GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2023 (COGC-2023)
Semester – V

Course Title: Internet of Things
(Course Code: 4351703)

Diploma programme in which this course is offered	Semester in which offered
Instrumentation and Control	5th Semester

1. RATIONALE

The purpose of this course is to present an introduction to the multidisciplinary field of Internet of Things for industrial applications. The course initially covers the fundamental concepts of Internet and its application in real and industrial world. It covers the concepts of wireless sensor network and methods implementation of IoT.

2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Understand concept of Internet of things.**
- **Select Hardware and software requirements for given IoT application**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

CO1	Summarize concept of IoT in Instrumentation Industry
CO2	Understand Fundamentals of Networking and Protocols
CO3	Choose the hardware for given IoT application
CO4	Summarize the database and GUI requirements for given IoT application
CO5	Relate the requirements for the cloud for given IoT application

Practical COs:

CO1	Implement the concept of Hardware interfacing for IoT application
CO2	Build a Graphical user interface for IoT application
CO3	Select appropriate database to handle the data stream from the IoT Nodes

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** - End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) that are the sub-components of the COs. *Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Compare IoT functional block with real IoT system	1	2Hrs
2	Study key deliverables from M2M policy of INDIA announced by Government of INDIA.	2	2Hrs
3	Create Network host and a data server and interact with your group and study the networking aspects of the same.	2	2Hrs
4	Prepare a comparison sheet / poster for Bluetooth, WiFi, Zigbee, LORA	2	2Hrs
5	Study Interfacing diagram for Arduino Mega 2560 development board	3	2Hrs
6	Interface a display, a sensor and a communication module with Arduino Mega 2560 and trigger a relay with the same.	3	4Hrs
7	Study Interfacing diagram for latest Raspberry Pi development board	3	2Hrs
8	Install webserver in your local machine and perform basic operations on the server.	3	2Hrs
9	Create an cloud based IoT Data server	4	2Hrs
10	Store and Sensor data on the created IoT Server	4	2Hrs
11	Create an android app for given IoT application	4	2Hrs
12	Compare Cloud based IoT Platforms	5	2Hrs
13	Study basic fundamental of COOJA IoT simulator.	5	2Hrs
14	Simulate an IoT program with 10 Nodes with COOJA simulator.	5	4Hrs
15	Develop an IoT based Micro project	5	4Hrs

Note

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

ii. *The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare experimental setup	20
2	Operate the equipment setup or circuit / Software	20
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	30
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practical in all institutions across the state.

Sr. No.	Equipment Name	PrO. No.
1	Bluetooth, WiFi, Zigbee, LORA modules	2
2	Arduino Mega 2560	5
3	HC SR 04 / LDR / LM35 any one sensor , Arduino Mega 2560 , Relay , Wires / Programing PC ,communication module	6,10,11
4	Raspberry Pi 3 or above	7
5	Computer system	6,8,9,10,11,12
6	Amazon / Cooja IoT Simulator software	13,14

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfil the development of this competency.

a) Work as a leader/a team member for Mirco project.
b) Follow best practices and procedure in Lab.
c) Realize the importance of engineering for societal development.
d) Develop gradually the engineering mindset in day-to-day observation.

8. UNDERPINNING THEORY:

Unit	Unit Outcomes (UOs)	Topics and Sub-topics

Unit – I Introduction of IoT	1.a. Summarize concept of IoT in Instrumentation Industry 1.b. Describe the characteristics of IoT 1.c. Write a Note on Physical Design of IoT 1.d. Explain IoT Functional Blocks. 1.e. Explain OSI Model for communication 1.f. Explain IoT Enabling Technologies 1.g. Discuss the role of wireless sensor network 1.h. Discuss role in IoT Big Data Analytics	1.1. Introduction of IoT a. Things that collect information and send it b. Things that receive data and act on it c. Things that can perform both these tasks 1.2. The benefits of IoT in the instrumentation industry 1.3. 10 Characteristics of IoT 1.4. IoT physical entities 1.5. IoT Building blocks – Architecture 1.6. IoT enabling technologies a. Wireless Sensor Network b. Cloud Computing c. Big Data Analytics d. Communications Protocols e. Embedded System 1.7. Overview of Wireless sensor Networks a. Introduction of WSN b. Working of WSN c. Role of WSN in IoT d. Applications 1.8. Overview of Big data a. Introduction of BD b. Working of BD c. Role of BD in IoT d. Applications
Unit – II IoT Protocols & Networking Fundamentals	2.a. Discuss about the working of M2M and its evolution 2.b. Explain the role of M2M in IoT 2.c. Explain the concept of server and client with an example 2.d. Describe the functions of each layer of OSI Reference model 2.e. Explain given technology with its advantages and disadvantages 2.f. Explain MQTT protocol with example	2.1. Introduction of M2M 2.2. Evolution of M2M 2.3. Working of M2M 2.4. Role of M2M in IoT 2.5. Concept of server and client a. Network Host and client b. Data server c. Web server 2.6. Brief functional description of each The OSI-ISO Reference Model layers with list of protocols 2.7. Peer-to-Peer Technologies a. Bluetooth Classic b. WiFi Direct c. Near-Field Communication 2.8. Low-power / Short-range / Low-data Mesh Technologies a. Bluetooth Low-Energy (BLE) / Bluetooth 5

		b. Zigbee c. Z-Wave d. 6LoWPAN 2.9. Local Area Network (LAN) Technologies 2.10. Long-distance Cellular Technologies a. GSM / GPRS b. LTE 2.11. Low-power Long-distance Technologies a. LoRa / LoRaWAN b. NB-IOT c. LTE-M 2.12. Overview of MQTT Protocol
Unit – III Hardware for IoT	3.a. Study basics fundamentals of Microprocessors and Microcontroller 3.b. Draw a pin diagram of Arduino Mega 2560 board 3.c. Discuss about sketch list various operators and structures 3.d. Explain given functions for Arduino programming 3.e. Explain given variable of data types for Arduino programming 3.f. Explain I2C communication for the Mega 2560 and draw block diagram of sensor interfaced with controller using I2C 3.g. Draw a pin diagram of Raspberry Pi 3 board 3.h. Present a comparison for Arduino development board and Raspberry Pi single board computer 3.i. List five other Development boards used for IoT developments	3.1. Introduction of Microprocessors & Controllers a. Concept of Clock b. RAM and ROM c. Peripherals d. Comparison 3.2. Introduction to Arduino Board Mega2560, GPIO in Mega2560 3.3. About Sketch a. Loop function b. Setup function c. Control Structure d. Arithmetic Operators e. Comparison Operators f. Boolean Operators 3.4. Basic functions of the programming a. Digital I/O b. Analog I/O c. Time d. Communication (Serial, SPI and WIRE) 3.5. Variables a. Constants b. Data Types 3.6. Interfacing I2C on Mega2560 3.7. Introduction to Raspberry PI 3 board, GPIO in Raspberry PI 3 3.8. Comparison for Arduino development board and Raspberry Pi single board computer 3.9. Five other Development boards used for IoT developments

Unit – IV Data base and UI for IoT	4.a. Explain need of Database for IoT 4.b. Discuss Key factors for selecting a database for IoT applications 4.c. List types of data in IoT 4.d. List different available database widely used for IoT 4.e. Explain the details and benefits of given database 4.f. Describe need of UI for IoT application	4.1. Introduction to Database 4.2. Need of Database for IoT 4.3. Key factors for selecting a database for IoT applications 4.4. Types of data in IoT 4.5. Different available database widely used for IoT a. InfluxDB b. CrateDB c. MongoDB d. RethinkDB e. SQLite Database 4.6. Introduction to IoT Graphical user interface 4.7. Need of GUI for IoT a. Receiving Automatic Notifications b. Monitoring Information Proactively c. Controlling the System Remotely
Unit - V Cloud Computing & IoT Simulation	5.a. Explain Cloud Computing 5.b. Benefits And Functions of IoT Cloud 5.c. Compare of Internet of Things and Cloud Computing 5.d. Explain the Role of Cloud Computing on the Internet of Things 5.e. Introduce cloud based IoT platforms with brief description 5.f. List different IoT Simulator 5.g. Explain features / advantages of using IoT simulator	5.1. Basics of Virtualization, Specific Characteristics that Define a Cloud 5.2. Understanding Elasticity, Resiliency, On-Demand and Measured Usage 5.3. Comparison of Internet of Things and Cloud Computing**:** a. Platform as a Service (PaaS), b. Infrastructure as a Service (IaaS) c. Software as a Service (SaaS) d. Public cloud e. Private cloud f. Hybrid cloud 5.4. Benefits, Challenges and Risks of Cloud Computing Platforms and Cloud Services 5.5. Introduction to cloud based IoT platforms a. IBM b. Bluemix c. Amazon 5.6. IoT Simulator a. Amazon IoT Simulator b. COOJA IoT Simulator

***Note**: The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

9. SUGGESTED SPECIFICATION TABLE FOR SEMINAR FINAL ESE (VIVA) DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction of IoT	8	4	6	4	14
II	IoT Protocols & Networking Fundamentals	8	4	4	6	14
III	Hardware for IoT	8	6	4	4	14
IV	Data base and GUI for IoT	10	4	4	6	14
V	Cloud Computing & IoT Simulation	8	4	6	4	14
Total		**42**	**22**	**24**	**24**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Understand the different protocols and their purposes used to communicate in IoT.
b) Learn and Understand different Cloud Platform Services Offered by Vendors
c) Learn the Deployment steps of any Domain specific IoT Services
d) Learn/Compare Different Hardware Boards for Creating IoT Services
e) Understand the different functionalities of sensors in IoT Devices
f) Understand integrating IoT Services to other third party Clouds
g) Discuss Privacy Issues in IOT
h) Quiz

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES

Following Sample strategies teacher can use to accelerate the attainment of the various outcomes in this course:

a) Inspire Student to read books on development and evolution of IoT , instruct them to take notes in form of summary
b) Prepare a short note on applications of IoT in Process industry.
c) Guide students to make presentation on various applications of IoT in medical field in small groups.
d) List out various programming languages / Database used in IoT along with their advantages and limitations.

12. SUGGESTED MICRO-PROJECTS

The micro-project could be industry application based, internet-based, workshop based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than 16 (sixteen) student engagement hours during the course. The student ought to submit a micro-project by the end of the semester to develop the industry oriented COs. A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

1) Prepare a chart / model of applications of IoT.
2) Prepare a project on interfacing sensor with any microcontroller sending data to cloud.
3) Prepare a database on existing cloud platform to the data from sensors.
4) Prepare a comparison sheet o cloud platforms offering IoT services

13. SUGGESTED LEARNING RESOURCES (MUST READ ONES!!!)

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Designing the Internet of Things	Adrian McEwen & Hakim Cassimality	Wiley India, ISBN: 9788126556861
2	Internet of Things – A Hands on Approach	Arshdeep Bahga and Vijay Madisetti	Universities Press, ISBN: 9788173719547
3	Getting Started with the Internet of Things	Cuno Pfister	ASIN : B00COVJUGI Publisher : Make Community LLC
4	Building the Internet of Things: Implement New Business Models, Disrupt Competitors, Transform Your Industry	Maciej Kranz	Publisher : Wiley; 1st edition ISBN-10 1119285666
5	Build Your Own IoT Platform: Develop a Fully Flexible and Scalable Internet of Things Platform in 24 Hours	Anand Tamboli	Publisher : Apress; 1st ed. Edition ISBN-10 : 1484244974

14. SOFTWARE/LEARNING WEBSITES

1. **https://iot4beginners.com**
2. **https://www.futurelearn.com/**
3. **https://ocw.mit.edu/ (MIT open course)**
4. **https://www.geeksforgeeks.org/difference-between-arduino-and-raspberry-pi/**
5. **https://www.electronicshub.org/arduino-mega-pinout/**
6. **https://www.techtarget.com/iotagenda/tip/Top-12-most-commonly-used-IoT-protocols-and-standards**
7. **https://www.tutorialspoint.com/what-are-the-characteristics-of-internet-of-things-iot**
8. **https://mindmajix.com/big-data-in-iot#what-is-iot**
9. **http://ai2.appinventor.mit.edu/reference/other/IoT.html**
10. **https://aws.amazon.com/solutions/implementations/iot-device-simulator/**

IoT and M2M Policy of INDIA

https://dot.gov.in/sites/default/files/National%20Telecom%20M2M%20Roadmap.pdf

15. PO-COMPETENCY-CO MAPPING

Semester V	Internet of Things (Course Code: 4351703)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Summarize concept of IoT in Instrumentation Industry	3	1	-	-	-	-	-
Understand Fundamentals of Networking and Protocols	2	2	1	2	-	-	2
Choose the hardware for given IoT application	3	3	2	2	-	1	2
Summarize the database and GUI requirements for given IoT application	2	2	1	2	1	-	2
Relate the requirements for the cloud for given IoT application	3	1	-	1	-	1	1

Legend: '**3'** for high, '**2**' for medium, **'1'** for low or **'-'** for the relevant correlation of each competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Member – Board of Studies (GTU), Electrical and Allied branches

Prof. Suresh Z. Shyara, IC Engineering, AVPTI, Rajkot

Prof. Mahesh J. Vadhavaniya, IC Engineering, Government Polytechnic, Palanpur

GTU Resource Persons

Prof. Dhaval Dhokia, IC Engineering, AVPTI, Rajkot

Prof. Urvish P. Soni, IC Engineering, Government Polytechnic, Ahmedabad