NAAN MUDHALVAN COURSE INDUSTRY 4.O FOR THE DIPLOMA STUDENTS OF MECHANICAL AND ALLIED BRANCHES

COURSE NAME	Industry 4.O
TOTAL DURATION	60 Hrs
MODE OF DELIVERY	Physical Classroom Training at Respective Polytechnic College
TRAINER TO STUDENT RATIO	1:60
TOTAL MARKS	70(External)+30(Internal)

COURSE DESCRIPTION

This course provides an in-depth understanding of Industry 4.0. It covers the theoretical concepts and practical applications of Plant Simulation software, layout design, resource allocation, and the integration of IoT devices in industrial systems. Through hands-on exercises and case studies, students will gain the necessary skills to optimize production processes, design efficient layouts, and leverage IoT technologies for improved performance in smart factories.

COURSE OBJECTIVES

1. Explore the disruptive technologies of Industry 4.0.
2. Understand the need and characteristics of cloud computing, Machine Learning and Artificial Intelligence.
3. Familiarize students with Open source Plant Simulation software and its interface for modelling and simulating manufacturing systems.
4. Develop students' understanding of layout design principles, resource allocation strategies, and their impact on system performance.
5. Enhance students' practical skills in designing and implementing IoT solutions for predictive maintenance.

COURSE OUTCOMES

By the end of this course, students will be able to:

1. Explain the disruptive technologies of Industry 4.0.
2. Explain the four pillars of IoT.
3. Classify the types of Machine Learning.
4. Differentiate augmented reality and virtual reality.
5. Design and simulate the plant using the open source interface.
6. Configure communication protocols.

DETAILED SYLLABUS

THEORY - (20 hrs)

Unit 1: Introduction to Industry 4.0 (4 hrs)

What is Industry 4.0 - Introduction, Evolution of Industry 4.0, Types of disruptive technologies - Connectivity, data and computational power, Analytics and connectivity, Human-Machine interaction and Advanced Engineering.

Unit 2: Connectivity, Data and Computational Power (4 hrs)

Cloud computing – Introduction, Need for Cloud computing, Characteristics of Cloud computing, Internet of Things – Introduction to IoT, Four pillars of IoT, Types of IoT , Sensors in IoT, IoT's applications in smart manufacturing.

Unit 3: Analytics and Intelligence (4 hrs)

Machine Learning – Introduction, Features of Machine Leaning, Need for Machine Learning, Classification of Machine Learning, Artificial Intelligence – Definition of AI, Need of AI, Goals of AI

Unit 4: Human-Machine Interaction (4 hrs)

Augmented reality and Virtual reality – Fundamental concepts of AR VR – Difference between AR and VR and their application in various industries, Reality–Virtuality Continuum.

Unit 5: Advanced Engineering (4 hrs)

Additive manufacturing - Introduction to additive manufacturing, Benefits of advanced manufacturing, 3D printing – Introduction, benefits.

PRACTICAL – (40 hrs)

Open source Plant simulation interface:

1. Familiarization with Open source Plant Simulation interface
2. Creating and simulating a basic manufacturing system
3. Analysing simulation results and identifying system behaviour
4. Designing layout models using Open source Plant Simulation
5. Optimizing resource allocation and balancing production lines
6. Analysing the impact of layout changes on system performance

Internet of Things:

7. Understanding IoT devices and their functionalities
8. Identifying IoT use cases in smart manufacturing
9. Hands-on experience with IoT devices and their integration with manufacturing systems (minimum 4 real time projects).
10. Setting up IoT devices and sensors for data collection
11. Configuring communication protocols and networks for IoT connectivity
12. Collecting and analysing real-time data from IoT devices
13. Hands-on experience with wireless IoT technologies and protocols
14. Implementing IoT solutions for predictive maintenance

INDUSTRIAL VISIT

- Mandatory one day industrial visit that features the technologies relevant to Industry 4.0.

STUDENT ASSESSMENTS

Assessment 1:

Written Exam: This exam will assess students' theoretical knowledge.

Assessment 2:

Practical Assignments: Students will complete practical assignments that involve using Open source Plant Simulation software, designing layouts, optimizing resource allocation, and implementing IoT solutions for various industrial scenarios.

MANDATORY PROJECT WORK

Students will undertake a mandatory project work that involves developing a simulation model of a real-world manufacturing system, incorporating IoT devices, and optimizing various parameters to improve overall system performance. The project work will require students to apply the theoretical knowledge and practical skills acquired throughout the course and present their findings in a comprehensive report and presentation.

INDUSTRIAL CASE STUDIES

1. Smart Factory Optimization: Improving production processes using real-time data collection and resource optimization.
2. Supply Chain Management: Utilizing IoT devices for efficient inventory tracking and demand forecasting.
3. Energy Efficiency in Manufacturing: Optimizing energy consumption through IoT-based monitoring and analysis.
4. Predictive Maintenance: Using IoT sensors to detect machine failures and schedule proactive maintenance.
5. Quality Control and Inspection: Implementing IoT-enabled systems for real-time quality monitoring and defect detection.
6. Warehouse Automation: Enhancing warehouse operations using IoT devices and autonomous robots.
7. Asset Tracking and Management: Tracking and managing assets through IoT-based solutions.

8. Human-Machine Collaboration: Examining the role of IoT in enabling seamless collaboration between humans and machines.
9. Remote Monitoring and Control: Enabling remote monitoring and control of industrial processes using IoT technologies.
10. Sustainable Manufacturing: Leveraging IoT and Industry 4.0 for eco-friendly and sustainable manufacturing practices.

LIST OF KITS AND SOFTWARE TO BE FACILITATED BY THE TRAINERS:

(For a batch of 60 students)

- Open source Plant Simulation Software - 30
- IoT Board with sensors – 30 kits

CURRICULUM

Industry 4.0 & its application in Manufacturing Industries:

Learning Outcomes	Assessment Criteria	Use Cases
Utilize Plant Simulation software to model and simulate manufacturing systems.	• Develop precise models of systems using simulation software. • Utilize advanced features of simulation tools for accurate modelling. • Apply simulation techniques to real-world manufacturing scenarios. • Identifying and correcting errors in simulation models.	**Smart Factory Optimization:** • Create a 3D Model of Plant Using Plant Simulation Software. • Run the Simulation with Different Experiment Scenarios. • Analyse the model and validate the results.
Design efficient layout models using Plant Simulation software.	• Develop optimized layout models for manufacturing systems using simulation software. • Apply design principles to develop efficient layouts in simulation tools. • Use simulation software to enhance manufacturing system layouts. • Proficiency in layout optimization through simulation projects.	**Quality Control and Inspection:** • Define Quality Control Parameters in the Model Layout • Simulate Quality Control Processes Incorporate with Quality Control Checkpoints • Deploy the Validated Model and Set Up Real-Time Monitoring
Design layout models to optimize resource allocation and production flow.	• Design layout models that minimize bottlenecks and optimize resource utilization. • Create efficient layouts to reduce bottlenecks and enhance resource use. • Apply simulation techniques to develop layouts that improve workflow and resource management. • Design layout focused on bottleneck reduction and resource optimization.	**Supply Chain Management:** • Build the Supply Chain Model Incorporate Real-World Constraints • Simulate the Model and identify Waiting Time and inefficiencies • Leverage Advanced Features and optimize supply chain process on gathering continuous monitoring
Analyze simulation results to identify system inefficiencies and improvement opportunities.	• Analyze simulation data to identify areas for optimization and improvement. • Verify Simulation results to find opportunities for enhancing efficiency. • Use data analysis to pinpoint improvements in manufacturing processes. • Identify optimization	**Quality Control and Assurance:** • Model the Production Process Simulate QC Processes • Perform Root Cause Analysis by analyzing Quality Data • Automate Quality Reporting and Advanced Features

	opportunities through detailed simulation data review.	Utilization
Optimize production lines and balance workload using Plant Simulation software.	• Optimize production lines to maximize throughput and minimize idle time. • Enhance production line efficiency to reduce idle time and increase output. • Apply strategies to improve production line performance and minimize downtime. • Demonstrate techniques to achieve higher throughput and lower idle time in production lines.	**Predictive Maintenance:** • Build and Simulate a Layout using different Scenarios. • Integrate Machines with IoT Device to Prevent Failures • Automate Maintenance Schedules for Continuous Monitoring
Develop skills in simulating complex manufacturing scenarios and evaluating system performance.	• Simulate complex manufacturing scenarios and evaluating system performance metrics. • Develop simulations for intricate manufacturing processes and assessing performance. • Create detailed models of manufacturing systems to analyze performance metrics. • Use simulation tools to evaluate the performance of complex manufacturing setups.	**Energy Efficiency in Manufacturing:** • Integrate with IoT Devices and Real-Time Data Collection • Analyze the simulation results to pinpoint areas of energy waste and inefficiency. • Compare the real time data with Benchmarking standards of Industries
Integrate IoT devices into Plant Simulation models for enhanced functionality and real-time monitoring.	• Integrate IoT devices into simulation models for real-time data collection and monitoring. • Use IoT technology in simulation models to facilitate real-time monitoring. • Implement IoT devices within simulation frameworks for continuous data collection. • Use IoT in simulations to achieve real-time data insights.	**Asset Tracking and Management:** • Create comprehensive inventory of all assets, including machinery, equipment, tools, and facilities. • Configure the system to capture and store relevant data such as asset location, status, maintenance history, and usage patterns. • Foster collaboration between different departments, including operations, maintenance, IT, and management, to ensure effective asset tracking and

		management.
Design and optimize manufacturing systems using Plant Simulation software.	• Collaborate with team members to design and optimize manufacturing systems. • Work effectively in a team to develop and improve manufacturing system designs. • Demonstrate teamwork skills in the creation and optimization of manufacturing systems. • Coordinate with peers to enhance manufacturing system efficiency and design.	**Remote Monitoring and Control:** • Establish a robust network infrastructure to support remote monitoring and control systems. • Configure remote monitoring systems to visualize real-time data in intuitive dashboards and reports. • Utilize encryption, authentication mechanisms, and access control policies to safeguard sensitive data and control commands.
Disruptive technologies of Industry 4.0, IoT - revolutionize manufacturing with automation	• Efficient real-time data analysis is essential for informed decision-making in both production and supply chain operations. • System should provide actionable insights to improve production processes and inventory management. • Seamless integration with existing infrastructure and scalability to adapt to changing needs ensures operational efficiency. • An intuitive interface grants easy access to real-time data for stakeholders across the factory and supply chain.	**Smart Factory Optimization Supply Chain Management:** • Utilize historical sales data, market trends, and customer insights to develop predictive demand forecasting models. • Select a sensor like the DHT22, HC-SR04, MFRC522. • Connect the VCC pin and Gnd to power supply. • Connect data pin to microcontroller like the Arduino or ESP32.

Demonstrate proficiency in identifying and classifying the four pillars of IoT.	• Evaluate real-time data collection from IoT sensors to monitor energy consumption. • Analysis and Insights: Assess the system's ability to analyze data for identifying energy usage patterns and anomalies. • Measure effectiveness in proposing and implementing strategies for energy optimization. • Evaluate impact on reducing energy costs through improved efficiency measures. • Consider contribution to reducing environmental footprint by minimizing energy consumption and emissions.	**In Energy Efficiency in Manufacturing:** • Select energy meters like the Schneider Electric, DS18B20 for monitoring ambient, YF-S201 for monitoring fluid flow • Connect the VCC pin and Gnd to power supply • Connect the data pin to a digital I/O pin on the microcontroller. • Use Arduino IDE or a similar platform to write code that reads data from the sensors.
Impact of Sensor Technology on Industrial Automation	• Assess analysis of temperature, pressure, and vibration sensors for monitoring equipment health. • Evaluate sensors' effectiveness in accurately collecting data on temperature, pressure, and vibration levels. • Diagnose sensors' accuracy in detecting potential equipment faults or abnormalities. • Evaluate sensors' ability to provide early warnings for proactive maintenance actions. • Integration and Scalability: Consider ease of integration into existing systems and scalability for monitoring multiple equipment units.	**Equipment Health Monitoring in Manufacturing Environments** In a manufacturing environment, students analyse the suitability of temperature, pressure, and vibration sensors for monitoring equipment health. • Evaluate the sensor's accuracy in measuring temperature variations within the manufacturing environment. • Assess the sensor's response time to detect rapid temperature changes. • Ensure the sensor's frequency range covers the spectrum of vibrations emitted by the equipment.
Configure communication protocols for IoT devices.	• Assess students' ability to configure communication protocols like MQTT or HTTP for remote monitoring and control via IoT. • Evaluate the efficiency of protocols in transmitting data between IoT devices and remote systems.	**In Remote Monitoring and Control:** • Connect sensors to a stable power source, such as batteries or an external power supply • Establish connections between sensors and data acquisition

	• Measure the implementation of encryption and authentication to ensure data security. • Evaluate the usability of the remote monitoring interface, including real-time data visualization. • Consider the system's fault tolerance and ability to maintain continuous monitoring and control even during network disruptions.	devices using wired or wireless Protocols.
Implement IoT solutions for predictive maintenance.	• Evaluate effectiveness of sensors in collecting real-time machine data. • Identify patterns indicating potential failures. • Measure accuracy of models in forecasting maintenance needs. • Evaluate seamless integration with existing maintenance systems. • Consider effectiveness in reducing maintenance costs and downtime.	**Predictive Maintenance:** • Install sensors on critical equipment to monitor parameters such as temperature, vibration, pressure, and fluid levels. • Collect real-time data from sensors using data acquisition systems or IoT devices. • Minimize unplanned downtime by addressing equipment issues before they lead to failures.
Hands-on experience with IoT devices and integration with manufacturing systems.	• Assess students' ability to integrate IoT devices for asset tracking. • Evaluate system's capability for real-time asset tracking and monitoring. • Measure accuracy of collected data on asset location and status. • Optimizing asset inventory management. • Consider system usability and scalability for asset managers.	**Asset Tracking and Management:** • Assign unique identifiers such as barcodes, QR codes, or RFID tags to each asset. • Choose appropriate sensors such as GPS, RFID, or Bluetooth Low Energy (BLE) for real-time tracking, if required. • Create a database or asset register to record detailed information about each asset, including description, serial number, location, and custodian.
Collect and analyze real-time data from IoT devices.	• Evaluate the effectiveness of collecting real-time data from IoT devices installed in industrial processes. • Assess the system's ability to	**Monitoring Through Wi-Fi:** • Choose sensors equipped with Wi-Fi connectivity for data

	analyse the collected data to monitor industrial processes remotely. • Measure the system's capability to control industrial processes remotely based on real-time data analysis. • Evaluate the system's responsiveness in providing real-time monitoring and control functionalities. • Consider the implementation of security measures to ensure data integrity and prevent unauthorized access to industrial processes.	transmission over wireless networks. • Select sensors suitable for asset monitoring applications, such as temperature sensors, motion sensors, or proximity sensors. • Configure sensors to transmit data in real-time or at scheduled intervals over the Wi-Fi network.
Implement wireless IoT technologies and protocols.	• Evaluate successful integration of wireless IoT for robot communication. • Assess reliability of IoT-enabled communication among robots. • Measure how well robots coordinate tasks via IoT communication. • Evaluate system's ability to respond to changes promptly. • Consider implemented protocols for ensuring safe human-robot interactions.	**Warehouse Automation:** • Implement RFID tagging, barcode scanning, or vision systems to track inventory movements in real-time. • Install safety sensors and scanners to detect obstacles, prevent collisions, and ensure safe interactions between humans and robots.
Enhance practical skills in designing IoT solutions for predictive maintenance.	• Assess design and implementation of IoT solutions for machine health monitoring. • Evaluate effectiveness of sensor data collection for performance metrics. • Measure accuracy of predictive models for maintenance forecasts. • Evaluate system's effectiveness in triggering timely maintenance actions. • Consider impact on reducing maintenance costs and production downtime.	**Predictive Maintenance:** • Hoose accelerometers suitable for industrial applications with appropriate sensitivity and frequency range to capture vibrations. • Install accelerometers on critical machinery and equipment at key vibration measurement points, such as bearings, shafts, and gearboxes. • Collect vibration data from accelerometers continuously
Develop proficiency in implementing condition monitoring techniques for heavy machinery.	• Evaluate effectiveness of sensors on critical machinery. • Assess ongoing sensor data monitoring. • Analyze data for patterns and anomalies.	• Determine the key components of heavy machinery critical to production processes. • Choose appropriate sensors, such as accelerometers for

	• Evaluate algorithm development for anomaly detection. • Assess implementation of maintenance actions based on data analysis.	vibration monitoring or temperature sensors for thermal analysis. • Mount sensors on critical machinery components to capture real-time data on operating conditions, vibrations, temperatures, and other relevant parameters
Gain proficiency in utilizing end-to-end simulation techniques to facilitate the cost-effective implementation of complex and efficient manufacturing production facilities	• Develop comprehensive simulation models spanning the entire manufacturing process. • Validate simulation outcomes against real-world data for accuracy. • Identify opportunities for process optimization and resource utilization improvement. • Assess scalability and flexibility of simulation models. • Integrate digital twin technology for real-time monitoring and predictive maintenance. • Analyze environmental impact and propose sustainable solutions.	**Production Facility Design and Optimization:** • Utilize Plant Simulation software to model and optimize facility layouts for improved workflow and efficiency. • Implement lean manufacturing principles to streamline processes, minimize waste, and enhance productivity • Prioritize safety measures and incorporate energy-efficient solutions in facility design to create a sustainable and safe working environment.
Develop proficiency in remote asset monitoring techniques in the oil and gas industry	• Remotely monitor equipment health to prevent unplanned downtime. • Optimize maintenance schedules using data-driven decision-making. • Improve safety and environmental compliance by remotely monitoring asset integrity.	**Implementing Multi-Parameter Sensor Systems** • Choose sensors capable of monitoring various parameters such as temperature, pressure, flow rate, vibration, and corrosion. • Deploy sensors on critical equipment including pumps, compressors, pipelines, valves, and storage tanks to continuously monitor asset health and integrity. • Utilize predictive

		maintenance models to forecast equipment failures and schedule maintenance activities proactively.

Course Duration: 60 Hours

Test Projects:

1. Smart Factory Optimisation: Improving production processes using real-time data collection and resource optimisation.
2. Supply Chain Management: Utilizing IoT devices for efficient inventory tracking and demand forecasting.
3. Energy Efficiency in Manufacturing: Optimizing energy consumption through IoT-based monitoring and analysis.
4. Predictive Maintenance: Using IoT sensors to detect machine failures and schedule proactive maintenance.
5. Quality Control and Inspection: Implementing IoT-enabled systems for real-time quality monitoring and defect detection.
6. Warehouse Automation: Enhancing warehouse operations using IoT devices and autonomous robots.
7. Asset Tracking and Management: Tracking and managing assets through IoT-based solutions.
8. Human-Machine Collaboration: Examining the role of IoT in enabling seamless collaboration between humans and machines.
9. Remote Monitoring and Control: Enabling remote monitoring and control of industrial processes using IoT technologies.
10. Sustainable Manufacturing: Leveraging IoT and Industry 4.0 for eco-friendly and sustainable manufacturing practices.

Student Assessment Plan:

Each of the above-mentioned test projects will be divided into tasks by the training partner for each specific institution. Such tasks will be jointly evaluated by the faculty and the training partner and the following weightage is to be followed.

- 70% weightage to the external practical assessment.
- 30% weightage to the internal assessment.

Final Test Project/External Assessment Plan:

The Final Test Project will be chosen from the list given above, jointly by the college faculty and the Training Partner. The Final Test Project will be assessed on the following tasks, for 70 marks:

Task	Description	Marks
Task 1	Create a new model in details and Identify the Process Flow require in the Plant.	10 marks
Task 2	Selecting the appropriate required tools	10 marks
Task 3	Simulation and Modelling of Plant Growth and Development	10 marks
Task 4	Creating the Report based on the Plant Model Given (Throughput/Man Power Allocation/No. of Machine Required/Type of Fleet Management) etc.	10 marks
Task 5	List out the hardware required for the sensor monitoring system & coding require for IIOT	10 marks
Task 6	How does the integration of diverse field sensors with IoT networks facilitate real-time data communication, and what are the key considerations when selecting communication protocols for such an interconnected sensor ecosystem?	10 marks
Task 7	Developing a simulation model for the supply chain scenario. Integrating IoT sensors to collect energy consumption data	10 marks