ECE Seventh Semester					
Theory					
Sl. No.	**Category**	**Subject Code**	**Subject Name**	**L-T-P**	**Credit**
1	PCC	22EC7PC01T	PCC11: Internet of Things (IoT)	3-0-0	3
2	PCC	22EC7PC02T	PCC12: Computer Network and Data Communication	3-0-0	3
3	PEC	**Professional Elective-5:**			
		22EC7PE01T	Artificial Intelligence	3-0-0	3
		22EC7PE02T	Radar Engineering		
		22EC7PE03T	Embedded Real Time Systems		
4	PEC	**Professional Elective-6:**			
		22EC7PE04T	VLSI Design Automation	3-0-0	3
		22EC7PE05T	Optical Communication		
		22EC7PE06T	Mobile Computing		
		22EC7PE07T	Wireless Communication Network		
5	OEC	**Open Elective-4 (For ECE Branch Students):**			
		22EE7OE01T	Energy Storage Systems	3-0-0	3
		22EE7OE02T/ 22EEE7OE01T	Energy Auditing and Management		
		22EEE7OE02T	Introduction to Biomedical Instrumentation		
		22ME7OE01T	Robotics (Introduction to Kinematics and Dynamics)		
		22ME7OE02T	Numerical Methods for Engineers		
		22CE7OE01T	Environmental Impact Assessment and Life Cycle Analysis		
		22CE7OE02T	Industrial Water Management and Disposal		
		22IT7OE01T	Cloud Computing		
		Open Elective-4 (To Other Branch Students):			
		22EC7OE01T	Principles of Mobile Communication		
		22EC7OE02T	Internet of Things (IoT)		

Total Credit (Theory)					**15**
Practical					
1	PCC	22EC7PC01L	**PCC Lab-11:** IoT Lab	0-0-2	1
2	PCC	22EC7PC02L	**PCC Lab-12:** Computer Network and Data Communication Lab	0-0-2	1
3	PSI	22EC7PS01L	Minor Project	0-0-6	3
4	PSI	22EC7PS02L	Summer Internship / Summer Training / MOOC Certification	0-0-2	1
5	HSMC	22CM7HS01L	Entrepreneurship Project	0-0-4	2
Total Semester Credit					**23**

Professional Core Course [PCC]

COURSE DESCRIPTION: INTERNET OF THINGS

Degree	B. Tech.	
Level	Graduate	
Branch	ECE	
Semester	7th	
Subject Name	**INTERNET OF THINGS**	
Course Type	Theory	
Course Code	**22EC7PC01T**	
Category	PCC	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	Basic Computer Networking, fundamental of communication	
Subject Description	This course introduces the architecture, protocols, and design methodologies of IoT systems. It covers M2M communication, device-level programming using Raspberry Pi, data analytics, and Industry 4.0 concepts, with applications in smart infrastructure, energy, and automation.	
Objectives and Outcomes	**Objectives:** The course should enable the students to: **1.** Understand the core concepts, architecture, and communication models in IoT. **2.** Learn about IoT protocols, M2M systems, and programmable networking technologies like SDN and NFV. **3.** Develop the ability to design IoT platforms and work with physical IoT devices such as Raspberry Pi.	

	4. Gain insights into IoT analytics and emerging trends such as Industry 4.0 and IoE.	
	Outcomes: Upon completion of this course, the student will be able to: **1.** Describe the IoT architecture, functional blocks, and application domains. **2.** Analyze IoT communication protocols and programmable network components. **3.** Design IoT systems using platform methodology and interface hardware components. **4.** Apply analytics tools for IoT data and understand trends driving Industry 4.0 and IoE.	
Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	**1.** Vijay Madisetti, Arshdeep Bahga, "Internet of Things- A Hands-On-Approach", Universities Press, 2015. **2.** David Hanes Atzor et.al, "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, Cisco Press, June 2017	
Reference Book(s)	**1.** Honbo Zhou,"The Internet of Things in the Cloud: A Middleware Perspective" — CRC Press, 2012. **2.** Luigi Atzor et.al, "The Internet of Things: A survey, ", Journal on Networks, Elsevier Publications, October 2010.	
Digital Learning Resources	Course Name: Introduction to internet of things, NPTEL Course Link: https://archive.nptel.ac.in/courses/106/105/106105166/ Course Instructor: Prof. Sudip Misra, IIT Kharagpur	

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Describe the IoT architecture, functional blocks, and application domains.	PO1, PO2/ PEO1, PEO3
CO2	Analyze IoT communication protocols and programmable network components.	PO1, PO2,PO3 / PEO1, PEO2, PEO3
CO3	Design IoT systems using platform methodology and interface hardware components	PO1, PO2,PO3,PO4,PO5 / PEO1, PEO2, PEO3
CO4	Apply analytics tools for IoT data and understand trends driving Industry 4.0 and IoE.	PO1, PO2, Po4, PO5/ PEO1, PEO2, PEO3

DETAILED SYLLABUS:

Module No. 1	**IoT Concepts, System Design, and Application**	**10 Hours**
Introduction & Concepts: Definition & Characteristics of IoT, IoT frameworks, Physical Design of IoT, Logical Design of IoT- IoT Functional Blocks, IoT Communication Models, IoT Communication APIs, IoT Enabling Technologies, IoT Levels & Deployment Templates. **Domain Specific IOTs**: Home Automation, Cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health & Life Style, Challenges and Issues		

Module No. 2	**IoT and M2M**	**6Hrs.**
IoT and M2M: Introduction, M2M-Difference between IoT and M2M, SDN and NFV for IoT-Software Defined Networking, Network Function Virtualization.		

Module No. 3	**IoT Platform Design Methodology**	**6 Hrs.**
IoT Protocol: IoT: Data Link Protocol: IEEE 802.15.4, 802.11ah, BLE, Z-wave, ZigBee; Network Layer Protocols: RPL, CORPL, 6LoWPAN; Session Layer Protocols: MQTT, SMQTT, AMQP, CoAP. **IoT Platform Design Methodology:** Purpose & Requirements Specification, Process Specification, Domain Model Specification, Information Model Specification, Service Specifications, IoT Level Specification, Functional View Specification, Operational View Specification, Device & Component Integration, Case study on IoT system: smart lightning, weather monitoring system.		

Module No. 4	IoT Physical Devices & End points	6 Hrs.
IoT Physical Devices & Endpoints: What is an IoT Device-Basic building blocks of an IoT Device, Exemplary Device: Raspberry Pi, About the Board, Linux on Raspberry Pi, Raspberry Pi Interfaces – Serial, SPI, I2C, Programming Raspberry Pi with Python-Controlling LED with Raspberry Pi, interfacing an LED and Switch with Raspberry Pi, Interfacing a Light Sensor (LDR) with Raspberry Pi**.**		

Module No. 5	IoT Data Analytics and Emerging Digital Ecosystem	8Hrs.
Data and Analytics for IoT: Use of Big Data and Visualization in IoT, IoT Data Analytics Overview and Challenges, Big Data Analytics Tools and Technology. **IoT & Beyond Industry 4.0:** Industry 4.0 concepts, The Various Industrial Revolutions, , Internet of Everything, Overview of RFID, Overview of Android. **Edge Devices for IoT:** Introduction to Arduino Uno and ESP32.		

COURSE DESCRIPTION: COMPUTER NETWORK AND DATA COMMUNICATION

Degree	B. Tech.	
Level	Graduate	
Branch	ECE (Electronics and Communication Engineering)	
Semester	7^{th}	
Subject Name	**COMPUTER NETWORK AND DATA COMMUNICATION**	
Course Type	Theory	
Course Code	**22EC7PC02T**	
Category	PCC	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	Communication Engineering, Digital electronics	
Subject Description	This course introduces the fundamental concepts, architectures, protocols, and technologies used in computer networks and data communication systems. It explores how data is transmitted across different types of networks and how network protocols enable communication between devices and systems. Emphasis is placed on the OSI and TCP/IP models, data transmission methods, networking hardware, addressing schemes, and common networking services.The course also covers practical aspects of networking, including LAN design, IP addressing, routing, switching, and the basic configuration of network devices. Through theoretical understanding and hands-on practice, students will gain the foundational knowledge required for more advanced networking topics or certifications.	
Objectives	**Objectives:** The course should enable the students to:	

<table>
<tr><td>and

Outcomes</td><td colspan="2">1. Basic concepts on Computer communication and networks.
2. develop an understanding of different components of computer networks, various protocols,
3. To have detail knowledge of data communication in different layers and different standard protocols.
4. To learn basic concepts of internetworking, addressing, and routing.</td></tr>
<tr><td></td><td colspan="2">Outcomes:
Upon completion of this course, the student will be able to:

1. Evaluate various computer networking techniques and reference models along with physical layer.
2. Describe the data link layer protocols with framing, flow control and error detection techniques along with wireless LAN, V-LAN and multiple access concepts.
3. Utilize the basic concepts of IP protocols to build routing mechanisms and to design, implement of networks using transport layer protocol.
4. To understand various applications of application layer protocol.</td></tr>
<tr><td rowspan="8">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">1. B.A. Forouzan, Data Communications and Networking, 5th Edition,McGraw Hill Education, 2017, India.
2. Andrew S. Tanenbaum,D. J. WetherallComputer Networks, 5th Edition, Pearson Education India, 2013, India.</td></tr>
<tr><td>Reference Book(s)</td><td colspan="2">1. 1. William StallingsData and Computer Communication, 10th Edition, Pearson Education, 2017, India.
2. 2. James F. Kurose, Keith W.RossComputer Networking – A top down approach featuring the Internet, 6thEdition, Pearson Education, 2017, India.</td></tr>
<tr><td>Digital Learning Resources</td><td colspan="2"><table><tr><td>Course Name</td><td>Data Communication</td></tr></table></td></tr>
</table>

Course Link	https://nptel.ac.in/courses/106/105/106105082/
Course Instructor	Prof. A. Pal, Dept. of Computer Science and Engineering, IIT Kharagpur.

Course Name	Communication Networks
Course Link	https://nptel.ac.in/courses/117/105/117105148/
Course Instructor	Prof. Goutam Das, G.S. Sanyal School of Telecommunication,IIT Khargapur

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Evaluate various computer networking techniques and reference models along with physical layer.	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.
CO2	Describe the data link layer protocols with framing, flow control and error detection techniques along with wireless LAN, V-LAN and multiple access concepts.	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.
CO3	Utilize the basic concepts of IP protocols to build routing mechanisms and to design, implement of networks using transport layer protocol.	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.
CO4	To understand various applications of application layer protocol.	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.

DETAILED SYLLABUS:

Module No. 1		**(8 hours)**
Introduction: Data communication, Networks and types of networks, Protocol layering: TCP/IP protocol suite, Detailed study of all seven layers of the OSI model and their corresponding TCP/IP layers, Multiplexing: FDM, TDM, WDM, switching: Circuit-switched networks, Packet switching.		

Module No. 2		**(10 hours)**
Data link layer: Introduction, Link-layer addressing, Error Detection and Correction: Introduction, Data Link Control services, DLC protocols, HDLC, Media Access Control: Random access, controlled access. **Wired LANs:** Ethernet protocol, standard Ethernet, Fast Ethernet, and Gigabit Ethernet. Bluetooth		

Module No. 3		**(8 hours)**
Connecting devices: Hubs, switches, routers, virtual LANs, Network Layer: Services, Packet switching, performance, IPV4 addresses, IPV6 addresses and protocols, transitions from IPv4 to IPv6, Basics of unicast routing and multicast routing		

Module No. 4		**(6 hours)**
Transport Layer: Connectionless and connection oriented protocols, Transport layer protocols, User datagram protocol, and transmission control protocol.		

Module No. 5		**(8 hours)**
Application Layer: Paradigms, WWW, HTTP, FTP, Telnet, DNS, SNMP, Multimedia		

Professional Elective Course [PEC]

COURSE DESCRIPTION: Artificial Intelligence

Degree	B. Tech.	
Level	Graduate	
Branch	ECE (Electronics and Communication Engineering)	
Semester	7th	
Subject Name	**Artificial Intelligence**	
Course Type	Theory	
Course Code	22EC7PE01T	
Category	PEC	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	Students should have a solid foundation in discrete mathematics (including logic, set theory, and graph theory), data structures and algorithms, probability and statistics, and programming proficiency in Python or C++, along with basic understanding of digital systems and signal processing concepts.	
Subject Description	This course introduces the fundamental concepts and techniques of Artificial Intelligence, covering intelligent agents, search algorithms, knowledge representation, reasoning systems, and machine learning approaches. Students will learn to design and implement AI solutions for real-world problems including game playing, expert systems, and decision-making under uncertainty.	
Objectives and	**Objectives:** The course should enable the students to: 1) Understand the fundamental concepts of intelligent agents, their types, and environmental interactions along with basic search techniques for	

<table>
<tr><td rowspan="2">Outcomes</td><td colspan="2">problem-solving.
2) Learn advanced search algorithms including heuristic methods, constraint satisfaction, and game-playing strategies with optimization techniques.
3) Master knowledge representation techniques using logic systems, semantic networks, and reasoning mechanisms for intelligent decision-making.
4) Explore planning methodologies, probabilistic reasoning, machine learning approaches, and expert system design for practical AI applications.</td></tr>
<tr><td colspan="2">Outcomes:
Upon completion of this course, the student will be able to:

1) Design and implement intelligent agents with appropriate search strategies for solving complex computational problems.
2) Demonstrate proficiency in applying heuristic search algorithms, constraint satisfaction techniques, and game-playing strategies with optimization methods.
3) Effectively utilize knowledge representation systems, logical reasoning, and inference mechanisms to build intelligent decision-making systems.
4) Develop expertise in creating planning systems, probabilistic models, learning algorithms, and expert systems for real-world AI applications.</td></tr>
<tr><td rowspan="8">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">1. Artificial Intelligence – Knight & Rich, McGraw Hill, 3rd Edition.
2. Principles of Artificial Intelligence – N. J. Nilson, 2nd Edition, Narosa Publishing.</td></tr>
</table>

Reference Book(s)	1. Artificial Intelligence A Modern Approach – Russel & Norvig, 2nd Edition, Pearson. 2. Introduction to Artificial Intelligence and Expert Sys – D.W. Patterson, Prentice Hall. 3. Expert System: Principle and programming - Joseph Giarratano, Gary Riley 4. NPTEL course - https://nptel.ac.in/courses/106106126/
Digital Learning Resources	Course Name: Artificial Intelligence Course Link: https://nptel.ac.in/courses/106/105/106105079/ Course Instructor: Prof. P. Dasgupta, IIT Kharagpur

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Students will be able to design and implement intelligent agents with appropriate search strategies for solving complex computational problems.	PO1, PO2, PO4, PO5, PO7, PO10, PO11, PO12, PEO1, PEO2.
CO2	Students will demonstrate proficiency in applying heuristic search algorithms, constraint satisfaction techniques, and game-playing strategies with optimization methods.	PO1, PO2, PO3, PO4, PO7, PO8, PO10, PO12, PEO1, PEO2.
CO3	Students will effectively utilize knowledge representation systems, logical reasoning, and inference mechanisms to build intelligent decision-making systems.	PO1, PO2, PO4, PO5, PO8, PO10, PO11, PEO1, PEO2.
CO4	Students will develop expertise in creating planning systems, probabilistic models, learning algorithms, and expert systems for real-world AI applications.	PO1, PO2, PO3, PO4, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.

DETAILED SYLLABUS:

Module No. 1	**Intelligence and AI, Agents**	**(8 Hrs.)**
Intelligence and AI, Agents, Model of different types of agent: reactive, deliberative, goal-driven, utility-driven, and learning agents, Environment, Properties of Environment, State Space, Knowledge, Rationality, Turing Test. Search Techniques - definition and importance, uninformed search – DFS, BFS, iterative deepening, iterative broadening, depth limited search,		

Module No. 2	Issues in design of heuristics	**(8Hrs.)**
Issues in design of heuristics, Best First search, A* and AO* search, Hill climbing, Simulated Annealing, Constraint Satisfaction Problem, 8-puzzle problem, Crypto arithmetic problem, **Game Playing**, minmax search, alpha-beta pruning.		

Module No. 3	**Knowledge Representation in AI, Logic**	**(8 Hrs.)**
Knowledge Representation in AI, Logic - propositional, predicate, First Order Logic. Normal forms. Modus Ponens & Modus Tollens, Theorem Proving, Principle of Resolutions, Non-Monotonic Reasoning. Semantic Net, Frame.		

Module No. 4	**Planning and its importance**	**(10 Hrs.)**
Planning and its importance. Classical & partial order planning, Conditional Planning. Uncertainty, type of uncertainty, Probabilistic Reasoning- joint distribution reasoning, Bayesian networks, learning, explanation based learning, induction learning-Decision Tree, statistical learning- Bayesian learning, expectation maximization, hidden Markov model, closed world problems.		

Module No. 5	**Expert Systems**	**(6 Hrs.)**
Expert Systems – Design Techniques, components, Problem and knowledge domain, Knowledge engineering approach, error in design of expert system, life cycle of expert system, MYCIN and dendral – an expert system.		

COURSE DESCRIPTION: Radar Engineering

Degree	B. Tech.	
Level	Undergraduate	
Branch	ECE (Electronics and Communication Engineering)	
Semester	7^{th}	
Subject Name	**Radar Engineering**	
Course Type	Theory	
Course Code	22EC7PE02T	
Category	PEC	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	Basics of Communication Engineering	
Subject Description	The "Radar Engineering" course offers an in-depth exploration of radar systems, focusing on their principles, types, and applications. Students will study continuous wave (CW), frequency modulated (FM-CW), moving target indication (MTI), and pulse Doppler radar systems, as well as their components and functionalities. The course emphasizes radar signal processing, tracking methods, and the influence of environmental factors on detection. Through lectures and tutorials, students will develop skills to analyze radar signals, understand system limitations, and apply radar technologies in real-world scenarios, preparing them for advanced studies or careers in electronics and communication engineering.	
Objectives and Outcomes	**Objectives:** The course should enable the students to: 1. Identify basic radar systems and their fundamental components. 2. Explain radar equations and principles of radar signal analysis. 3. Use radar concepts to solve detection and range estimation problems. 4. Analyze radar system performance and limitations in different scenarios.	
	Outcomes: Upon completion of this course, the student will be able to: 1. Demonstrate an understanding of radar fundamentals and factors that influence the detection process. 2. Differentiate radar types based on their operational principles and fields of application. 3. Familiarize with radar displays and their applications in real-time scenarios.	

<table>
<tr><td></td><td colspan="2">4. Analyze radar signals and system components, applying tracking principles to enhance detection accuracy.</td></tr>
<tr><td rowspan="9">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">1. Merrill I. Skolnik, Introduction to Radar Systems, Third Edition, Tata McGraw-Hill, 2001, New Delhi.</td></tr>
<tr><td>Reference Book(s)</td><td colspan="2">1. Byron Edde, Radar Principles, Technology, Applications, First Edition, Pearson Education, 2007, New Delhi.
2. Nathanson, Radar Design Principles, Second Edition, Mc-Graw Hill, 1991, New York.
3. Peyton Z. Peebles, Radar Principles, First Edition, Wiley, 1998, New York.
4. Mark A. Richards, James A. Scheer, William A. Holm. Yesdee, Principles of Modern Radar: Basic Principles, First Edition, Scitech Publishing, 2013, Raleigh, North California</td></tr>
<tr><td>Digital Learning Resources</td><td colspan="2"><table><tr><td>Course Name</td><td>Radar Engineering</td></tr><tr><td>Course Link</td><td>https://nptel.ac.in/courses/108/105/108105154/</td></tr><tr><td>Course Instructor</td><td>Prof. Amitabha Battacharya, Department of Electronics and Electrical Communication Engineering, IIT Kharagpur</td></tr></table></td></tr>
</table>

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Demonstrate an understanding of radar fundamentals and factors that influence the detection process	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.
CO2	Differentiate radar types based on their operational principles and fields of application	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11,

		PO12, PEO1, PEO2.
CO3	Familiarize with radar displays and their applications in real-time scenarios	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.
CO4	Analyze radar signals and system components, applying tracking principles to enhance detection accuracy	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.

DETAILED SYLLABUS:

Module No. 1	**Introduction to Radar**	**10 Hours**

Introduction to Radar:

Basic radar, maximum unambiguous range, building blocks of radar, simple form of radar equation, Block diagram of Radar transmitter, Radar frequencies. Applications to radar.

Radar equation:

Prediction of Range performance, minimum detectable signal, receiver noise, SNR. Radar Cross Section, transmitter power, PRF, range ambiguities, and system losses.

Module No. 2	**CW and FM-CW Radar**	**8 Hours**

CW and Frequency Modulated Radar:

Doppler Effect, CW Radar – Block Diagram, Isolation between Transmitter and Receiver, Non-zero IF Receiver, Receiver Bandwidth Requirements, Applications of CW radar.

FM-CW Radar:

Range and Doppler Measurement, Block Diagram and Characteristics (Approaching/ Receding Targets).

Module No. 3	MTI and Pulse Doppler Radar	6 Hours

MTI and Pulse Doppler Radar:

Introduction, Principle, MTI Radar with - Power Amplifier Transmitter and Power Oscillator Transmitter, Delay Line Cancellers – Filter Characteristics, Blind Speeds, Staggered PRFs. MTI Radar Parameters, Limitations to MTI Performance. MTI versus Pulse Doppler Radar.

Module No. 4	Tracking Radar	6 Hours

Tracking Radar:

Tracking with Radar- Types of Tracking Radar Systems, Monopulse Tracking- Amplitude Comparison Monopulse. Phase Comparison Monopulse. Sequential Lobing, Conical Scan Tracking, Block Diagram of Conical Scan Tracking Radar, Tracking in Range.

Module No. 5	Radar Receiver and Modern Radars	6 Hours

Radar Receiver:

Block Diagram of Radar Receiver & Radar Displays- A-scope and PPI.

Modern Radars:

Height Finding Radars, Synthetic Aperture Radar.

COURSE DESCRIPTION: EMBEDDED REAL TIME SYSTEMS

Degree	B. Tech.	
Level	Graduate	
Branch	ECE (Electronics and Communication Engineering)	
Semester	7th	
Subject Name	**EMBEDDED REAL TIME SYSTEMS**	
Course Type	Theory	
Course Code	22EC7PE03T	
Category	PEC	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	Microprocessors, Operating Systems, Basic Embedded Systems	
Subject Description	Embedded Real-Time Systems is an advanced course that focuses on the design, development, and analysis of real-time embedded systems used in mission-critical and time-sensitive applications. The course introduces the fundamental principles of embedded system architecture, real-time operating systems (RTOS), and embedded software development. Students will learn how to build time-deterministic systems through task scheduling, synchronization, interrupt handling, and hardware-software interfacing. This course also covers practical aspects of embedded systems such as interfacing peripherals, using industry-standard tools, and implementing real-time applications on platforms like ARM, Arduino, and Raspberry Pi. Through case studies and hands-on assignments, learners will gain experience in applying RTOS concepts and embedded system design techniques to real-world problems in domains such as automotive, healthcare, smart homes, and IoT.	

<table>
<tr><td rowspan="2">Objectives

and

Outcomes</td><td colspan="2">Objectives:

The course should enable the students to:

1. Understand the architecture and components of embedded systems.
2. Learn the architecture and programming of ARM processor
3. Explore and analyze different real-time operating system (RTOS) concepts.
4. Get the concepts of embedded hardware and firmware design</td></tr>
<tr><td colspan="2">Outcomes:
Upon completion of this course, the student will be able to:

1. Describe the architecture and components of embedded and real-time systems.
2. Learn the architecture and programming of ARM processor.
3. Explain the working of RTOS components such as scheduler, tasks, and inter-task communication.
4. Design and develop embedded systems using integration techniques, development tools, and EDLC principles.</td></tr>
<tr><td rowspan="9">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
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<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">1. Introduction to Embedded Systems, K V Shibu, TMH Private Limited, New Delhi,2009
2. Embedded System Design” by SantanuChattopadhay, 2nd edition, PHI</td></tr>
<tr><td>Reference Book(s)</td><td colspan="2">1. LylaB.Das, ―Embedded Systems : An Integrated Approach‖ Pearson Education, 2013.
2. Jonathan W.Valvano, ―Embedded Microcomputer Systems Real Time Interfacing‖, Third Edition Cengage Learning, 2012.
3. C.M. Krishna, Kang G. Shin, ―Real-Time Systems‖, International Editions, McGraw Hill 1997
4. K.V.K.K.Prasad, ―Embedded Real-Time Systems: Concepts, Design &</td></tr>
</table>

	Programming‖, Dream Tech Press, 2005.
Digital Learning Resources	

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Describe the architecture and components of embedded and real-time systems.	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11, , PEO1, PEO2.
CO2	Learn the architecture and programming of ARM processor	PO1, PO2, PO4, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.
CO3	Explain the working of RTOS components such as scheduler, tasks, and inter-task communication.	PO1, PO2, PO3, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.
CO4	Design and develop embedded systems using integration techniques, development tools, and EDLC principles.	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PEO1, PEO2.

DETAILED SYLLABUS:

Module No. 1		
Introduction to Embedded Systems :What is an Embedded System, Embedded Systems VS General Computing Systems, History of Embedded Systems, Classification of Embedded Systems, The Typical Embedded System, Core of the Embedded System, Memory, Sensors and Actuators, Communication Interface, Embedded Firmware, Other System Components, PCB and Passive Components, Characteristics and Quality Attributes of Embedded Systems, Hardware Software Co-Design and Program Modeling, Fundamental Issues in Hardware Software Co-design		

Module No. 2		
Embedded Hardware Design and Development: Analog Electronic Components, Digital Electronic Components, VLSI and Integrated Circuit Design, Electronic Design Automation (EDA) Tools, **Embedded Firmware Design and Development**: Embedded Firmware Design Approaches Embedded Firmware Development Languages.		

Module No. 3		
ARM: ARM pipeline, Instruction Set Architecture ISA: Registers, Data Processing Instructions, Data Transfer Instructions, Multiplication's instructions, Software interrupts, Conditional execution, branch instruction, Swap instruction, and THUMB instructions.		

Module No. 4		
Real-Time Operating System (RTOS) based Embedded System Design: Operating System Basics, Types of Operating Systems, Tasks, Process and Threads**, Multiprocessing and Multitasking, Task Scheduling, Threads, Processes and Scheduling:** Putting them Altogether **,** Task Communication, Task Synchronizations, Device Drivers, How to Choose an RTOS.		

Module No. 5		
Design and Development of Embedded System: Integrating and Testing of Embedded Hardware and Firmware, Integration of Hardware and Firmware, Board Bring up. The Embedded System Development Environment: The Integrated Development Environment (IDE), Types of Files Generated on Cross-Compilation, Disassembler/ Decompiler, Simulators, Emulators and Debugging. The Embedded Product Development Life Cycle (EDLC): Definition and objective of EDLC, Different Phases of EDLC, EDLC Approaches		

COURSE DESCRIPTION: VLSI Design Automation

Degree	B. Tech.	
Level	Graduate	
Branch	ECE (Electronics and Communication Engineering)	
Semester	7th	
Subject Name	VLSI Design Automation	
Course Type	Theory	
Course Code	**22EC7PE04T**	
Category	PEC	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	Digital logic design fundamentals, basic understanding of hardware description languages (Verilog), computer architecture concepts, and introductory knowledge of integrated circuit design principles.	
Subject Description	VLSI Design Automation covers the complete design methodology and flow for integrated circuits, from architectural design through physical implementation, with emphasis on design optimization techniques for area, timing, and power. The course focuses extensively on SystemVerilog for modeling sequential circuits, advanced data types, procedural programming constructs, and testbench development for verification of complex digital systems.	
Objectives and	**Objectives:** The course should enable the students to: 5) Understand VLSI design flow, synthesis, and optimization for area, timing, and power.	

<table>
<tr><td rowspan="2">Outcomes</td><td colspan="2">6) Master sequential circuit modeling with FSMs, timing analysis, and blocking statements.
7) Develop SystemVerilog proficiency with data types, arrays, and procedural constructs.
8) Create efficient testbenches using SystemVerilog routines and interface constructs.</td></tr>
<tr><td colspan="2">Outcomes:
Upon completion of this course, the student will be able to:

5) Design and optimize VLSI circuits using complete design flow methodology and synthesis techniques.
6) Implement sequential circuits with proper FSM design, timing analysis, and statement usage.
7) Program complex digital systems using SystemVerilog data types, arrays, and procedural statements.
8) Develop comprehensive testbenches for verification using SystemVerilog routines and interfaces.</td></tr>
<tr><td rowspan="8">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">1. Samir Palnitkar “Verilog HDL: A Guide to Digital Design and Synthesis”, Prentice Hall.
2. Chris Spears, “ System Verilog for Verification”, Springer, 2nd Edition</td></tr>
<tr><td>Reference Book(s)</td><td colspan="2">1. H.Gerez, “Algorithms for VLSI Design Automation”, John Wiley, 1999.
2. Z. Dr Mark, “Digital System Design with System Verilog”,Pearson, 2010.

3. S.Sutherland, S. Davidmann& P. Flake, “System Verilog for Design”, 2nd Edition, Springer, 2006.

4. Essential Electronics design Automation (EDA)- Mark D.Birnbaum,</td></tr>
</table>

	Prentice Hall,2004 5. M.J.S.Smith, "Application Specific Integrated Circuits",Pearson, 2008 6. Electronics Design Automation: Synthesis, verification & Test (System on Silicon)- LaungTerng Wang, Morgan Kaufmann,2009
Digital Learning Resources	Course Name: Electronic Design and Automation Course Link: NPTEL : Computer Science and Engineering - Electronic Design and Automati https://nptel.ac.in/courses/106/105/106105083/ Course Instructor: Prof.I.Sengupta, IIT Kharagpur

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Design and optimize VLSI circuits using complete design flow methodology and synthesis techniques.	PO1, PO2, PO4, PO5, PO7, PO10, PO11, PO12, PEO1, PEO2.
CO2	Implement sequential circuits with proper FSM design, timing analysis, and statement usage.	PO1, PO2, PO3, PO4, PO7, PO8, PO10, PO12, PEO1, PEO2.
CO3	Program complex digital systems using SystemVerilog data types, arrays, and procedural statements.	PO1, PO2, PO4, PO5, PO8, PO10, PO11, PEO1, PEO2.
CO4	Develop comprehensive testbenches for verification using SystemVerilog routines and interfaces.	PO1, PO2, PO3, PO4, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.

DETAILED SYLLABUS:

Module No. 1	Design Methodology	**(6 Hrs.)**
.Design Methodology: Design Flow-Architecture, Functional design and verification, Synthesis, Physical design. Design Optimization-Area, Timing and Power, System representation.		

Module No. 2	Modelling sequential circuits	**(10 Hrs.)**
Modelling sequential circuits: Latches and Flip-flops, counters, mealy and Moore FSM, shifters, sequential circuit using FSM, Blocking and non-blocking statements, Static timing analysis		

Module No. 3	System Verilog- Introduction	**(10 Hrs.)**
System Verilog- Introduction, Design hierarchy, Data types: Built-in data types, Fixed-size arrays, Dynamic arrays, Queues, Associative arrays, Array methods, Choosing a storage type, Creating new types with typedef.		

Module No. 4	System Verilog Procedural statements	**(8 Hrs.)**
Creating user-defined structures, Type conversion, Enumerated types, Constants strings, Expression width. System Verilog Procedural statements and routines: Procedural statements, tasks, functions and void functions.		

Module No. 5	System Verilog routines	**(6 Hrs.)**
Routine arguments, Returning from a routine, Local data storage, Time values Connecting the testbench and design: Separating the testbench and design, Interface constructs.		

COURSE DESCRIPTION: Optical Communication

Degree	B. Tech.	
Level	Graduate	
Branch	ECE (Electronics and Communication Engineering)	
Semester	7th Semester	
Subject Name	**Optical Communication**	
Course Type	Theory	
Course Code	22EC7PE05T	
Category	Professional Elective	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	Analog & Digital Communication	
Subject Description	This course investigates the basic aspects of fiber-optic communication systems. Topics include sources and receivers, optical fibers and their propagation characteristics, and optical fiber systems.	
Objectives and Outcomes	**Objectives:** The course should enable the students to: 1. To study about the various optical fiber modes, configuration and transmission characteristics of optical fibers. 2. To learn about the various optical sources, detectors and transmission techniques. 3. To explore various idea about optical fiber measurements and various coupling technique. 4. To enrich the knowledge about optical communication systems and networks.	

	Outcomes: Upon completion of this course, the student will be able to: 1. Realize basic elements in optical fibers, different modes and configurations. 2. Analyze the transmission characteristics associated with dispersion and polarization techniques. 3. Design optical sources and detectors with their use in optical communication system and get the idea of fiber optic receiver systems, measurements and coupling techniques. 4. Design optical communication systems and its networks.	
Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	1) John M. Senior, "Optical Fiber Communication Principles and Practice," Pearson, Prentice Hall, 3rd edition 2) Gerd Kiser, "Optical Fiber Communication," McGraw Hill Education Private Limited, 4th edition 3) Govind P Agrawal, "Fiber-Optic Communication Systems," John Wiley & Sons, 4th Edition	
Reference Book(s)	1) R. P khare, "Fiber Optics and Optoelectronics," Oxford University press, 2) RajibRamaswamy and Kumar Sivarajan, " Optical Network," M. K Publication, 2nd edition	
Digital Learning Resources	1) https://nptel.ac.in/courses/108/106/108106167/ by Prof. DeepaVenkttesh, Dept. of Electrical Engineering, IIT, Madras 2) https://nptel.ac.in/courses/117/101/117101002/ by Prof. R. K. Shevgaonkar, Dept. of Electrical Engineering, IIT, Bombay	

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Realize basic elements in optical fibers, different modes and configurations	
CO2	Analyze the transmission characteristics associated with dispersion and polarization techniques.	
CO3	Design optical sources and detectors with their use in optical communication system and get the idea of fiber optic receiver systems, measurements and coupling techniques.	
CO4	Design optical communication systems and its networks.	

DETAILED SYLLABUS:

Module No. 1	**INTRODUCTION TO OPTICAL FIBERS**	**6 Hours**
Introduction-general optical fiber communication system- basic optical laws and definitions optical modes and configurations-mode analysis for optical propagation through fiber modes in planar wave guide-modes in cylindrical optical fiber-transverse electric and transverse magnetic modes- - fiber optic cables-classification of optical fiber-single mode fiber-graded index fiber.		

Module No. 2	**TRANSMISSION CHARACTERISTIC OF OPTICAL FIBER**	**6 Hours**
Attenuation-absorption-scattering losses-bending losses-core and cladding losses-signal dispersion – inter symbol interference and bandwidth-intra model dispersion-material dispersion- waveguide dispersion-polarization mode dispersion-intermodal dispersion, dispersion optimization of single mode fiber-characteristics of single mode fiber		

Module No. 3	**OPTICAL SOURCES AND DETECTORS**	**10 Hours**

Sources: Intrinsic and extrinsic material-direct and indirect band gaps-LED-LED structures surface emitting LED-Edge emitting LED-quantum efficiency and LED power-light source materials-modulation of LED-LASER diodes-modes and threshold conditions-Rate equations-external quantum efficiency-resonant frequencies-structures and radiation patterns-single mode laser-external modulation-temperature effort. *Detectors:* PIN photo detector-Avalanche photo diodes-Photo detector noise-noise sources-SNR-detector response time-Avalanche multiplication noise-temperature effects-comparisons of photo detectors.

Module No. 4	**OPTICAL RECEIVER, MEASUREMENTS AND COUPLING**	**9 Hours**
Fundamental receiver operation-preamplifiers-digital signal transmission-error sources-Front end amplifiers-digital receiver performance-probability of error-receiver sensitivity-quantum limit. Optical power measurement-attenuation measurement-dispersion measurement- Fiber Numerical Aperture Measurements- Fiber cut- off Wave length Measurements- Fiber diameter measurements-Source to Fiber Power Launching-Lensing Schemes for Coupling Management-Fiber to Fiber Joints-LED Coupling to Single Mode Fibers-Fiber Splicing-Optical Fiber connectors		

Module No. 5	**OPTICAL COMMUNICATION SYSTEMS AND NETWORKS**	**9 Hours**
System design consideration Point – to –Point link design –Link power budget –rise time budget, WDM –Passive DWDM Components-Elements of optical networks-SONET/SDH Optical Interfaces-SONET/SDH Rings and Networks-High speed light wave Links-OADM configuration-Optical ETHERNET-Soliton. Introduction to emerging solutions in optical communication such as Photonic Integrated Circuits (PICs), Optical Wireless Communication (OWC), and Space Division Multiplexing (SDM)		

COURSE DESCRIPTION: MOBILE COMPUTING

Degree	B. Tech.	
Level	Graduate	
Branch	ECE (Electronics and Communication Engineering)	
Semester	7^{th}	
Subject Name	**MOBILE COMPUTING**	
Course Type	Theory	
Course Code	19EC7PE06T	
Category	Professional Elective	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	Cellular System, Mobile Communication, Computer Network	
Subject Description	This course covers mobile computing architectures, wireless communication standards, and mobility management. Topics include GSM, GPRS, WLAN (IEEE 802.11), Mobile IP, MANET protocols, Bluetooth, WAP, WLL, and satellite systems, with focus on protocol design, handoff, and tunneling mechanisms.	
Objectives and Outcomes	**Objectives:** The course should enable the students to: **5.** Analyze wireless communication infrastructure with respect to mobility, scalability, energy efficiency, and security in wireless networks. **6.** Demonstrate understanding of mobile network architecture, including mobility management, resource allocation, and handoff	

<table>
<tr><td></td><td colspan="2">strategies.
7. Explain the principles and standards of WLANs and cellular technologies, and understand the transition toward 3G and beyond.
8. Describe various mobile satellite communication systems and evaluate their role in global data communication.</td></tr>
<tr><td></td><td colspan="2">Outcomes:
Upon completion of this course, the student will be able to:

5. To understand the infrastructure to develop wireless communication systems and analyses security, energy efficiency, mobility, scalability, and their unique characteristics in wireless networks.
6. To understand network architecture and its components. Gain knowledge of mobility management, resources management and handoff management concepts
7. To aware the working principles of different wireless LAN, 3G and its standards. • Understand migration to 3G Technologies.
8. To understand different types of mobile satellite network and their aspect of data communication</td></tr>
<tr><td rowspan="8">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">3. P.K. Patra, S.K. Dash: Mobile Computing, Scitech Publications.
4. J. Schiller: Mobile Communication, Pearson Education</td></tr>
<tr><td>Reference Book(s)</td><td colspan="2">3. Mobile Computing by Rajkamal, Oxford University Press.
4. Mobile Computing by Talukdar, Tata McGraw-Hill Education.
5. Principles of Mobile Computing by Hansmann, Merk, 2nd Edition, Springer</td></tr>
<tr><td>Digital Learning Resources</td><td colspan="2">Course Name: Mobile computing
Course Link: NPTEL:
https://www.youtube.com/playlist?list=PLsK7K7rfGYke2ZfFugu2cppvNHNrdjD-u
Course Instructor: Shadab Ghazali, IIT Kharagpur</td></tr>
</table>

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	To understand the infrastructure to develop wireless communication systems and analyse security, energy efficiency, mobility, scalability, and their unique characteristics in wireless networks.	PO1, PO2/ PEO1, PEO3
CO2	To understand network architecture and its components. Gain knowledge of mobility management, resources management and handoff management concepts	PO1, PO2 / PEO1, PEO3
CO3	To aware the working principles of different wireless LAN, 3G and its standards. • Understand migration to 3G Technologies.	PO1, PO5 / PEO1, PEO2, PEO3
CO4	To understand different types of mobile satellite network and their aspect of data communication	PO1, PO2/ PEO1, PEO2, PEO3

DETAILED SYLLABUS:

Module No. 1	**Mobile Computing & Cellular Networks**	**12 Hrs.**

Introduction to Mobile Computing: Introduction, mobile computing architecture, simplified reference model, evaluation of wireless technology.

Personal Communications Services (PCS): Features, PCS Network Architecture, Mobility Management.

Global System for Mobile Communication (GSM): Mobile services, System architecture, Radio interface, GSM Channels, Localization and calling, Handoff, Network signalling

Module No. 2	**Packet Data and Wireless LANs**	**8 Hrs.**

General Packet Radio Services (GPRS): GPRS Architecture, GPRS Network Nodes, GPRS-Data Routing.

WLANs (Wireless LANs): Wireless Applications and Standards, IEEE 802.11WLAN

Technologies 202.11 standards, services, IEEE 202.11- Network Architecture, protocol Architecture.

Wireless Enterprise Networks: Introduction to Virtual Networks, Blue tooth- User Scenarios, Architecture, Protocol stack, Bluetooth Connection Establishment.

Module No. 3	**Mobile IP and Ad-hoc Networks**	**6 Hrs.**

Mobile IP: Goals, Entities and terminology, IP Packet Delivery, Registration, Tunnelling and Encapsulation, Reverse tunneling.

Mobile ad-hoc networks: Overview, properties of MANET, Routing and various routing Algorithm, Adhoc routing protocols: DSDV, CGSR, DSR.

Module No. 4	**Wireless Application Protocol (WAP)**	**6 Hrs.**

Wireless Application Protocol (WAP): WAP Forum, the Mobile Internet Standard, WAP Architecture, WAP Gateway and Protocols, Wireless Markup Languages (WML), WAP push Pull Architecture.

Wireless Local Loop (WLL): Introduction to WLL Architecture, wireless Local Loop Technologies

Module No. 5	**Global Mobile Satellite Systems**	**4 Hrs.**

Global Mobile Satellite Systems: Types of satellite systems, Satellite system architecture, Case studies of the IRIDIUM, ICO and GLOBALSTAR systems

COURSE DESCRIPTION: Wireless Communication Network

Degree	B. Tech.	
Level	Graduate	
Branch	ECE (Electronics and Communication Engineering)	
Semester	7th	
Subject Name	**Wireless Communication Network**	
Course Type	Theory	
Course Code	**22EC7PE07T**	
Category	Professional Elective	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	Cellular System, Mobile Communication, Computer Network	
Subject Description	A wireless communication network connects devices and computers without using network cables. Devices use radio communications to send data between each other. Devices can communicate directly with other wireless devices, or connect to an existing network through a wireless AP.	
Objectives and Outcomes	**Objectives:** The course should enable the students to: 1. An understanding on system architecture, functioning and various standards in cellular communication. 2. An understanding on signal propagation in cellular environment. 3. An ability to explain multiple access techniques for Wireless Communication. 4. An understanding on architecture, functioning, protocols,	

	capabilities and application of various wireless communication networks.	
	Outcomes: Upon completion of this course, the student will be able to: 1. Describe the cellular concept and analyze capacity improvement techniques. 2. Mathematically analyze propagation mechanisms in wireless mobile radio. 3. Analyze and examine the multiple access techniques and its application in wireless communication. 4. Demonstrate an understanding on architecture, functioning, protocols, capabilities and application of various wireless communication networks.	
Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	1. V K Garg,*Wireless Communication and Networking, Essential Reading*, Morgan Kaufman Publishers India; 2008. 2. T.S. Rappaport,Wireless Communications:Principles and practice, 2nd Ed, Pearson, 2018.	
Reference Book(s)	1. Andreas F. Molisch, *Wireless Communication*,2nd Edition, John Wiley and Sons Ltd., India, 2011. 2. A Goldsmith, *Wireless communication*, Cambridge University Press, India, 2009. 3. Michel DaoudYacoub,*Wireless Technology: Protocols, Standards, and Techniques*, CRC Press, 2002.	
Digital Learning Resources	Course Name: Introduction to Wireless and Cellular Communications Course Link: https://nptel.ac.in/courses/106/106/106106167/# Course Instructor: Prof. David Koilpillai, Dept. Electrical Engineering, IIT Madras	

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Describe the cellular concept and analyze capacity improvement techniques.	PO1, PO2/ PEO1, PEO3
CO2	Mathematically analyze propagation mechanisms in wireless mobile radio.	PO1, PO2 / PEO1, PEO3
CO3	Analyze and examine the multiple access techniques and its application in wireless communication.	PO1, PO5 / PEO1, PEO2, PEO3
CO4	Demonstrate an understanding on architecture, functioning.	PO1, PO2/ PEO1, PEO2, PEO3

DETAILED SYLLABUS:

Module No. 1	**Overview of wireless systems and Cellular concepts:**	**8 Hrs.**
Introduction, frequency reuse, channel assignment strategies, Handoff strategies, Interference and system capacity, Trunking and grade of service, Improving coverage and capacity in cellular system.		

Module No. 2	**Radio propagation and path-loss models**	**6 Hrs.**
Introduction, free-space attenuation, attenuation over reflecting surface, radio wave propagation, characteristics of wireless channel, signal fading characteristics, Level crossing rate and average fade duration.		

Module No. 3	**Multiple access techniques for Wireless Communication**	**6 Hrs.**

Introduction, FDMA, TDMA, Spread spectrum multiple access, space division multiple access, CDMA, Packet radio, capacity of cellular system.

Module No. 4	**Wireless Wide-Area Network**	**8 Hrs.**
Introduction, WWAN subsystem entities, Logical channels, Channel and frame structure, Speech processing, power levels in mobile stations. Wireless application protocol: Introduction, WAP and WWW, the WAP programming model, WAP architecture, advantages and disadvantages, applications.		

Module No. 5	**Wireless Personal Area Network**	**8 Hrs.**
WPAN, Bluetooth - protocol stack, link types, security, network connection establishment, error correction, network topology, applications. Wireless Local Area Network: Introduction, topologies, WLAN technologies, IEEE 802.11 WLAN, WiMAX.		

Open Elective Course [OEC] offered by ECE to other branch students

COURSE DESCRIPTION: Principles of Mobile Communication

Degree	B. Tech.	
Level	Graduate	
Branch	ECE (Electronics and Communication Engineering)	
Semester	7th	
Subject Name	**Principles of Mobile Communication**	
Course Type	Theory	
Course Code	22EC7OE01T	
Category	OEC	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	Basic knowledge of basic electronics digital communication, electromagnetic wave propagation, and signal processing is recommended.	
Subject Description	This course provides a comprehensive understanding of cellular and mobile communication systems, covering cellular architecture, radio propagation models, wireless system evolution, multiple access techniques, and spread spectrum technologies essential for modern wireless communication networks.	
Objectives and	**Objectives:** 1. The basic cellular concepts and capacity enhancement techniques like sectoring, cell splitting, microcell, picocell etc. 2. Analyze various channel models and fading characteristics. 3. The principles and applications of various multiple access techniques	

<table>
<tr><td rowspan="2">Outcomes</td><td colspan="2">and compare them.
4. The principles and applications of various digital modulation techniques used in mobile communication.</td></tr>
<tr><td colspan="2">Outcomes:
Upon completion of this course, the student will be able to:

1. Identify and discuss the fundamental operational and design problems of cellular mobile communication systems.
2. Analyze the Mobile radio propagation, fading, diversity concepts and the channel modeling.
3. Explore various wireless mobile communication standards and analyze their system performance.
4. Analyze various multiple access techniques and compare their system performance in terms of capacity and spectral efficiency.</td></tr>
<tr><td rowspan="9">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">1. V K Garg Wireless Communication and Networking: Essential Reading, Morgan Kaufman Publishers, India, 2008.
2. T S Rappaport, Wireless Communications, 2nd Edition, Pearson Education, India, 2010.</td></tr>
<tr><td>Reference Book(s)</td><td colspan="2">1. UpenaDalal and Manoj K. Shukla,Wireless and Mobile Communication, Oxford University Press, India, 2016.
2. W C Y Lee , Mobile Communication Engineering – Theory and Applications, 2nd Edition, McGraw Hill Education, India, 2017.
3. A Goldsmith,Wireless communication, Cambridge University Press, India, 2009.</td></tr>
</table>

Digital Learning Resources	https://nptel.ac.in/courses/117/102/117102062/

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Identify and discuss the fundamental operational and design problems of cellular mobile communication systems.	1,2
CO2	Analyze the Mobile radio propagation, fading, diversity concepts and the channel modeling.	3,4
CO3	Explore various wireless mobile communication standards and analyze their system performance.	5
CO4	Analyze various multiple access techniques and compare their system performance in terms of capacity and spectral efficiency.	5

DETAILED SYLLABUS:

Module No. 1	**Fundamentals of Cellular Communications**	**8 Hours**
Introduction, Cellular Systems: Hexagonal Cell Geometry, Frequency reuse, channel Assignment; Handoff Strategies; Interfaces and System Capacity-Co-Channel Interference Ratio, Cellular System Design in Worst-Case Scenario with an Omni directional Antenna, Co-channel Interference Reduction, ACI, Cell Splitting; Sectoring, Directional Antennas in Seven-Cell Reuse Pattern; Microcell &Picocell Zone Concept.		

Module No. 2	**Radio Propagation Models**	**8 Hours**
Large Scale Propagation: Introduction, Free Space Propagation Model; Basic propagation mechanisms, Ground Reflection (2-ray) Model; Free-space Attenuation, Attenuation over Reflecting Surfaces; Outdoor propagation and Indoor Propagation Path Loss Models. **Small Scale Propagation:** small scale multi path propagation; Characteristics of Wireless Channel, Parameters of multi path channels; types of multi path fading.		

Module No. 3	Mobile Wireless Communication Systems	8 Hours
Evolution of cellular communication system, Cellular Communications from 1G to 3G, Road map for higher data rate capability in 3G, Wireless 4G Systems-vision, 4G Features and Challenges, Future Wireless Networks: GSM- System architecture, Radio interface, GSM Channels, Localization and calling. Evolution of mobile communication from 1G to 6G with roadmap focus on 4G, 5G, and beyond.		

Module No. 4	Multiple Access Techniques	
Introduction, Narrowband Channelized Systems, Comparisons of FDMA, TDMA and DS-CDMA, Comparison of DS-CDMA vs. TDMA; Spectral Efficiency, System Capacity, Capacity of a DS-CDMA System.		

Module No. 5	Spread Spectrum and Equalization Techniques	
Spread Spectrum(SS) Systems- Introduction, Concept of Spread Spectrum, System Processing Gain, Frequency-Hopping Spread Spectrum Systems.		

COURSE DESCRIPTION: INTERNET OF THINGS (OE)

Degree	B. Tech.	
Level	Graduate	
Branch	EEE, EE, Civil, Mechanical	
Semester	7^{th}	
Subject Name	**INTERNET OF THINGS**	
Course Type	Theory	
Course Code	22EC7OE02T	
Category	OEC	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	Basic Computer Networking, fundamental of communication	
Subject Description	This course introduces the architecture, protocols, and design methodologies of IoT systems. It covers M2M communication, device-level programming using Raspberry Pi, data analytics, and Industry 4.0 concepts, with applications in smart infrastructure, energy, and automation.	
Objectives and Outcomes	**Objectives:** The course should enable the students to: 1. To stand the fundamental architecture, communication models, and challenges of IoT systems. 2. Explore the role of IoT across industrial domains and smart infrastructure. 3. To learn cloud, networking concepts, and communication technologies	

<table>
<tr><td></td><td colspan="2">that support IoT.
4. To study data analytics techniques, big data tools, and Industry 4.0 enabling services.</td></tr>
<tr><td></td><td colspan="2">Outcomes:
Upon completion of this course, the student will be able to:

1. Describe the architecture, characteristics, and communication protocols of IoT systems.
2. Analyze real-world and industrial applications of IoT across various domains.
3. Apply IoT platform design methodologies and integrate basic hardware components.
4. Utilize data analytics tools for IoT and explain the relevance of Industry 4.0 technologies.</td></tr>
<tr><td rowspan="9">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">1. VijayMadisetti, Arshdeep Bahga, “Internet of Things- A Hands-On-Approach”, Universities Press, 2015.
2. David Hanes Atzor et.al, “IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, Cisco Press, June 2017</td></tr>
<tr><td>Reference Book(s)</td><td colspan="2">1. Honbo Zhou,”The Internet of Things in the Cloud: A Middleware Perspective” — CRC Press, 2012.
2. Luigi Atzor et.al, “The Internet of Things: A survey, “, Journal on Networks, Elsevier Publications, October 2010..</td></tr>
<tr><td>Digital Learning Resources</td><td colspan="2"><table><tr><td>Course Name</td><td>Introduction to internet of things, NPTEL</td></tr><tr><td>Course Link</td><td>https://archive.nptel.ac.in/courses/106/105/106105166/</td></tr><tr><td>Course Instructor</td><td>Prof. Sudip Misra, IIT Kharagpur</td></tr></table></td></tr>
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CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Describe the architecture, characteristics, and communication protocols of IoT systems.	PO1, PO2/ PEO1, PEO3
CO2	Analyze real-world and industrial applications of IoT across various domains	PO1, PO2,PO3 / PEO1, PEO2, PEO3
CO3	Apply IoT platform design methodologies and integrate basic hardware components	PO1, PO2,PO3,PO4,PO5 / PEO1, PEO2, PEO3
CO4	Utilize data analytics tools for IoT and explain the relevance of Industry 4.0 technologies.	PO1, PO2, Po4, PO5/ PEO1, PEO2, PEO3

DETAILED SYLLABUS:

Module No. 1	**IoT Architecture, Design, and Domain Application**	**10 Hours**
Introduction & Concepts: Definition & Characteristics of IoT, IoT frameworks, Physical Design of IoT- Things in IoT, IoT Protocols, Logical Design of IoT- IoT Functional Blocks, IoT Communication Models, IoT Communication APIs, IoT Enabling Technologies, IoT Levels & Deployment Templates. **Domain Specific IoTs:** Home Automation, Cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health & Life Style, Challenges and Issues.		

Module No. 2	**IoT and M2M**	**8 Hrs.**
IoT and M2M: Introduction, M2M-Difference between IoT and M2M, SDN and NFV for IoT-Software Defined Networking, Network Function Virtualization.		

Module No. 3	**IoT Platform Design Methodology**	**6 Hrs.**
IoT Platform Design Methodology: Purpose & Requirements Specification, Process Specification, Domain Model Specification, Information Model Specification, Service Specifications, IoT Level Specification, Functional View Specification, Operational View Specification, Device & Component Integration, Case study on IoT system: smart lightning,		

weather monitoring system.

Module No. 4	IoT Physical Devices & Endpoints	6Hrs.
IoT Physical Devices & Endpoints: What is an IoT Device-Basic building blocks of an IoT Device, Exemplary Device: Raspberry Pi, About the Board, Linux on Raspberry Pi, Raspberry Pi Interfaces – Serial, SPI , I2C , Programming Raspberry Pi with Python-Controlling LED with Raspberry Pi ,interfacing an LED and Switch with Raspberry Pi, Interfacing a Light Sensor (LDR) with Raspberry Pi**.**		

Module No. 5	IoT Analytics and Emerging Technologies	6 Hrs.
Data and Analytics for IoT: Use of Big Data and Visualization in IoT, IoT Data Analytics Overview and Challenges, Big Data Analytics Tools and Technology. **IoT &Beyond Industry 4.0:** Industry 4.0 concepts, The Various Industrial Revolutions, , Internet of Everything, Overview of RFID, Overview of Android. **Edge Devices for IoT:** Introduction to Arduino Uno and ESP32.		

Laboratory Course

COURSE DESCRIPTION: Internet of Things Lab

Degree	B. Tech.	
Level	Undergraduate	
Branch	ECE (Electronics and Communication Engineering)	
Semester	7th	
Subject Name	**Internet of Things Lab**	
Course Type	Laboratory	
Course Code	**22EC7PC01L**	
Category	PCC	
Credit Point	1	
Time Commitment	Lecture	05 Hours
	Tutorial	Nil
	Practice	20 Hours
	Total	25 Hours
Recommended Background Knowledge	Digital Electronics, Analog Electronics, Embedded System.	
Subject Description	This course introduces the fundamental concepts, architecture, and applications of the Internet of Things (IoT). Students will explore the integration of physical devices with network technologies to create smart environments and systems. The course covers IoT system architecture, sensors and actuators, communication protocols, data processing, cloud integration, and security issues. Real-world applications across domains such as smart homes, healthcare, agriculture, and industrial automation are discussed. Hands-on projects and labs provide practical experience in building and deploying IoT systems using platforms like Arduino, ESP32, Raspberry Pi, and cloud services.	
Objectives	**Objectives:** The course should enable the students to:	

and **Outcomes**	1. Understand the core concepts and architecture of IoT systems 2. Explore sensor technologies and microcontroller programming 3. Learn about IoT communication protocols 4. Develop skills for data acquisition, processing, and cloud integration 5. Apply knowledge to real-world applications through case studies and projects	
	Outcomes: Upon completion of this course, the student will be able to: 1. Explain the fundamental concepts, architecture, and real-world applications of the Internet of Things (IoT). 2. Interface sensors and actuators with microcontrollers and utilize appropriate communication protocols for IoT system development. 3. Design and implement IoT solutions using development platforms (e.g., Arduino, Raspberry Pi) and integrate with cloud-based services. 4. Analyze and apply techniques for IoT data visualization, security, and privacy to ensure effective and secure system performance.	
Assessment/ Evaluation	Lab Experiments	20%
	Record Writing	10%
	Behavior/ Attitude	05%
	Quiz	10%
	Attendance	05%
	Final Lab Test	30%
	Final Viva/ Final Lab Quiz Test	20%
	Lab Experiments	20%

CO's Mapping with PO's and PEO's

Course	Course Outcome Statement	PO's / PEO's

Outcomes		
CO1	Explain the fundamental concepts, architecture, and real-world applications of the Internet of Things (IoT).	1,2,4,5,7,11
CO2	Interface sensors and actuators with microcontrollers and utilize appropriate communication protocols for IoT system development.	1,2,3,4,5,8,9.10
CO3	Design and implement IoT solutions using development platforms (e.g., Arduino, Raspberry Pi) and integrate with cloud-based services.	2,3,5,6,8,9,11,12
CO4	Analyze and apply techniques for IoT data visualization, security, and privacy to ensure effective and secure system performance.	2,3,4,8,9,10.11

Perform any 10 Experiment

Sl. No.	Name of Experiments	Duration in Hrs
1	Read analog data from a potentiometer using esp32.	2
2	Read digital data from a push bottom switch using esp32.	2
3	Send analog data to ThingSpeak cloud using esp32.	2
4	Write DHT11 sensor data to cloud using HTTP method.	2
5	Read DHT11 sensor data from cloud using HTTP method.	2
6	Mini Project: ▪ Board1: Write DHT11 data on cloud, and read switch condition from cloud and based on switch condition (From Board2) control the relay. ▪ Board2: Read DHT11 data from cloud, and write switch condition on cloud.	2
7	a) Interfacing of LoRa Gateway with multiple sensor nodes. b) Interfacing of 4G network with LoRa Gateway.	2
8	Introduction to a Raspberry Pi OS installation and Environment setup.	2

9	Investigation of GPIO Control and LED Blinking using Raspberry Pi	2
10	IR Sensor Interface with Raspberry Pi for Obstacle Detection	2
11	Temperature and Humidity Monitoring using DHT11 Sensor with Raspberry Pi	2
12	USB camera interfacing with Raspberry Pi to capture image	2
13	Development of a Mobile Application to Display Real-Time Sensor Data from an IoT Device.	2
14	Storing Real-Time IoT Sensor Data into a Cloud/Local Database.	2

COURSE DESCRIPTION: COMPUTER NETWORK AND DATA COMMUNICAITON

Degree	B. Tech.	
Level	Undergraduate	
Branch	ECE (Electronics and Communication Engineering)	
Semester	7^{th}	
Subject Name	COMPUTER NETWORK AND DATA COMMUNICAITON LABORATORY	
Course Type	Laboratory	
Course Code	22EC7PC02L	
Category	PCC	
Credit Point	1	
Time Commitment	Lecture	05 Hours
	Tutorial	Nil
	Practice	20 Hours
	Total	25 Hours

Recommended Background Knowledge	Fundamentals of networking, IP addressing and subnetting, OSI and TCP/IP models, basic command line interface (CLI) skills.
Subject Description	This lab course provides practical exposure to computer networking concepts through hands-on experiments. Students will work with LAN hardware, perform cabling, and use tools like Cisco Packet Tracer and NS2 to simulate real-world networks. The course includes network setup, router and VLAN configuration, subnetting, and analyzing data flow using different topologies. It also emphasizes IP addressing, network commands, and congestion analysis. By the end, students will be equipped to design, configure, and troubleshoot networks in simulated environments.
Objectives and Outcomes	**Objectives:** The course should enable the students to: 6. Gain a comprehensive understanding on data communication, layered architecture, and wireless network device concepts. 7. Understand the various techniques used to access a shared channel in the network and IEEE specifications for LANs. 8. Learn about different types of networking devices, backbone networks and Internet Protocol (IP) addressing. 9. Explore the functions of network, transport, and application layer protocols.
	Outcomes: Upon completion of this course, the student will be able to: 1. Identify and implement different types of LAN cabling techniques and configure basic LAN setups using networking hardware and software tools. 2. Apply basic network commands and IP configuration techniques for network setup and troubleshooting in real and simulated environments. 3. Design and simulate different network topologies, including the use of routers, subnetting, and VLANs, using Packet Tracer and NS2. 4. Analyze network performance using simulation tools by evaluating data transfer, congestion, and determining IP-related details programmatically.

Assessment/ Evaluation	Lab Experiments	20%
	Record Writing	10%
	Behavior/ Attitude	05%
	Quiz	10%
	Attendance	05%
	Final Lab Test	30%
	Final Viva/ Final Lab Quiz Test	20%

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Identify and implement different types of LAN cabling techniques and configure basic LAN setups using networking hardware and software tools.	PO1, PO2, PO3, PO4, PO5, PO12, PEO1, PEO2.
CO2	Apply basic network commands and IP configuration techniques for network setup and troubleshooting in real and simulated environments.	PO1, PO2, PO3, PO4, PO5, PO12, PEO1, PEO2.
CO3	Design and simulate different network topologies, including the use of routers, subnetting, and VLANs, using Packet Tracer and NS2.	PO1, PO2, PO3, PO4, PO5, PO9, PO12, PEO1, PEO2.
CO4	Analyze network performance using simulation tools by evaluating data transfer, congestion, and determining IP-related details programmatically.	PO1, PO2, PO3, PO4, PO5, PO9, PO12, PEO1, PEO2.

Perform any 10 Experiment

Sl. No.	Name of Experiments	Duration in Hrs
1	Design and Preparation of Ethernet LAN Cable Using RJ-45.	2
2	To study basic network commands and network configuration commands and understand IP addressing..	2
4	To study and configure a basic router setup using Packet Tracer.	2
5	To implement and configure a three-router topology using Packet Tracer simulator.	2
6	To perform subnetting and analyze network performance using Packet Tracer.	2
7	To study and configure Virtual LANs (VLANs) using Packet Tracer	2
8	To simulate and study the data transfer between two nodes using NS2 (Network Simulator 2).	2
9	To implement and study the performance of a star topology network using NS2.	2
10	To implement and study the performance of a ring topology network using NS2.	2
11	To simulate the transmission of ping and trace route messages in a network of 6 nodes and analyze packet loss due to congestion.	2
12	To Write a program to find out class of a given IP address, sub-net mask, first & last IP address of that subnet etc.	2
13	Implementation and Comparison of Data Transmission Techniques Using LoRa, Wi-Fi, and Bluetooth Protocols.	2
14	Implementation of Network Applications Using Wired Ethernet and Wireless Bluetooth Communication.	2
15	Socket Programming for Client-Server Communication Using HTTP Protocol	2