

Professional Elective – III

	Mobile Application Development for IoT
	Software Testing Methodologies
	Cloud Computing and Virtualization
	Artificial Intelligence
	Lightweight Cryptography

 # Courses in PE – III and PE – III Lab must be in 1-1 correspondence.

Professional Elective – IV

	Quantum Computing
	Wireless Networks
	Augmented Reality & Virtual Reality
	IoT Automation
	Ad-hoc & Sensor Networks

Professional Elective - V

	Embedded Software Design
	5G & IoT Technologies
	Cognitive Computing
	Distributed Systems
	Edge Computing

Professional Elective – VI

	Industrial IoT
	Fog Computing
	Smart Sensor Technologies
	Digital Forensics
	Blockchain Technology

IOT CLOUD PROCESSING AND ANALYTICS

B.Tech. IV Year I Sem.

L	T	P	C
3	0	0	3

Course Objectives: Knowledge on IoT networking connectivity protocols and IoT Analytics for the cloud processing.

Course Outcomes: At the end of the course, students will be able to**:**
1. Implement the architectural components and protocols for application development.
2. Identify data analytics and data visualization tools as per the problem characteristics.
3. Collect, store and analyze IoT data.

UNIT - I
IoT devices, Networking basics, IoT networking connectivity protocols, IoT networking data messaging protocols, Analyzing data to infer protocol and device characteristics.

UNIT - II
IoT Analytics for the Cloud: Introduction to elastic analytics, Decouple key components, Cloud security and analytics, Designing data processing for analytics, Applying big data technology to storage.

UNIT - III
Exploring IoT Data: Exploring and visualizing data, Techniques to understand data quality, Basic time series analysis, Statistical analysis.

UNIT - IV
Data Science for IoT Analytics: Introduction to Machine Learning, Feature engineering with IoT data, Validation methods, Understanding the bias–variance tradeoff, Use cases for deep learning with IoT data.

UNIT - V
Strategies to Organize Data for Analytics: Linked Analytical Datasets, Managing data lakes, data retention strategy.

TEXT BOOKS:
1. Arshdeep Bahga and Vijay Madisetti, "Internet of Things – A Hands on Approach", Universities Press, 2015.
2. Kevin, Townsend, Carles, Cufí, Akiba and Robert Davidson, "Getting Started with Bluetooth Low Energy" O'Reilly.

REFERENCE BOOKS:
1. Madhur Bhargava "IoT Projects with Bluetooth Low Energy, Packt Publishing, August 2017.
2. Robin Heydon," Bluetooth Low Energy: The Developer's Handbook", Pearson, October 2012
3. Kumar Saurabh," Cloud Computing", Wiley India, 1st Edition, 2016.

IOT SECURITY

B.Tech. IV Year I Sem.   L T P C
                                                                              3 0 0 3

Course Objectives:
1. Understand the fundamentals, various attacks and importance of Security aspects in IoT.
2. Understand the techniques, protocols and some idea on security towards Gaming models.
3. Understand the operations of Bitcoin blockchain, crypto-currency as application of blockchain technology.
4. Understand the essential components of IoT.
5. Understand security and privacy challenges of IoT.

Course Outcomes:
1. Incorporate the best practices learnt to identify the attacks and mitigate the same.
2. Adopt the right security techniques and protocols during the design of IoT products.
3. Assimilate and apply the skills learnt on ciphers and block chains when appropriate.
4. Describe the essential components of IoT.
5. Find appropriate security/privacy solutions for IoT.

UNIT - I
Fundamentals of IoT and Security and its need, Prevent Unauthorized Access to Sensor Data, Block ciphers, Introduction to Blockchain, Introduction of IoT devices, IoT Security Requirements, M2M Security, Message integrity, Modeling faults and adversaries, Difference among IoT devices, computers, and embedded devices.

UNIT - II
IoT and cyber-physical systems RFID Security, Authenticated encryption Byzantine Generals problem sensors and actuators in IoT. IoT security (vulnerabilities, attacks, and countermeasures), Cyber Physical Object Security, Hash functions, Consensus algorithms and their scalability problems, Accelerometer, photoresistor, buttons.

UNIT - III
Security engineering for IoT development Hardware Security, Merkle trees and Elliptic curves digital signatures, verifiable random functions, Zero-knowledge systems motor, LED, vibrator. IoT security lifecycle, Front-end System Privacy Protection, Management, Secure IoT Databases, Public-key crypto (PKI), blockchain, the challenges, and solutions, analog signal vs. digital signal.

UNIT - IV
Data Privacy Networking Function Security Trees signature algorithms proof of work, Proof of stake, Networking in IoT, Device/User Authentication in IoT IoT Networking Protocols, Crypto-currencies, alternatives to Bitcoin consensus, Bitcoin scripting language and their use Real-time communication.

UNIT - V
Introduction to Authentication Techniques Secure IoT Lower Layers, Bitcoin P2P network, Ethereum and Smart Contracts, Bandwidth efficiency, Data Trustworthiness in IoT Secure IoT Higher Layers, Distributed consensus, Smart Contract Languages and verification challenges data analytics in IoT - simple data analyzing methods.

TEXT BOOKS:
1. B. Russell and D. Van Duren, "Practical Internet of Things Security," Packt Publishing, 2016.
2. FeiHU, "Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and

Implementations", CRC Press, 2016.
   3. Narayanan et al., "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction," Princeton University Press, 2016.

REFERENCE BOOKS:
   1. A. Antonopoulos, "Mastering Bitcoin: Unlocking Digital Cryptocurrencies," O'Reilly, 2014.
   2. T. Alpcan and T. Basar, "Network Security: A Decision and Game-theoretic Approach," Cambridge University Press, 2011.
   3. Security and the IoT ecosystem, KPMG International, 2015.
   4. Internet of Things: IoT Governance, Privacy and Security Issues" by European Research Cluster.
   5. Ollie Whitehouse, "Security of Things: An Implementers' Guide to Cyber-Security for Internet of Things Devices and Beyond", NCC Group, 2014
   6. Josh Thompson, 'Blockchain: The Blockchain for Beginnings, Guide to Blockchain Technology and Blockchain Programming', Create Space Independent Publishing Platform, 2017.

QUANTUM COMPUTING (Professional Elective – IV)

B.Tech. IV Year I Sem.   L   T   P   C
                                                                              3   0   0   3

Course Objectives:
1. To introduce the fundamentals of quantum computing
2. The problem-solving approach using finite dimensional mathematics

Course Outcomes:
1. Understand basics of quantum computing
2. Understand physical implementation of Qubit
3. Understand Quantum algorithms and their implementation
4. Understand the Impact of Quantum Computing on Cryptography

UNIT - I
Introduction to Essential Linear Algebra: Some Basic Algebra, Matrix Math, Vectors and Vector Spaces, Set Theory. **Complex Numbers:** Definition of Complex Numbers, Algebra of Complex Numbers, Complex Numbers Graphically, Vector Representations of Complex Numbers, Pauli Matrice, Transcendental Numbers.

UNIT - II
Basic Physics for Quantum Computing: The Journey to Quantum, Quantum Physics Essentials, Basic Atomic Structure, Hilbert Spaces, Uncertainty, Quantum States, Entanglement.
Basic Quantum Theory: Further with Quantum Mechanics, Quantum Decoherence, Quantum Electrodynamics, Quantum Chromodynamics, Feynman Diagram Quantum Entanglement and QKD, Quantum Entanglement, Interpretation, QKE.

UNIT - III
Quantum Architecture: Further with Qubits, Quantum Gates, More with Gates, Quantum Circuits, The D-Wave Quantum Architecture. **Quantum Hardware:** Qubits, How Many Qubits Are Needed? Addressing Decoherence, Topological Quantum Computing, Quantum Essentials.

UNIT - IV
Quantum Algorithms: What Is an Algorithm? Deutsch's Algorithm, Deutsch-Jozsa Algorithm, Bernstein-Vazirani Algorithm, Simon's Algorithm, Shor's Algorithm, Grover's Algorithm.

UNIT - V
Current Asymmetric Algorithms: RSA, Diffie-Hellman, Elliptic Curve. **The Impact of Quantum Computing on Cryptography:** Asymmetric Cryptography, Specific Algorithms, Specific Applications.

TEXT BOOKS:
1. Nielsen M. A., Quantum Computation and Quantum Information, Cambridge University Press
2. Dr. Chuck Easttom, Quantum Computing Fundamentals, Pearson

REFERENCE BOOKS:
1. Quantum Computing for Computer Scientists by Noson S. Yanofsky and Mirco A. Mannucci
2. Benenti G., Casati G. and Strini G., Principles of Quantum Computation and Information, Vol. Basic Concepts. Vol. Basic Tools and Special Topics, World Scientific.
3. Pittenger A. O., An Introduction to Quantum Computing Algorithms.

WIRELESS NETWORKS (Professional Elective – IV)

B.Tech. IV Year I Sem.   L T P C
                                                                                                             3 0 0 3

Prerequisite: Wireless Sensor Networks.

Course Objectives:
1. To study the fundamentals of wireless Ad-Hoc Networks.
2. To study the operation and performance of various Ad Hoc wireless network protocols.
3. To study the architecture and protocols of Wireless sensor networks.

Course Outcomes:
1. Students will be able to understand the basis of Ad-hoc wireless networks.
2. Students will be able to understand design, operation and the performance of MAC layer protocols of Ad Hoc wireless networks.
3. Students will be able to understand design, operation and the performance of routing protocol of Ad Hoc wireless network.
4. Students will be able to understand design, operation and the performance of transport layer protocol of Ad Hoc wireless networks.
5. Students will be able to understand sensor network Architecture and will be able to distinguish between protocols used in Adhoc wireless networks and wireless sensor networks.

UNIT - I:
Wireless LANs and PANs: Introduction, Fundamentals of WLANS, IEEE 802.11 Standards, HIPERLAN Standard, Bluetooth, Home RF.
Ad-Hoc Wireless Networks: Introduction, Issues in Ad Hoc Wireless Networks.

UNIT - II:
MAC Protocols: Introduction, Issues in Designing a MAC protocol for Ad Hoc Wireless Networks, Design goals of a MAC Protocol for Ad Hoc Wireless Networks, Classifications of MAC Protocols, Contention - Based Protocols, Contention - Based Protocols with reservation Mechanisms, Contention – Based MAC Protocols with Scheduling Mechanisms, MAC Protocols that use Directional Antennas, Other MAC Protocols.

UNIT - III:
Routing Protocols: Introduction, Issues in Designing a Routing Protocol for Ad Hoc Wireless Networks, Classification of Routing Protocols, Table –Driven Routing Protocols, On – Demand Routing Protocols, Hybrid Routing Protocols, Routing Protocols with Efficient Flooding Mechanisms, Hierarchical Routing Protocols, Power – Aware Routing Protocols.

UNIT - IV:
Transport Layer Protocols: Introduction, Issues in Designing a Transport Layer Protocol for Ad Hoc Wireless Networks, Design Goals of a Transport Layer Protocol for Ad Hoc Wireless Networks, Classification of Transport Layer Solutions, TCP Over Ad Hoc Wireless Networks, Other Transport Layer Protocol for Ad Hoc Wireless Networks.

UNIT - V:
Wireless Sensor Networks: Introduction, Sensor Network Architecture, Data Dissemination, Data Gathering, MAC Protocols for Sensor Networks, Location Discovery, Quality of a Sensor Network, Evolving Standards, Other Issues.

TEXT BOOKS:
1. Ad Hoc Wireless Networks: Architectures and Protocols - C. Siva Ram Murthy and B.S.Manoj, 2004, PHI.
2. Wireless Ad- hoc and Sensor Networks: Protocols, Performance and Control - Jagannathan Sarangapani, CRC Press.

REFERENCE BOOKS:
1. Ad- Hoc Mobile Wireless Networks: Protocols & Systems, C.K. Toh, 1st Ed. Pearson Education.
2. Wireless Sensor Networks - C. S. Raghavendra, Krishna M. Sivalingam, 2004, Springer.

AUGMENTED REALITY AND VIRTUAL REALITY (Professional Elective – IV)

B.Tech. IV Year I Sem.
	L	T	P	C
	3	0	0	3

Course objectives:
1. The objective of this course is to provide a foundation to the fast-growing field of AR and make the students aware of the various AR devices.
2. To give historical and modern overviews and perspectives on virtual reality. It describes the fundamentals of sensation, perception, technical and engineering aspects of virtual reality systems.

Course Outcomes:
1. Describe how AR systems work and list the applications of AR.
2. Understand and analyze the hardware requirement of AR.
3. Describe how VR systems work and list the applications of VR.
4. Understand the design and implementation of the hardware that enables VR systems tobe built.

UNIT - I:
Introduction to Augmented Reality: What Is Augmented Reality - Defining augmented reality, history of augmented reality, The Relationship Between Augmented Reality and Other Technologies-Media, Technologies, Other Ideas Related to the Spectrum Between Real and Virtual Worlds, applications of augmented reality Augmented Reality Concepts- How Does Augmented Reality Work? Concepts Related to Augmented Reality, Ingredients of an Augmented Reality Experience**.**

UNIT - II:
AR Devices & Components: AR Components – Scene Generator, Tracking system, monitoring system, display, Game scene. AR Devices – Optical See- Through HMD, Virtual retinal systems, Monitor bases systems, Projection displays, Video see-through systems.

UNIT - III:
Introduction to Virtual Reality: Defining Virtual Reality, History of VR, Human Physiology and Perception, Key Elements of Virtual Reality Experience, Virtual Reality System, Interface to the Virtual World-Input & output- Visual, Aural & Haptic Displays, Applications of Virtual Reality

UNIT - IV:
Representing the Virtual World: Representation of the Virtual World, Visual Representation in VR, Aural Representation in VR and Haptic Representation in VR, Case Study: GHOST (General Haptics Open Software Toolkit) software development toolkit.

UNIT - V:
Visual Perception & Rendering: Visual Perception - Perception of Depth, Perception of Motion, Perception of Color, Combining Sources of Information, Visual Rendering -Ray Tracing and Shading Models, Rasterization, Correcting Optical Distortions, Improving Latency and Frame Rates.

TEXT BOOKS:
1. Allan Fowler-AR Game Developmentǁ, 1st Edition, A press Publications, 2018, ISBN 978-1484236178
2. Augmented Reality: Principles & Practice by Schmalstieg / Hollerer, Pearson Education India; First edition (12 October 2016), ISBN-10: 9332578494

REFERENCE BOOKS:
1. Virtual Reality, Steven M. LaValle, Cambridge University Press, 2016.
2. Understanding Virtual Reality: Interface, Application and Design, William R Sherman and Alan B Craig, (The Morgan Kaufmann Series in Computer Graphics)". Morgan Kaufmann Publishers, San Francisco, CA, 2002.
3. Developing Virtual Reality Applications: Foundations of Effective Design, Alan B Craig,William R Sherman and Jeffrey D Will, Morgan Kaufmann, 2009.
4. Designing for Mixed Reality, Kharis O'Connell Published by O'Reilly Media, Inc., 2016, ISBN: 9781491962381.
5. Sanni Siltanen- Theory and applications of marker-based augmented reality. Julkaisija – Utgivare Publisher. 2012. ISBN 978-951-38-7449-0.
6. Gerard Jounghyun Kim, "Designing Virtual Systems: The Structured Approach", 2005.

IOT AUTOMATION (Professional Elective – IV)

B.Tech. IV Year I Sem.   L T P C
                                                                              3 0 0 3

Course Objectives:
1. While the promise of the Industrial Internet of Things (IIoT) brings many new business prospects, it also presents significant challenges ranging from technology architectural choices to security concerns.
2. Students acquire the upcoming Industrial IoT: Roadmap to the Connected World Course offers important insights on overcoming the challenges and thrive in this exciting space.

Course Outcomes:
1. Discover key IIoT concepts including identification, sensors, localization, wireless protocols, data storage and security
2. Explore IoT technologies, architectures, standards, and regulation
3. Realize the value created by collecting, communicating, coordinating, and leveraging the data from connected devices
4. Examine technological developments that will likely shape the industrial landscape in the future
5. Understand how to develop and implement own IoT technologies, solutions, and applications
6. At the end of the program, students will be able to understand how to develop and implement their own IoT technologies, solutions, and applications.

UNIT - I:
Introduction & Architecture: What is IIoT and the connected world? the difference between IoT and IIoT, Architecture of IIoT, IOT node, Challenges of IIOT. Fundamentals of Control System, introductions, components, closed loop & open loop system.

UNIT - II:
IIOT Components: Introduction to Sensors (Description and Working principle): What is sensor? Types of sensors, working principle of basic Sensors -Ultrasonic Sensor, IR sensor, MQ2, Temperature and Humidity Sensors (DHT-11). Digital switch, Electro Mechanical switches.

UNIT - III:
Communication Technologies of IIoT: Communication Protocols: IEEE 802.15.4, ZigBee, Z Wave, Bluetooth, BLE, NFC, RFID Industry standards communication technology (LoRAWAN, OPC UA, MQTT), connecting into existing Modbus and Profibus technology, wireless network communication.

UNIT - IV:
Visualization and Data Types of IIoT: Front-end EDGE devices, Enterprise data for IIoT, Emerging descriptive data standards for IIoT, Cloud database, Cloud computing, Fog or Edge computing.
Connecting an Arduino/Raspberry pi to the Web: Introduction, setting up the Arduino/Raspberry pi development environment, Options for Internet connectivity with Arduino, Configuring your Arduino/Raspberry pi board for the IoT.

UNIT - V:
Retrieving Data: Extraction from Web: Grabbing the content from a web page, Sending data on the web, Troubleshooting basic Arduino issues, Types of IoT interaction, Machine to Machine interaction (M2M). **Control & Supervisory Level of Automation:** Programmable logic controller (PLC), Real-time control system, Supervisory Control & Data Acquisition (SCADA). HMI in an automation process, ERP & MES.

TEXT BOOKS:
1. The Internet of Things in the Industrial Sector, Mahmood, Zaigham (Ed.) (Springer Publication)
2. Industrial Internet of Things: Cyber manufacturing System, Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer Publication)
3. Industrial IoT Challenges, Design Principles, Applications, and Security by Ismail Butun (editor)

REFERENCE BOOK:
1. Jerker Delsing, IoT Automation: Arrowhead Framework, CRC Press.

AD-HOC & SENSOR NETWORKS (Professional Elective – IV)

B.Tech. IV Year I Sem.

	L	T	P	C
	3	0	0	3

Prerequisites
1. A course on "Computer Networks".
2. A course on "Mobile Computing".

Course Objectives:
- To understand the concepts of sensor networks.
- To understand the MAC and transport protocols for ad hoc networks.
- To understand the security of sensor networks.
- To understand the applications of adhoc and sensor networks.

Course Outcomes:
- Ability to understand the state-of-the-art research in the emerging subject of Ad Hoc and Wireless Sensor Networks
- Ability to solve the issues in real-time application development based on ASN.
- Ability to conduct further research in the domain of ASN

UNIT - I
Introduction to Ad Hoc Networks - Characteristics of MANETs, Applications of MANETs and Challenges of MANETs.
Routing in MANETs - Criteria for classification, Taxonomy of MANET routing algorithms, Topology-based routing algorithms-**Proactive**: DSDV; **Reactive**: DSR, AODV; Hybrid: ZRP; Position-based routing algorithms-**Location Services**-DREAM, Quorum-based; **Forwarding Strategies:** Greedy Packet, Restricted Directional Flooding-DREAM, LAR.

UNIT - II
Data Transmission - Broadcast Storm Problem, **Rebroadcasting Schemes**-Simple-flooding, Probability-based Methods, Area-based Methods, Neighbor Knowledge-based: SBA, Multipoint Relaying, AHBP. **Multicasting: Tree-based:** AMRIS, MAODV; **Mesh-based:** ODMRP, CAMP; **Hybrid:** AMRoute**,** MCEDAR.

UNIT - III
Geocasting: Data-transmission Oriented-LBM; Route Creation Oriented-GeoTORA, MGR**.**
TCP over Ad Hoc TCP protocol overview, TCP and MANETs, Solutions for TCP over Ad hoc

UNIT - IV
Basics of Wireless, Sensors and Lower Layer Issues: Applications, Classification of sensor networks, Architecture of sensor network, Physical layer, MAC layer, Link layer, Routing Layer.

UNIT - V
Upper Layer Issues of WSN: Transport layer, High-level application layer support, Adapting to the inherent dynamic nature of WSNs, Sensor Networks and mobile robots.

TEXT BOOKS:
1. Ad Hoc and Sensor Networks – Theory and Applications, Carlos Corderio Dharma P. Aggarwal, World Scientific Publications, March 2006, ISBN – 981–256–681–3.
2. Wireless Sensor Networks: An Information Processing Approach, Feng Zhao, Leonidas Guibas, Elsevier Science, ISBN – 978-1-55860-914-3 (Morgan Kauffman).

EMBEDDED SOFTWARE DESIGN (Professional Elective – V)

B.Tech. IV Year I Sem.   L   T   P   C
                                                                             3   0   0   3

Course Objectives: Knowledge on fundamental concepts of real time embedded systems and applications.

Course Outcomes:
1. Understand requirements for real time software design method for embedded systems.
2. Understand and analyze overview of Real-Time Software Design Method for Embedded Systems.
3. Discussion on State Machines for Real-Time Embedded Systems with examples.
4. Understand the importance of software architectural Patterns for Real-Time Embedded Systems.

UNIT - I
Introduction - The Challenge, Real-Time Embedded Systems and Applications, Characteristics of Real-Time Embedded Systems, Distributed Real-Time Embedded Systems, Cyber-Physical Systems, Requirements for Real-Time Software Design Method for Embedded Systems, COMET/RTE: A Real-Time Software Design Method for Embedded Systems, Visual Modeling Languages: UML, SysML, and MARTE.
Real-Time Software Design and Architecture Concepts - Object-Oriented Concepts, Information Hiding, Inheritance, Active and Passive Objects, Concurrent Processing, Cooperation between Concurrent Tasks, Information Hiding Applied to Access Synchronization, Runtime Support for Real-Time Concurrent Processing, Task Scheduling, Software Architecture and Components.

UNIT - II
Overview of Real-Time Software Design Method for Embedded Systems - COMET/RTE System and Software Life Cycle model, Phases in COMET/RTE Life Cycle model.
Structural Modeling for Real-Time Embedded Systems with SysML and UML - Static Modeling Concepts, Categorization of Blocks and Classes using Stereotypes, Structural Modeling of the Problem Domain with SysML, Structural Modeling of the System Context, Hardware/Software Boundary Modeling, Structural Modeling of the Software System Context, Defining Hardware/Software Interfaces, System Deployment Modeling. Use Case Modeling for Real-Time Embedded Systems.

UNIT - III
State Machines for Real-Time Embedded Systems- State Machines and examples, Events and Guard Conditions, Actions, Hierarchical State Machines, Cooperating State Machines, Inherited State Machines, Developing State Machines from Use Cases.
Object and Class Structuring for Real-Time Embedded Software- Object and Class Structuring Criteria, Object and Class Structuring Categories, Object Behavior and Patterns, Boundary Classes and Objects, Entity Classes and Objects, Control Classes and Objects, Application Logic Classes and Objects.
Dynamic Interaction Modeling for Real-Time Embedded Software - Object Interaction Modeling, Message Sequence Description, Approach for Dynamic Interaction Modeling, Stateless Dynamic Interaction Modeling, State Dependent Dynamic Interaction Modeling. Modeling: Microwave Oven System.

UNIT - IV
Software Architectures for Real-Time Embedded Systems- Overview of Software Architectures, Multiple Views of a Software Architecture, Transition from Analysis to Design, Separation of Concerns

in Subsystem Design, Subsystem Structuring Criteria, Decisions about Message Communication between Subsystems.

Software Architectural Patterns for Real-Time Embedded Systems - Software Design Patterns, Layered Software Architectural Patterns, Control Patterns for Real-Time Software Architectures, Client/Service Software Architectural Patterns, Basic Software Architectural Communication Patterns, Software Architectural Broker Patterns, Group Message Communication Patterns.

UNIT - V

Component-Based Software Architectures for Real-Time Embedded Systems- Concepts for Component-Based Software Architectures, Designing Distributed Component-Based Software Architectures, Component Interface Design, Designing Composite Components, Component Structuring Criteria, Design of Service Components, Distribution of Data, Software Deployment, Design of Software Connectors.

Concurrent Real-Time Software Task Design - Concurrent Task Structuring Issues, Categorizing Concurrent Tasks, I/O Task Structuring Criteria, Internal Task Structuring Criteria, Task Priority Criteria, Task Clustering Criteria, Design Restructuring by Using Task Inversion, Developing the Task Architecture, Task Communication and Synchronization, Task Interface and Task Behavior Specifications.

TEXT BOOK:

1. Real-Time Software Design for Embedded Systems by Hassan Gomaa.

REFERENCE BOOK:

1. K. Shibu, Introduction to Embedded Systems, McGraw Hill Education.

5G & IOT TECHNOLOGIES (Professional Elective – V)

B.Tech. IV Year I Sem.   L   T   P   C
                                                                     3   0   0   3

Course Objectives: Students will be explored to the interconnection and integration of the physical world and the cyber space. They are also able to design & develop IoT Devices.

Course Outcomes:
1. Able to understand the application areas of IoT.
2. Able to realize the revolution of Internet in Mobile Devices, Cloud & Sensor Networks.
3. Able to understand building blocks of Internet of Things and characteristics.
4. Understand IoT and M2M.

UNIT - I
Overview of 5G Broadband Wireless Communications: Evolution of mobile technologies 1G to 4G (LTE, LTEA, LTEA Pro), An Overview of 5G requirements, Regulations for 5G, Spectrum Analysis and Sharing for 5G.

UNIT - II
The 5G wireless Propagation Channels: Channel modeling requirements, propagation scenarios and challenges in the 5G modeling, Channel Models for mmWave MIMO Systems, 3GPP standards for 5G, IEEE 802.15.4

UNIT - III
Introduction to Internet of Things –Definition and Characteristics of IoT, Physical Design of IoT – IoT Protocols, IoT communication models, Iot Communication APIs, IoT enabled Technologies – Wireless Sensor Networks, Cloud Computing, Big data analytics, Communication protocols, Embedded Systems, IoT Levels and Templates, Domain Specific IoTs – Home, City, Environment, Energy, Retail, Logistics, Agriculture, Industry, health and Lifestyle.

UNIT - IV
IoT and M2M – Software defined networks, network function virtualization, difference between SDN and NFV for IoT. Basics of IoT System Management with NETCOZF, YANGNETCONF, YANG, SNMP NETOPEER

UNIT - V
IoT Physical Devices and Endpoints - Introduction to Raspberry PI - Interfaces (serial, SPI, I2C). Programming – Python program with Raspberry PI with focus of interfacing external gadgets, controlling output, reading input from pins.

TEXT BOOKS:
1. Internet of Things - A Hands-on Approach, Arshdeep Bahga and Vijay Madisetti, Universities Press, 2015, ISBN: 9788173719547
2. Getting Started with Raspberry Pi, Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2014, ISBN: 9789350239759

REFERENCE BOOKS:
1. Jonathan Rodriguez, "Fundamentals of 5G Mobile Networks", John Wiley & Sons.
2. Amitabha Ghosh and Rapeepat Ratasuk "Essentials of LTE and LTE-A", Cambridge University Press.
3. Athanasios G. Kanatos, Konstantina S. Nikita, Panagiotis Mathiopoulos, "New Directions in Wireless Communication Systems from Mobile to 5G", CRC Press.
4. Theodore S. Rappaport, Robert W. Heath, Robert C. Danials, James N. Murdock "Millimeter Wave Wireless Communications", Prentice Hall Communications.

COGNITIVE COMPUTING (Professional Elective – V)

B.Tech. IV Year I Sem.	L	T	P	C
	3	0	0	3

Prerequisites: Probability theory
Course Objectives:
1. To provide an understanding of the central challenges in realizing aspects of human cognition.
2. To provide a basic exposition to the goals and methods of human cognition.
3. To develop algorithms that use AI and machine learning along with human interaction and feedback to help humans make choices/decisions.
4. To support human reasoning by evaluating data in context and presenting relevant findings along with the evidence that justifies the answers.

Course Outcomes:
1. Understand what cognitive computing is, and how it differs from traditional approaches.
2. Plan and use the primary tools associated with cognitive computing.
3. Plan and execute a project that leverages cognitive computing.
4. Understand and develop the business implications of cognitive computing.

UNIT - I
Introduction to Cognitive Science: Understanding Cognition, IBM's Watson, Design for Human Cognition, Augmented Intelligence, Cognition Modeling Paradigms: Declarative/ logic-based computational cognitive modeling, connectionist models of cognition, Bayesian models of cognition, a dynamical systems approach to cognition.

UNIT - II
Cognitive Models of memory and language, computational models of episodic and semantic memory, modeling psycholinguistics.

UNIT - III
Cognitive Modeling: modeling the interaction of language, memory and learning, Modeling select aspects of cognition classical models of rationality, symbolic reasoning and decision making.

UNIT - IV
Formal models of inductive generalization, causality, categorization and similarity, the role of analogy in problem solving, Cognitive Development Child concept acquisition. Cognition and Artificial cognitive architectures such as ACT-R, SOAR, OpenCog, CopyCat, Memory Networks.

UNIT - V
DeepQA Architecture, Unstructured Information Management Architecture (UIMA), Structured Knowledge, Business Implications, Building Cognitive Applications, Application of Cognitive Computing and Systems.

 TEXT BOOKS:
1. The Cambridge Handbook of Computational Psychology by Ron Sun (ed.), Cambridge University Press.
2. Formal Approaches in Categorization by Emmanuel M. Pothos, Andy J. Wills, Cambridge University Press.

REFERENCE BOOKS:
1. Judith S. Hurwitz, Marcia Kaufman, Adrian Bowles Cognitive Computing and Big Data Analytics, Wiley
2. Vijay V Raghavan, Venkat N. Gudivada, Venu Govindaraju, Cognitive Computing: Theory and Applications: Volume 35 (Handbook of Statistics), North Holland.

DISTRIBUTED SYSTEMS (Professional Elective – V)

B.Tech. IV Year I Sem.   **L T P C**
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Pre-requisites
- A course on "Operating Systems".
- A course on "Computer Organization & Architecture".

Course Objectives:
1. This course provides an insight into Distributed systems.
2. Topics include- Peer to Peer Systems, Transactions and Concurrency control, Security and Distributed shared memory

Course Outcomes:
1. Ability to understand Transactions and Concurrency control.
2. Ability to understand Security issues.
3. Understanding Distributed shared memory.
4. Ability to design distributed systems for basic level applications.

UNIT - I
Characterization of Distributed Systems-Introduction, Examples of Distributed systems, Resource sharing and web, challenges, System models -Introduction, Architectural and Fundamental models, Networking and Internetworking, Interprocess Communication, Distributed objects and Remote Invocation-Introduction, Communication between distributed objects, RPC, Events and notifications, Case study-Java RMI

UNIT - II
Operating System Support- Introduction, OS layer, Protection, Processes and Threads, Communication and Invocation, Operating system architecture, Distributed File Systems-Introduction, File Service architecture.

UNIT - III
Peer to Peer Systems–Introduction, Napster and its legacy, Peer to Peer middleware, Routing overlays, Overlay case studies-Pastry, Tapestry, Application case studies-Squirrel, OceanStore. Time and Global States-Introduction, Clocks, events and Process states, Synchronizing physical clocks, logical time and logical clocks, global states, distributed debugging. Coordination and Agreement-Introduction, Distributed mutual exclusion, Elections, Multicast communication, consensus and related problems.

UNIT - IV
Transactions and Concurrency Control-Introduction, Transactions, Nested Transactions, Locks, Optimistic concurrency control, Timestamp ordering. Distributed Transactions-Introduction, Flat and Nested Distributed Transactions, Atomic commit protocols, Concurrency control in distributed transactions, Distributed deadlocks, Transaction recovery.

UNIT - V
Replication-Introduction, System model and group communication, Fault tolerant services, Transactions with replicated data. Distributed shared memory, Design and Implementation issues, Consistency models.

TEXT BOOKS:
1. Distributed Systems Concepts and Design, G Coulouris, J Dollimore and T Kindberg, Fourth Edition, Pearson Education.
2. Distributed Systems, S. Ghosh, Chapman & Hall/CRC, Taylor & Francis Group, 2010.

REFERENCE BOOKS:
1. Distributed Systems – Principles and Paradigms, A.S. Tanenbaum and M.V. Steen, Pearson Education.
2. Distributed Computing, Principles, Algorithms and Systems, Ajay D. Kshemakalyani and Mukesh Singhal, Cambridge, rp 2010.

EDGE COMPUTING (Professional Elective – V)

B.Tech. IV Year I Sem.   L T P C
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Course Objectives: Knowledge on how edge computing and Internet of Things (IoT) can be used as a way to meet application demands in intelligent IoT systems.

Course Outcomes:
1. Understand use of the IoT architecture with its entities and protocols, from the IoT devices.
2. Security and privacy issues related to the area of edge computing and IoT.
3. Understand the RaspberryPi architecture and its components.
4. Work with RaspberryPi components and evaluate its performance.

UNIT - I
IoT and Edge Computing Definition and Use Cases: Introduction to Edge Computing Scenario's and Use cases - Edge computing purpose and definition, Edge computing use cases, Edge computing hardware architectures, Edge platforms, Edge vs Fog Computing, Communication Models - Edge, Fog and M2M.

UNIT - II
IoT Architecture and Core IoT Modules-A connected ecosystem,IoT versus machine-to-machine versus, SCADA, The value of a network and Metcalfe's and Beckstrom's laws, IoT and edge architecture, Role of an architect, Understanding Implementations with examples-Example use case and deployment, Case study – Telemedicine palliative care, Requirements, Implementation, Use case retrospective.

UNIT - III
RaspberryPi: Introduction to RaspberryPi, About the RaspberryPi Board: Hardware Layout and Pinouts, Operating Systems on RaspberryPi, Configuring RaspberryPi, Programming RaspberryPi, Connecting Raspberry Pi via SSH, Remote access tools, Interfacing DHT Sensor with Pi, Pi as Webserver, Pi Camera, Image & Video Processing using Pi.

UNIT - IV
Implementation of Microcomputer RaspberryPi and device Interfacing, Edge to Cloud Protocols-Protocols, MQTT, MQTT publish-subscribe, MQTT architecture details, MQTT state transitions, MQTT packet structure, MQTT data types, MQTT communication formats, MQTT 3.1.1 working example.

UNIT - V
Edge computing with RaspberryPi, Industrial and Commercial IoT and Edge, Edge computing and solutions.

TEXT BOOKS:
1. IoT and Edge Computing for Architects - Second Edition, by Perry Lea, Publisher: Packt Publishing, 2020, ISBN: 9781839214806.
2. Raspberry Pi Cookbook, 3rd Edition, by Simon Monk, Publisher: O'Reilly Media, Inc., 2019, ISBN: 978149204322.

REFERENCE BOOKS:
1. Fog and Edge Computing: Principles and Paradigms by Rajkumar Buyya, Satish Narayana Srirama, wiley publication, 2019, ISBN: 9781119524984.
2. David Jensen, "Beginning Azure IoT Edge Computing: Extending the Cloud to the Intelligent Edge, MICROSOFT AZURE.

IOT SECURITY & CLOUD COMPUTING LAB

B.Tech. IV Year I Sem.
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<tr><td>**L**</td><td>**T**</td><td>**P**</td><td>**C**</td></tr>
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Prerequisite of course: Fundamentals of computer network, wireless sensor network, communication & internet technology, web technology, information security.

Course Objective:
1. To learn about how to integrate the security aspect into their IoT design taking into consideration all the threats that can possibly happen.
2. To develop web applications in cloud.
3. To learn the design and development process involved in creating a cloud-based application.

Course Outcomes:
1. Understand the vision of IoT from a global context for secure and smart city.
2. Use of Devices, Gateways and Data Management in IoT. Its security building state of the art architecture in IoT, with Security deployment.
3. Configure various virtualization tools such as Virtual Box, VMware workstation.
4. Design and deploy a web application in a PaaS environment.

LIST OF EXPERIMENTS: (IOT SECURITY LAB)
1. Introduction to Open Source Hardware & its Application.
    a. Arduino
    b. Raspberry Pi
2. Exploring various types of Sensors
3. Develop Applications using Arduino and Raspberry Pi
4. Exploring Open Source tools for Security and Privacy issues in IoT.
5. Implement Eclipse IoT Project with Emphasis on Security related issues.
6. Explore the working of AWS IoT Device Defender.

REFERENCE BOOKS:
1. Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 1st Edition, VPT, 2014.
2. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything",1st Edition, Apress Publications, 2013.
3. Cuno Pfister, Getting Started with the Internet of Things, O"Reilly Media, 2011, ISBN: 978-1-4493-9357-1.

SUPPLEMENTARY RESOURCES:
1. https://github.com/connectIOT/iottoolkit
2. https://www.arduino.cc/
3. http://www.zettajs.org/
4. Contiki (Open source IoT operating system)
5. Arduino (open source IoT project)
6. IoT Toolkit (smart object API gateway service reference implementation)
7. Zetta (Based on Node.js, Zetta can create IoT servers that link to various devices and sensors)

LIST OF EXPERIMENTS: (CLOUD COMPUTING LAB)
1. Install Virtualbox/Vmware Workstation with different flavors of linux or windows OS on top of windows7 or 8.
2. Install a C compiler in the virtual machine created using virtual box and execute Simple Programs

3. Install Google App Engine. Create a hello world app and other simple web applications using python/java.
4. Find a procedure to transfer the files from one virtual machine to another virtual machine.
5. Find a procedure to launch virtual machine using trystack (Online Openstack Demo Version)
6. Install Hadoop single node cluster and run simple applications like word count.

E-RESOURCES:
1. https://www.iitk.ac.in/nt/faq/vbox.htm
2. https://www.google.com/urlsa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjqrNG0z a73AhXZt1YBHZ21DWEQFnoECAMQAQ&url=http%3A%2F%2Fwww.cs.columbia.edu%2F~ sedwards%2Fclasses%2F2015%2F1102-fall%2Flinuxvm.pdf&usg=AOvVaw3xZPuF5xVgk- AQnBRsTtHz
3. https://www.cloudsimtutorials.online/cloudsim/
4. https://edwardsamuel.wordpress.com/2014/10/25/tutorial-creating-openstack-instance-in- trystack/
5. https://www.edureka.co/blog/install-hadoop-single-node-hadoop-cluster