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INDUSTRIAL INTERNET OF THINGS **Course Code : 316342**

Programme Name/s	**: Automation and Robotics**
Programme Code	**: AO**
Semester	**: Sixth**
Course Title	**: INDUSTRIAL INTERNET OF THINGS**
Course Code	**: 316342**

I. RATIONALE

Internet of Things (IoT) enables real-time monitoring, predictive maintenance, and remote control of industrial assets, leading to increased efficiency, reduced downtime, and optimized production. This Industrial IoT (IIoT) course explores vital components of IoT such as sensors, gateways, cloud computing, and communication protocols. It will help students become familiar with this technological transformation and develop the ability to design, create, and deploy advanced, smart IoT solutions to thrive in the rapidly evolving industrial landscape. Additionally, this course will provide students with hands-on experience in IIoT technologies, industrial communication protocols, and cloud-based data analytics.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help students to attain the following industry/employer expected outcome through various teaching learning experiences:
Maintain industrial systems based on IoT.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Interpret the architecture of IoT.
- CO2 - Integrate sensors and actuators to develop IoT based applications using NodeMCU.
- CO3 - Use IoT communication protocols for data handling.
- CO4 - Describe the role of IIoT in Industry 4.0.
- CO5 - Analyze data for predictive maintenance in industry applications.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											Total Marks
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
316342	INDUSTRIAL INTERNET OF THINGS	IIT	DSC	4	-	4	2	10	5	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Sem. : 0 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.

7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe the architecture of IoT system. TLO 1.2 List types of IoT system. TLO 1.3 Illustrate design of IoT system with sketch. TLO 1.4 Explain IoT enabling technology for the given application. TLO 1.5 Describe the challenges in IoT based system.	**Unit - I Basics of Internet of Things (IoT)** 1.1 Basics of IoT: Need, history, definition, characteristics, architecture of IoT with block diagram, IoT applications 1.2 Types of IoT system 1.3 Physical and logical design of IoT 1.4 Overview of enabling technologies for IoT: Big data analytics, cloud computing, wireless sensor networks, embedded systems with example 1.5 IoT system challenges for design and security	Video Demonstrations Lecture Using Chalk-Board Presentations Collaborative learning
2	TLO 2.1 Describe the architectural block diagram of NodeMCU with sketch. TLO 2.2 Use NodeMCU open-source IoT platform for given application. TLO 2.3 Configure Wi-Fi on NodeMCU. TLO 2.4 Interface sensors and actuators with NodeMCU for IoT applications. TLO 2.5 Connect wireless modules with NodeMCU.	**Unit - II Fundamental of NodeMCU and Arduino IDE** 2.1 NodeMCU ESP8266: Features, specifications, hardware architecture, pins configuration, UART, I2C, SPI 2.2 Arduino IDE setup, creating, compiling and uploading programs from Arduino IDE to NodeMCU 2.3 Wi-Fi configuration on NodeMCU: Wi-Fi libraries, code for connecting NodeMCU to Wi-Fi networks 2.4 Programming and interfacing sensors and actuators with NodeMCU: 2.4.1 Sensors: Gas, pressure, vibration, current, voltage, proximity, liquid/gas flow 2.4.2 Actuators: Solenoids, servo drives, pneumatic and hydraulic actuators. 2.5 Wireless communication module with NodeMCU: Interface RFID, bluetooth modules	Model Demonstration Video Demonstrations Presentations Lecture Using Chalk-Board Collaborative learning
3	TLO 3.1 Illustrate the IoT communication protocols with suitable example. TLO 3.2 Configure NodeMCU as webserver. TLO 3.3 Describe the procedure for data communication using MQTT protocol. TLO 3.4 Explain the given IoT network technology with suitable application. TLO 3.5 Discribe the given Industrial communication protocol with suitable example.	**Unit - III IoT Communication Protocol** 3.1 IoT Protocols: HTTP-REST, MQTT, CoAP, (features, methods, communication, applications) 3.2 Procedure to create webserver with NodeMCU connection on Web page for NodeMCU and control applications remotely 3.3 Data Communication using MQTT with NodeMCU: Connect to a broker, publish and subscribe topics, collect, send and receive data using MQTT 3.4 IoT networking technology: LoRa, NBIoT (Features and applications) 3.5 Industrial communication protocols: 3.5.1 Modbus (RTU): Basics, working, and implementation 3.5.2 OPC-UA: Introduction 3.5.3 Modbus communication between IoT gateway and PLC 3.5.4 OPC-UA for industrial automation 3.5.5 Data transfer from PLC/SCADA to cloud using MQTT	Video Demonstrations Lecture Using Chalk-Board Collaborative learning Presentations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Differentiate IoT and IIoT. TLO 4.2 Explain role of IIoT in Industry 4.0. TLO 4.3 Describe the architecture of IIoT system. TLO 4.4 Select appropriate IIoT components for various applications. TLO 4.5 Interface PLC and SCADA system with IoT gateway. TLO 4.6 Explain real-time data processing in edge computing.	**Unit - IV Overview of Industrial IoT** 4.1 IIoT basics: Compare IoT and IIoT, benefits of IIoT 4.2 Role of IIoT in industry 4.0 and smart manufacturing 4.3 IIoT system architecture and deployment: 4.3.1 IIoT Layers: Sensor, edge, gateway, cloud, analytics 4.3.2 Selecting IIoT components: Sensors, PLCs, edge devices, cloud 4.4 PLC-based automation and SCADA systems for IIoT 4.5 Real time edge computing - Introduction and data processing	Video Demonstrations Presentations Lecture Using Chalk-Board Collaborative learning
5	TLO 5.1 Identify relevant cloud for storage and processing tools of industrial data. TLO 5.2 Describe data logging and visualization in IIoT. TLO 5.3 Distinguish preventive and predictive maintenance. TLO 5.4 Explain the concept of digital twin. TLO 5.5 Analyze data for predictive maintenance in industry applications.	**Unit - V Cloud Computing & Predictive Maintenance in IIoT** 5.1 Overview of IoT cloud platforms: AWS, Azure, Google Cloud, ThingSpeak 5.2 Cloud-based storage and processing for industrial data 5.3 Data logging and visualization: Using Grafana, Node-RED, and Power BI for industrial dashboards, real-time monitoring dashboards 5.4 Digital Twin in IIoT 5.5 Predictive maintenance and industrial data analytics: Preventive and predictive maintenance, machine learning for industrial analytics, vibration and temperature-based fault detection, condition monitoring using IIoT sensors	Video Demonstrations Presentations Case Study Collaborative learning

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Establish a connection between the NodeMCU-ESP8266 and a computer using appropriate cables and drivers. LLO 1.2 Configure Arduino IDE for NodeMCU programming.	1	*Installation and configuration of Arduino IDE for NodeMCU	2	CO1 CO2
LLO 2.1 Interface LED and switch with NodeMCU to turn ON and OFF LED.	2	Interfacing LED and Switch with NodeMCU	2	CO2
LLO 3.1 Control relay operation using NodeMCU and IR sensor.	3	*Interfacing relay and IR sensor with NodeMCU	2	CO2
LLO 4.1 Interface DHT11 sensor with NodeMCU. LLO 4.2 Measure humidity and temperature using DHT 11 and NodeMCU.	4	Interfacing Humidity sensor with NodeMCU	2	CO2
LLO 5.1 Detect object motion using PIR sensor and NodeMCU.	5	Interfacing PIR Sensor with NodeMCU	2	CO2
LLO 6.1 Configure NodeMCU to connect to a WiFi network and troubleshoot connectivity issue.	6	*Connecting NodeMCU to Wi-Fi network	2	CO2
LLO 7.1 Use HTTP protocol to send sensor data from NodeMCU to a web	7	*Transmission of data from NodeMCU to Web Server.	2	CO3

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
server (Use any cloud service).				
LLO 8.1 Set up MQTT communication to publish and subscribe to topics using NodeMCU.	8	*Implementation of MQTT Protocol with NodeMCU	2	CO3
LLO 9.1 Measure data from LDR to monitor light intensity and transmit it to cloud. LLO 9.2 Control intensity of LED according to the data received from cloud (Use any cloud service).	9	*Monitoring and controlling light intensity using NodeMCU	2	CO2 CO3
LLO 10.1 Transmit sensor data to an IoT cloud platform.	10	Transmission of sensor data to ThingSpeak cloud using NodeMCU	2	CO2 CO3
LLO 11.1 Develop an MQTT-based IoT application for remote control.	11	*Controlling devices using MQTT and NodeMCU	2	CO2 CO3
LLO 12.1 Integrate a Bluetooth module with NodeMCU/Raspberry Pi. LLO 12.2 Display real-time sensor data on a smartphone.	12	*Bluetooth Integration with IoT gateway for sensor data	2	CO2
LLO 13.1 Measure fluid flow and transmit data to cloud. LLO 13.2 Control intensity of LED according to the data received from cloud (Use any cloud service).	13	Monitoring and controlling fluid flow using NodeMCU	2	CO2 CO3 CO4
LLO 14.1 Send data from sensors to the cloud for analysis. LLO 14.2 Control actuators based on the data analysis to maintain optimal conditions.	14	Monitoring of air quality, temperature, humidity, and other environmental parameters	2	CO2 CO3 CO4
LLO 15.1 Use vibration and temperature sensors data to monitor the condition of industrial equipment. LLO 15.2 Transmit data to the cloud for real-time analysis. LLO 15.3 Activate actuators for maintenance or shutdown to prevent equipment damage.	15	*Monitoring the condition of industrial equipment using vibration and temperature sensors.	2	CO2 CO3 CO4 CO5
LLO 16.1 Set up Raspbian OS on Raspberry Pi.	16	*Configuring Raspberry Pi (Gateway)	2	CO4
LLO 17.1 Set up network and SSH for remote access.	17	*Configuring Raspberry Pi as an IoT gateway	2	CO4
LLO 18.1 Interface a DHT22 sensor with Raspberry Pi. LLO 18.2 Measure sensor data using Python.	18	Interfacing DHT22 sensor with Raspberry Pi to monitor temperature and humidity data.	2	CO2 CO4
LLO 19.1 Implement MQTT communication between devices.	19	*Connecting Raspberry Pi to NodeMCU using MQTT	2	CO3
LLO 20.1 Configure Mosquitto as a local broker on Raspberry Pi.	20	*Setting up a local MQTT broker on Raspberry Pi	2	CO3
LLO 21.1 Measure industrial sensor data using Modbus protocol.	21	*Interfacing a Raspberry Pi with a PLC (Modbus RTU)	2	CO3 CO4
LLO 22.1 Store sensor data in a time-series database.	22	*Storing industrial data to InfluxDB and Grafana using Raspberry Pi	4	CO5
LLO 23.1 Visualize IIoT data using Grafana dashboards.	23	Creating a real-time dashboard using Grafana	2	CO5

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 24.1 Transmit IoT gateway data to AWS cloud.	24	Transmission of data from Raspberry Pi (gateway) to cloud	2	CO3 CO5
LLO 25.1 Develop an IoT workflow using Node-RED.	25	Using Node-RED for industrial automation	4	CO4 CO5
LLO 26.1 Implement an edge computing application on Raspberry Pi. LLO 26.2 Set up a cloud computing service to process data from Raspberry Pi.	26	Demonstration of edge computing vs. cloud computing using Raspberry Pi	4	CO4 CO5
LLO 27.1 Acquire equipment data from sensors. LLO 27.2 Use machine learning to predict equipment maintenance.	27	*Implementing predictive maintenance using machine learning	2	CO5
LLO 28.1 Acquire sensor data from industrial equipment using IIoT devices. LLO 28.2 Analyze acquired data using data analytics techniques to detect faults in industrial equipment.	28	Implementing fault detection in industrial equipment using IIoT and data analytics	2	CO4 CO5
LLO 29.1 Develop an end-to-end IIoT system by integrating hardware, software, and cloud.	29	Building a complete IIoT system from data collection to intelligent control	4	CO2 CO3 CO4 CO5
LLO 30.1 Use electrical power sensors to measure and transmit data to the cloud for analysis.	30	Power consumption monitoring using electrical power sensors	2	CO2 CO3 CO4 CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

- Compare various Raspberry Pi models (Pi 4, Raspberry Pi 3B+, Raspberry Pi Zero W, and Raspberry Pi 400) for IIoT applications, focusing on their CPU, RAM, connectivity features, and suitability for industrial use.
- Explain the role of Raspberry Pi as an IIoT gateway, detailing its functionality, key features, and advantages in industrial IoT applications.
- Compare edge and cloud computing in IIoT on the basis of processing capabilities, latency, and data handling.
- Describe data transfer between industrial sensors, PLCs, IIoT gateways and cloud platforms.
- List the industrial communication protocols supported by Raspberry Pi and explain how it manages various protocols such as MQTT, Modbus, OPC-UA, HTTP, and WebSockets for IIoT applications.
- Compare different IIoT gateways with their features, protocols, and applications.
- Explain different Industrial communication protocols supported by IIoT gateways.
- Describe the process by which Raspberry Pi gathers data from PLC-connected sensors (e.g., temperature, pressure) and transmits it to the cloud for data analytics.

Micro project

- Develop a Weather Monitoring System – Collect and display weather parameters data using NodeMCU/Raspberry Pi and sensors
- Design an IoT-based Smart Home System – Control home appliances using NodeMCU and MQTT.
- Develop an RFID-based Smart Attendance System – Use an RFID module with NodeMCU for automatic attendance recording and display it on cloud

- Design a Smart Irrigation System – Automate watering based on soil moisture sensor data using IIoT gateway
- Design an IIoT-enabled Remote Machine health Monitoring System – Use an IIoT gateway to send real-time machine health data from PLC (temperature, vibration) to the cloud.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	NodeMCU ESP8266 Processor: Tensilica L106 32-bit microcontroller Wi-Fi: 2.4 GHz, IEEE 802.11 b/g/n GPIO: 11 Digital I/O, UART, I2C SPIPower: 3.3V	1,2,3,4,5,6,7,8,9,10,11
2	Arduino IDE This is an open-source Arduino Software (IDE) used to write code and upload it to the board. This software can be used with any Arduino board.	1,2,3,4,5,6,7,8,9,11,12,13,14,15,10
3	Servo Motor (MG996R, DS3218, Industrial-Grade Servo) Use Case: Robotic arms, industrial valves, smart actuators Interface: PWM	11
4	Power Supply (12V/24V) with Buck Converter to step down voltage for Raspberry Pi	11
5	DC Motor (12V/24V High-Torque Motor) Use Case: Industrial automation, conveyor belts, robotic arms Interface: PWM (via Motor Driver)	11,27,28,29
6	Stepper Motor (NEMA 17, NEMA 23, NEMA 34) Use Case: CNC machines, precision industrial control nterface: Step/Direction via Stepper Driver (A4988, TB6600)	11,27,28,29
7	Water Flow Sensor (YF-S201) Use Case: Water usage monitoring in factories Flow Rate: 1-30 L/min Interface: Pulse Output	13
8	Gas Sensor (MQ-2) Detectable Gases: Methane, Propane, Smoke Operating Voltage: 5V	14
9	BMP280 (Barometric Pressure Sensor) Use Case: Weather stations, altitude monitoring in drones Range: 300-1100 hPa, ±1 hPa accuracy Interface: I2C/SPI	14
10	Raspberry Pi 4 Model B CPU: Quad-core Cortex-A72 (ARM v8) 64-bit @ 1.5 GHz RAM: 2GB/4GB/8GB LPDDR4	16,18,19,20,21,22,23,24,25,26,27,28,29,30,17

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
	Storage: microSD card slot Connectivity: 2.4/5 GHz Wi-Fi, Bluetooth 5.0, Gigabit Ethernet Ports: 2× USB 3.0, 2× USB 2.0, HDMI	
11	Raspberry Pi OS (64-bit / 32-bit, Lite/Desktop) Purpose: Primary OS for Raspberry Pi, supports industrial applications Installation Tool: Raspberry Pi Imager	16,18,19,20,21,22,23,24,25,26,27,28,29,30,17
12	Yocto Project-based OS Purpose: Custom Linux OS for embedded and industrial applications Best for: Advanced IIoT custom builds	16,18,19,20,21,22,23,24,25,26,27,28,29,30,17
13	Pneumatic Solenoid Valve (12V/24V, 5/2 Way, 3/2 Way) Use Case: Industrial automation, air-based control systems Interface: GPIO (via Relay Module)	21,22
14	Hydraulic Cylinder (12V/24V Solenoid Control) Use Case: Heavy industrial equipment automation Interface: GPIO (via Relay or MOSFET Switch)	21,22
15	Modbus Protocol (For Industrial Automation & PLC Communication) Library: pymodbus (pip install pymodbus) Best for: Reading data from industrial controllers	21,22,25,26,27,28,29
16	Grafana (Real-Time IIoT Data Visualization) Installation: sudo apt install grafana Best for: Industrial sensor data monitoring	22
17	InfluxDB (Time-Series Database for Industrial Data Logging) Installation: sudo apt install influxdb Best for: Storing real-time sensor data	22
18	Node-RED (Visual Flow-Based IIoT Programming) Installation: sudo apt install node-red Best for: Creating industrial dashboards, automation	25
19	TensorFlow Lite (For Edge AI on Raspberry Pi in Industrial Applications) Installation: pip install tflite-runtime Best for: Industrial image processing	26
20	VL53L0X (Time-of-Flight Distance Sensor) Use Case: Precision object measurement in factories Range: 30mm - 2m Interface: I2C	27,28,29
21	Raspberry Pi Camera Module v2 Use Case: Industrial inspection, object detection Resolution: 8 MP Interface: CSI (Camera Serial Interface)	27,28,29
22	Thermal Camera (MLX90640 32x24 IR Sensor) Use Case: Industrial temperature scanning, safety monitoring Temperature Range: -40°C to 300°C Interface: I2C	27,28,29
23	ADXL345 (Accelerometer - Vibration Sensor) Use Case: Machine health monitoring, predictive maintenance Range: ±2g/4g/8g/16g Interface: I2C/SPI	27,28,29,15
24	LoRaWAN Gateway Software (For Long-Range Wireless IIoT Communication)	27,28,29,30

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
	Software: ChirpStack LoRa Server Best for: Connecting remote IIoT devices	
25	OPC UA (For Secure Industrial Data Exchange) Software: FreeOpcUa (pip install opcua) Best for: SCADA & Industrial IoT applications	29,30
26	PZEM-004T (Energy Meter Sensor) Use Case: IoT-based smart energy monitoring Parameters: Voltage, current, power, energy Interface: UART	30
27	Temperature & Humidity Sensor (DHT22) Temperature Range: -40°C to 80°C, ±0.5°C accuracy Humidity Range: 0-100% RH, ±2-5% accuracy	4,18,14
28	SHT31 (High Precision Temp & Humidity Sensor) Use Case: Precision climate control in pharmaceuticals, food industry Range: Temperature (-40°C to 125°C), Humidity (0-100%) Interface: I2C	4,8,14
29	MQTT Broker (For IoT & Industrial Communication) Software: Mosquitto (sudo apt install mosquitto mosquitto-clients) Best for: IIoT data exchange between devices	8,19
30	12V/24V Power Supply & Relays (SRD-05VDC, SRD-12VDC, or SSR-40DA Solid-State Relay) MOSFET Module (IRF520 or IRLZ34N for High-Current Loads)	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Basics of Internet of Things (IoT)	CO1	10	4	4	4	12
2	II	Fundamental of NodeMCU and Arduino IDE	CO2	14	4	4	8	16
3	III	IoT Communication Protocol	CO3	12	2	6	6	14
4	IV	Overview of Industrial IoT	CO4	12	4	4	6	14
5	V	Cloud Computing & Predictive Maintenance in IIoT	CO5	12	2	4	8	14
Grand Total				**60**	**16**	**22**	**32**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two offline unit tests of 30 marks each will be conducted, and the average of both unit test scores will be considered out of 30 marks for formative assessment. Laboratory learning will be assessed for 25 marks. Each practical will be evaluated with a weighting of 60% for the process and 40% for the product.

Summative Assessment (Assessment of Learning)

- End semester assessment will be conducted for 70 marks. Additionally, the end semester summative assessment for laboratory learning will be of 25 marks.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)	Programme Specific Outcomes*

								(PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	1	1	1	1	1	3			
CO2	3	3	3	3	2	2	3			
CO3	3	3	3	3	2	2	3			
CO4	3	2	3	3	3	3	3			
CO5	3	3	3	3	3	3	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Arshdeep Bahga and Vijay Madisetti	Internet of Things: A Hands-on Approach	University Press ISBN:9788173719547
2	David Hanes, GonzaloSalgueiro, Patrick Grossetete, Rob Barton, Jerome Henry	IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things	Cisco Press ISBN:978-1587144561
3	Raj Kamal	Internet Of Things (IOT): Architecture and Design Principles	McGraw Hill Education (India)Private Limited ISBN:9789390727384
4	Rahul Dubey	An Introduction to Internet of Things:Connecting Devices, Edge Gateway, and Cloud with Applications	Cengage India Private Limited ISBN: 9789353500931931
5	Alasdair Gilchrist	Industry 4.0: The Industrial Internet of Things	Apress ISBN:978-1484220467
6	Frank Lamb	Industrial Automation	McGraw Hill Education (India) Private Limited ISBN:978-0071816458
7	Derek Molloy	Exploring Raspberry Pi: Interfacing to the Real World with Embedded Linux	Wiley India ISBN:978-1119188681
8	Simon Monk	Raspberry Pi Cookbook	O'Reilly Media ISBN:978-1491939108

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.arduino.cc/en/software	Arduino IDE software
2	https://nptel.ac.in/courses/106105166	Introduction to internet of things, by Prof. Sudip Misra IIT Kharagpur (nptel course)
3	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_01382728402214912072/overview	Getting Started with ESP8266- Infosys Springboard course
4	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_013842651241504768199 50_shared/overview	IoT Raspberry Pi for Programmers with Projects- Infosys Springboard course
5	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_01415770359142809627 5/overview	Introduction to Microsoft Azure IoT

Sr.No	Link / Portal	Description
6	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_01374907891258982450/overview	Raspberry Pi Course
7	https://professionalprograms.mit.edu/online-program-internet-of-things/	MIT Professional Education: Industrial Internet of Things 2
8	https://www.coursera.org/learn/industrial-internet-of-things	Coursera: Industrial Internet of Things (IIoT) – University of Michigan
9	https://thinger.io/	Thinger.io (Open-source IoT Cloud Platform)
10	https://nptel.ac.in/courses/106105195	Introduction to Industry 4.0 and Industrial Internet of Things, by Prof. Sudip MisraIIT Kharagpur (nptel course)

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students