



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Diploma Engineering

Level: Diploma

**Branch: Electronics & Communication Engineering /
Information & Communication Technology**

Subject Code : DI05000041

Subject Name : IoT

W. E. F. Academic Year:	2026-27
Semester:	5 th
Category of the Course:	PEC-03 / 04

Prerequisite:	Students should have basic knowledge of: • Fundamentals of Electrical and Electronics Engineering • Basic Computer and Internet concepts • Basic programming concepts • Basic understanding of sensors and electronic components
Rationale:	The Internet of Things (IoT) is an emerging technology that enables interconnection of physical devices through the Internet for monitoring, data collection and remote control. This subject introduces students to the fundamental concepts, architecture, communication technologies and cloud platforms used in IoT systems. The course also provides hands-on understanding of ESP32 based IoT development including interfacing of sensors and actuators, wireless data communication and remote monitoring. This knowledge will help students understand modern smart systems used in industries, smart homes, smart cities and other real-world applications.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Explain basic concepts, architecture and components of Internet of Things (IoT).	Remember(R) Understand (U)
02	Describe IoT networking technologies, communication protocols and cloud platforms.	Understand (U)
03	Develop basic programs for ESP32 using Arduino IDE.	Apply (A)
04	Interface sensors and actuators with ESP32 for IoT applications.	Apply (A)
05	Identify and analyze real-world IoT applications and case studies.	Remember(R) Understand (U)

**Revised Bloom's Taxonomy (RBT)*



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Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Tutorial / Practical		
				ESE (E)	PA (M)	PA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Fundamentals of Internet of Things (IoT) 1.1 Introduction to IoT - Definition of Internet of Things, Evolution and history of IoT - Need of IoT in modern world, Characteristics of IoT systems, IoT ecosystem overview - Examples of IoT in everyday life 1.2 Architecture of IoT - Four-layer architecture: Sensing Layer, Network Layer, Data Processing Layer, Application Layer 1.3 Physical and Logical Design of IoT - Physical components of IoT system: Sensors, Actuators, Microcontroller, Communication module - Logical design components: IoT Functional Blocks, IoT Communication Models, IoT Communication APIs 1.4 IoT Enabling Technologies - Wireless Sensor Networks (WSN)(Basic concept) - Cloud Computing (Basic concept) - Artificial Intelligence in IoT (Basic idea) 1.5 IoT Communication Overview - Machine to Machine (M2M) communication - Device-to-Device (D2D) communication - Device-to-Cloud communication - Role of the Internet in IoT 1.6 Challenges in IoT Systems - Design, Security & Deployment Challenges	08	18%
2.	IoT Networking, Protocols and Cloud Technologies 2.1 Fundamentals of IoT Networking Need for networking in IoT, Client–Server architecture	08	18%



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	• Publish–Subscribe architecture, Concept of IP address, MAC address and port number in IoT. • URL and Domain name concept in IoT. 2.2 IoT Communication Protocols • HTTP protocol and REST architecture (GET, POST methods) • MQTT protocol (working, broker, topics, QoS levels) • CoAP protocol (basic concept and applications) • Comparison of HTTP, MQTT and CoAP 2.3 Wireless Communication Technologies in IoT • Wi-Fi (IEEE 802.11) – features and applications • Bluetooth and BLE (basic concept) • LoRa – features and applications • NB-IoT – features and applications • Comparison of Wi-Fi, LoRa and NB-IoT 2.4 IoT Data Formats and APIs • Concept of API, REST API • JSON data format, Data exchange between device and server 2.5 Introduction to IoT Cloud Computing • Concept of Cloud Computing • Need of cloud in IoT • Cloud service models (IaaS, PaaS, SaaS) • IoT Cloud Platforms for Learning: ThingSpeak, Blynk IoT, Arduino IoT Cloud, Ubidots, ThingsBoard (Features, applications and basic implementation)		
3.	ESP32 -WROOM-32 Architecture and Programming Fundamentals 3.1 Introduction to ESP32-WROOM-32) • Overview, features and technical specifications of ESP32 (WROOM-32) • Block diagram, Pin configuration and GPIO mapping • CPU, memory, Wi-Fi and Bluetooth overview of ESP32 • Communication Peripherals of ESP32: UART, I2C, SPI • Comparison of ESP32 with ESP8266 and Arduino 3.2 Basic Terms and Development Environment • Terms used with ESP32: firmware, Wi-Fi, MAC address, SSID, IP address • ESP32 firmware concept • Introduction to Arduino IDE	11	24%



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	• Installation and configuration of Arduino IDE for ESP32, Board configuration and port selection 3.3 Program Development using Arduino IDE • Structure of ESP32 program (setup() and loop()) • Creating, compiling and uploading program to ESP32 • Use of variables, data types, built-in constants, operators, control statements and loops, built-in library functions, user-defined functions, Timer functions and delay functions. 3.4 Digital, Analog, PWM and Serial Operations using ESP32 • GPIO configuration, digital input and digital output operations, LED and switch interfacing through programming. • Analog data reading using ADC, POT interfacing through programming. • PWM generation, duty cycle control and LED brightness control • Serial communication with ESP32, Debugging using Serial Monitor		
4.	Interfacing and Internet-Based Control using ESP32 4.1 Interfacing and Programming of Sensors using ESP32 • Interfacing and programming of temperature and humidity sensor (DHT11 / DHT22), LDR sensor, PIR sensor, Gas sensor (MQ-4), Ultrasonic sensor and Water level sensor • Sensor data acquisition and serial monitoring 4.2 Interfacing and Programming of Actuators using ESP32 • Interfacing and programming of Relay module, DC motor, Stepper motor, Servo motor, Solenoid valve, Buzzer. 4.3 Wi-Fi Based Data Transmission and Control • Connecting ESP32 to Wi-Fi network, Transferring sensor data through Wi-Fi • Sending data to cloud platform, Receiving remote control commands • Controlling actuators through internet • MQTT Communication using ESP32: Connecting ESP32 to MQTT broker, publishing and subscribing topics, sending and receiving sensor data. 4.4 End-to-End IoT System Architecture and Applications • Complete IoT data flow: Sensor → ESP32 Device → Communication Network (Wi-Fi) → Cloud Platform → User Interface → Actuator	11	24%



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	• Illustrative application examples for conceptual understanding of IoT data flow: – Smart Temperature Monitoring and Fan Control System – Smart Motion Detection and Security Alert System <i>(The above examples are intended to explain the complete IoT system workflow / Dataflow from sensing to actuation. No programming implementation is required.)</i>		
5.	IoT Applications and Modern Case Studies 5.1 Broad Categories of IoT Applications • Consumer IoT (CIoT) • Commercial IoT (COIoT) • Industrial IoT (IIoT) • Infrastructure IoT (InIoT) • Internet of Military Things (IoMT) 5.2 Emerging Domains of Internet of Things <i>(Concept and introductory overview only)</i> • Internet of Battlefield Things (IoBT) • Internet of Vehicles (IoV) • Internet of Underwater Things (IoUT) • Internet of Drones (IoD) • Internet of People (IoP) • Internet of Nano Things (IoNT) • Internet of Everything (IoE) 5.3 Modern IoT Case Studies <i>(Conceptual block diagram / sketch and basic working explanation only)</i> • Smart Home Automation System • IoT Based Health Monitoring System • Smart City Street Light Monitoring System • EV Battery Monitoring System • IoT Based Waste Management System	07	16%
	Total	45	100%

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	U Level	A Level	N Level	E Level	C Level
20	45	35	-	-	-

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)



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References/Suggested Learning Resources:

(a) Books:

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Internet of Things: A Hands-On Approach	Arshdeep Bahga, Vijay Madiseti	Universities Press, Hyderabad, 2015, ISBN: 978-8173719547
2	Internet of Things: Principles and Paradigms	Rajkumar Buyya, Amir Vahid Dastjerdi	Morgan Kaufmann, USA, 2016, ISBN: 978-0128053959
3	Designing the Internet of Things	Adrian McEwen, Hakim Cassimally	Wiley, UK, 2014, ISBN: 978-1118430620
4	IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things	David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry	Cisco Press, USA, 2017, ISBN: 978-1587144561
5	Learning ESP32	Rakesh K. Singh, Anita Gehlot, S. B. Goyal	Packt Publishing, UK, 2021, ISBN: 978-1789956672
6	Internet of Things with ESP32	Agus Kurniawan	PE Press / Leanpub, 2019 (ISBN varies by edition)
7	ESP32 Technical Reference Manual	Espressif Systems	Espressif Systems, Latest Edition (Official Documentation)
8	ESP32-WROOM-32 Datasheet	Espressif Systems	Espressif Systems, Latest Version (Official Hardware Datasheet)

(b) Open-source Software, Websites, YouTube Channels, Free MOOC Courses

Category	Name	What It Offers / Why Useful	Source / Link
Open-source Simulation Platform	Tinkercad Circuits	Online electronics and Arduino simulation platform used to design and test circuits virtually without hardware. Useful for learning basic microcontroller programming and circuit design.	https://www.tinkercad.com
Open-source Simulation Platform	Wokwi	Online simulator supporting Arduino, ESP32, STM32 and Raspberry Pi Pico. Allows testing of IoT projects, sensors, and protocols such as MQTT and HTTP directly in the browser without physical hardware. (docs.wokwi.com)	https://wokwi.com
Open-source Software / Development Tool	Arduino IDE	Popular open-source development environment used for writing, compiling and uploading programs to Arduino and ESP32 boards. Widely used in IoT education.	https://www.arduino.cc



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IoT Cloud Platform	ThingSpeak	Cloud platform for collecting, visualizing and analyzing IoT sensor data using APIs and MATLAB analytics. Useful for IoT data monitoring projects.	https://thingspeak.com
IoT Dashboard Platform	Blynk IoT	Platform for building mobile dashboards and remote control applications for IoT devices like ESP32 and Arduino.	https://blynk.io
IoT Learning Website	Random Nerd Tutorials	Popular website providing tutorials on ESP32, IoT projects, sensors, MQTT, Wi-Fi communication and cloud platforms.	https://randomnerdtutorials.com
Electronics Learning Website	Electronics Hub	Provides articles and tutorials on IoT concepts, sensors, communication protocols and embedded systems.	https://www.electronicshub.org
YouTube Channel	Programming Electronics Academy	Provides beginner-friendly tutorials on Arduino programming, circuits and IoT projects.	https://www.youtube.com/@ProgrammingElectronics
YouTube Channel	DroneBot Workshop	Educational channel focusing on Arduino, ESP32, IoT devices, sensors and embedded systems projects.	https://www.youtube.com/@DroneBotWorkshop
Free MOOC Course	Introduction to the Internet of Things	Online course explaining IoT architecture, communication models and applications.	https://www.coursera.org
Free MOOC Course	IoT Programming and Big Data	Covers IoT programming, sensors, networking and cloud integration concepts.	https://www.edx.org
Free Learning Platform	NPTEL – Internet of Things	Free video lectures and course material on IoT concepts, protocols and applications from Indian universities.	https://nptel.ac.in

Suggested Course Practical List:

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Study the IoT ecosystem and identify major components such as sensors, actuators, communication network, gateway and cloud platform used in IoT systems.	1	2



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2	Study the architecture, specifications and pin configuration of ESP32 microcontroller used in IoT applications.	1	2
3	Install and configure ESP32 development environment using Arduino IDE and verify ESP32 board connectivity with computer.	2	2
4	Write and execute ESP32 programs for GPIO interfacing including the following exercises: a) LED blinking using ESP32 b) Switch input reading using ESP32 c) Switch controlled LED operation d) Multiple LED control using ESP32 GPIO pins	2	2
5	Study serial communication in ESP32 and perform serial data transmission and receiving using Serial Monitor.	2	2
6	Demonstration of Wi-Fi connectivity using ESP32 for IoT communication.	3	2
7	Interface environmental and motion sensing devices with ESP32 and read sensor data including the following exercises: a) Interfacing Temperature and Humidity sensor (DHT11/DHT22) b) Interfacing LDR sensor c) Interfacing PIR motion sensor d) Interfacing Ultrasonic distance sensor	3	4
8	Interface actuator devices with ESP32 and perform control operations including the following exercises: a) Interfacing buzzer for alert indication b) Interfacing relay module for switching electrical loads c) Interfacing DC motor and performing motor control d) Interfacing servo motor for position control	3	4
9	Implement IoT cloud connectivity using ESP32 including the following exercises: a) Upload sensor data from ESP32 to an IoT cloud platform such as ThingSpeak, Blynk, Ubidots or ThingsBoard. b) Configure IoT cloud dashboard to display real-time sensor data using widgets such as gauges, charts or indicators	4	4
10	Implement remote control of ESP32 connected devices (LED/relay) using commands from the IoT cloud dashboard.	4	2
11	Develop IoT application for data logging to Google Sheets using ESP32 and Google Apps Script by transmitting sensor data through HTTP request and storing the data in spreadsheet format.	4	4
12	Develop IoT application to generate SMS alert notifications using ESP32 and Twilio API when sensor readings exceed predefined threshold values (e.g., temperature or motion alert).	5	4
13	Develop a simple IoT based alert system using ESP32 and sensors (e.g., motion detection or temperature alert).	4	2
14	Prepare a case study on IoT applications in healthcare systems such as remote patient monitoring, wearable health devices and smart medical equipment.	5	2
15	Study and prepare a case study report on IoT based Electric Vehicle (EV) Battery Monitoring System highlighting sensing parameters, communication architecture and cloud based monitoring of battery health and safety.	5	2



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16	Design and implement a mini IoT application using ESP32 integrating sensors, actuators, Wi-Fi communication and cloud platform (e.g., smart environment monitoring or smart home device control).	4	4
TOTAL			44 Hour (Minimum 30 Hour)

Note:

1. **More number of Practical Exercises may be designed and offered by the respective course teacher** to develop industry-relevant skills and learning outcomes in alignment with the Course Outcomes (COs). The above list is only a **suggestive set of practical exercises**.
2. The practical exercises should emphasize **hands-on implementation using ESP32 based IoT systems**, including sensor interfacing, actuator control, communication, and cloud integration.
3. Teachers are encouraged to design **additional experiments or mini-projects** based on emerging IoT applications such as smart home systems, environmental monitoring, smart agriculture, or industrial automation.
4. The practical sessions should focus on **developing programming skills, hardware interfacing skills, and IoT system integration capabilities** required for real-world applications.

List of Laboratory/Learning Resources Required:

1. Laboratory Equipment

Sr. No.	Equipment / Component	Specification / Example	Purpose
1	ESP32 Development Board	ESP32 WROOM-32	Core controller for IoT experiments
2	Breadboard	Standard solderless breadboard	Circuit prototyping
3	USB Data Cable	Micro-USB cable compatible with ESP32	Programming and power supply
4	Jumper Wires	Male-Male, Male-Female	Interconnection of components
5	LED Module / LEDs	Red, Green, Blue LEDs	GPIO output experiments
6	Push Button Switch	Momentary push button	Digital input experiments
7	Resistors	220Ω, 330Ω, 10kΩ	Current limiting and pull-up/pull-down
8	LDR Sensor Module	Light dependent resistor module	Light intensity sensing
9	DHT Sensor	DHT11 or DHT22 temperature & humidity sensor	Environmental monitoring



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10	PIR Motion Sensor	HC-SR501 or equivalent	Motion detection
11	Ultrasonic Sensor	HC-SR04 distance sensor	Distance measurement
12	Buzzer	Active / Passive buzzer module	Sound alert output
13	Relay Module	1-channel 5V relay module	Control of electrical loads
14	Servo Motor	SG90 micro servo motor	Position control experiments
15	DC Motor	Small DC motor with driver	Motor control experiments
16	Motor Driver Module	L293D / L298N driver	Driving motors from ESP32
17	Wi-Fi Internet Router	Standard wireless router	Internet connectivity for IoT
18	Power Supply	5V regulated power supply	Powering modules
19	Laptop / Desktop Computer	Internet enabled system	Programming and cloud connectivity
20	Basic Electronics Tool Kit	Screwdriver, wire cutter, etc.	Assembly and testing

2. Software / Learning Resources

Sr. No.	Software / Resource	Type	Purpose
1	Arduino IDE	Open Source Software	Programming ESP32 and uploading firmware
2	ESP32 Board Support Package	Development Tool	Enables ESP32 programming in Arduino IDE
3	ThingSpeak	IoT Cloud Platform	Data logging and visualization
4	Blynk IoT	IoT Cloud Platform	Mobile based IoT dashboards and control
5	Ubidots	IoT Cloud Platform	Sensor data monitoring and analytics
6	ThingsBoard	IoT Platform	IoT dashboard and device management
7	Arduino IoT Cloud	IoT Cloud Platform	Cloud-based IoT device management
8	MQTT Broker (Mosquitto / HiveMQ)	Communication Platform	Testing MQTT publish/subscribe communication
9	Serial Monitor (Arduino IDE)	Debugging Tool	Monitoring ESP32 data communication



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10	Web Browser	General Software	Accessing cloud dashboards and IoT services
11	ESP32 Documentation	Technical Reference	Understanding ESP32 architecture and APIs
12	GitHub	Online Repository	Accessing open source IoT example codes
13	Random Nerd Tutorials	Online Learning Resource	ESP32 IoT project tutorials
14	YouTube Educational Channels	Learning Resource	Visual demonstrations of IoT experiments
15	Free MOOC Platforms (NPTEL, Coursera, edX)	Online Courses	Self-learning IoT and embedded systems

Suggested Project List:

Sr. No.	Project Title	Brief Description	Hardware and Software Required
1	Smart Temperature and Humidity Monitoring System	Monitor temperature and humidity using ESP32 and upload real-time data to an IoT cloud dashboard.	ESP32, DHT11/DHT22 sensor, Wi-Fi router, Arduino IDE, IoT cloud platform
2	IoT Based Smart Street Light System	Automatically control street lights based on ambient light intensity using LDR and monitor status remotely.	ESP32, LDR sensor, relay module/LED, Arduino IDE, IoT cloud platform
3	Smart Motion Detection and Security Alert System	Detect human movement using PIR sensor and send alerts or trigger alarm through IoT cloud.	ESP32, PIR motion sensor, buzzer, Arduino IDE, IoT cloud platform
4	IoT Based Smart Parking Monitoring System	Detect parking availability using ultrasonic sensor and display status on IoT dashboard.	ESP32, Ultrasonic sensor, Wi-Fi router, Arduino IDE, IoT cloud platform



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5	Smart Water Level Monitoring System	Measure water level in tank using ultrasonic sensor and monitor readings on cloud dashboard.	ESP32, Ultrasonic sensor, Arduino IDE, IoT cloud platform
6	IoT Based Home Appliance Control System	Remotely control household electrical devices using ESP32 and relay module via mobile dashboard.	ESP32, relay module, electrical load/LED, Arduino IDE, IoT cloud platform
7	Smart Door Lock System	Control door locking mechanism using ESP32 and servo motor through IoT interface.	ESP32, servo motor, Arduino IDE, IoT cloud platform
8	IoT Based Environmental Monitoring System	Monitor environmental parameters such as temperature, humidity and light intensity using sensors and cloud dashboard.	ESP32, DHT11/DHT22, LDR sensor, Arduino IDE, IoT cloud platform
9	Smart Intruder Alarm System	Detect intrusion using motion sensor and trigger buzzer alarm with remote monitoring capability.	ESP32, PIR sensor, buzzer, Arduino IDE, IoT cloud platform
10	IoT Based Distance Monitoring System	Measure and monitor distance using ultrasonic sensor and display data on cloud charts.	ESP32, Ultrasonic sensor, Arduino IDE, IoT cloud platform
11	Smart Fan Control System	Automatically control a fan using temperature sensor data and relay module through IoT platform.	ESP32, DHT11/DHT22, relay module, Arduino IDE, IoT cloud platform
12	IoT Based Smart Lighting System	Control room lighting remotely and automatically based on light intensity using IoT platform.	ESP32, LDR sensor, relay module/LED, Arduino IDE, IoT cloud platform



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13	IoT Based Motion Activated Lighting	Automatically switch ON lights when motion is detected using PIR sensor and ESP32.	ESP32, PIR sensor, relay module/LED, Arduino IDE, IoT cloud platform
14	IoT Based Smart Doorbell System	Send notification to cloud or mobile dashboard when doorbell button is pressed.	ESP32, push button switch, buzzer, Arduino IDE, IoT cloud platform
15	IoT Based Smart Room Monitoring System	Monitor room environmental conditions such as temperature, humidity and motion through IoT dashboard.	ESP32, DHT11/DHT22, PIR sensor, Arduino IDE, IoT cloud platform
16	IoT Based Automatic Alarm System	Generate alarm when sensor values exceed predefined threshold conditions.	ESP32, sensors (DHT11/LDR/PIR), buzzer, Arduino IDE, IoT cloud platform
17	IoT Based Smart Garage Door Control	Open and close garage door remotely using servo motor through IoT interface.	ESP32, servo motor, Arduino IDE, IoT cloud platform
18	IoT Based Smart Plant Monitoring System	Monitor environmental conditions around plants and display readings on IoT dashboard.	ESP32, DHT11/DHT22, LDR sensor, Arduino IDE, IoT cloud platform
19	IoT Based Security Monitoring System	Monitor movement and send alerts through IoT dashboard when intrusion is detected.	ESP32, PIR sensor, buzzer/relay module, Arduino IDE, IoT cloud platform
20	IoT Based Smart Device Monitoring System	Monitor status of connected electrical devices and display information on IoT cloud dashboard.	ESP32, relay module, LED/load, Arduino IDE, IoT cloud platform



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Note:

The above project list is only suggestive. Students may select or propose any suitable IoT based project aligned with the course outcomes and course content using ESP32, sensors, actuators, Wi-Fi communication and IoT cloud platforms. The respective course teacher may modify or assign additional projects based on available laboratory resources, emerging technologies and industry requirements.

Suggested Activities for Students:

Sr. No.	Activity	Description
1	Identification of IoT Devices in Daily Life	Students identify and list IoT enabled devices used in homes, industries or smart cities and discuss how sensors, connectivity and cloud are used in them.
2	ESP32 Development Board Familiarization	Students physically explore the ESP32 development board, identify GPIO pins, communication interfaces and basic hardware components using datasheet and board layout.
3	IoT Sensor Demonstration Activity	Students demonstrate the working of different sensors such as temperature & humidity sensor, LDR, motion sensor and ultrasonic sensor by interfacing them with ESP32.
4	Actuator Control Demonstration	Students perform simple control operations of actuators such as buzzer, relay module, DC motor and servo motor using ESP32.
5	Wi-Fi Connectivity Setup Activity	Students configure Wi-Fi connectivity on ESP32 and test successful network communication with a computer or cloud platform.
6	IoT Cloud Dashboard Creation	Students create a simple IoT dashboard on a cloud platform to display sensor data using graphical widgets such as charts, gauges or indicators.
7	MQTT Communication Demonstration	Students demonstrate publish and subscribe communication using MQTT protocol between ESP32 and an IoT cloud broker.
8	Case Study Presentation on IoT Applications	Students prepare and present short case studies on IoT applications such as smart parking, smart street lighting, smart surveillance or smart energy systems.
9	End-to-End IoT System Demonstration	Students demonstrate the complete IoT data flow from sensor to cloud and user interface using a simple ESP32 based IoT setup.
10	Exploration of Emerging IoT Domains	Students explore modern IoT domains such as IoV, IoD, IoNT or IoE and prepare a short technical note or presentation.
11	IoT Data Visualization Activity	Students analyse sensor data stored on cloud platforms and interpret graphical charts or dashboards generated from the data.
12	Mini IoT Project Development	Students develop a small IoT based system using ESP32, sensors and cloud platform for monitoring or control application.



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Note:

The above activities are suggestive in nature. The respective course teachers may design additional activities aligned with the course outcomes, practical work and emerging IoT technologies to enhance student learning.

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