Ramdeobaba University, Nagpur

Department of Electronics and Communication Engineering

Multi Disciplinary Minor (MDM)

Track – 1: Embedded systems and IoT

Semester	MDM	Course
III	MDM – 1	Sensors for IoT
IV	MDM – 2	Microcontrollers and IoT Applications
V	MDM – 3	IoT System Architecture
VI	MDM – 4	Use Cases of IoT

Semester	MDM	Course code	Course
III	MDM – 1	**24EE05TH0306-1**	Sensors for IoT
IV	MDM – 2	**24EE05TH0408-1**	Microcontrollers and IoT Applications
V	MDM – 3	**24EE05TH0507-1**	IoT System Architecture
VI	MDM – 4	**24EE05TH0608-1**	Use Cases of IoT

Syllabus for Semester III

MDM – 1 [Embedded Systems and IoT Track]

Course Code: 24EE05TH0306-1 **Course:** Sensors for IoT **(MDM Course)**

L: 3 Hrs, T: 0 Hr, P: 0 Hrs. Per week **Total Credits: 03**

CO1 Understand the definitions, classifications, and characteristics of sensors and actuators.
CO2 Illustrate the working principles and characteristics of physical sensing mechanisms.
CO3 Explain the types, principles, and control mechanisms of actuators.
CO4 Interpret the structure, function, and communication of smart sensors.
CO5 Select suitable sensors/actuators for a given application and analyze constraints.

Unit I: Introduction to Sensors and Transducers

- Definitions: Sensor, Transducer, Actuator
- Classification of sensors and actuators
    - Based on signal type: Analog/Digital
    - Based on energy domain: Active/Passive, Mechanical, Electrical, Thermal
- Measurement system: block diagram
- Static and dynamic characteristics: accuracy, resolution, drift, linearity, hysteresis
- Error sources, standards, and calibration procedures

Unit II: Physical Sensing Mechanisms and Sensors

- **Mechanical/Displacement Sensors:** Potentiometers, LVDT, capacitive sensors
- **Thermal Sensors:** Thermistor, RTD, Thermocouples – characteristics and comparison

- **Pressure/Force Sensors:** Strain gauge (resistive), piezoelectric sensors
- **Motion and Acceleration:** MEMS accelerometers, gyroscopes
- **Light and Radiation:** LDR, photodiode, phototransistor, photoconductive and photovoltaic sensors
- **Chemical and Bio-sensors:** Gas sensors (MQ series), pH sensors, glucose, ECG, SpO2

Unit III: Actuators and Their Operating Principles

- Classification of actuators: mechanical, electrical, fluidic
- **Electromagnetic Actuators:** DC motors, stepper motors, servo motors – working and control
- **Thermal Actuators:** Shape memory alloys (SMA), thermopiles
- **Piezoelectric Actuators:** Operating principle and applications
- **Hydraulic and Pneumatic Actuators:** Force generation and control applications
- Signal conditioning and driver circuits (qualitative overview)

Unit IV: Smart Sensors

- Smart sensors: architecture, on-chip signal processing, self-calibration
- Comparison between conventional and smart sensors
- Digital communication protocols: UART, I2C, SPI (basics only)
- Microelectromechanical Systems (MEMS): basics, applications in sensing and actuation
- Miniaturization and integration trends in sensor-actuator systems

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Unit V: Sensor and Actuator Selection and Applications

- Selection criteria for sensors and actuators: range, sensitivity, resolution, linearity, power
- Case studies in:
    - **Industrial Automation:** position sensing, pressure control
    - **Health Care Systems:** wearable sensors, haptic feedback
    - **Automotive:** proximity sensors, throttle/steering actuators
    - **Consumer Electronics:** touch sensors, vibration motors

- Reliability, environmental considerations, lifecycle, cost constraints

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Textbooks

1. **Clarence de Silva**, *Sensors and Actuators: Engineering System Instrumentation*, CRC Press
2. **E. A. Doebelin**, *Measurement Systems: Application and Design*, McGraw-Hill

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Syllabus for Semester IV,

MDM – 2 [Embedded Systems and IoT Track]

Course Code: 24EE05TH0408-1 **Course:** Microcontrollers and IoT Applications **(MDM Course)**

L: 3 Hrs, T: 0 Hr, P: 0 Hrs. Per week **Total Credits: 03**

Course Outcomes:
At the end of this course, students will be able to:

CO1: Understand the architecture and features of modern microcontrollers with a focus on ESP32.
CO2: Interface ESP32 with sensors, actuators, and communication modules.
CO3: Develop embedded software for data acquisition, control, and IoT communication.
CO4: Implement basic IoT projects using Wi-Fi, Bluetooth, and cloud services.
CO5: Analyze and optimize IoT solutions for power, connectivity, and scalability.

Module 1: Introduction to IoT and Microcontrollers

- What is IoT? Applications and Ecosystem
- Role of microcontrollers in IoT
- Comparison: Arduino, ESP8266, ESP32, Raspberry Pi Pico
- Introduction to ESP32: Features, architecture, GPIO, memory, peripherals

Lab: Setting up ESP32 with Arduino IDE

Module 2: ESP32 Programming Fundamentals**

- GPIO programming
- Digital and analog I/O
- Pulse Width Modulation (PWM)
- Interrupt handling

Lab: Blinking LED, Button control, PWM control of LED/Buzzer

Module 3: Sensors and Actuators Interfacing

- Analog sensors: Temperature, light
- Digital sensors: DHT11, Ultrasonic

- Actuators: Relays, motors
- ADC and DAC with ESP32

Lab: Sensor reading and data display on serial monitor or OLED

Module 4: Communication Interfaces

- I2C and SPI with ESP32
- UART communication
- Interfacing external modules like RFID, OLED, GPS

Lab: I2C OLED display + SPI sensor module integration

Module 5: Wireless Communication

- ESP32 Wi-Fi setup and connectivity
- Web server creation with HTML/CSS
- Bluetooth Classic and BLE communication
- MQTT protocol and cloud integration (e.g., ThingSpeak, Blynk, Firebase)

Lab: IoT weather station (sensor → Wi-Fi → cloud dashboard)

Module 6: Power Management & Deployment

- Deep sleep modes and power optimization
- Battery and solar power options
- Flashing, OTA updates
- Case study: Real-world IoT deployments using ESP32

Lab: ESP32 deep sleep + wakeup using timer or sensor

Mini Project (Final Assessment)
Each student/team will build a basic IoT system (e.g., smart home device, weather station, security alarm) using ESP32, sensors, and cloud integration.

Tools and Platforms:

Hardware: ESP32 DevKit, sensors, actuators, breadboard, jumper wires
Software: Arduino IDE, Blynk/ThingSpeak/Firebase, MQTT Broker
Languages: C/C++