'3D Printing' - SEM-VI						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
H3DPC601	**3D Printing: Introduction & Processes**	**04**	**-**	**04**	**-**	**04**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
H3DPC601	**3D Printing: Introduction & Processes**	**20**	**20**	**20**	**80**	**03**	**-**	**100**

Course Objectives	1. To familiarise with importance of Rapid Prototyping. 2. To study programming aspects of subtractive manufacturing process. 3. To familiarize with basic process of additive manufacturing in particularly 3D printing.
Course Outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Illustrate understanding of various cost-effective alternatives for manufacturing productsand select the feasible RP process for specific technical applications 2. Build and create data for 3D printing of any given object using liquid based rapid prototypingand tooling processes 3. Build and create data for 3D printing of any given object using solid based rapid prototypingand tooling processes 4. Build and create data for 3D printing of any given object using powder based rapid prototyping and tooling processes 5. Select an appropriate material and tools to develop a given product using rapid prototypingmachine 6. Select proper rapid prototyping and reverse engineering techniques for specific technical applications. 7. Demonstrate basics of virtual reality

Module	Contents	Hours
1.	**Additive Manufacturing:** Introduction to AM, Classification of AM Processes, Advantages & disadvantages, AM Applications; in Design, Concept Models, Form & fit checking, Functional testing, CAD data verification, Rapid Tooling, and bio fabrication.	9

2.	**Liquid based systems:** **Stereo lithography apparatus (SLA):** Models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. **Solid ground curing (SGC):** Models and specifications, process, working, principle, applications, advantages and disadvantages, case studies.	9
3.	**Solid based systems:** **Laminated object manufacturing (LOM):** Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies. **Fused Deposition Modeling (FDM):** Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies.	8
4.	**Powder Based Systems:** **Selective laser sintering (SLS):** Models and specifications, process, working principle, applications, advantages and disadvantages, case studies. **Three-dimensional printing (3DP):** Models and specification, process, working principle, applications, advantages and disadvantages, case studies. **Electron Beam Melting (EBM):** Models and specification, process, working principle, applications, advantages and disadvantages, case studies.	8
5.	**Materials for Additive manufacturing** Types of material: polymers, metals, ceramics and composites, liquid-based materials, photo polymer development, solid based materials, powder-based materials. **Material properties** Colour, dimensional accuracy, stability, surface finish, machinability, environmental resistance, operational properties.	10
6.	**Reverse Engineering** Introduction to Digitizing Methods, Contact type and Non-contact type, Brief introduction to the types of medical imaging. Virtual reality: Definition, features of VR, Technologies used in VR, Introduction to Augmented reality	8

Text/Reference Books:-

1. Rapid Prototyping, Principles and Applications by Rafiq I. Noorani, Wiley & Sons
2. Rapid Prototyping: Principles and Applications by Chua C.K, Leong K.F and Lim C.S, 2nd Edition, World Scientific
3. Rapid Manufacturing – An Industrial revolution for the digital age by N.Hopkinson, R.J. M. Hauge, P M, Dickens, Wiley

4. Advanced Manufacturing Technology for Medical applications: Reverse Engineering, Software conversion and Rapid Prototyping by Ian Gibson, Wiley
5. Rapid Prototyping and Manufacturing: Fundamentals of Stereolithography by Paul F. Jacobs, McGraw Hill
6. Rapid Manufacturing by Pham D T and Dimov S S, Springer Verlog
7. "Rapid Prototyping" Chee Kai Chua, World Scientific Publishing

Website Reference / Video Courses:

NPTEL Web Course:

1. Rapid Manufacturing, By Prof. J. Ramkumar, Prof. Amandeep Singh, IIT Kanpur, https://onlinecourses.nptel.ac.in/noc20_me50/preview
2. Fundamentals of Additive Manufacturing Technologies, By Prof. Sajan Kapil, IIT Guwahati, https://onlinecourses.nptel.ac.in/noc21_me115/preview

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

'3D Printing' - SEM-VII						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
H3DPC701	**Applications of 3D Printing**	**04**	**-**	**04**	**-**	**04**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
H3DPC701	**Applications of 3D Printing**	**20**	**20**	**20**	**80**	**03**	**-**	**100**

Course Objectives	1. To familiarise with applications of 3D Printing technologies. 2. To acquaint with the process of using biomedical data for 3D modelling. 3. To familiarize with basic process of additive manufacturing in different industries.
Course Outcomes	**Upon successful completion of this course, the learner will be able:** 1. To understand the perspectives for 3D printing in Jewellery industries for selection of an appropriate material and tools to develop a given product using rapid prototyping techniques. 2. Develop 3D model using various types of available biomedical data. 3. To understand the perspectives for 3D printing in Aerospace industries for selection of an appropriate material and tools to develop a given product using rapid prototyping techniques. 4. Illustrate understanding of various cost-effective alternatives for manufacturing products. 5. Use rapid prototyping and tooling concepts in any real-life applications. 6. Contribute towards the Product Development at the respective domain in the industry

Module	Contents	Hours
1.	**Applications in Jewellery Industries** **Introduction to 3D Printing Jewellery:** Steps Involved in Jewellery 3D Printing, Why 3D Printing for Jewellery Making, Techniques Involved in Jewellery 3D Printing, 3D Printing Processes for Jewellery Designing, Challenges with Jewellery 3D Printing, 3D Printing vs Traditional Methods, Types of Jewellery can be 3D Printed, **3D Printers for Jewellery Making –** How They Work & Which to Choose	10
2.	**Medical Applications in Additive manufacturing** Presurgical Planning Models, Mechanical Bone Replicas, Teaching Aids and Simulators, Customized Surgical Implants, Prosthetics and Orthotics', Anthropology, Forensics	8

3.	**Applications in Aerospace Industries** Use of AM in Aerospace, Metal AM in Aerospace, Super alloys, Non-Destructive Evaluation, Space technology	8
4.	**Applications in Tooling** **Methods of Rapid tooling:** Direct Soft Tooling, Indirect Soft Tooling, Direct Hard Tooling, Indirect Hard Tooling.	9
5.	**Applications in various industries** Automotive, Défense, Coin industries, Household appliance, Toy industry, Ship building, Un-manned Aerial Vehicles (UAV), Furniture, Construction and food	9
6.	**Applications in Design** Design for Additive Manufacturing (DFAM), Topology optimization for AM, Generative design **Applications in Engineering, Analysis and Planning**	8

Text/ Reference Books:-

1. Makers: The New Industrial Revolution (Telord 1403), by Chris Anderson
2. Medical Modelling The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
3. 3D Printing in Aerospace and Defense Standard Requirements, by Gerardus Blokdyk
4. Additive Manufacturing for the Aerospace Industry, by Francis Froes, Rodney Boyer
5. 3D Printing in Medicine, 1st Edition - April 1, 2017, by Deepak Kalaskar
6. An Update on Medical 3D Printing Hardcover – 1 January 2019, by Dr Raju Vaishya, Dr Abid Haleem, Dr Lalit Maini
7. 3D Printing in Medicine: A Practical Guide for Medical Professionals Hardcover – Import, 12 October 2017, by Frank J. Rybicki, Gerald T. Grant
8. Rapid Prototyping, Principles and Applications by Rafiq I. Noorani, Wiley & Sons
9. Rapid Prototyping: Principles and Applications by Chua C.K, Leong K.F and Lim C.S, 2nd Edition, World Scientific
10. Rapid Manufacturing – An Industrial revolution for the digital age by N.Hopkinson, R.J. M. Hauge, P M, Dickens, Wiley
11. Advanced Manufacturing Technology for Medical applications: Reverse Engineering, Software conversion and Rapid Prototyping by Ian Gibson, Wiley

Website Reference / Video Courses:

NPTEL Web Course:

1. Rapid Manufacturing, By Prof. J. Ramkumar, Prof. Amandeep Singh, IIT Kanpur, https://onlinecourses.nptel.ac.in/noc20_me50/preview
2. Fundamentals of Additive Manufacturing Technologies, By Prof. Sajan Kapil, IIT Guwahati, https://onlinecourses.nptel.ac.in/noc21_me115/preview

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

‘3D Printing’ - SEM-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
H3DPC801	**3D Printing in Medical Technology**	**04**	**-**	**04**	**-**	**04**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
H3DPC801	**3D Printing in Medical Technology**	**20**	**20**	**20**	**80**	**03**	**-**	**100**

Course Objectives	1. To acquaint with the process of using biomedical data for 3D modeling. 2. To familiarize with basic process of additive manufacturing in particularly 3D printing
Course Outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Describe the creation of highly accurate physical models of human anatomy 2. Identify medical imaging for human body 3. Understand the modelling based on Biomedical data 4. Build and create data for 3D printing of any given object using rapid prototyping and tooling processes. 5. Illustrate the understanding of different manufacturing processes 6. To Identify the processes and tooling concepts in Biomedical

Module	Contents	Hours
1.	**Introduction** Stages of the medical modelling process, The human form, Basic anatomical terminology, technical terminology	8
2.	**Introduction to medical imaging** Computed tomography (CT), Cone beam CT (CBCT), Magnetic resonance (MR), Noncontact surface scanning, Medical scan data, Point cloud data	10
3.	**Working with medical scan data** Pixel data operations, Using CT data: a worked example, Point cloud data operations, Two-dimensional formats, Pseudo 3D formats, True 3D formats, File management and exchange	12
4.	**Physical reproduction** Basic principles of medical modelling: orientation, sectioning, separating and joining, trapped volumes	8

5.	Introduction to Additive manufacturing processes used for Bio-Modelling, Computer numerical controlled machining, Cleaning and Sterilizing medical models	8
6.	**Case Studies based on Bio-Modelling & Future Development**	6

Text/Reference Books:-

1. Medical Modelling The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
2. 3D Printing in Medicine, 1st Edition - April 1, 2017, by Deepak Kalaskar
3. An Update on Medical 3D Printing Hardcover – 1 January 2019, by Dr Raju Vaishya, Dr Abid Haleem, Dr Lalit Maini
4. 3D Printing in Medicine: A Practical Guide for Medical Professionals Hardcover – Import, 12 October 2017, by Frank J. Rybicki, Gerald T. Grant
5. Rapid Prototyping, Principles and Applications by Rafiq I. Noorani, Wiley & Sons
6. Rapid Prototyping: Principles and Applications by Chua C.K, Leong K.F and Lim C.S, 2nd Edition, World Scientific
7. Advanced Manufacturing Technology for Medical applications: Reverse Engineering, Software conversion and Rapid Prototyping by Ian Gibson, Wiley

Website Reference / Video Courses:

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2. Fundamentals of Additive Manufacturing Technologies, By Prof. Sajan Kapil, IIT Guwahati, https://onlinecourses.nptel.ac.in/noc21_me115/preview

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

‘3D Printing’ - SEM-VII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Practical/ Tutorial	Theory	Practical/ Tutorial	Total
H3DPSBL701	**Skill Based Lab – Digital Fabrication**		**04**	**--**	**02**	**02**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)			
		Test 1	Test 2	Avg.					
H3DPSBL701	**Skill Based Lab – Digital Fabrication**	**-**	**-**	**-**	**-**	**-**	**50**	**50**	**100**

Course Objectives	1. To impart the geometric modeling skills for development of 3D models of engineering components. 2. To familiarize with production drawings with important features like GD &T, surface finish, heat treatments etc. 3. To familiarize with additive manufacturing process 4. To acquaint with basic process of 3D modeling using biomedical data.
Course Outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Illustrate basic understanding of types of CAD model creation. 2. Build geometric model of a given object using 3D modeling software 3. Generate assembly models of given objects using assembly tools of a modeling software 4. Demonstrate CAM Tool path and prepare NC- G code 5. Develop 3D model using available biomedical data 6. Build any given real life object using 3D printing process

Module	Contents	Hours
1.	Geometric modeling of an Engineering component, demonstrating skills in sketching commands of creation (line, arc, circle etc.) modification (Trim, move, rotate etc.) and viewing using (Pan, Zoom, Rotate etc.)	06
2.	Demonstrating modeling skills using commands like Extrude, Revolve, Sweep, Blend, Loft etc. Mesh of curves, free form surfaces etc. Feature manipulation using Copy, Edit, Pattern, Suppress, History operations etc.	04
3.	Assembly: Constraints, Exploded views, interference check. Drafting (Layouts, Standard & Sectional Views, Detailing & Plotting).	04
4.	Solid modeling of any engineering component using any 3D modeling software.	04
5.	Non - Contact Scanning – Generation of CAD model using 3D scanning equipment.	04
6.	Reverse Engineering of a legacy component – Selection of components, 3D scanning, CAD model verification, 3D print of CAD model.	04

7.	Modeling of a component using 3D modelling software and development of G – Code output using Fractal Software.	06
8.	Design an object with free form surface using Autodesk Fusion 360 and development of G – Code output using Fractal Software.	04
9.	Segmentation in Slicer's Segment Editor module for the purpose of 3D printing.	04
10.	Creation of 3D model from 2D images using any image processing software and printing it. (3D Slicer open source) (Application: Any body organ like Heart, Gallbladder etc. as per available Dicom files)	04
11.	Development of physical 3D mechanical structure using any one of the Additive manufacturing processes – Material to be used Metal	06
12.	Development of physical 3D mechanical structure using any one of the Additive manufacturing processes - Material to be used Plastic	04

Text/Reference Books:-

1. Machine Drawing by N.D. Bhatt.
2. A textbook of Machine Drawing by Laxminarayan and M.L.Mathur, Jain brothers Delhi
3. Machine Drawing by K.I. Narayana, P. Kannaiah, K.Venkata Reddy
4. Medical Modelling - The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd
5. Biomaterials, artificial organs and tissue engineering, Edited by Larry L. Hench and Julian R. Jones, Woodhead Publishing and Maney Publishing, CRC Press 2005
6. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, I. Gibson l D. W. Rosen l B. Stucker, Springer Publication.

Website Reference / Video Courses:

1. https://www.autodesk.in/products/fusion-360/learn-support
2. https://knowledge.autodesk.com/support/inventor
3. https://www.slicer.org/wiki/Documentation/4.10/Training

Term work:

Term work shall consist of all twelve experiments.
The distribution of marks shall be as follows:

Experiments Performance	: 20 marks
Course Project	: 20 marks
Attendance	: 10 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on entire lab work of **H3DPSBL701 - Skill Based Lab – Digital Fabrication**

University of Mumbai

Syllabus for

Honours/Minor Degree Program

In

Industrial Automation

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai
Industrial Automation
(With effect from 2022-23)

Year & Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar /Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	**HIAC501: Fundamentals of Industrial Automation**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
										Total Credits = 04
TE Sem. VI	**HIAC601: Industrial Internet of Thing (IIOT)**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
										Total Credits = 04
BE Sem VII	**HIAC701: AI and ML for Automation**	04	--	--	20	80	-	-	100	04
	HIAL701: AI and ML for Automation-Lab	-	-	04	-	-	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**100**		**200**	**06**
										Total Credits = 06
BE Sem VIII	**HIAC801: Applied Predictive Analytics**	04	--	--	20	80	-	-	100	04
	Total	**04**	**-**	**-**	**100**		**-**		**100**	**04**
										Total Credits = 04
										Total Credits for Semesters V, VI, VII &VIII = 04+04+06+04 = 18

Industrial Automation : Sem. V								
Course code	**Course Name**	**Teaching scheme**			**Credit assigned**			
HIAC 501	**Fundamentals of Industrial Automation**	**Theory**	**Pract.**	**Tut.**	**Theory**	**Pract**	**Tut.**	**Total**
		4	**-**	-	**4**	**-**	-	**4**

Course Code	**Course Name**	**Examination scheme**							
		Theory (out of 100)				**Term work**	**Pract. and Oral**	**Oral**	**Total**
		Internal Assessment			**End sem Exam**				
		Test1	**Test2**	**Avg.**					
HIAC 501	**Fundamentals of Industrial Automation**	**20**	**20**	**20**	**80**	**-**	**-**	**-**	**100**

Course objective	1. To impart knowledge of Industrial Automation. 2. To make the students learn industrial sensors. 3. To make the students learn various actuators. 4. To make the students learn about controller strategy and various automation tools like PLC. 5. To give the students an overview of DCS and HMI. 6. To give students an overview of communication protocols.
Course Outcome	The students will able to 1. Recognize Industrial automation. 2. Select and configure industrial sensors. 3. Comprehend and work with various actuators. 4. Know various automation tools. 5. Work with DCS and HMI. 6. Select various communication protocols.

Pre requisites: Sensors and Transducers basics

Module	**Contents**	**Hours.**	**CO**
1	**Introduction** Introduction- Automation in production system, Principles and strategies of automation, Basic elements of an automated system, types of Automation, Hierarchical level in automation, Advanced automation functions, Automated flow lines and transfer mechanisms. Material handling and identification technologies, Conveyor system, Automated guided vehicle system, Automated storage systems, Automatic Identification Methods.	6	CO1

2	**Sensors** Introduction to Industrial Measurement, overview of sensors, classification, sensor characteristics, physical principles of sensing, sensor Materials and Technologies. Inductive sensors, capacitive sensors, vision sensors, ultrasonic sensors, Electronic SMART Digital remote sensor , Robotic sensors, Tactile sensing, Proximity sensors, Range sensor, Position sensors, Fibre optic sensors, Guided microwave sensor, wireless sensors, Electrical characteristics of sensors, specifications of sensors, performance testing, selection guidelines.	8	CO2
3	**Actuators** Pneumatic and hydraulic-directional and pressure control valves, cylinders, servo proportional control valves, rotary actuators. Electrical actuation: A.C and DC motors, stepper motors, mechanical switches and solid state switches. Mechanical Actuation: types of motion, kinematic chain, cams, gears, ratchets and pawl, belt and chain drives, bearings, mechanical aspects of motor selection, piezoelectric actuators, magneto-strictive actuators, memory metal actuators. Selection Criteria of Actuators	8	CO3
4	**Controller strategy / Automation Tools. PLC** Overview and Features, Types, specifications, PLC Architecture, PLC working, PLC SCAN, new trends in PLC, PLC programming Languages, PLC instructions set, Development of Ladder programme, case study Example, PLC Applications, Overview of Motion control.PLC Installation and wiring. **SCADA** Overview, SCADA Architecture, SCADA-Hardware functions, New trends in scada systems, applications, case study examples.	10	CO4
5	**DCS & HMI** DCS: Overview and Features of DCS, DCS Architecture, Hardware elements, working of DCS, DCS displays, DCS interfacing with PLC , DCS wiring diagram. Applications and suppliers. HMI : Overview, need, Types, wiring practice, Data Handling , configuration and interfacing with **PLC & PC, Communication standards. ASM Graphics**	10	**CO5**
6	**Communication protocols** Overview of sensor networks, AS interface,CAN, HART, FF, Profibus, Interbus, Mbus, Wireless sensor network, networks-IEEE, Zigbee, sensor interfaces.	6	**CO6**

Internal Assessment:

Internal Assessment consists of two tests out of which, one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will consist of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 or 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weight age of each module will be proportional to number of respective Lecture hours as mentioned in the syllabus.

Text Books Recommended:

1. Jacob K Freden; Handbook of Modern sensors, Springer, 5th Edition
2. Tony Kuphaldt; Lessons in industrial instrumentation, version 4
3. Walt Boyes; Instrumentation Reference book, Fourth Edition.
4. William C Dunn; Fundamentals of Industrial Instrumentation and process control, McGraw Hill.
5. C.L. Albert and D.A. Coggan, Fundamentals of Industrial Control, ISA, 1992.
6. Bela G. Liptak, Instrument Engineer's HandBook – Process Measurement and Analysis, ISA CRC Press , 4th Edition, 2003.
7. Andrew Williams, Applied instrumentation in the process industries, 2nd Edition, Vol. 1 & 3, Gulf publishing company.
8. Douglas. M.Considine; Process Instruments & Control Handbook, McGraw-Hill
9. S C Mukhopadhyay; Intelligent sensing, Instrumentation and Measurement, Springer.

Industrial Automation : Sem. VI								
Course code	**Course Name**	**Teaching scheme**			**Credit assigned**			
HIAC601	**Industrial Internet of Thing (IIOT)**	**Theory**	**Pract.**	**Tut.**	**Theory**	**Pract.**	**Tut.**	**Total**
		4	**-**	-	**4**	**-**	-	**4**

Course Code	**Course Name**	**Examination scheme**							
		Theory (out of 100)				**Term work**	**Pract. and Oral**	**Oral**	**Total**
		Internal Assessment			**End sem Exam**				
		Test1	**Test2**	**Avg.**					
HIAC601	**Industrial Internet of Thing (IIOT)**	**20**	**20**	**20**	**80**	**-**	**-**	**-**	**100**

Course objective	1. Introduce how IoT has become a game changer in the new economy where the customers are looking for integrated value 2. Bring the IoT perspective in thinking and building solutions 3. Introduce the tools and techniques that enable IoT solution and Security aspects.
Course Outcome	The students will able to 1. Describe IOT, IIOT 2. Design and develop the real-life IoT applications using off the shelf hardware and software 3. Know various IoT Layers and their relative importance 4. Recognize various IoT platforms and Security 5. Realize the importance of Data Analytics in IoT 6. Design and thinking concepts of IIoT

Prerequisites: Microcontroller based Architecture and Programming			
Module	**Content**	**Hours**	**CO**
1	**Introduction:** Introduction of Industry 4.0, Elements of industry 4.0, Introduction to IOT, what is IIOT? IOT Vs. IIOT, History of IIOT, Components of IIOT - Sensors, Interface, Networks, People &Process, Hype cycle, IOT Market, Trends& future Real-life examples, Key terms – IOT Platform, Interfaces, API, clouds, Role of IIOT in Manufacturing Processes Use of IIOT in plant maintenance practices, Sustainability through Business excellence tools Challenges & Benefits in implementing IIOT	6	CO1

2	**Architectures:** Overview of IOT components; Various Architectures of IOT and IIOT, Advantages & disadvantages, Industrial Internet - Reference Architecture; IIOT System components: Sensors, Gateways, Routers, Modem, Cloud brokers, servers and its integration, WSN, WSN network design for IOT	8	CO2
3	**Sensor and Interfacing:** Introduction to sensors, Transducers, Classification, Roles of sensors in IIOT, Various types of sensors, Design of sensors, sensor architecture, special requirements for IIOT sensors, Role of actuators, types of actuators, IT and OT Integration.	10	CO3
4	**Protocols and Cloud:** Need of protocols; Types of Protocols, Wi-Fi, Wi-Fi direct, Zigbee, Z wave, BACnet, BLE, Modbus, SPI , I2C, IIOT protocols –COAP, MQTT,6lowpan, lwm2m, AMPQ IIOT cloud platforms: Overview of cots cloud platforms, Predix, thingworks, azure etc. Data analytics, cloud services, Business models: Saas, Paas, Iaas.	8	CO4
5	**Cyber security for industry, Privacy, and Governance** Cyber physical system, cyber security life cycle, cyber security guidelines, standard IEC 62443 Introduction to web security, Conventional web technology and relationship with IIOT, Vulnerabilities of IoT, Privacy, Security requirements, Threat analysis, Trust, IoT security tomography and layered attacker model, Identity establishment, Access control, Message integrity, non-repudiation and availability, Security model for IoT.	8	CO5
6	**IOT Analytics and CASE study:** Role of Analytics in IOT, Data visualization Techniques, Introduction to R Programming, Statistical Methods. Internet of Things Applications: Smart Metering, e-Health Body Area Networks, City Automation, Automotive Applications, Home Automation, Smart Cards, Plant Automation, Real life examples of IIOT in Manufacturing Sector.	8	CO6

Internal Assessment:

Internal Assessment consists of two tests out of which, one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will consist of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 or 5 marks will be asked.

4. Remaining questions will be mixed in nature.
5. In question paper weight age of each module will be proportional to number of respective Lecture hours as mentioned in the syllabus.

Text Books:

1. Daniel Minoli, Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications, ISBN: 978-1-118-47347-4, Willy Publications 2. Bernd Scholz-Reiter, Florian
2. Michahelles, Architecting the Internet of Things, ISBN 978-3- 642-19156-5 e-ISBN 978-3-642-19157-2,Springer

Reference Books:

1. Hakima Chaouchi, The Internet of Things Connecting Objects to the Web, ISBN : 978-1-84821-140-7, Willy Publications
2. Olivier Hersent, David Boswarthick, Omar Elloumi, The Internet of Things: Key Applications and Protocols, ISBN: 978-1-119-99435-0, 2nd Edition, Willy Publications
3. Inside the Internet of Things (IoT), Deloitte University Press
4. Internet of Things- From Research and Innovation to Market Deployment; By Ovidiu & Peter; River Publishers Series
5. Five thoughts from the Father of the Internet of Things; by ByPhil Wainewright - Kevin Ashton
6. How Protocol Conversion Addresses IIoT Challenges: White Paper By Red Lion.

Industrial Automation: Sem. VII								
Subject Code	**Subject Name**	**Teaching Scheme**			**Credit Assigned**			
		Th	**Pract.**	**Tut.**	**Th**	**Pract.**	**Tut.**	**Total**
HIAC701	**Artificial Intelligence and Machine Learning for Automation**	**4**	**-**	**-**	**4**	**-**	**-**	**4**

Sub Code	**Subject Name**	**Examination scheme**							
		Theory				**Term work**	**Pract. and Oral**	**Oral**	**Total**
		Internal Assessment			**End sem Exam**				
		Test1	**Test2**	**Avg.**					
HIAC701	**Artificial Intelligence and Machine Learning for Automation**	**20**	**20**	**20**	**80**	**-**	**-**	**-**	**100**

Course Objectives	1. To familiarize student with basic concepts of Artificial Intelligence and Machine learning. 2. To provide understanding of the concepts of regression, classification, clustering and deep learning algorithms. 3. To introduce the students to various applications of Artificial Intelligence and Machine learning for industrial automation
Course Outcomes	Students will be able to: 1. Introduce concepts of Artificial Intelligence and Machine learning 2. Explicate statistical tools and development of database for AI/ML. 3. Analyze the various algorithms for Regression, Classification and Clustering. 4. Evaluate metrics for ML/AI algorithms. 5. Examine the algorithms for deep learning. 6. Explain examples of ML/AI algorithms for industrial automation.

Module	**Contents**	**Hrs.**	**CO Mapping**
1.	**Introduction to Artificial Intelligence:** Evolution, definition, types, application examples, benefits/advantages, limitations/issues, comparison.	**06**	**CO1**
2.	**Review of statistical concepts:** Mean, variance, covariance, standard deviation, random variable, probability distribution, probability distribution function, normal distribution, binomial distribution, poisson distribution, central limit theorem, vector norms, principal component analysis. **Data collection and preparation:** Collecting, cleaning, normalization, standardization, missing data, underfitting and overfitting, neglecting outliers, annotation, labelling. Data Splitting: Training, Validation, and Test Datasets. Public datasets for machine learning.	**08**	**CO2**

3.	**Regression:** Simple Linear regression, Multiple Linear Regression, Polynomial Regression, Logistic regression. **Classifiers:** k-Nearest Neighbours, Decision trees, naïve Bayes, SVM for Linearly separable data, Kernel SVM for Non-Linearly separable data. **Clustering:** k-means clustering.	**10**	**CO3**
4.	**Evaluation Metrics**: True Positive, True Negative, False Positive, False Negative, accuracy, precision, recall or True Positive Rate, False Positive Rate, Receiver Operating Characteristic, Area Under the Curve, Confusion matrix, F-score.	**04**	**CO4**
5.	**Deep Learning:** Multilayer Perceptron (MLP), Convolutional Neural Network (CNN), Recurrent Neural Network (RNN)	**08**	**CO5**
6.	**Application in Industrial Automation**: **Robotics, Factory automation, Process control, Electrical Engineering** Challenges, Data Screening, Feature Engineering, Projected improvement, Model Design, Limitations, Future scope, References.	**12**	**CO6**

Internal Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on Minimum 02 Modules) and the other is either a class test or assignment on live problems or Course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 or 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Text Books:

1. Harrington, Peter. *Machine learning in action*. Simon and Schuster, 2012.
2. Zheng, Alice, and Amanda Casari. *Feature engineering for machine learning: principles and techniques for data scientists*. " O'Reilly Media, Inc.", 2018.
3. Jiang, Hui. *Machine Learning Fundamentals: A Concise Introduction*. Cambridge University Press, 2021.
4. Huyen, C. *"Designing Machine Learning Systems: An Iterative Process for Production-Ready Applications"*, O'Reilly Media, 2022.
5. Gupta, Itisha, and Garima Nagpal. *Artificial Intelligence and Expert Systems*. Stylus Publishing, LLC, 2020.

Reference Books:

1. Pandey, Yogendra Narayan, et al. *Machine Learning in the Oil and Gas Industry*. apress, Texas, 2020.
2. Bangert, Patrick, ed. *Machine learning and data science in the oil and gas industry: Best practices, tools, and case studies*. Gulf Professional Publishing, 2021.
3. Das, Santosh Kumar, et al., eds. *Machine learning algorithms for industrial applications*. Cham: Springer, 2021.

Industrial Automation: SEM VII								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Th	Pract.	Tut.	Th	Pract.	Tut.	Total
HIASBL701	Artificial Intelligence and Machine Learning for Automation Lab	-	4	-	-	4	-	2

Subject Code	Subject Name	Examination scheme						
		Theory (out of 100)				Term work	Oral	Total
		Internal Assessment			End sem Exam			
		Test1	Test2	Avg.				
HIASBL701	Artificial Intelligence and Machine Learning for Automation Lab	--	--	--	--	50	50	100

Course Objectives	1. To familiarize student with basic concepts of Artificial Intelligence and Machine learning. 2. To provide understanding of the concepts of regression, classification, clustering and deep learning algorithms. 3. To introduce the students to various applications of Artificial Intelligence and Machine learning for industrial automation
Course Outcomes	Students will be able to 1. Write programs based on data compression and dimensionality reduction. 2. Write programs for regression, classification and clustering. 3. Calculate evaluation metrics for various algorithms. 4. Write programs based on deep learning algorithms. 5. Demonstrate working of AI/ML in Robotics and Factory automation. 6. Validate working of AI/ML in Process control and Electrical Engineering.

Syllabus: Same as that of Subject HIAC701.

List of the Laboratory Experiments:

Sr. No.	Contents	CO Mapping
1.	Write a python program to perform PCA for dimension reduction or data compression.	CO1
2.	Develop/download database of any industrial machine/system. Explain hardware system used for data collection. Explain specifications/characteristics of collected data.	CO2

3.	Write a python program to implement linear regression with one variable, two variables for given dataset.	CO2
4.	Demonstrate the working of SVM classifier for a linearly separable data set.	CO2
5.	Demonstrate the working of Kernel SVM classifier for a non-linearly separable data set.	CO2
6.	Demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.	CO2
7.	Calculate evaluation metrics such as accuracy, precision, recall, confusion matrix, F-score, etc for regression, classification and clustering algorithms.	CO3
8.	Calculate evaluation metrics such as Receiver Operating Characteristic, Area Under the Curve, etc for regression, classification and clustering algorithms.	CO3
9.	Implement multilayer Perceptron (MLP) for predicting stock price. Time series forecasting.	CO4
10.	Implement Convolutional Neural Network (CNN) to recognize hand-written digits dataset.	CO4
11.	Implement Recurrent Neural Network (RNN) for speech recognition.	CO4
12.	Case study or mini project on application of AI/ML in Robotics.	CO5
13.	Case study or mini project on application of AI/ML in Factory automation.	CO5
14.	Case study or mini project on application of AI/ML in Process control.	CO6
15.	Case study or mini project on application of AI/ML in Electrical Engineering.	CO6

Any other experiment based on syllabus which will help students to understand topic/concept.

Oral Examination:

Oral examination will be based on entire syllabus.

Term Work:

Term work shall consist of minimum 12 experiments.
The distribution of marks for term work shall be as follows:
Laboratory work (Experiments): : 20 Marks
Laboratory work (programs / journal): 20 Marks
Attendance: : 10 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Industrial Automation: SEM VIII								
Subject code	**Subject Name**	**Teaching scheme**			**Credit assigned**			
HIAC801	**Applied Predictive Analytics**	**Theory**	**Pract.**	**Tut.**	**Theory**	**Pract.**	**Tut.**	**Total**
		4	**-**	-	**4**	**-**	-	**4**

Sub Code	**Subject Name**	**Examination scheme**							
		Theory (out of 100)				**Term work**	**Pract. and Oral**	**Oral**	**Total**
		Internal Assessment			**End sem Exam**				
		Test1	**Test2**	**Avg.**					
HIAC801	**Applied Predictive Analytics**	**20**	**20**	**20**	**80**	**-**	**-**	**-**	**100**

Course objective	1. To deliver Knowledge of core operations in Energy Vertical Solving complex issues analyzing available data in Operations, Maintenance, Reliability, Safety, Procurement, Inventory etc., 2. To introduce forecasting and predictive techniques.
Course Outcome	The students will able to 1. Identify the use of analytics and its tools 2. Interpret data and preparation of data 3. Use descriptive modeling techniques 4. Practice predictive modeling techniques such as decision tree, logistic regression and neural network 5. Apply and build models using clustering, regression and classification techniques and its corresponding algorithms 6. Discuss the case studies of Predictive Analytics and Predictive Maintenance

Pre requisites: Data Science concepts			
Module	**Content**	**Hours.**	**CO**
1	**Overview of Predictive Analytics:** What and Why Analytics, Predictive Analytics? Supervised vs. Unsupervised Learning, Parametric vs. Non-Parametric Models, Business Intelligence, Predictive Analytics vs. Business Intelligence, Predictive Analytics vs. Statistics, Statistics and Analytics, Predictive Analytics and Statistics Contrasted, Predictive Analytics vs. Data Mining, Challenges in Using Predictive Analytics. Concept of hb	06	CO1
2	**Data Understanding and Data Preparation:** Single Variable Summaries, Applying Simple Statistics in Data Understanding, Categorical Variable Assessment, Data Visualization in One Dimension, Two or Higher Dimensions. Data Preparation, Fixing Missing Data, Feature Creation, Simple Variable Transformations, Fixing Skew, Binning Continuous Variables, Numeric Variable	08	CO2

	Scaling, Nominal Variable Transformation, Ordinal Variable Transformations, Date and Time Variable Features, Multidimensional Features		
3	**Descriptive Modeling:** Data Preparation, Issues with Descriptive Modeling, Principal Component Analysis, The PCA Algorithm, Applying PCA to New Data, PCA for Data Interpretation, Additional Considerations before Using PCA, The Effect of Variable Magnitude on PCA Models, Clustering Algorithms, The K-Means Algorithm, Data Preparation for K-Means	07	CO3
4	**Predictive Modeling:** Decision Trees, The Decision Tree Landscape, Building Decision Trees, Logistic Regression, Interpreting Logistic Regression Models, Other Practical Considerations for Logistic Regression, Neural Networks, Building Blocks: The Neuron, Neural Network Training, The Flexibility of Neural Networks, Neural Network Settings, Neural Network Pruning, Interpreting Neural Networks, Neural Network Decision Boundaries, Other Practical Considerations for Neural Networks	09	CO4
5	**Predictive Modeling:** K-Nearest Neighbor, the k-NN Learning Algorithm, Distance Metrics for k-NN, Other Practical Considerations for k-NN, Naïve Bayes, Bayes' Theorem, The Naïve Bayes Classifier Interpreting Naïve Bayes Classifiers, Other Practical Considerations for Naïve Bayes, Regression Models, Linear Regression, Linear Regression Assumptions, Variable Selection in Linear Regression, Interpreting Linear Regression Models, Using Linear Regression for Classification, Other Regression Algorithms	09	CO5
6	**Assessing Predictive Models:** Batch Approach to Model Assessment, Percent Correct Classification, Rank-Ordered Approach to Model Assessment, Assessing Regression Models. **Case studies:** Quality Prediction in a Mining Process, predicting the consumption of electricity in the coming future (refer Kaggle data set) **Predictive Maintenance:** Find a defect in the production, Sensor Fault Detection(refer Kaggle data set), Boiler Fault Detection ((refer https://ieee-dataport.org/)	09	CO6

Internal Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on Minimum 02 Modules) and the other is either a class test or assignment on live problems or Course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
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4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Text Books:

1. Dean Abbott, “Applied Predictive Analytics: Principles and Techniques for the Professional Data Analyst” , ISBN: 978-1-118-72796-6
2. P. Kaliraj, T. Devi, “Big Data Applications in Industry 4.0”, ISBN 9781032008110, Published February 10, 2022 by Auerbach Publications
3. Mahir Oner, Sultan Ceren Oner, “Data Analytics in Industry 4.0: In the Perspective of Big Data”.

Reference Books:

1. Gareth James, Daniela Witten, Trevor Hastie Robert Tibshirani. “An Introduction to Statistical Learning with Applications in R”
2. Joel Grus, “Data science from scratch”, Orielly publication, ISBN: 9781492041139, May 2019
3. David Roi Hardoon, Galit Shmueli, “Getting Started with Business Analytics: Insightful Decision-Making”, CRC Press, ISBN 9781498787413
4. James R Evans, “Business Analytics”, Pearson publication, ISBN: 9780135231678