Minor in **'Industry 4.0 Technology'**

Courses and Course Contents

Internet of Things

Course Code	Course Name
MI-BT021	**Internet of Things (IOT)**

Course pre-requisites	General knowledge of networking, sensing, databases, programming, and related technology

Course Objectives

Upon successful completion of the course, students will be

1. Explored the interconnection and integration of the physical world and the cyberspace.
2. They are also able to design & develop IOT Devices.

Course Outcomes

After successful completion of the course, student should be able to

1. Describe the theory related to the Internet of Things
2. Apply theoretical knowledge of IOT in practice
3. Select the hardware & software for different applications.
4. Develop an application using IOT hardware & software

Course Content

Module No.	*Details*	*Hrs.*
1	**Introduction** Fundamentals of Internet of Things (IOT), Components in IOT: sensors, actuators, microcontrollers, connectivity, Architecture of IOT, IoT ecosystem, edge computing, cloud computing, big data, analytics	02
2	**Enabling Technologies of IOT** Technology Roadmap, RFID, Augmented Reality, Blue Tooth, Zigbee, WiFi, RFLinks, MEMS etc	02
3	**Programming the Microcontroller for IOT** Cloud computing and IOT –Arduino/Equivalent Microcontroller platform – Setting up the board - Programming for IOT – Reading from Sensors - Communication- Connecting microcontroller with mobile devices – communication through Bluetooth and USB – connection with the internet using WiFi / Ethernet	06
4	**Resource Management** Understanding the Elements of IOT (Sensors, Connectivity through network, Application Layer), Overview of Sensors, Gateways, Sensors Available in Market, Selecting the Right Sensor for the Right Use case, Considerations for Mounting Sensors for Right Results	04
5	**IOT Platforms & IOT PROTOCOLS** Network Protocols, Comparing communication protocols for different applications, Selecting the Right Network for the Right Use case, Introduction, Necessity of IOT Platform, Overview of platforms: Arduino IDE, Node-RED, Tinkercad. Industrial Grade Platform, Overview of Cloud Platforms for IoT**,** Features, IOT Platform Architecture, Getting access to IOT platforms, Introduction to Model based development on IOT platforms	04
6	**Data Management and Analytics** Data Acquisition and Storage: Methods for data collection and transmission, Local	06

	and cloud data storage solutions Data Processing and Analytics: Real-time vs. batch processing, Analytics tools and techniques: machine learning, AI Visualization and Reporting: Tools for data visualization: Creating actionable insights and reports	
7	**Challenges & Opportunities of IOT** Privacy and data security in IoT, New business markets in IOT, IOT Design Challenges, IOT Design Opportunities, Technological challenges faced by IOT devices, Emerging IoT technologies (5G, edge AI, IoT-Blockchain integration)	04

Internal Evaluation

Tutorial/Term Work:

It consists of **at least one** tutorial and/or assignments and/or hands-on exercises from each module of the curriculum mentioned for the course.

One Presentation / Seminar related to IOT

Mini Project

Practical Components- Laboratory Sessions

Hands-on projects using IoT development boards (Arduino, Raspberry Pi)

Case studies relevant to civil, mechanical, and electrical engineering

Capstone Project

Interdisciplinary project addressing a real-world problem using IoT technologies

Text Books

1. Dieter Uckelmann et.al, “Architecting the Internet of Things”, Springer, 2011
2. "Internet of Things: A Hands-On Approach" by Arshdeep Bahga and Vijay Madisetti
3. "Building the Internet of Things: Implement New Business Models, Disrupt Competitors, Transform Your Industry" by Maciej Kranz
4. "Architecting the Internet of Things" by Dieter Uckelmann, Mark Harrison, and Florian Michahelles

Reference Books

1. Charalampos Doukas , “Building Internet of Things with the Arduino”, Create space, April 2002

Online Courses

- Coursera: IoT Specialization by University of California, Irvine
- edX: The Internet of Things by Curtin University

Research Papers and Journals

- IEEE Internet of Things Journal
- International Journal of IoT and Cyber-Physical Systems

Additive Manufacturing

Course Code	Course Name
MI-BT022	**Additive Manufacturing**

Course pre-requisites	Applied Physics, Manufacturing Processes, Kinematics of Machinery

Course Objectives

1. To study the fundamentals of additive manufacturing technologies.
2. To study basic concepts of additive manufacturing and their application in product development.
3. To study different working materials and systems used in additive manufacturing techniques
4. To study layering techniques in additive manufacturing systems

Course Outcomes

At the end of the course, the students shall be able to

1. Describe the working principles of additive manufacturing techniques
2. Select proper additive manufacturing techniques for specific technical applications.
3. Select an appropriate material and tools to develop a given product using additive manufacturing machine.
4. Design layering technique for additive manufacturing

Course Content

Module No.	*Details*	*Hrs.*
1	**Additive manufacturing (AM)** • Historical Development • Applications: Design, Planning, Manufacturing and Tooling • Applications: Automotive, Jewelry, Bio-Medical and aerospace • Fundamentals of Additive Manufacturing, Design Process • Additive Manufacturing Process Chain	4
2	**Subsystems of additive manufacturing Machine** • Generalized Subsystems of additive manufacturing machines o Optical System o Mechanical Scanning System o Computer Interfacing hardware, DAQs, Signal Flow, 3D Model to AM Prototype • Introduction to 3D Modeling Softwares (Auto-CAD, PROE, CATIA, IDEAs etc.) • Slicing and Scan Path Generation Algorithms • Data Conversion and Transmission • File Formats, IGES, STL • Preprocessing and post-processing	6

3	**Liquid Based Additive Manufacturing Systems** • Materials • Stereolithography • Solid Ground Curing • Solid Object UV (Ultra-Violet) Printer • Two Laser System • Micro-stereolithography. OBJECT	6
4	**Solid Based Additive Manufacturing Systems** • Materials • LOM (Laminated Object Manufacturing) System • FDM (Fuse Deposition Modeling) System • Multi-Jet Modeling (MJM) System • Model Maker and Pattern Master • Shape Deposition Manufacturing Process	6
5	**Powder Based Additive Manufacturing Systems** • Materials • SLS (Selective Laser Sintering) • (3DP) Three-Dimensional Printing • (LENS) Laser Engineered Net Shaping • (MJS) Multiphase Jet Solidification • (EBM) Electron Beam Melting	6
6	**Advances in Additive Manufacturing Systems and Case Studies** • Advances in RP: Resolution & Accuracy issues, Integrated Hardening Process, Two Photon Process for Micro/Nano Fabrication, Reverse Engineering Process and Applications.	6
7	Case Study: Wind-Tunnel Testing with RP Models Case Study: Investment Casting with RP Case Study: Fabrication of microlens arrays Case Study: Fabrication of Scaffolds for medical applications	6

Internal Evaluation

Tutorial/Term Work

1. Assignments based on each module.
2. Seminar based on recent advances in the subject
3. At least one Case study
4. Development of slicing and scanning program for additive manufacturing techn

Reference Books

1. Chua C.K., Leong K.F., and Lim C.S., "Rapid Prototyping Principles and Applications", World Publishing Co. Pte.Ltd.
2. James O. Hamblen, and Michael D. Furman, "Rapid Prototyping of Digital Systems",

Kluwer Academic Publishers.
3. Kenneth G. Cooper, "Rapid Prototyping Technology Selection and Application", 2001, Marcel Dekker Inc, New York.
4. Ali Kamrani, EmadAbouel Nasr, "Rapid Prototyping Theory and Practice", 2006, Springer Inc.
5. BopayaBidanda, Paulo J. Bartolo, "Virtual Prototyping and Bio Manufacturing in Medical Applications", 2008, Springer Inc.
6. I. Gibson, D.W. Rosen, and B. Stucker, "Additive Manufacturing Technologies Rapid Prototyping to Direct Digital Manufacturing", 2010, Springer Inc.

Artificial Intelligence and Machine Learning

Course Code	Course Name
MI-BT023	**Artificial Intelligence and Machine Learning**

Course pre-requisites	Mathematics, Knowledge of programming language (Python preferred)

Course Objectives

The students, after studying these topics, should be able to

1. Understand applications of Artificial Intelligence and Machine Learning for engineering applications
2. Apply suitable algorithms for simple engineering problems using computer code

Course Outcomes

Upon successful completion of the course, students should be able to

1. **Discuss** applications of Artificial Intelligence for engineering problem solving
2. **Apply** fundamental concepts in machine learning and select machine learning algorithms for engineering problem solving
3. **Compose** computer code for solving problems using machine learning algorithms
4. **Explain** advanced machine learning concepts such as Neural Network, Reinforcement Learning & Generative Artificial Intelligence (GENAI)

Course Content

Module	Details	Hrs.
1	**Introduction to AI and ML** Definition and history of AI and ML, Importance of AI and ML in modern engineering of AI, Agents, Environments, General Model, Problem Solving Techniques, uninformed search techniques, Heuristic search. Knowledge representation, Propositional and predicate calculus	02
2	**Introduction to Machine Learning** Learning algorithm: Supervised and Unsupervised Learning, Introduction to Reinforcement Learning, Data Collection and Cleaning, Feature Engineering, Data Visualization, Linear, multivariate regression, overfitting/under fitting and regularization, Training/Testing/Validation datasets, Model evaluation metrics, Feature reduction and Principal Component Analysis (PCA)etc.	04
3	**Classification Algorithms:** Logistic regression, Naive Bayes, Instance based learning: K-Nearest Neighbors (KNN) classifiers, Support Vector Machine, Kernel function and Kernel SVM, Decision trees etc.	06
4	**Applications of AI and ML in Engineering:** o Civil: Smart cities, traffic prediction, , structural health monitoring o Mechanical: Predictive maintenance, Robotics, design optimization o Electrical: Smart grids, fault detection and diagnosis	04
5	**Neural network:** Perceptron, multilayer network, backpropagation, introduction to deep neural network (deep learning), CNN, RNN, GAN etc. Introduction to Generative Artificial Intelligence (GENAI) etc.	04
6	**Clustering:** k-means, DBSCAN and hierarchical clustering	06
7	**Ethical, Societal, and Future Implications** **Ethical Considerations:** Bias in AI, transparency, and accountability, Privacy and data	04

	protection Collaborative filtering-based recommendation, **Societal Impact:** Job displacement, AI in decision making, AI in public policy and infrastructure **Future Trends:** Emerging technologies (Quantum computing, AI in IoT), The future of AI in engineering disciplines	

Internal Evaluation

Term Work/Tutorial/Laboratory:

1. Journal work shall consist of e-folder with computer code for solutions to problems based on each module.
2. Seminar
3. Mini-project

Text Books

Text Books:

1. Tom Mitchell, Machine Learning, First Edition, McGraw- Hill.
2. Stuart Russel and Peter Norvig, Artificial Intelligence – A modern approach, Pearson
3. Ethem Alpaydin, Introduction to Machine Learning, PHI.
4. Gopal M., Applied Machine Learning, McGraw Hill

Online Courses:

- Coursera: Machine Learning by Andrew Ng
- edX: Introduction to Artificial Intelligence (AI) by IBM

Research Papers and Journals:

- IEEE Transactions on Neural Networks and Learning Systems
- Journal of Machine Learning Research (JMLR)

Digital Twin

Course Code	Course Name
MI-BT024	Digital Twin

Course pre-requisites	CAD, BIM, Sensors, Simulation, MATLAB, Physics

Course Objectives

1. To understand the fundamentals of Industry 4.0 & digital twin
2. To understand the enabling technologies for digital twin
3. To understand how to build a digital twin
4. To study application areas of digital twin
5. To understand digital twin as an interdisciplinary technology along with its integration
6. To understand New business and Revenue models of digital twin

Course Outcomes

Upon successful completion of the course, students should be able

1. Explain & write basic concepts of digital twin
2. Identify various enabling technologies of digital twin.
3. Apply theoretical knowledge in practice
4. Develop small application using digital twin related software

Course Content

Module	Details	Hrs.
1	INDUSTRY 4.0: Introduction to Industry 4.0, Technologies drivers & enablers of Industry 4.0 like sensors, computing power, data speed, connectivity, accessibility, and advanced analytics.	4
2	Evolution of Digital Twins, Introduction to Digital twins, Basic concepts of Digital twins, Growth drivers for digital twins, Product & Process digital twins, Digital Model, Digital Shadow, Digital twin Prototype (DTP), Digital Twin Instance (DTI), Digital Twin Aggregate (DTA), Partial digital twin, Clone digital twin, Augmented digital twin	6
3	Enabling technologies for Digital Twin like Artificial Intelligence (AI), Machine Learning(ML), Deep Learning (DL), Big Data Analytics, Internet of Things (IoT), Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), Cloud Computing Services (CCS), Generative AI, Edge Computing, Block Chain, Simulation, 4G/5G networks, Sensors etc.	6
4	How to build a digital Twin, Steps in building a digital twin, integration of IOT & CAD, integration of IOT, BIM data & machine Learning, Hardware & Software related to digital twin, working of a digital twin, Digital Twin Platforms Concurrent engineering & digital twin, digital twin as a smart service to industries.	6
5	Use cases of Digital Twin in Product development, Logistics Manufacturing, Simulation, Predictive Maintenance, Asset Maintenance, Construction industry, Facility Management Architecture, Electrical engineering, digital	6

	twin-driven power transformer service, Health Care & etc.	
6	Integration of Digital Twin with Product Life Cycle Management (PLM), Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Supplier Relationship Management(SRM), Manufacturing Execution Systems (MES) etc.	6
7	Building New Business/Revenue models, Developing maturity model of digital twin, Benefits of Digital Twins, Challenges in applying & implementing digital twins, Future research areas of digital twin, Careers in Digital twin, Digital Twin Engineer	6

Internal Evaluation

Term Work/ Tutorial

1. Journal work shall consist of one assignment on each module
2. Seminar
3. One Mini Project

Text Books

1. Digital Twin: Possibilities of the new Digital twin technology, Anand Iyer,
2. Digital Twin Development & Deployment on the Cloud, Ist edition, Nassim Khaled Bibin Pattel Affan Siddiqu,
3. Digital Twin Technologies & Smart Cities, Maryam Farsi, Alireza Daneshkhah, Amin Hosseinian-Far, Hamid Jahankahani,
4. Digital Twin Driven Smart Manufacturing, By Fei Tao, Meng Zhang, A.Y.C. Nee,
5. Advances in Computers, The Digital Twin Paradigm for Smarter Systems and Environments: The Industry, Pethuraj & Preetha Evanjaline, ELSEVIER

Reference Books

1. Digital Twin Driven Smart Design by Fei Tao, Ang Liu, Tianliang Hu, A.Y.C. Nee, ELSEVIER,
2. Handbook Of Digital Enterprise Systems: Digital Twins, Simulation And Ai, by Wolfgang Kühn, World Scientific Publishing Co.
3. Digital Twin Complete Self-Assessment Guide,