Naan Mudhalvan Course

for Computer Engineering and Information Technology

Industrial Metaverse

Semester : V

Target Group	Polytechnic

Subject	Industrial Metaverse	The total duration of the training in Hours	60 hours (2 credits)
Theory Class Training in Hrs.	15 hours (1 credit)	Practical Class training in Hrs.	45 hours (1 credit)
Theory class focus area	Basic introduction, 3d models, AR VR, Industrial IoT platforms, data modeling, digital twins, simulation, business cases, use models	Practical class focus area	IoT integration to data modeling & simulation 3d (digital twin) equipment in metaverse
Total credits	2 credits	Type of training	**Physical Mode**

Introduction to Industrial Metaverse:

- The "Industrial Metaverse" could refer to the integration of virtual and augmented reality technologies into industrial processes, creating a digital twin ofthe physical industrial environment.
- The metaverse is a collective virtual shared space created by the convergence of physical and virtual reality. It's a space where users can interact with a computer-generated environment and other users
- The Industrial Metaverse could leverage digital twin technology, creating virtual replicas of physical assets, systems, and processes in real time.
- The Industrial Metaverse could facilitate collaborative work by enabling geographically dispersed teams to work in a shared virtual space.
- This can enhance communication, problem-solving, and decision-making in industrial settings.

How can the Industrial Metaverse help with today’s business challenges?

- The Industrial Metaverse has the potential to address several contemporary business challenges by leveraging advanced technologies to enhance efficiency, collaboration, and decision-making in industrial settings.
- The Industrial Metaverse can provide immersive virtual environments for remote collaboration and training.
- Digital twins and real-time monitoring in the Industrial Metaverse allow for constant analysis of industrial processes.
- The Industrial Metaverse, through IoT integration and AI analytics, enables predictive maintenance
- Sensors can continuously monitor equipment conditions, and AI algorithms can predict when maintenance is needed, reducing downtime and extending the lifespan of assets.
- The Industrial Metaverse can assist in tracking and ensuring compliance by providing a digital record of processes and activities, making it easier to demonstrate adherence to regulatory standards.

Training Objectives

- Students will be proficient in implementing Digital Twins, creating virtual representations ofphysical assets
- Students will possess hands-on skills in integrating IoT devices and sensors with Digital Twins forreal-time data analysis.
- Students will apply this knowledge to address industrial challenges, optimizing processes andimplementing predictive maintenance.
- The training program fosters critical thinking, collaborative project experience, and a continuouslearning mindset, empowering Students to lead in industrial innovation.

Training Outcomes

Students will be able to:

- LO 1: apply best practices on industrial metaverse
- LO 2: integrate IoT and Cloud Computing technologies
- LO 3: design various models using latest technologies
- LO 4: Integrate cloud with 3D models design
- LO 5: develop Industrial Metaverse related implementation

Course Syllabus

Category	Course Code	Course Title	L	T	P	C
Physical Mode	**XXXXXX**	Industrial Metaverse	**1**	**0**	**2**	**2**

Unit – I Fundamentals of Metaverse

Introduction to Industrial Metaverse, Digital Twin, Building blocks of metaverse Tools for Metaverse, Sensors, Communication Protocols, ESP32, STM32, Arduino, Introduction to Wokwi, Example Programs, Sketch template, keywords and functions, Wokwi simulations, Project Use cases and demonstrations.

Lab component:

Basic Metaverse Simulation

Outcome:

- work with Wokwi simulations
- explore different project use cases

Unit – II Integration of IoT and Cloud Computing

Introduction to IoT, DHT and Ultrasonic Sensors with Wokwi, Measuring the humidity, temperature, and distance (in cms) in Wokwi, Introduction to cloud Computing, Types of cloud, cloude service model, Introduction to ThingSpeak, ThingSpeak interface, channel, creating a channel, ThingSpeak cloud reading and writing process - writing data into the channel, Visualization and alert generation.

Lab component:

Working with sensors and integration of cloud

Outcome:

- Identify various sensors in IoT
- interact with real time data
- read and write data between device and cloud

Unit – III Basics of Modelling

Introduction to Blender, Model Creation, Introduction to Unity, IDE, Basic concepts, Scripting Languages, Tools used in Unity, object oriented concepts, Importing Model In Unity, Design Strategies.

Lab component:

Create and import different models to Unity Engine.

Outcome:

- Create and Import 3D models
- use Materials and Textures
- handle Lighting and Camera

Unit – IV Integrating cloud with 3D Models

Introduction to Unity Animation, Sound Effects, Multiple Scene, User Interfaces, Unity and Cloud Integration, Project Use cases and demonstrations.

Lab component:

Integrate cloud and Unity Engine with 3D Models

Outcome:

- integrate unity engine with various plug-ins
- apply various sound effects in Unity engine
- interact with User Interface and different scene

Unit – V Industrial Metaverse

Introduction to AR/VR, Key Elements, AR/VR Systems, Virtual Input and output interface, AR/VR Plugin integration, Implementation, Project Use cases and demonstrations.

Lab component:

Industrial metaverse with real time implementation

Outcome:

- develop AR/VR model
- demonstrate the real time problem in AR/VR
- Build the APK file

Use Cases:

Green House: Constructing a digital twin for a "Greenhouse" in which the environment is continuously monitored based on various factors such as temperature, soil, humidity, and poweron/off.

Poultry Farming: Develop an industrial metaverse project where we would be creating a virtual twin of "Poultry Farming". Poultry Farming is a domestic or commercial breeding of birds primarily for their meat, eggs, and feathers. In this instance, it is necessary to continuously monitor the real-time data in order to automate the feeding and temperature.

Smart Solar Panels: Solar panels are devices that collect energy from the Sun in the form of sunlight and convert it into electricity. Creating a digital replica of actual solar panels and adjusting their angle to face the direction of the sun would result in more effective electricity production. With the aid of this digital twin system, a clever method for a more advanced power generation is implemented.

Smart Home Technology: Creating a digital twin based on smart home technology in a large residential space where an automatic shutdown system is installed. Here the sensor receives the physical world data to find whether any human presence is around and would cause all electrical equipment to turn off.

Pick & Place Robot: Developing a digital twin that controls a factory robot to perform any pick-and-place tasks. These industrial robots are monitored to implement automated solutions like lifting or moving objects which do not require a lot of thought processes.

Supply Chain System: A supply chain system plays a vital role in the production pipeline from raw goods to finished products. Conveyors are employed in these situations to facilitate simple and quick supply chain support. In order to incorporate the industrial metaverse in supply chain management, a digital twin is deployed to control and observe the conveyor system.

Heavy Vehicles - Load Monitoring System: A lorry, truck, or other large vehicle used to transport freight weighing in tones is a heavy-duty vehicle. A maximum of 2.5 Tons of industrial materials can be loaded upon an industrial vehicle, which has the dimensions in feet (9 L x 5.5 W x 5 H). We are deploying a digital twin that intelligently monitors the weight of the vehicles by playing an alarm during the overload situation to track the load units (kgs) in heavy-duty trucks.

Smart Street Lights: In rural areas, street lights are usually operated manually or automatically switched on/off based on time. We also observe street lights that turn on and off in response to passing automobiles. We are creating a virtual twin of street lights and adjusting the light source's intensity to enable smartness. The light changes from bright to dim depending on the passing vehicle.

Gantry Crane Machine: A gantry crane machine can be used to carry objects horizontally as well as lift and lower them. The majority of its applications involve lifting big objects and moving them to new locations. We are developing a digital twin for monitoring and controlling the Gantry crane based on real-time data.

Fish Farming: Fish farming or pisciculture involves the commercial breeding of fish, mainly for food, in fish tanks or artificial enclosures such as fish ponds. A digital twin thathelps us keep track of the water level is being deployed in this situation. Based on the amount of water in the tank, the motor is designed to automatically turn on and off.

Reservoir Automation: A reservoir is an artificial lake where water is stored. Most reservoirs are formed by constructing dams across rivers. The majority of reservoirs are created by building dams across rivers. Building an Industrial Metaverse that uses digital twin technology to automate, manage, and track reservoirs

Hospital Monitoring: Developing a digital twin of the hospital to help with forecasting and decision-making about the availability of beds, ambulances, doctors, and other services to shorten the response time for each patient.

Students who finish the Industrial Metaverse Course will be qualified to apply for the following jobroles:

- Digital Twin Engineer
- IoT Solutions Architect
- Industrial Data Analyst
- Innovation and Technology Strategist
- IoT Product Manager
- Smart Manufacturing Engineer

Prerequisites:

Any college student with a basic knowledge & interest in Industrial Metaverse can join this course.

Hardware & Software to be used:

- PC/Laptop: 7th Gen i5 with 8 GB RAM & 2GB graphic card
- Software Requirement: Blender, Unity, Industrial Metaverse related tools and frameworks

Industrial Metaverse using AR &VR:

LEARNING OUTCOME	ASSESSMENT CRITERIA	USE CASES
• Implement environmental control systems for temperature, humidity, and light levels. • Monitor plant growth parameters and optimize cultivation techniques for maximum yield. • Utilize IoT sensors and automated irrigation systems for efficient water management.	• VR based Realistic Metaverse simulation of greenhouse environments. • Integration of climate control systems. • Crop growth and health monitoring. • Data collection and analysis for yield optimization. • User interface for scenario testing.	**Use Case 1** - Green House **Scenario:** Creating a virtual greenhouse environment in the Industrial Metaverse. **Task:** Developing simulations for different greenhouse configurations and crop management techniques.
• Implement smart feeding and monitoring systems for poultry health and productivity. • Utilize IoT sensors to monitor temperature, humidity, and air quality in poultry houses. • Optimize breeding and hatchery processes using data-driven insights and automation.	• VR based Metaverse Simulation of poultry housing and environmental conditions. • Design and integration of feeding systems. • Health and growth monitoring mechanisms. • Environmental control systems simulation. • Efficiency and productivity analysis.	**Use Case 2** - Poultry Farming **Scenario:** Implementing a virtual poultry farm using Industrial Metaverse tools. **Task:** Designing and simulating poultry housing, feeding systems, and monitoring mechanisms.
• Develop smart monitoring systems to track solar panel performance and energy production. • Implement predictive maintenance techniques to maximize solar panel lifespan and efficiency. • Integrate IoT connectivity for remote monitoring and control of solar power systems	• VR Simulation of solar panel placement and angles using Metaverse. • Performance testing under various weather conditions. • Energy output and efficiency analysis. • Integration of predictive maintenance systems. • Real-time performance monitoring.	**Use Case 3** - Smart Solar Panels **Scenario:** Building a virtual environment to optimize the placement and efficiency of solar panels. **Task:** Simulating the performance of solar panels under different weather conditions and angles.

• Design home automation systems for remote control of lighting, HVAC, and security devices. • Develop smart energy management solutions to optimize electricity consumption. • Implement voice recognition and AI-driven assistants for personalized smart home experiences.	• VR Simulation of a smart home environment in Metaverse. • Integration of smart devices like thermostats and security systems. • Scenario-based system testing. • Energy efficiency analysis. • User interface for controlling smart devices.	**Use Case 4** - Smart Home Technology **Scenario:** Constructing a virtual smart home system in the Industrial Metaverse. **Task:** Integrating and testing various smart devices such as thermostats, lights, and security systems.
• Develop blockchain-based supply chain solutions for transparent and secure transactions. • Implement RFID and barcode tracking systems for real-time inventory management. • Optimize logistics operations using data analytics and predictive modeling techniques.	• Virtual Reality Simulation of a Metaverse virtual supply chain network. • Real-time inventory tracking. • Logistics and distribution optimization. • Product flow simulation. • Cost and efficiency analysis.	**Use Case 5** - Supply Chain System **Scenario:** Building a virtual supply chain network using Industrial Metaverse platforms. **Task:** Simulating the flow of products, inventory management, and logistics optimization.
• Design load monitoring sensors and systems for heavy vehicles to prevent overloading. • Develop real-time monitoring solutions to ensure safe transportation of goods. • Implement telematics systems for fleet management and predictive maintenance.	• Design and simulation of load monitoring sensors using VR. • Integration with vehicle systems. • Simulation of different load scenarios in Metaverse. • Stress and strain analysis. • Real-time load monitoring.	**Use Case 6** - Heavy Vehicles - Load Monitoring System **Scenario:** Creating a virtual system to monitor and optimize the loads of heavy vehicles. **Task:** Designing load monitoring sensors and simulating their integration with vehicle systems.
• Develop intelligent street lighting systems with motion sensors and dimming capabilities. • Implement IoT connectivity for remote monitoring and control of street light operation. • Utilize data analytics to optimize energy consumption and reduce maintenance costs.	• AR app-based Simulation of smart street lighting in urban areas using Metaverse. • Programming smart lighting controls. • Traffic pattern and environmental condition analysis. • Energy consumption evaluation.	**Use Case 7** - Smart Street Lights **Scenario:** Implementing a virtual smart street lighting system for urban areas. **Task:** Programming and simulating smart lighting controls based on traffic patterns and environmental

	• Reliability and maintenance simulation using AR.	conditions.
• Design automated gantry crane systems for efficient material handling in warehouses and manufacturing facilities. • Develop motion control algorithms for precise positioning and lifting of heavy loads	• Design and AR based simulation of a gantry crane in Metaverse. • AR Simulation of loading and unloading operations. • Efficiency and accuracy analysis. • Stress testing. • Maintenance predictions.	**Use Case 8** - Gantry Crane Machine **Scenario:** Developing a virtual gantry crane system for material handling in industrial settings. **Task:** Designing and simulating the operation of the gantry crane in loading and unloading scenarios.
• Develop aquaculture monitoring systems to track water quality parameters such as pH, oxygen levels, and temperature. • Design automated feeding systems for optimal fish growth and nutrition.	• VR based Simulation of virtual aquaculture setups. • Water quality management simulation in Metaverse. • Automated feeding system design. • Monitoring fish growth and health. • Environmental impact analysis.	**Use Case 9** - Fish Farming: **Scenario:** Constructing a virtual fish farming facility in the Industrial Metaverse. **Task**: Simulating water quality management, feeding systems, and fish growth in different aquaculture setups.
• Develop automated reservoir management systems to optimize water storage and distribution. • Implement predictive analytics to forecast water demand and prevent shortages or overflows.	• Design and simulation of a water management system using VR. • Integration of control valves. • Water level and quality monitoring. • Flood prevention measures simulation in Metaverse. • Real-time monitoring and maintenance.	**Use Case 10** - Reservoir Automation: **Scenario:** Building a virtual reservoir automation system for water management. **Task:** Designing and simulating water level monitoring, control valves, and flood prevention measures

● Develop patient monitoring systems for real-time tracking of vital signs and medical data. ● Design RFID-based asset tracking systems to manage medical equipment and supplies.	● VR Simulation of a virtual hospital setup in Metaverse. ● Integration of patient health monitoring sensors. ● Real-time data analysis. ● Equipment status monitoring. ● Environmental control system integration.	**Use Case 11 -** Hospital Monitoring: **Scenario:** Implementing a virtual monitoring system for hospital operations and patient care. **Task:** Integrating sensors and devices to monitor patient health, equipment status, and facility conditions.
● Design and optimize virtual production lines for automotive manufacturing processes. ● Simulate quality control procedures to ensure product reliability and safety. ● Implement virtual assembly planning and optimization techniques for efficient production.	● Simulation of a virtual reality manufacturing plant in Metaverse. ● Optimization of assembly processes. ● Quality control procedure simulation using VR. ● Production line design. ● Efficiency and resource management.	**Use Case 12 -** Automotive Manufacturing: **Scenario:** Creating a virtual automotive manufacturing plant in the Industrial Metaverse. **Task:** Designing production lines, optimizing assembly processes, and simulating quality control procedures.
● Integrate renewable energy sources into the grid for sustainable power generation. ● Optimize energy distribution and manage grid stability using virtual simulations. ● Analyze smart grid technologies and their applications in energy distribution systems.	● AR based Simulation of a smart grid system in Metaverse. ● Integration of renewable energy sources. ● Load balancing and grid stability simulation using AR. ● Energy consumption optimization. ● Predictive maintenance integration.	**Use Case 13 -** Smart Grid Management: **Scenario:** Developing a virtual smart grid system for efficient energy distribution. **Task:** Integrating renewable energy sources, managing grid stability, and optimizing energy consumption.
● Develop virtual warehouse layouts and automated storage systems. ● Optimize inventory management processes and streamline order fulfillment workflows. ● Simulate robotic picking and packing operations for efficient warehouse operations.	● VR based Simulation of an automated warehouse in Metaverse. ● Design of robotic picking and packing systems. ● Inventory management optimization. ● Order fulfillment process simulation using VR. ● Efficiency and accuracy analysis.	**Use Case 14 -** Warehouse Automation: **Scenario:** Building a virtual warehouse with automated storage and retrieval systems. **Task:** Designing robotic picking and packing systems, optimizing inventory management, and simulating order

		fulfillment processes.
• Integrate IoT sensors and data analytics for smart traffic management and waste disposal. • Design virtual infrastructure models to enhance public safety and energy efficiency. • Implement smart city concepts and principles for sustainable urban development.	• AR based Simulation of smart city infrastructure. • Integration of IoT sensors for various urban systems. • Traffic management simulation in AR. • Energy efficiency and waste management analysis. • Public safety and emergency response simulation.	**Use Case 15 -** Smart City Planning: **Scenario:** Designing a virtual smart city infrastructure for sustainable urban development. **Task:** Integrating IoT sensors for traffic management, waste disposal, energy efficiency, and public safety.
• Develop immersive training simulations for various industries and job roles. • Create interactive scenarios to simulate real-world situations and challenges in VR. • Design training modules for employee skill development and safety drills.	• Development of interactive training scenarios. • Creation of realistic virtual reality environments in Metaverse. • User interaction and feedback integration. • Training outcome analysis. • Skill and knowledge assessment.	**Use Case 16 -** Virtual Training Simulations: **Scenario:** Creating immersive training simulations using AR VR Metaverse for various industries and job roles. **Task:** Developing interactive scenarios for employee training, safety drills, and emergency response exercises.
• Develop AR interfaces to visualize equipment schematics and maintenance procedures. • Implement AR solutions for troubleshooting and remote assistance in maintenance tasks. • Utilize augmented reality tools for equipment maintenance in industrial settings.	• Design of AR interfaces for maintenance. • Metaverse Visualization of equipment schematics and manuals. • Interactive maintenance guidance. • Real-time troubleshooting support. • Maintenance task efficiency analysis.	**Use Case 17 -** Augmented Reality Maintenance: **Scenario:** Implementing augmented reality tools for equipment maintenance and troubleshooting. **Task:** Designing AR interfaces for technicians to visualize equipment

		schematics, manuals, and maintenance procedures.
• Create digital twin models to replicate real-time manufacturing processes. • Monitor and analyze production data to optimize manufacturing efficiency. • Predict equipment failures and schedule maintenance activities using virtual simulations.	• Development of digital twin models in Metaverse. • Real-time monitoring of production systems. • Performance and efficiency analysis. • AR based Predictive maintenance simulations. • Resource utilization optimization.	**Use Case 18 -** Digital Twin for Manufacturing: **Scenario:** Developing digital twin models for real-time monitoring and optimization of manufacturing processes. **Task:** Creating virtual replicas of production systems to analyze performance, predict maintenance needs, and improve efficiency.
• Integrate wearable sensors and IoT devices for patient health monitoring. • Design virtual platforms for remote medical consultations and emergency response. • Implement remote healthcare monitoring technologies in telemedicine applications.	• Integration of wearable sensors and IoT devices. • Real-time health data collection. • AI algorithms for health analysis. • Remote medical assistance simulation using VR Metaverse. • Patient and doctor interaction platforms.	**Use Case 19 -** Remote Healthcare Monitoring: **Scenario:** Establishing a virtual platform using VR for remote healthcare monitoring and telemedicine services. **Task:** Integrating wearable sensors, IoT devices, and AI algorithms to monitor patient health and provide medical assistance from a distance.

Course Duration: 60 Hours

Test Projects:

1. Green House
2. Poultry Farming
3. Smart Solar Panels
4. Smart Home Technology
5. Pick & Place Robot
6. Supply Chain System
7. Heavy Vehicles - Load Monitoring System
8. Smart Street Lights
9. Gantry Crane Machine
10. Fish Farming
11. Reservoir Automation
12. Hospital Monitoring
13. Automotive Manufacturing
14. Smart Grid Management
15. Warehouse Automation
16. Smart City Planning
17. Virtual training Simulations
18. Augmented Reality Maintenance
19. Remote Healthcare Monitoring
20. Digital Twin Monitoring

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	Hardware and Cloud Integration	20 marks

Task 2	Engine Integration	20 marks
Task 3	Operating the project in AR	30 marks