GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-V

Course Title: Internet of Things
(Course Code: 4351101)

Diploma programmer in which this course is offered	Semester in which offered
Electronics & Communication Engineering	5th Semester

1. RATIONALE

The Internet of Things (IoT) connects physical devices, vehicles, buildings, and other items to the Internet, enabling them to collect and exchange data. IoT aims to improve efficiency, enhance decision-making, and create new business opportunities. This course introduces the fundamental concepts, technologies, and applications of the IoT. Students will learn how to design and implement IoT systems, analyze and interpret data from IoT devices, and understand the impact of IoT on various industries.

2. COMPETENCY

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

- **Develop, test and maintain IoT System.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

1) Understand the basic concepts, components, and architecture of IoT.
2) Learn the various protocols used to design IoT systems.
3) Design and implement IoT systems by using sensors, actuators, and platforms (Arduino/NodeMCU/Raspberry Pi).
4) Demonstrate IoT-based Cloud Service and Case Study.

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	
2	0	2	3	30*	70	25	25	100

(*): 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) are the subcomponents of the Course Outcomes (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'.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	To study IoT Architecture	I	2
2	To study IoT Protocols	II	2
3	Getting started with NodeMCU, Arduino with ESP8266 and ESP32 in the Arduino IDE.	III	2
4	GPIO Interfacing and programming (LED, Switch, Motor).	III	2
5	Digital on/off sensor (PIR and IR) Interfacing programming.	III	2
6	Controlling devices remotely using Bluetooth link.	III	2
7	Controlling devices remotely using Wi-Fi link.	III	2
8	Web based device control (Perform the practical to build a web server and control device from a local web server).	IV	2
9	Getting started with different cloud system.	IV	2
10	Analog sensor programming and uploading sensor data on cloud.	IV	2
11	Interfacing and programming of actuators, Control devices remotely using cloud.	IV	2
12	Introduction to raspberry pi and installing operating system for raspberry pi	IV	2
13	Controlling devices remotely using raspberry pi based server	IV	2
14	Getting started with cisco packet tracer and implement IoT based home automation using it.	IV	2
			28 Hrs.

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.*

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Understand the basic concept, components, and architecture of IoT System	20
2	Program Embedded IoT devices	30
3	Use IoT protocol to upload sensor data and to control devices	20
4	Design IoT application	30
Total		**100**

5. MAJOR EQUIPMENT/ INSTRUMENTS AND SOFTWARE REQUIRED

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

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Computer system with operating system: Windows 7 or higher Ver., macOS, and Linux, with 4GB or higher RAM, Python versions: 3.7.X	All
2	Various Sensors, various Actuator, and Physical Devices (NodeMCU, Arduino with ESP8266, ESP32 in the Arduino IDE, Raspberry-pi)	All

6. 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 fulfill the development of this course competency.

a. Work as a leader/a team member (while doing a micro-project).
b. Follow safety practices.
c. Maintain tools and equipment's.
d. Adhere to ethical practices.

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit-I **Introduction to IoT**	Students will able to:- 1.a Understand the basic concept of IoT 1.b Explain IoT Architecture and the major components of IoT 1.c Challenges and applications of IoT	**1.1** IoT Definition **1.2** IoT characteristics **1.3** M2M and IoT **1.4** End-to-End IoT Architecture **1.5** The physical design of IoT **1.6** Logical Design of IoT **1.7** Interdependencies of IoT and cloud computing **1.8** IoT challenges **1.9** IoT applications • Consumer IoT, • Commercial IoT, • Industrial IoT, • Infrastructure IoT, • Military Things (IoMT)
Unit-II **IoT Protocols**	Students will be able to:- 2.a Understand the protocols and their need in IoT	**2.1** Lists and operations on Lists **2.2** Link layer protocols, **2.3** Network layer protocols **2.4** Transport layer protocols **2.5** Application layer protocols: • Hypertext transfer protocol (HTTP), • Systematic HTTP access methodology, • Web Socket. **2.6** Constrained application protocol (CoAP) **2.7** Message Queue Telemetry Transport Protocol (MQTT) **2.8** Secure MQTT **2.9** XMPP **2.10** AMQP
Unit-III **IoT Physical Devices and Endpoints**	Students will be able to:- 3.a Understand the various physical devices 3.b Able to interface with, controlling hardware, actuator, and sensors with Arduino/NodeMCU	**3.1** Introduction to • Arduino • NodeMCU, • Raspberry Pi **3.2** Serial, SPI, I2C **3.3** Controlling actuators- (interface with Arduino/ NodeMCU)

		• Connecting LED, • Buzzer, • Switching High Power devices with transistors, • Controlling AC Power devices with Relays, • Controlling servo motor, • Speed control of the DC Motor, • Unipolar and Bipolar Stepper motors **3.4** Sensors- (interface with Arduino/ NodeMCU) • Light sensor, • Temperature sensors, • voltage sensor, • Temperature and Humidity Sensor DHT11, • Motion Detection Sensors, • Wireless Bluetooth Sensors, Level Sensors, • Distance Measurement with Ultrasonic sensor • NFC • RFID • Fingerprint Sensor
Unit-IV **IoT Physical Servers, Cloud Offerings with some case studies**	Students will be able to:- 4.a Understand the various cloud service 4.b Learn some IoT-based case studies	**4.1** Introduction to • Cloud Storage models • Communication APIs **4.2** Web Server • Web server for IoT, • Cloud for IoT **4.3** IoT Case Study • Home automation with IoT, River water pollution monitoring, • Smart city street light control and monitoring, • Health care monitoring,

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to IoT	6	4	8	4	16
II	IoT Protocols	8	4	12	4	20
III	IoT Physical Devices and Endpoints	8	4	4	12	20

IV	IoT Physical Servers, Cloud Offerings with some case studies	6	2	4	8	14
Total		**28**	**14**	**28**	**28**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
Note*: This specification table provides general guidelines to assist students for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to 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 slightly vary 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 perform following activities in group (or individual) and prepare reports of about 5 pages for each activity. They should also collect/record physical evidence for their (student's) portfolio which may be useful for their placement interviews:

a) Undertake micro-projects in teams .
b) Give a seminar on any relevant topics.
c) Participate in various online hackathons programmes/competition.
d) Make a list of IoT based emerging technology/applications.
e) Students are encouraged to register themselves in various MOOCs such as: Swayam, edx, Coursera, Udemy, Sololearn etc. to further enhance their learning.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/subtopics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4 means*** different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) Code reviews: Conduct code reviews to provide feedback to students on their coding skills. This will help them to identify areas where they need to improve and also learn best practices from their peers.
e) Online resources: Provide students with access to online resources, such as tutorials, videos, and forums that will help them to deepen their understanding of Python concepts and also provide them with additional practice opportunities.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

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 duration of the micro project should be about **12-14 *(Twelve to fourteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects based on cisco packet tracer/ Raspbery pi/ node MCU is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Smart Agriculture Monitoring System using IoT
b) Smart Parking System using IoT
c) Home Security System using IoT
d) Waste Management System using IoT
e) Smart Water Management System using IoT
f) Air Quality Monitoring System using IoT
g) Smart Health Monitoring System using IoT
h) Smart Transportation System using IoT
i) Industrial Automation System using IoT
j) Smart Retail Management System using IoT

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	"Internet of Things (A Hands-on-Approach)"	Vijay Madisetti and Arshdeep Bahga	Paperback, 2015 ISBN : 978-0996025515
2	"An Introduction to Internet of Things: Connecting Devices, Edge Gateway, and Cloud with Applications"	Rahul Dubey,	Paperback, 2019 ISBN: 9789353501020
3	Internet of Things: Architecture and Design Principles	Raj Kamal,	Mc Graw Hill Education ISBN-13: 978-93-5260-522-4 ISBN-10: 93-5260-522-5

14. SOFTWARE/LEARNING WEBSITES

- NPTEL online course on IoT: https://onlinecourses.nptel.ac.in/noc18_cs08
- https://docs.arduino.cc/learn/starting-guide/getting-started-arduino
- https://projects.raspberrypi.org/en/projects/raspberry-pi-getting-started
- https://www.netacad.com/courses/packet-tracer
- http://tutorials.ptnetacad.net/
- https://www.javatpoint.com/iot-internet-of-things
- IoT Tutorial point www.tutorialspoint.com
- https://www.microsoft.com/en-us/internet-of-things/0
- https://www.scnsoft.com/blog/iot-architecture-in-a-nutshell-and-how-it-works

- https://wso2.com/whitepapers/a-reference-architecture-for-the-internet-of-things

15. PO-COMPETENCY-CO MAPPING:

Semester V	Internet of Things (Course Code:4351101)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solution	PO4 Engineering Tools, Experimen-tation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Manage-ment	PO 7 Life-long learning
Competency	**Develop, test, and Maintain IoT System**						
Course Outcomes CO1- Understand the basic concepts, components, and architecture of IoT	3	2	1	-	-	2	3
CO2- Learn the various protocols used to design IoT systems	3	1	2	1	-	2	3
CO3- Design and implement IoT systems by using sensors, actuators, and platforms (Arduino /NodeMCU /Raspberry Pi)	3	3	3	2	1	3	3
CO4- Demonstrate IoT-based Cloud Service and Case Study	3	3	3	2	1	3	3

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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