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GU/Acad –PG/BoS -NEP/2025/379 Date: 08.09.2025

CIRCULAR

The University has decided to implement the Curriculum and Credit Framework for the Undergraduate Programme (CCFUP) of Bachelor of Engineering in Civil Engineering under the National Education Policy (NEP), 2020 based on All India Council for Technical Education (AICTE) and National Credit Framework (NCrF) Guidelines from the Academic Year 2024-2025 onwards.

The Syllabus of Semester III & IV Courses offered under Specialization **Mechanical and Smart Manufacturing** of **Bachelor of Engineering in Mechanical Engineering** Programme is attached.

The Dean, Faculty of Engineering and Principals of affiliated Engineering Colleges are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2025.09.08 17:04:47 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,

1. The Dean, Faculty of Engineering, Goa University.
2. The Principals of affiliated Engineering Colleges.

Copy to,

1. The Director, Directorate of Technical Education, Govt. of Goa
2. The Chairperson, BoS in Mechanical Engineering.
3. The Controller of Examinations, Goa University.
4. The Assistant Registrar, Prof. Examinations (Technical and Allied), Goa University.
5. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

Mechanical Engineering

Specialization: Mechanical and Smart Manufacturing

Sr. No.	Semester	Course Code	Title of the Course	L	T	P	TCr
1	**III**	**MEC-281**	Additive Manufacturing	3	1	0	4
2	**IV**	**MEC-282**	Industry 4.0 and Industrial Internet of Things	3	0	0	3
		MEC-283	Industry 4.0 and Industrial Internet of Things Lab	0	0	1	1
3	**V**	**MEC-381**	PLC and SCADA	3	0	0	3
		MEC-382	PLC and SCADA Lab	0	0	1	1
4	**VI**	**MEC-383**	Introduction to Digital Twin Technology	3	0	0	3
		MEC-384	Introduction to Digital Twin Technology Lab	0	0	1	1
5	**VII**	**MEC-481**	Artificial Intelligence and Data Science	3	0	0	3
		MEC-482	Artificial Intelligence and Data Science Lab	0	0	1	1
			Total	**15**	**1**	**4**	**20**

Approved by: Standing Committee of the Academic Council on 24th & 25th July 2025

SEMESTER III

Name of the Programme : Mechanical Engineering (Mechanical and Smart Manufacturing)
Course Code : MEC-281
Title of the course : Additive Manufacturing
Number of Credits : 4
Effective from AY : 2024-25

Pre-requisites for the course	Nil	
Course Objectives	• To provide an overview of the selection of material, equipment, and development of a Rapid Prototype for smart manufacturing in Industry 4.0. • To Explain the concepts of reverse engineering. • To provide an overview of the software and design methodology of additive manufacturing	
Units	Topics	**No of hours**
Unit 1	**Introduction**: Need-Classification -Additive Manufacturing Technology in Product Development, Materials for Additive Manufacturing Technology, Tooling Applications. Liquid-based and Solid-based additive manufacturing systems: Classification, **Liquid-based system**: Stereolithography Apparatus (SLA) Principle, process, advantages and applications, Digital Light Processing (DLP)- Principle **Solid-based system**: Fused Deposition Modeling –Principle, process, advantages and applications	**15**
Unit 2	**Powder-based additive manufacturing systems:** Selective Laser Sintering – Principle, Process, advantages and applications, Three-Dimensional Printing –Principle, process, advantages and applications, Laser Engineered Net Shaping (LENS), Electron Beam Melting. **Laminated Object Manufacturing:** Principle of operation, LOM materials, process details, Applications. **Solid Ground Curing:** Principle of operation, Machine details, Applications	**15**
Unit 3	**Concepts Modelers:** Principle, Thermal jet printer, Laser Engineering Net Shaping (LENS) **Rapid Tooling:** Soft Tooling vs. Hard Tooling, Indirect Rapid tooling -Silicon rubber tooling, Aluminum filled epoxy tooling, Spray metal tooling, Cast Kirksite, 3D Keltool. **Direct Rapid Tooling:** Direct AIM, Quick cast process, Copper polyamide, Rapid Tool DMILS, Sand casting tooling	**15**

	Rapid manufacturing process optimization: Factors influencing accuracy, data preparation errors, Part building errors, Errors in finishing, and influence of build orientation.	
Unit 4	**Software for Additive Manufacturing:** STL files, Overview of Solid view, Magics, Mimics, Magic communicator. **CAD & Reverse Engineering:** Basic Concept, Digitization techniques, Model Reconstruction, Data Processing for Additive Manufacturing Technology CAD model preparation: Part Orientation and support generation, Model Slicing, Tool path Generation. Surface digitizing, surface generation from point cloud, surface modification, data transfer to solid models. **AM Applications**: 3D printing of implants in jaw & face surgery, Prosthetics, Surgical planning & Instruments, Dental applications, Tablet Printing, 3D Bioprinting of tissues & Organ Printing, Automotive & Aerospace applications, 3D printing of a building. **Introduction to 4D and 5D printing** **Note:** Hands on exercises on Additive Manufacturing process and Reverse Engineering with a standard 3 D Printer by slicing STL file to be covered in tutorials	**15**
Pedagogy	The teaching-learning process shall integrate interactive, reflective, and inquiry-based methods, with a strong emphasis on critical thinking and problem-solving skills.	
References/ Readings:	**Text Books** 1. Paul F. Jacobs, Stereolithography and Other RP & M Technologies,1/e, Society of Manufacturing Engineers in cooperation with the Rapid Prototyping Association of SME, ASME Press, Dearborn, Michigan, 1996, ISBN-10: 0872634671 2. Chua C.K., Leong K.F., Lim C.S., Rapid Prototyping: Principles and Applications, Third Edition, World Scientific Publishers, Singapore, 2010, ISBN-13: 978-9812778987 3. Liou L.W., Liou F.W., Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development,1/e, CRC Press, Boca Raton, Florida, 2007, ISBN-13: 978-0849334092	
	Reference Books 1. I. Gibson, D. Rosen, B. Stucker, Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping and Direct Digital Manufacturing, 1/e, Springer, New York, 2015, ISBN-13: 978-1493921123 2. Kamrani A.K., Nasr E.A., Rapid Prototyping: Theory and Practice, 1/e, Springer, New York, 2006, ISBN-13: 978-0387232904	
Course Outcomes:	CO 1. Understand the various processes of additive manufacturing, rapid tooling and reverse engineering	

	CO 2. Apply the knowledge of additive manufacturing, rapid tooling and reverse engineering for engineering applications CO 3. Select the appropriate additive manufacturing and rapid tooling process for a desired application CO 4. Develop simple prototypes using the concepts of computer-aided design and additive manufacturing

SEMESTER IV

Name of the Programme : Mechanical Engineering (Mechanical and Smart Manufacturing)
Course Code : MEC-282
Title of the course : Industry 4.0 and Industrial Internet of Things
Number of Credits : 3
Effective from AY : 2024-25

Pre-requisites for the course	Nil	
Course Objectives	• To Understand the fundamental concepts of Industry 4.0 • To provide an overview of Industrial Internet of Things (IIoT) and its communication models used to develop smart industrial applications. • To provide an overview of various cybersecurity threats, challenges in IIoT security, and their impact on industrial automation. • To Understand the role of Artificial Intelligence (AI), Machine Learning (ML), Big Data Analytics, and Cloud Computing in Industry 4.0	
Units	Topics	**No of hours**
Unit 1	**Introduction to Industry 4.0** – Fourth Industrial Revolution, Definition and Digital Megatrends in Industry 4.0, Design principles, Digital twin, Smart Factory, PLM for Industry 4.0 **Industrial Internet of Things (IIoT):** Definition of IoT, IoT functional blocks, IoT communication models, Levels of IoT, Wireless sensor networks, Introduction to cyber-physical systems, Smart sensor, Intelligent sensor, 5C architecture for cyber-physical systems, Introduction to M2M communication, IIOT layer-wise architecture	**11**
Unit 2	**Communication in Industry 4.0:** - IEEE 802.15.4, Zigbee, Z wave, Bluetooth, RFID, MQTT, Basics of 5G and API **Domain-specific IoTs:** Smoke/gas detector, Smart parking, Remote vehicle diagnostics, Machine diagnosis & prognosis, Indoor air quality monitoring, Wearable electronics, Smart vending machine **Cybersecurity:** Hacking, Common threats: Malware, Ransomware, Phishing, Social engineering **Cybersecurity in IIoT:** Purpose, Elements protected, Components of cybersecurity, Requirements of cybersecurity & IIoT security standards **Virtual Reality (VR) and Augmented Reality (AR):** Introduction, Features, Applications, Types of AR & VR	**11**
Unit 3	**Big Data Analytics:** Classification of digital data, Introduction to big data, Definition, Characteristics of big data, Data sources, Typical data warehouse environment and Hadoop environment,	**11**

	Introduction to Big data analytics, Big data analytics for Industry 4.0, Types of analytics **Data exploration:** Data pre-processing, Data Quality, Data cleaning- Missing values, Binning, outliers, Data cleaning process, Data reduction- Dimensionality and numerosity reduction, Sampling, Data compression, Brief overview of data transformation strategies and data integration, Normalization, Data visualization- Relationship between features, Scatter plot, bar plots, histogram, box plots	
Unit 4	**Artificial Intelligence and Machine Learning:** Introduction, Scope, Machine learning, Role of AI in Industry 4.0 & IIoT, Types of ML algorithms-, Supervised and unsupervised learning, Clustering, Regression model Collaborative filtering, Association rule mining, Decision tree, applications of IIoT with ML **Cloud computing in IIoT:** Introduction, Need for cloud, Cloud components, Full and para virtualization, Cloud deployment models, Services, Applications, Cloud based IIoT architecture, Cloud of Things, Introduction to Google cloud platform and Amazon web services, Fog computing **IIoT Case studies:** IIoT processing for self-driving car, IoT system for weather monitoring	**12**
Pedagogy	The teaching-learning process shall integrate interactive, reflective, and inquiry-based methods, with a strong emphasis on critical thinking and problem-solving skills.	
References/Readings:	**Text Books** 1. S. Misra, C. Roy, A. Mukherjee, Introduction to Industrial Internet of Things and Industry 4.0, 1/e, CRC Press, Boca Raton, Florida, 2020, ISBN-13: 978-0367460712 2. Jiawei Han, Micheline Kamber, Jian Pei, Data Mining: Concepts and Techniques, 3rd Edition, Elsevier, Amsterdam, 2011, ISBN-13: 978-0123814791 3. A. Bahga, V. Madisetti, Internet of Things: A Hands-On Approach, 1st Edition, CreateSpace Independent Publishing Platform, Scotts Valley, California, 2014, ISBN-13: 978-0996025515	
References/ Readings:	**Reference Books** 1. Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things, 1st Edition, Apress, New York, 2016, ISBN: 1484220467 2. S. Misra, A. Mukherjee, A. Roy, Introduction to IoT, 1/e, Cambridge University Press, Cambridge, 2020, ISBN: 9781108842952	
Course Outcomes:	CO 1. Understand the technologies like Cyber-Physical Systems, Internet of Things, Data Analytics, Cloud Computing, and Machine Learning that drive Industry 4.0	

	CO 2. Apply concepts of data analytics and machine learning for simple real-life applications CO 3. Analyze Industrial IoT based applications CO 4. Analyze Industry 4.0 tool integration for optimized smart manufacturing

Name of the Programme : **Mechanical Engineering (Mechanical and Smart Manufacturing)**
Course Code : **MEC-283**
Title of the course : **Industry 4.0 and Industrial Internet of Things Lab**
Number of Credits : **1**
Effective from AY : **2024-25**

Pre-requisites for the course	Nil	
Course Objectives	• To Understand the basics of IIoT and AI/ML, including microcontroller programming and sensor-actuator interfacing. • To provide an Overview of using Arduino, Raspberry Pi, and NodeMCU for data acquisition, visualization, and cloud integration. • To Understand AI/ML models using Python/R for data preprocessing and regression. • To provide an overview of Automated processes, sending alerts, and enabling smart decision-making using IIOT	
List of Experiments		**No of hours**
	1. Modules and Sensors Interfacing (LM35, DHT 11, POT, IR sensor, Ultrasonic sensors) using Arduino/Raspberry Pi/NodeMCU 2. Modules and Actuators Interfacing (Relay, Motor, Buzzer) using Arduino/Raspberry Pi/Node MCU 3. Visualization of diverse sensor data using dashboard (part of IoT's 'control panel') 4. Write a program to interface Push button/Digital sensor (IR/LDR) and to turn ON LED /Buzzer for 1 sec after every 2 seconds. 5. Write a program to interface OLED with Arduino/Raspberry Pi and write a program to print temperature and humidity readings on it. 6. To interface Bluetooth with Arduino/Raspberry Pi and write a program to send sensor data to smartphone using Bluetooth 7. Write a program on Arduino/Raspberry Pi/Node MCU to upload & retrieve temperature and humidity data from cloud. 8. Introduction to Python & ML Libraries 9. To perform data preprocessing and cleaning techniques for preparing raw data for analysis 10. To implement and evaluate linear/multiple regression models for predictive analysis	**30**
Pedagogy	The teaching-learning process shall combine instructional learning, constructive thinking, inquiry-based and collaborative learning, experiential learning, and problem-solving approaches.	

Course Outcomes:	CO 1. Demonstrate the ability to interface sensors, actuators, and communication modules with IIoT devices. CO 2. Implement real-time data acquisition and visualization using dashboards and cloud storage. CO 3. Develop Python-based AI/ML models for analyzing and predicting sensor data trends. CO 4. Design an IIoT system for automation and smart monitoring applications.