GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Subject Code: BE04045021
Subject Name: Fundamental of IoT

w. e. f. Academic Year:	2024-25
Semester:	4
Category of the Course:	Professional Core Course

Prerequisite:	Basic knowledge of programming, computer networks, and Basics of Microcontroller, Processors, and Electronics
Rationale:	The Internet of Things (IoT) plays a vital role in connecting a wide range of devices through the Internet, enabling smarter and more efficient systems. As a rapidly evolving technology, IoT has found applications in various sectors such as manufacturing, healthcare, agriculture, transportation, mining, smart cities, and more. This subject introduces the fundamental concepts of IoT, including its architecture, protocols, and real-world applications. It also provides an overview and hands-on programming experience with two widely used IoT platforms: Arduino and Raspberry Pi.

Course Outcomes:

Sr. No.	CO statement	Marks% weightage
CO-1	Explain the fundamental concepts, architecture, and evolution of the Internet of Things, including its applications across various domains. **(Cognitive Level: Understanding)**	15
CO-2	Identify and compare different IoT communication protocols, hardware components, and software platforms used in the development of IoT systems. **(Cognitive Level: Analyzing)**	20
CO-3	Demonstrate the ability to interface sensors and actuators with microcontrollers such as Arduino and ESP32 for data acquisition and control. **(Cognitive Level: Applying)**	20
CO-4	Develop basic IoT applications using Arduino and Raspberry Pi and integrate them with cloud platforms for real-time data visualization and analytics. **(Cognitive Level: Creating)**	25
CO-5	Analyze security threats in IoT systems and propose lightweight cryptographic solutions to ensure data integrity, confidentiality, and availability. **(Cognitive Level: Evaluating)**	20

Teaching and Examination Scheme:

Teaching - Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
L	T	P	PBL *	TH		Theory		Tutorial / Practical			
						ESE (E)	PA (M)	PA (I)	PBL (I)	ESE (V)	
45	0	30	45	120	04	70	30	20	30	50	200

Content:

Sr. No.	Content	Total Hrs
1	**Introduction to Internet of Things:** Definition and key characteristics of IoT, challenges in IoT adoption, evolution and enabling technologies; applications across domains such as smart homes, healthcare, agriculture, and industry; comparison between IoT, M2M, CPS, and WSN; IoT reference architectures including 3-layer and 5-layer models.	8
2	**Sensors and Actuators:** Overview of sensors, actuators, gateways, and edge devices; types of sensors and their working principles; characteristics and requirements of constrained nodes in IoT environments.	8
3	**IoT Hardware and Platforms:** Architecture and features of microcontrollers and microprocessors (ESP8266, ESP32, Arduino Uno, Raspberry Pi, NodeMCU), Arduino architecture and programming using Arduino IDE with sensor and module interfacing, Raspberry Pi architecture and application development, NodeMCU programming and use in IoT systems.	8
4	**IoT Protocols:** Wired and wireless communication technologies, application layer protocols like HTTP, MQTT, CoAP, and link-layer protocols such as LoRa, Zigbee, Bluetooth, BLE, Wi-Fi; network layer protocols including IPv4, IPv6, 6LoWPAN; device discovery and addressing mechanisms.	8

5	**Cloud for IoT:** Role of cloud computing in IoT, cloud architecture for IoT systems, IoT data storage and processing, cloud-based communication models, integration with platforms like ThingSpeak, Firebase, AWS IoT, Blynk, scalability and reliability, security and privacy in cloud-enabled IoT.	**8**
6	**IoT Security:** Security challenges in IoT; data confidentiality, integrity, and availability; lightweight cryptography; authentication and access control; secure communication protocols.	**5**
	TOTAL	**45**

Suggested Specification table with Marks (Theory): (For B.E. only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
5	**20**	**25**	**15**	**15**	**20**

R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things" - David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, and Jerome Henry.
2.Internet of Things, Vasudevan, Nagrajan and Sundaram, Wiley India
3. Internet of Things – A Hands-on Approach, Arshdeep Bahga, Vijay Madisetti
4. Mastering the Internet of Things, Peter Waher
5. Internet of Things (IoT): Architecture and Applications, Rajkumar Buyya
6. Learning IoT with ESP32, Manoj Thakur (for practicals)

List of Experiments:
1) Study and installation of Arduino IDE and programming environment for writing and uploading basic programs to Arduino/NodeMCU.

2) Write a program to blink an LED using Arduino or NodeMCU to demonstrate digital output control.

3) Interface a DHT11 sensor with Arduino/NodeMCU to measure temperature and humidity and display output on the serial monitor.
4) Interface an LDR (Light Dependent Resistor) with Arduino to detect light intensity and control an LED based on threshold.
5) Interface an ultrasonic sensor to measure distance and trigger an action such as activating a buzzer or LED when an object is near.
6) Control a DC motor or servo motor using Arduino with input from a push button or sensor to demonstrate actuator control.
7) Interface a relay module with Arduino to simulate smart appliance control (e.g., turning ON/OFF a bulb or fan).
8) Connect NodeMCU/ESP32 to Wi-Fi and display the connection status on the serial monitor.
9) Send sensor data to a web server or local IP page using ESP8266/ESP32 over Wi-Fi.
10) Implement MQTT protocol by publishing temperature data to a broker and subscribing to control an LED remotely.
11) Send live sensor data to ThingSpeak and visualize it in real-time on cloud dashboards.
12) Push sensor data to Firebase Realtime Database using ESP8266/ESP32 and retrieve it via cloud dashboard.
13) Control an IoT device using the Blynk platform with a smartphone app (e.g., toggle LED or read sensor data).
14) Install and configure Raspberry Pi with Raspbian OS, and demonstrate basic GPIO control (e.g., LED blinking).
15) Interface a motion sensor (PIR) with Raspberry Pi or Arduino to detect movement and trigger a response.
16) Demonstrate a simple encryption technique (e.g., XOR or basic AES) to secure data before transmission over the network.
17) Design and implement a mini IoT project integrating sensors, actuators, and cloud (e.g., smart irrigation, home automation, or weather station).

Major Equipment:

Arduino Uno, ESP32/ESP8266 (NodeMCU), Raspberry Pi, Breadboards, Jumper wires, Power supply modules, DHT11/DHT22 sensors, LDR, Ultrasonic sensor, PIR sensor, Relay module, DC/Servo motors, LEDs, Resistors, IoT Wi-Fi module, USB cables, SD card (for Raspberry Pi), and access to Internet/Wi-Fi and computers with Arduino IDE, Python/MicroPython, and cloud platform access.

List of Open Source Software/learning website:

- **W3Schools – Internet of Things Tutorials**
  Learn the **basic concepts** of IoT, architecture, and protocols in a beginner-friendly way.
  https://www.w3schools.com/iot/

- **IoTbyHVM.OOO – Learn IoT Practically**
  Offers tutorials on **Arduino, ESP8266, MQTT, protocols**, and hands-on interfacing with sensors.
  https://iotbyhvm.ooo
- **Random Nerd Tutorials – ESP32 & ESP8266 Projects**
  Great resource for **practical coding**, interfacing sensors, cloud integration, and dashboards.
  https://randomnerdtutorials.com
- **CircuitDigest – IoT Projects and Tutorials**
  Includes **circuit diagrams, code, and applications** for Arduino, Raspberry Pi, and other platforms.
  https://circuitdigest.com
- **Hackster.io – Community IoT Projects**
  Explore thousands of **real-world IoT projects**, many using cloud services like Blynk, Firebase, AWS IoT.
  https://www.hackster.io
- **ThingSpeak – Official Documentation and Guides**
  Learn how to **log and visualize IoT data** on the cloud using ThingSpeak with ESP/Arduino.
  https://thingspeak.com/docs

- **List of suggested activities for Problem Based Learning:**

Sl. No.	Name of the activity	No. of hours	Evaluation Criteria
1	Assignment writing. Numerical based assignment is preferable.	5 assignments of 3h each. Total = 15h	Based on the assignment submitted.
2	Problem solving/Coding using C, C++, Python, SCILAB, MATLAB, MS-EXCEL or any other relevant software	5 small coding-based problems of 3h each. Total = 15h	Based on the coding solution submitted.
3	Technical Video based learning related to the subject	Duration of video = 5h Report preparation & Presentation = 10h Total = 15h	Report /presentation based on the video learning outcomes.
4	Discussion on research paper based on relevant subject	3 research paper = 15h	Summarize research paper and evaluation critical parameters
5	Poster/chart/power point preparation on technical topics	Duration = 10 h	Based on poster/chart preparation and presentation skills
6	Application/Software development	Duration = 15 h	Depending on the complexity of the Application/Software

7	Group Discussion on emerging/trending technical topics based on subject	Duration = 1 h each	Based on performance in group discussion, technical depth, knowledge etc.
8	Seminar / Presentation	Duration for study and preparation=5h Report writing=3h Presentation=2h Total=10h	Topic can be selected technical content beyond syllabus
9	Real world case studies-based learning	Duration of data collection/study = 5h Report preparation = 10h Total = 15h	Based on in-depth study, technical depth, data collected, fact finding, etc.
10	Working/non-working model on technical topics	Working = 12 h Non- working = 8 h	Based on inter department/external evaluation
11	Self-learning on-line course	Minimum duration of the course should be 15h.	Examination based assessment at the end of course. Based on the certificate produced.
12	Complex problem solving	Maximum 3 problem. Study of the problem and solution finding, Total = 15h	Based on the depth of the solution submitted.
13	Industry/Research laboratory visit	Visit = 5h, Report preparation = 5h Total = 10h	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
14	Videos on Industrial safety aspects based on subject	Duration of video = 5h Report preparation = 5h Total = 10h	Based on quiz/report submitted
15	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment /health/any other issue	Duration = 15 h for industrial exposure Problem identification and tentative solution = 10 h Total = 20 h	Based on evaluation of critical problems and solutions

Note:

- All the suggested activity should be related to the subject.
- Min 3 activities must be carried out as per the availability of faculties and students.
- The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
- Rubrics for the evaluation can be prepared by the faculty.

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