

SMART MANUFACTURING SYSTEMS**Course Code :**

Programme Name/s : Mechatronics
Programme Code : MK
Semester : Sixth
Course Title : SMART MANUFACTURING SYSTEMS
Course Code :

I. RATIONALE

This course provides students with the fundamental knowledge and practical skills required to work in modern manufacturing environments that leverage Industry 4.0 technologies such as IoT, AI, Robotics, CAM, CNC, PLC, and Cloud Computing. Course bridges the gap between conventional manufacturing and future-ready digital industries, preparing students for careers in automated production systems, industrial robotics, and smart factories.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the students to attain the following industry identified outcome through various teaching learning experiences: Plan smart manufacturing systems for various industrial/ field applications using relevant knowledge & skills.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Compare features of traditional manufacturing, smart manufacturing and Industry 4.0.
- CO2 - Apply digital technologies in manufacturing.
- CO3 - Use smart manufacturing control and monitoring systems.
- CO4 - Apply Automation and Robotics in Smart Manufacturing.
- CO5 - Plan smart manufacturing applications in given industry.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme													Total Marks
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL				
															Practical								
				CL	TL	LL	FA-TH				SA-TH		Total		FA-PR		SA-PR		SLA				
Max	Max	Max	Min	Max	Min	Max	Min	Max	Min														
	SMART MANUFACTURING SYSTEMS	SMS	DSE	4	-	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175		

SMART MANUFACTURING SYSTEMS**Course Code :****Total IKS Hrs for Sem. : 0 Hrs**

Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @\$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's) aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Explain Traditional Manufacturing system. TLO 1.2 Explain the need of smart manufacturing system. TLO 1.3 State basic principles of smart manufacturing. TLO 1.4 Explain evolution of smart manufacturing systems. TLO 1.5 List Key technologies of Smart manufacturing. TLO 1.6 Compare features of traditional manufacturing and smart manufacturing system.	Unit - I Introduction to Smart Manufacturing 1.1 Traditional manufacturing system. Definition, advantages & applications. 1.2 Need of smart manufacturing system. 1.3 Smart Manufacturing-Definition, basic principles, objectives, types & benefits . 1.4 Evolution of smart manufacturing systems. 1.5 Key components and overview of technologies used in Smart Manufacturing (IIoT, AIML, Big data analytics, Automation & Robotics etc.)	Lecture Using Chalk-Board Presentations Video Demonstrations Flipped Classroom

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Sr.No	Theory Learning Outcomes (TLO's) aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
2	<p>TLO 2.1 Explain the need of Industry 4.0.</p> <p>TLO 2.2 Explain Various Technologies of Industry 4.0.</p> <p>TLO 2.3 Draw factory layout with IoT.</p> <p>TLO 2.4 Plan for incorporating industry 4.0 for given manufacturing application.</p> <p>TLO 2.5 Identify the challenges of IoT in Manufacturing.</p> <p>TLO 2.6 Explain need of cloud computing in manufacturing.</p> <p>TLO 2.7 State concept of Digital Twin Technology.</p>	<p>Unit - II Fundamentals of Industry 4.0</p> <p>2.1 Industry 4.0- History, Need & importance.</p> <p>2.2 Introduction to Technologies of Industry 4.0- IoT, AI, cloud computing, big data, robotics, additive manufacturing.</p> <p>2.3 Basics of IoT- Concept, Connecting devices and machines, layout.</p> <p>2.4 Industrial Applications-Real-time monitoring, predictive maintenance, optimized supply chains, and enhanced product tracking.</p> <p>2.5 Benefits & challenges of IoT in Manufacturing.</p> <p>2.6 Cloud Computing in Manufacturing- Storing and accessing data in the cloud. Cloud-based manufacturing applications.</p> <p>2.7 Digital Twin Technology- Concept, benefits & applications.</p>	<p>Video</p> <p>Demonstrations</p> <p>Presentations</p> <p>Site/Industry Visit</p> <p>Lecture Using Chalk-Board</p>
3	<p>TLO 3.1 Describe the process of computer aided manufacturing control.</p> <p>TLO 3.2 Explain step by step process of computer aided quality control (CAQC), PLC & SCADA.</p> <p>TLO 3.3 Describe applications of AIML in smart Manufacturing.</p> <p>TLO 3.4 List Cybersecurity measures.</p>	<p>Unit - III Digital Manufacturing Technologies</p> <p>3.1 Computer aided manufacturing Control (CAMC): Generate computer program in machining. Interfacing part program to CNC.</p> <p>3.2 Computerized monitoring & control-Computer aided quality control (CAQC), Programmable logic control (PLC), & SCADA.</p> <p>3.3 Artificial Intelligence & Machine Learning (AIML)- Concept, data collection, storage & processing. Predictive analysis & machine learning. Applications of AI in manufacturing.</p> <p>3.4 Cybersecurity-Measures & best practices, cybersecurity for industrial control systems.</p>	<p>Video</p> <p>Demonstrations</p> <p>Presentations</p> <p>Site/Industry Visit</p> <p>Lecture Using Chalk-Board</p> <p>Flipped Classroom</p>
4	<p>TLO 4.1 Explain given types of automation.</p> <p>TLO 4.2 Suggest the strategies for automation in given situation.</p> <p>TLO 4.3 Explain role of PLM & SCM in smart Manufacturing.</p> <p>TLO 4.4 List applications of robotics in manufacturing.</p> <p>TLO 4.5 State the function of various types of Cobots.</p>	<p>Unit - IV Factory automation & Robotics in smart manufacturing</p> <p>4.1 Automation in Manufacturing Types of automation: Fixed, programmable, and flexible.</p> <p>4.2 Strategies in automation-Online inspection, online monitoring, automated guided vehicles (AGVs) and conveyor systems. Process control & optimization, control of plant operations & CIM (Computer Integrated Manufacturing).</p> <p>4.3 Computer Integrated Manufacturing (CIM)-Role of Product Life Cycle Management, Role of Supply Chain Management (SCM) In Smart Manufacturing.</p> <p>4.4 Robotics in Manufacturing- Material Handling, Processing operations, Automated assemblies & inspections.</p> <p>4.5 Collaborative Robot (Cobot)-Definition, types- Power & force limiting, safety monitored stop, speed & separation & hand guiding, industrial robot & Cobot.</p>	<p>Video</p> <p>Demonstrations</p> <p>Presentations</p> <p>Site/Industry Visit</p> <p>Case Study</p> <p>Demonstration</p>

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Sr.No	Theory Learning Outcomes (TLO's) aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
5	TLO 5.1 List different areas of applications of Smart manufacturing. TLO 5.2 Explain Sustainability and environmental considerations in Smart Manufacturing. TLO 5.3 List the Challenges in Smart Manufacturing.	Unit - V Smart Manufacturing-Implementation & Challenges 5.1 Implementation- Factories and Assembly Line, Food Industry, Medical, Power Plants, Inventory Management & Quality. 5.2 Data Acquisition and Analysis. Sustainability and environmental considerations in Smart Manufacturing. 5.3 Challenges in smart manufacturing.	Video Demonstrations Case Study Site/Industry Visit Lecture Using Chalk-Board

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Study various manufacturing processes. LLO 1.2 Prepare a manufacturing process report considering traditional manufacturing system.	1	*Report generation of traditional manufacturing systems (Considering any product assembly).	2	CO1
LLO 2.1 Study different network topologies for system communication. LLO 2.2 Built up communication between machines and cloud storage.	2	Communication network between hardware and Cloud storage.	2	CO1 CO2
LLO 3.1 Interpret different methods of data analysis. LLO 3.2 Observe remote factory data Using cloud platforms.	3	Visualization of remote factory data Using cloud platforms.	2	CO1 CO2
LLO 4.1 Draw simple 3D model for path simulation. LLO 4.2 Generate and simulate tool paths using CAM software.	4	*Tool path generation and simulation of simple parts.	2	CO1 CO3
LLO 5.1 Study different machining parameters. LLO 5.2 Perform toolpath simulation and analyze machining parameters.	5	*Tool path simulation & analysis of machining parameters.	2	CO1 CO3
LLO 6.1 Develop CNC part programs for turning operations. LLO 6.2 Operate CNC machine for turning operation.	6	*CNC part program for turning operation.	2	CO1 CO3
LLO 7.1 Develop CNC part programs for milling operations. LLO 7.2 Operate CNC machine for milling operation.	7	CNC part program for milling operation.	2	CO3
LLO 8.1 Study different SCADA software and systems in the market. LLO 8.2 Select Suitable SCADA Software for given application.	8	SCADA software for factory operations.	2	CO3

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 9.1 Collect machine data for fault prediction. LLO 9.2 Analyze machine data for fault prediction.	9	Machine data collection for fault prediction.	2	CO3
LLO 10.1 Study different types of sensors & actuators used in manufacturing systems. LLO 10.2 Interface proximity sensors and actuators for real-time control with PLC.	10	*Proximity sensors and actuators interface with PLC.	2	CO3
LLO 11.1 Measure part tolerances using Coordinate Measuring Machine (CMM). LLO 11.2 Operate CMM machine for measurement of part tolerance.	11	* CMM for measuring different variables.	2	CO3
LLO 12.1 Study different CIM software for product development. LLO 12.2 Use PLM (Product life cycle Management) software for CIM related to any simple product.	12	PLM software for simple product Manufacturing.	2	CO4
LLO 13.1 Study different CIM software for product development. LLO 13.2 Use Supply Chain Management (SCM) software for CIM related to any simple product.	13	*SCM software for simple product Manufacturing.	2	CO4
LLO 14.1 Study of collaborative robot. LLO 14.2 Analyze different operating parameters of Cobot.	14	Observe actual/Video of collaborative robot.	2	CO4
LLO 15.1 Study industrial robot anatomy. LLO 15.2 Use robots for different Manufacturing processes.	15	*Robots for automated assemblies and inspections.	2	CO4
LLO 16.1 Study of smart manufacturing systems in Industry. LLO 16.2 Analyze different operations in smart manufacturing system.	16	Observe actual/Video of smart manufacturing systems.	2	CO5
Note : Out of above suggestive LLOs - <ul style="list-style-type: none"> • '*' Marked Practicals (LLOs) Are mandatory. • Minimum 80% of above list of lab experiment are to be performed. • Judicial mix of LLOs are to be performed to achieve desired outcomes. 				

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

- Collect information about traditional manufacturing systems & smart manufacturing systems.
- “Smart manufacturing systems are highly efficient than traditional manufacturing systems” Justify.
- Collect an information about cybersecurity for industrial control systems.
- Carry out comprehensive study of technologies used in Smart Manufacturing (IIoT, AIML, Big data analytics, Automation & Robotics etc.)

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- Collect information about online inspection, online monitoring, automated guided vehicles (AGVs) and conveyor systems.
- Prepare a report on applications of smart manufacturing systems in various sectors.
- Make power point presentation including videos on AIML, IoT, Cloud computing, Digital twin technology.

Micro project

- Prepare a chart showing basic principles, objectives, types & benefits of Smart Manufacturing.
- Prepare and present a seminar on technologies of Industry 4.0.
- Examine & prepare a report on inspection of parts using CAQC software by CMM/other system.
- Prepare charts on digital twin technology & cloud computing in smart manufacturing.
- Prepare charts on technologies used in Smart Manufacturing systems.
- Prepare a model showing components of smart manufacturing systems.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicious mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	PLC (Min 8 input/output)	10
2	ERP, PLM & SCM software (1+10 user)	12,13
3	Industrial Robot with standalone servo controller as well as compatible PLC interface with following features: 1) Minimum 3 linkages 2) Minimum 6 degree of freedom (6 DoF) 3) Various sensors 4) Compatible Robot vision system for inspection.	14,15
4	Robot offline simulation software-Any suitable freeware	15
5	Computers with internet connectivity (Minimum i7 Core Processor, 8GB RAM, 500GB HDD)	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Smart Manufacturing	CO1	10	4	4	4	12
2	II	Fundamentals of Industry 4.0	CO2	12	2	8	6	16
3	III	Digital Manufacturing Technologies	CO3	14	2	8	6	16
4	IV	Factory automation & Robotics in smart manufacturing	CO4	14	2	6	8	16

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Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
5	V	Smart Manufacturing-Implementation & Challenges	CO5	10	2	4	4	10
Grand Total				60	12	30	28	70

X. ASSESSMENT METHODOLOGIES/TOOLS**Formative assessment (Assessment for Learning)**

- Two-unit tests of 30 marks and average of two-unit tests.
- For laboratory learning 25 Marks
- For Self Learning 25 Marks

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks.
- End semester assessment of 25 marks for laboratory learning.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	-	-	1	2	-	3			
CO2	3	2	2	3	2	2	3			
CO3	2	2	2	3	2	2	3			
CO4	2	2	2	3	2	2	3			
CO5	3	2	2	3	3	2	3			
Legends :- High:03, Medium:02,Low:01, No Mapping: -										
*PSOs are to be formulated at institute level										

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Alasdair Gilchrist	Industry 4.0: The Industrial Internet of Things	Apress (1 January 2019) ISBN:978-1484249703
2	Dr Shirish Gandhare	Basics and Introduction to Industry 4.0	Notion Press ,ISBN: 9798896730323
3	M. Niranjanamurthy , Sheng-Lung Peng , E. Naresh .	Advances in Industry 4.0: Concepts and Applications (Smart Computing Applications, 5)	De Gruyter ,ISBN:978-3110725360.

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Sr.No	Author	Title	Publisher with ISBN Number
4	Domanic T Matt , Vladimir Modrak	Implementing Industry 4.0 in SMEs	Springer Nature Switzerland AG, ISBN: 9783030705183
5	Dr. Shruti Vashist, Dr. Sujata Nayak, Mr. Piyush Mahendru and Dr. Prashant Bhardwaj	Industry 4.0: New age of Robotics, Automation and Communication Engineering	AkiNik Publications, ISBN:978-93-5570-343-9
6	M. Groover	CAD/CAM: Computer-Aided Design and Manufacturing	Pearson Education ,ISBN: 978-8174906700

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=7iWriXyI2cE&t=6s	Introduction to IoT
2	https://www.youtube.com/watch?v=gWu2Jxfae74&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=5	IoT networking
3	https://www.youtube.com/watch?v=KqSqyKwVuA8&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=17	Cyber security
4	https://www.youtube.com/watch?v=eKiepu2D-XQ&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=8	Sustainability in Manufacturing
5	https://www.youtube.com/watch?v=JC3cQ2MB_34	Data Handling
6	https://www.youtube.com/watch?v=zLMgdYI82IE&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=14	Virtual & augmented reality
7	https://www.youtube.com/watch?v=CN1gn4J_Plk	Study of Cobots
8	https://www.youtube.com/watch?v=De8MQWbhu3k&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=11	Smart factories
9	https://www.youtube.com/watch?v=C_dYxnTDIPE&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=50	Applications of smart manufacturing in factories assembly line
10	https://www.youtube.com/watch?v=XLY4M0mm05A&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=51	Applications of smart manufacturing in food industries
11	https://www.youtube.com/watch?v=I59n_ScFIp4&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=54	Applications of smart manufacturing in inventory management
12	https://www.youtube.com/watch?v=Tyvj4Hmrzj7w&list=PLbRMhDVUMngdcLdH4-YF1uJI4IuhcDZPR&index=65	Applications of smart manufacturing in Virtual reality lab

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

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