SEMESTER-VII

Course Code	**2312401**						
Course Name	**Embedded System in Robotics**						
Type of Course	PCC						
Teaching Scheme and Credits Weekly Working Hrs	TH(Hrs.)		TU(Hrs.)		PR(Hrs.)		Total Credits
	03		--		--		03
Assessment Scheme	CCE	TW	PR	OR	ISE	ESE	Total (Marks)
	20	--	--	--	20	60	100

Prerequisites for the Course: Fundamentals of Electronics Engineering, Microprocessor & Microcontroller

The course aims to:

Course Objectives	Description
1	To introduce the fundamentals of embedded systems and their significance in robotic applications.
2	To understand the architecture and functionality of microcontrollers commonly used in robotics.
3	To develop skills in embedded C/C++ programming for real-time robotic control applications.
4	To learn about various sensors and actuators used in robotic systems and how to interface them with embedded hardware.
5	To explore communication protocols (e.g., I2C, SPI, UART, CAN) essential for data exchange between embedded components in robots.

On completion of the course, learner will be able to–

Course Outcomes	Description
CO1	Demonstrate the concept of embedded system, microcontroller, different components of microcontroller and their interactions.
CO2	Get familiarized with programming environment to develop embedded solutions.
CO3	Program ARM microcontroller to perform various tasks.
CO4	Demonstrate the key concepts of embedded systems such as I/O, timers, interrupts and interaction with peripheral devices

Course context, Relevance, Practical Significance:

The course **"Embedded Systems"** introduces students to the design and development of intelligent, autonomous, and real-time systems that form the backbone of modern electronic and robotic applications. It covers foundational concepts, including the architecture of embedded systems, programming techniques, real-time operating systems, communication protocols, and device drivers. This course bridges hardware and software concepts, empowering students to build real- world embedded solutions with an emphasis on reliability, efficiency, and performance.

Course Contents:

Unit and Chapter	Contents	Lecture Hours
1	**Fundamentals of Embedded System** Basic structure of embedded systems: Power-supply, Sensors, A-D/D-A converters, processor and ASICs and Actuators, memory. Communication Interface, Real time operating systems, Safety and reliability, environmental issues. Ethical practice. Characteristics, advantages and disadvantages of embedded systems.	7
2	**Embedded Hardware and Design** Microcontroller Unit (MCU) 48, A Popular 8-bit MCU, Memory for Embedded Systems, Low Power Design, Pullup and Pulldown Resistors, Introduction to ARM-v7-M (Cortex-M3), ARM-v7-R (CortexR4) and comparison in between them. Embedded Product development life cycle, Program modeling concepts: DFG, FSM, Petri-net, UML 2	7
3	**Embedded system programming** Embedded C-programming concepts, Constants, Variables & Data Types, Operators, Functions, and Software's, interfacing of LED, LCD, motors, and switches. Serial Communication Programming: Introduction to Serial Communication, Types of Serial Communication, and Description of SFR associated with Serial Communication, Programming of UART, Interfacing of ADC, sensor interfacing, embedded networking	7
4	**Embedded Serial Communication** Study of basic communication protocols like SPI, SCI (RS232, RS485), I2C, 10 CAN, Field-bus (Profibus), USB (v2.0), Bluetooth, Zig-Bee, Wireless sensor network	7
5	**Real Time Based Operating System(RTOS) & Linux Fundamentals & Device Driver Programming** POSIX Compliance , Need of RTOS in Embedded system software, Foreground/Background systems, multitasking, context switching, IPC, Scheduler policies, Architecture of kernel, task scheduler, ISR, Semaphores, mailbox, message queues, pipes, events, timers, memory management, RTOS services in contrast with traditional OS. Linux Fundamentals, Linux Commands, VI Editors, Introduction to Device Driver, The Role of Device Driver, Kernel Module Vs Application, Types of Device Driver, Character Driver, Block Driver & network Driver.	7

Course Mapping

Unit and Chapter	Bloom's Taxonomy Level	CO Mapped	PO Mapped	PSO Mapped
1	Understand, Apply	1,4	PO1, PO2, PO7, PO8	1,2
2	Understand, Analyze	1,2	PO1, PO2, PO3, PO5, PO12	1,2
3	Apply, Analyze	2,3	PO1, PO2, PO3, PO4, PO5, PO10, PO12	1,2
4	Understand, Evaluate	3,4	PO1, PO2, PO4, PO5, PO6	1,2

5	Analyse, Create	4	PO1, PO3, PO4, PO5, PO8, PO12	1,2

References Books

1. 1.K. V. Shibu, Introduction to Embedded Systems, TMH, ISBN: 978-9339219680
2. F. Vahid, Embedded System Design – A unified hardware and software introduction, John Wiley, ISBN: 978-0-471 38678-0

Text Books

1. 3. Rajkamal, Embedded Systems, TMH.
2. 4. L. B. Das, EMBEDDED SYSTEMS and Integrated approach, Pearson, ISBN: 978-81- 317-8766-
3. 5. M. Mazidi, Pic Microcontroller and Embedded System

e Resources

Course Name	Instructor / Institute	Link
Embedded Systems Design	Prof. Santanu Chattopadhyay (IIT Kharagpur)	https://nptel.ac.in/courses/108/105/108105102
Embedded Systems	Prof. Dhananjay V. Gadre (NSUT Delhi)	https://nptel.ac.in/courses/117/102/117102095
Real-Time Systems	Prof. Rajib Mall (IIT Kharagpur)	https://nptel.ac.in/courses/106/105/106105156/

Useful websites / Video

Channel Name	Useful For	Link
Paul McWhorter	Arduino-based programming, sensor interfacing, real-time projects	Paul McWhorter Teaches Technology
FreeRTOS Tutorials by - Dave Jones (EEVBlog)	RTOS concepts, multitasking, and embedded C	- YouTubeSimulator Software Proteus
The Linux Foundation	Linux device drivers, kernel basics	YouTube
GreatScott!	Embedded design, SPI, I2C, UART, ADC	GreatScott! - YouTube interfacing

Course Code	**2312402**						
Course Name	**PLC & SCADA Programming**						
Type of Course	PCC						
Teaching Scheme and Credits Weekly Working Hrs	TH(Hrs.)		TU(Hrs.)		PR(Hrs.)		Total Credits
	03		--		--		03
Assessment Scheme	CCE	TW	PR	OR	ISE	ESE	Total (Marks)
	20	--	--	--	20	60	100

Prerequisites for the Course: Basic Electrical and Electronics Engineering , Mathematics

The course aims to:

Course Objectives	Description
1	To introduce the fundamentals, evolution, architecture, and working principles of Programmable Logic Controllers (PLC).
2	To develop students' ability to design, write, and implement PLC programs using standard programming techniques like ladder logic and functional block diagrams.
3	To familiarize students with the hardware components, addressing methods, and communication protocols used in PLC-based systems.
4	To provide a comprehensive understanding of SCADA and Distributed Control Systems (DCS), including their structure, operation, and applications in industrial automation.
5	To enable students to apply PLC and SCADA concepts for real-time industrial process control applications involving sensors, actuators, and control logic.

On completion of the course, learner will be able to–

Course Outcomes	Description
CO1	Understand basic concepts of PLCs and SCADA in automation
CO2	Identify PLC hardware and software components
CO3	Develop and simulate PLC programs using ladder logic
CO4	Design basic SCADA systems for industrial monitoring
CO5	Apply PLC-SCADA integration in real-world automation

Course context, Relevance, Practical Significance:

This course introduces the fundamentals of PLC and SCADA programming, focusing on automation and real-time control in industrial systems. It equips students with hands-on skills to design, simulate, and troubleshoot automation processes used in manufacturing, robotics, and smart infrastructure.

Course Contents:

Unit and Chapter	Contents	Lecture Hours
1	**Introduction to PLCs and SCADA Systems** Introduction to Automation, Evolution and Importance of PLCs- History, advantages over traditional control systems, and applications, SCADA Systems: Introduction to Supervisory Control and Data Acquisition systems, their components, and significance, real-world industrial applications	7
2	**PLC Hardware and Software Components** PLC Architecture: Central Processing Unit (CPU), memory, power supply, and I/O modules, Input/ Output Modules: Types, specifications, and interfacing techniques, Programming Devices: Tools and software used for PLC programming	7
3	**PLC Programming Techniques** Programming Languages: Introduction to Ladder Logic- Introduction to Ladder Diagram syntax and rungs, Rules of ladder logic programming, Function Block Diagram, and Structured Text, Latching and interlocking circuits, Basic Instructions: Bit logic operations, timers- On-Delay Timer, Off-Delay Timer, Retentive Timer, Counter Instructions, Up-Counter, Down-Counter and arithmetic operations, Advanced Instructions: Data handling, analog processing, and PID control. Real Time Applications using ladder logic programming method- Traffic light control system, Conveyor belt control system, Applications of counters in Industrial Automation, Application of Timers in Automation	7
4	**SCADA System Design and Implementation** Functions of SCADA, SCADA Architecture- Basic components: RTU, PLC, HMI, SCADA Software, Centralized vs distributed SCADA ,systems, Communication in SCADA, Human-Machine Interface (HMI), Difference Between SCADA, DCS, PLC, and HMI, Industrial Applications and Case Studies	7
5	**Industrial Application** Automatic water level controller, Start-Stop motor control with interlock, Two-tank liquid filling system, Automatic street light control using LDR, Lift (Elevator) control logic, Conveyor-Based Sorting Robot Using Color Sensors and Diverter Logic, Robotic Welding System Using Timers and Safety Interlocks, Lift (Elevator Type) Robotic Movement Using Level Sensors and Timers case studies using PLC and SCADA interfacing	7

Course Mapping

Unit and Chapter	Bloom's Taxonomy Level	CO Mapped	PO Mapped	PSO Mapped
1	Remember Understand	1,2	PO1, PO2, PO5, PO10	1,2
2	Apply, Analyse	1	PO1, PO2, PO3, PO4, PO5, PO12	1,2
3	Analyse, Evaluate	1,3	PO1, PO2, PO3, PO4, PO5, PO12	1,2
4	Analyse, Evaluate	3,4	PO1, PO2, PO3, PO4, PO5, PO11, PO12	1,2
5	Apply, Create	3,4	PO1, PO2, PO3, PO4, PO5, PO10, PO11, PO12	1,2

References Books

1. J. W. Webb and R. A. Reis, *Programmable Logic Controllers: Principles and Applications*, 5th ed. Upper Saddle River, NJ, USA: Prentice Hall, 2002. ISBN: 978- 0130607188.

2. J. W. Webb and R. A. Reis, *Programmable Logic Controllers: Principles and Applications*, 5th ed. Upper Saddle River, NJ, USA: Prentice Hall, 2002. ISBN: 978-0130607188.
3. S. Mukhopadhyay and S. Sen, *Industrial Instrumentation and Control*, 2nd ed. New Delhi, India: PHI Learning, 2016. ISBN: 978-8120352445

Text Books

1. Programmable Logic Controllers: Principles and Applications – *John W. Webb, Ronald A. Reis* ISBN: 978-0130607188
2. Programmable Logic Controllers *Frank D. Petruzella* ISBN: 978-0073510880
3. SCADA: Supervisory Control and Data Acquisition *Stuart A. Boyer* ISBN: 978-1936007097

e Resources

NPTEL (IIT Courses) – Industrial Automation and Control

https://nptel.ac.in/courses/108/102/108102045

(Includes PLC, SCADA, and automation systems)

Useful websites / Video

Channel Name	Useful For	Link

Strength of CO - PO/PSO Mapping (Sample): Attainment of a PO/PSO depends both on the attainment levels of associated COs of courses and the strengths to which it is mapped

• Each Course Outcome addresses a sub-set of POs and PSOs to varying levels (strengths: 1- Low, 2 – Medium, 3 - Strong).

Strength of CO-PO/PSO Mapping														
Strength of COs	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	3	2	-	-	-	-	-	-	-	1	-	1	2	1
CO 2	3	2	-	-	1	-	-	-	-	1	-	2	2	2
CO 3	3	3	2	-	3	-	-	-	2	2	2	2	3	3
CO 4	2	2	3	-	3	-	-	-	2	2	2	2	2	3
CO5	2	3	3	2	3	2	1	1	3	2	2	2	3	3

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for CCE	Marks Allotted
1	Tests on each unit using LMS (Each test for 10 M and total will be converted out of 5 M)	05
2	Quiz on each topic of having 3 marks and total marks is converted into 5marks	05
3	Timely Assignment Submission	10
	Total	20

Name and Sign of Academic Coordinator **Name and Sign of BoS Chairperson**

Course Code	2312403						
Course Name	Lab work in Embedded Systems in Robotics						
Type of Course	PCC						
Teaching Scheme and Credits	TH(Hrs.)		TU(Hrs.)		PR(Hrs.)		Total Credits
Weekly Working Hrs	--		--		2		1
Assessment Scheme	CCE	TW	PR	OR	ISE	ESE	Total (Marks)
(Marks)	--	25	25	--	--	--	50

Prerequisites for the Course:
Basic Electrical and Electronics Engineering , Mathematics

The course aims to:

Course Objectives	Description
1	Understand the concept of embedded system, microcontroller, different components of microcontroller and their interactions
2	Get familiarized with programming environment to develop embedded solutions.
3	Program ARM microcontroller to perform various tasks
4	Understand the key concepts of embedded systems such as I/O, timers, interrupts and interaction with peripheral devices

On completion of the course, learner will be able to–

Course Outcomes	Description	Bloom's Level
CO1	Understand the concept of embedded system, microcontroller, different components of microcontroller and their interactions	1, 2
CO2	Get familiarized with programming environment to develop embedded solutions.	3
CO3	Program ARM microcontroller to perform various tasks	4, 5
CO4	Understand the key concepts of embedded systems such as I/O, timers, interrupts and interaction with peripheral devices	3, 4

Course context, Relevance, Practical Significance:
Introduces the fundamentals of PLC and SCADA systems for industrial automation and control. Highly relevant to modern industries adopting automation, robotics, and Industry 4.0 technologies. Provides hands-on skills in designing, programming, and simulating real-time control systems.

Course Contents:

Experiment No.	Contents	Pr. Hours	Cos Mapped
1	Porting of ucos-II on ARM7/Cortex controller.		CO1

2	Implementation/Verification of multitasking (minimum 03 tasks) with ucos-II on ARM7/Cortex controller.	2	CO2
3	Implementation of semaphore with ucos –II service ARM7/Cortex controller for resource management and synchronization	2	CO3
4	Implementation of inter process communication with ucos-II mailbox and message queue service on ARM7/Cortex controller.	2	CO3
5	Programming with exploring on chip ADC of Cortex /MSP430 based microcontroller.	2	CO3
6	Programming on motor control with exploring on chip PWM of Cortex based microcontroller.	2	CO3
7	Exercise on Porting of Linux on ARM board (ARM9 preferably)	2	CO3
8	Programming for device driver with Embedded Linux	2	CO4

References Books

K. V. Shibu, Introduction to Embedded Systems, TMH, ISBN: 978-9339219680

F. Vahid, Embedded System Design – A unified hardware and software introduction, John Wiley, ISBN: 978-0-471- 38678-0

Rajkamal, Embedded Systems, TMH.

L. B. Das, EMBEDDED SYSTEMS and Integrated approach, Pearson, ISBN: 978-81-317-8766-

M. Mazidi, Pic Microcontroller and Embedded System

e Resources

1] Siemens TIA Portal – *Getting Started with PLC Programming*
Available: https://new.siemens.com/global/en/products/automation/topic-areas/tia-portal.html
[2] Rockwell Automation – *RSLogix 500 and Studio 5000 Resources*
Available: https://www.rockwellautomation.com/en-us/support/documentation/software.html
[3] Automation Direct – *PLC Learning Resources and Tutorials*
Available: https://www.automationdirect.com/adc/overview/catalog/programmable-controllers/plc-training

Useful websites / Video

1] S**iemens Automation Learning Portal**

https://new.siemens.com/global/en/products/automation/topic-areas/tia-portal.html

Official resource for Siemens PLC programming and TIA Portal training.

2] **Rockwell Automation – Learning+**

https://www.rockwellautomation.com/en-us/training.html

Courses and documentation for RSLogix 500, Studio 5000, and SCADA systems.

Strength of CO - PO/PSO Mapping (Sample): Attainment of a PO/PSO depends both on the attainment levels of associated COs of courses and the strengths to which it is mapped

• Each Course Outcome addresses a sub-set of POs and PSOs to varying levels (strengths: 1-Low,2 – Medium, 3 - Strong).

Strength of CO-PO/PSO Mapping														
Strength of COs	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	2	2	1	1	1	1					1	1	2	1
CO 2	1	1	3			1						1	2	1
CO 3	1	1	2	2	2								2	1
CO 4	1	1	3	2	2	1			1				2	1

Name and Sign of Academic Coordinator **Name and Sign of BoS Chairperson**

Course Code	2312404						
Course Name	PLC & SCADA Programming Lab						
Type of Course	PCC						
Teaching Scheme and Credits	TH(Hrs.)		TU(Hrs.)		PR(Hrs.)		Total Credits
Weekly Working Hrs	--		--		2		1
Assessment Scheme	CCE	TW	PR	OR	ISE	ESE	Total (Marks)
(Marks)	--	25	25	--	--	--	50

Prerequisites for the Course:
Basic Electrical and Electronics Engineering , Mathematics

The course aims to:

Course Objectives	Description
1	To introduce students to the fundamentals of Programmable Logic Controllers (PLC), including architecture, hardware components, and programming interfaces
2	To develop the ability to write, simulate, and test ladder logic programs using basic instructions, timers, counters, and control structures.
3	To enable students to design and implement automation solutions for electro-pneumatic, electro-hydraulic, and robotics-based systems using PLCs
4	To provide practical exposure to SCADA systems for developing and monitoring real-time process control applications, and integrating SCADA with PLC for complete industrial automation.

On completion of the course, learner will be able to–

Course Outcomes	Description	Bloom's Level
CO1	Identify and demonstrate basic PLC hardware components, communication setup, and software interface for automation systems.	1, 2
CO2	Develop and test basic ladder logic programs using logical operations, timers, and counters for discrete control applications	3
CO3	Design and implement PLC programs for electro-pneumatic, electro-hydraulic, and electro-mechanical systems in automation	4, 5
CO4	Develop SCADA-based process control applications and integrate them with PLC systems for industrial automation.	3, 4

Course context, Relevance, Practical Significance:
Introduces the fundamentals of PLC and SCADA systems for industrial automation and control. Highly relevant to modern industries adopting automation, robotics, and Industry 4.0 technologies. Provides hands-on skills in designing, programming, and simulating real-time control systems.

Course Contents:

Experiment No.	Contents	Pr. Hours	Cos Mapped
1	Familiarization of PLC environment and establishing connections	2	CO1
2	Develop and test logic using PLC Ladder for; i) AND, OR and Latching operation ii) Simple ladder logic program using timers	2	CO2

	iii) Simple ladder logic program using counters		
3	PLC programming for Electro-pneumatic system	2	CO3
4	PLC programming for Electro-hydraulic system	2	CO3
5	PLC programming for robotics and electro-mechanical system	2	CO3
6	Develop process control application using SCADA	2	CO3
7	Interface SCADA with PLC for given application	2	CO3
8	Design of digital system in virtual simulation using SCADA	2	CO4

References Books

[6] J. W. Webb and R. A. Reis, *Programmable Logic Controllers: Principles and Applications*, 5th ed. Upper Saddle River, NJ, USA: Prentice Hall, 2002. ISBN: 978- 0130607188.
[7] S. K. Singh, *Industrial Instrumentation and Control*, 3rd ed. New Delhi, India: McGraw-Hill Education, 2013. ISBN: 978-1259062577.

[8] S. A. Boyer, *SCADA: Supervisory Control and Data Acquisition*, 4th ed. Research Triangle Park, NC, USA: ISA, 2010. ISBN: 978-1936007097.

[1] S. K. Singh, *Industrial Instrumentation and Control*, 3rd ed. New Delhi, India: McGraw-Hill Education, 2013. ISBN: 978-1259062577.

[2] M. D. Singh and J. G. Joshi, *PLC and SCADA Theory and Practice*, 1st ed. New Delhi, India: Laxmi Publications, 2014. ISBN: 978-8131808970.

e Resources

1] Siemens TIA Portal – *Getting Started with PLC Programming*
Available: https://new.siemens.com/global/en/products/automation/topic-areas/tia-portal.html
[4] Rockwell Automation – *RSLogix 500 and Studio 5000 Resources*
Available: https://www.rockwellautomation.com/en-us/support/documentation/software.html
[5] Automation Direct – *PLC Learning Resources and Tutorials*
Available: https://www.automationdirect.com/adc/overview/catalog/programmable-controllers/plc-training

Useful websites / Video

3] **Siemens Automation Learning Portal**
https://new.siemens.com/global/en/products/automation/topic-areas/tia-portal.html
Official resource for Siemens PLC programming and TIA Portal training.
4] **Rockwell Automation – Learning+**
https://www.rockwellautomation.com/en-us/training.html
Courses and documentation for RSLogix 500, Studio 5000, and SCADA systems.

Strength of CO - PO/PSO Mapping (Sample): Attainment of a PO/PSO depends both on the attainment levels of associated COs of courses and the strengths to which it is mapped
• Each Course Outcome addresses a sub-set of POs and PSOs to varying levels (strengths: 1-Low,2 – Medium, 3 - Strong).

Strength of CO-PO/PSO Mapping

Strength of COs	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	2	2	1	1	1	1					1	1	2	1
CO 2	1	1	3			1						1	2	1

CO 3	1	1	2	2	2								2	1
CO 4	1	1	3	2	2	1			1				2	1

Name and Sign of Academic Coordinator **Name and Sign of BoS Chairperson**

Course Code	2312405A						
Course Name	Elective 5 (A) Natural Language Processing						
Type of Course	PEC						
Teaching Scheme and Credits	TH(Hrs.)		TU(Hrs.)		PR(Hrs.)		Total Credits
Weekly Working Hrs	2		-		-		2
Assessment Scheme	CCE	TW	PR	OR	ISE	ESE	Total (Marks)
(Marks)	-	-	-	-	20	30	50

Prerequisites for the Course: students are expected to have a good understanding of Data Analytics

The course aims to:

Course Objectives	Description
1	To be familiar with fundamental concepts and techniques of natural language processing (NLP)
2	To acquire the knowledge of various morphological, syntactic, and semantic NLP tasks
3	To develop the various language modeling techniques for NLP
4	To use appropriate tools and techniques for processing natural languages
5	To comprehend the advance real world applications in NLP domain

On completion of the course, learner will be able to–

Course Outcomes	Description	Bloom's Level
CO1	Describe the fundamental concepts of NLP, challenges and issues in NLP	2
CO2	Describe the concepts of morphology, syntax, semantics of natural language	2
CO3	Illustrate various language modelling techniques	2
CO4	Integrate the NLP techniques for the information retrieval task	2
CO5	Demonstrate the use of NLP tools and techniques for text-based processing of natural languages	2

Course context, Relevance, Practical Significance: This course introduces core concepts and techniques of Natural Language Processing (NLP), covering text processing, syntax, semantics, language modeling, and real-world applications. With hands-on use of tools like NLTK and spaCy, it equips students to process and analyze human language, making it highly relevant for AI, search engines, chatbots, and other language-based technologies.

Course Contents:

Unit	Contents	Lecture Hours	Cos Mapped
1	**Unit 1: Introduction to Natural Language Processing** **Introduction:** Natural Language Processing, Why NLP is hard? Programming languages Vs Natural Languages, Are	7	1

	natural languages regular? Finite automata for NLP, Stages of NLP, Challenges and Issues(Open Problems) in NLP **Basics of text processing:** Tokenization, Stemming, Lemmatization, Part of Speech Tagging		
2	**Unit 2: Language Syntax and Semantics:** **Morphological Analysis:**What is Morphology? Types of Morphemes, Inflectional morphology &Derivational morphology, Morphological parsing with Finite State Transducers (FST) **Syntactic Analysis:** Syntactic Representations of Natural Language, Parsing Algorithms, Probabilistic context-free grammars, and Statistical parsing **Semantic Analysis:** Lexical Semantic, Relations among lexemes & their senses – Homonymy,Polysemy, Synonymy, Hyponymy, WordNet, Word Sense Disambiguation (WSD), Dictionary based approach, Latent Semantic Analysis	7	2
3	**Unit III : Language Modelling:** Probabilistic language modeling, Markov models, Generative models of language, Log-Liner Models, Graph-based Models **N-gram models:** Simple n-gram models, Estimation parameters and smoothing, Evaluating language models, Word Embeddings/ Vector Semantics: Bag-of-words, TFIDF, word2vec, doc2vec, Contextualized representations (BERT) **Topic Modelling**: Latent Dirichlet Allocation (LDA), Latent Semantic Analysis, Non Negative Matrix Factorization	7	3
4	**Unit IV : Information Retrieval using NLP:** **Information Retrieval:** Introduction, Vector Space Model **Named Entity Recognition:** NER System Building Process, Evaluating NER System Entity Extraction, Relation Extraction, Reference Resolution, Coreference resolution, Cross Lingual Information Retrieva	7	4
5	**Unit V : NLP Tools and Techniques:** **Prominent NLP Libraries:** Natural Language Tool Kit (NLTK), spaCy, TextBlob, Gensim etc. **Linguistic Resources:** Lexical Knowledge Networks, WordNets, Indian Language WordNet (IndoWordnet), VerbNets, PropBank, Treebanks, Universal Dependency	7	5

	Treebanks Word Sense Disambiguation: Lesk Algorithm Walker's algorithm, WordNets for Word Sense Disambiguation		

References Books

1. Steven Bird, Ewan Klein, Edward Loper, "Natural Language Processing with Python – Analyzing Text with the Natural Language Toolkit", O'Reilly Publication
2. Dipanjan Sarkar , "Text Analytics with Python: A Practical Real-World Approach to Gaining Actionable Insights from your Data", Apress Publication ISBN: 9781484223871
3. Alexander Clark, Chris Fox, and Shalom Lappin, "The Handbook of Computational Linguistics and Natural Language Processing", Wiley Blackwell Publications
4. Jacob Eisenstein, "Natural Language Processing", MIT Press
5. Jacob Eisenstein, "An Introduction to Information Retrieval", Cambridge University Press

Text Books

1. Jurafsky, David, and James H. Martin, "Speech and Language Processing: An Introduction to Natural Language Processing", Computational Linguistics and Speech Recognition‖, ,PEARSON Publication .
2. Manning, Christopher D., and nrich Schütze , "Foundations of Statistical Natural Language Processing", Cambridge, MA: MIT Press

e Resources

1. https://onlinecourses.nptel.ac.in/noc23_cs45/preview

Useful websites / Video

1. https://www.ibm.com/think/topics/natural-language-processing

Strength of CO - PO/PSO Mapping (Sample): Attainment of a PO/PSO depends both on the attainment levels of associated COs of courses and the strengths to which it is mapped
• Each Course Outcome addresses a sub-set of POs and PSOs to varying levels (strengths: 1-Low,2 – Medium, 3 - Strong).

Strength of CO-PO/PSO Mapping

Strength of COs	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	2	2	1	-	-	-	-	-	-	-	-	-	1	-
CO 2	2	2	2	2	2	-	-	-	-	-	-	1	1	-
CO 3	2	2	2	2	2	-	-	-	-	-	-	2	1	-
CO 4	2	2	2	2	2	-	2	2	-	-	-	3	1	-
CO 5	2	2	2	2	2							3	-	-

Name and Sign of Academic Coordinator **Name and Sign of BoS Chairperson**

Course Code	**2312405B**						
Course Name	Intelligent Manufacturing Systems						
Type of Course	PEC						
Teaching Scheme and Credits	TH(Hrs.)		TU(Hrs.)		PR(Hrs.)		Total Credits
Weekly Working Hrs	3		--		--		3
Assessment Scheme	CCE	TW	PR	OR	ISE	ESE	Total (Marks)
(Marks)	20	--	--	--	20	60	100

Prerequisites for the Course:

1. Artificial Intelligence for Robotics
2. Swarm Intelligence for Robotics,
3. Flexible Manufacturing systems.

The course aims to:

Course Objectives	Description
1	Understand basic concepts of Manufacturing Systems
2	Demonstrate the applications of intelligent systems in industrial planning and decision making
3	Introduce applications of intelligent systems to optimize manufacturing processes

On completion of the course, learner will be able to–

Course Outcomes	Description	Bloom'sLevel
CO1	Explain the components of manufacturing systems	2
CO2	Demonstrate various layers of intelligent manufacturing framework	3
CO3	Apply intelligence systems for optimization of manufacturing processes	3
CO4	Analyze the strategies to solve complex decision making problems in manufacturing systems.	4

Course context, Relevance, Practical Significance:

Intelligent Manufacturing Systems (IMS) are highly relevant in the fields of robotics and automation because they form the backbone of modern, efficient, and adaptive industrial production.IMS integrates artificial intelligence (AI), machine learning, and data analytics to enable robots and automated systems to make real-time decisions, predict maintenance needs, optimize production processes dynamically etc.

Course Contents:

Unit	Contents	Lecture Hours	Cos Mapped
1	**Introduction to Manufacturing systems** Importance of manufacturing systems, functions and characteristics of manufacturing systems, Types of manufacturing systems: Mass customization, custom manufacturing, flexible manufacturing system, continuous manufacturing system, Intermittent manufacturing systems	7	CO1
2	**Component of Intelligent Manufacturing Technologies** Development of Intelligent systems for Design, Supporting	7	CO1, CO2

	technologies for IMS: Industry Internet of Things, Cyber Physical Systems, Cloud computing, RFID Technologies, Data Analytics, other Information and Communications Technology, Digital twin.		
3	**Layers of an Intelligent Manufacturing Framework** Perception Layer (Physical Layer), Network Layer (Communication Layer), Data Processing Layer, Intelligence Layer, Control Layer, Application Layer	7	CO2
4	**Intelligent Design of manufacturing Systems** Production planning using fuzzy cognitive maps, computer aided process planning, Methods for inventory space allocation and storage processes analysis, Optimization of production costs and methods finding of the best process plan, Methods for production equipment selection and layout, Heuristic scheduling of multiple resources, Line balancing, group technology, Fuzzy multiple attribute decision making methods	7	CO3
5	**Intelligent techniques for manufacturing process optimization** Parametric optimization of machining processes using Taguchi design of experiments, response surface methodology, principal component analysis and evolutionary optimization methods. Applications of Fuzzy Logic and Neural Networks for manufacturing process modelling and optimization.	7	CO4

References Books

1. Sunil Pathak, "Intelligent Manufacturing", Springer, 2021
2. KamalakantaMuduli, V. P. Kommula, Devendra K. Yadav, M. ChithiraiPonSelvan, JayakrishnaKandasamy (Eds.), "Intelligent Manufacturing Management Systems", Scrivener Publishing LLC, 2023
3. LejlaBanjanović-Mehmedović, FahrudinMehmedović Intelligent Manufacturing Systems Driven by Artificial Intelligence in Industry 4.0, IGI Global, 2020

Text Books

1. Mikell P. Groover, "Automation, Production Systems and Computer Integrated Manufacturing", 8th edition, PHI, 2008.
2. Hamid R. Parsaei and Mohammad Jamshidi, "Design and Implementation of Intelligent Manufacturing Systems", PHI, 2009
3. Andre Kusaic, " Intelligent Manufacturing Systems", PHI,1989

e Resources

1. https://pchats.tripod.com/int_manu.pdf

Useful websites / Video

1. https://www.youtube.com/watch?v=De8MQWbhu3k

Strength of CO - PO/PSO Mapping (Sample): Attainment of a PO/PSO depends both on the attainment levels of associated COs of courses and the strengths to which it is mapped

• Each Course Outcome addresses a sub-set of POs and PSOs to varying levels (strengths: 1-Low,2 – Medium, 3 - Strong).

Strength of CO-PO/PSO Mapping

Strength of COs	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	2	2	2										1	
CO 2	2	2	3		2				2	2	1		2	
CO 3	2	2	2	3	2	1	1				2	2	1	
CO 4	2	2	3	3	2	1	1		1		2	2	1	

GuidelinesforContinuousComprehensiveEvaluationofTheoryCourse		
Sr. No.	**ComponentsforContinuousComprehensiveEvaluation**	**MarksAllotted**
1	Tests on each unit using LMS (Each test for 20 M and total will be converted out of 10 M)	5
2	Timely Assignment Submission	10
3	Real life case studies to solve real life problems using evolutionary computing	5
	Total	

Name and Sign of Academic Coordinator **Name and Sign of BoS Chairperson**

Course Code	**2312405C**						
Course Name	Micro-Electro Mechanical Systems						
Type of Course	PEC						
Teaching Scheme and Credits	TH(Hrs.)		TU(Hrs.)		PR(Hrs.)		Total Credits
Weekly Working Hrs	3		--		--		3
Assessment Scheme	CCE	TW	PR	OR	ISE	ESE	Total (Marks)
(Marks)	20	--	--	--	20	60	100

Prerequisites for the Course:

Applied Electronics Engineering ,Sensory Technology

The course aims to:

Course Objectives	Description
1	Understand basic concepts of Manufacturing Systems
2	Demonstrate the applications of intelligent systems in industrial planning and decision making
3	Introduce applications of intelligent systems to optimize manufacturing processes

On completion of the course, learner will be able to–

Course Outcomes	Description	Bloom'sLevel
CO1	Understand the operation of micro devices, micro systems and their applications	2
CO2	Design the micro devices, micro systems using the MEMS fabrication process.	3
CO3	Gain a knowledge of basic approaches for various sensor design	3
CO4	Gain a knowledge of basic approaches for various actuator design	4

Course context, Relevance, Practical Significance:

Course Contents:

Unit	Contents	Lecture Hours	Cos Mapped
1	Introduction to MEMS: What is MEMS? , Definition and Classification, History of MEMS, Intrinsic Characteristics of MEMS: Minitiarization, Microelectronics Integration, Parallel Fabrication with precision, Sensors and Actuator:Energy domains and transducers , Sensor Consideration, Actuator Consideration, Review of Electrical and Mechanical Concepts:	7	CO1

	Semiconductor devices ,Stress and strain analysis ,Flexural beam bending, Torsional deflection.		
2	Unit II: Microfabrication: Overview of Microfabrication : Photolithography, Thin film Deposition, Thermal oxidation of Silicon, wet etching, Silicon anisotropic etching, wafer dicing, wafer bonding etc., The Microelectronics Fabrication Process Flow , Silicon-Based MEMS Processes, New Materials and Fabrication Processes, LIGA Process , Assembly of 3D MEMS , Foundry process.	7	CO1, CO2

3	Sensors and actuators I: Electrostatic sensors, Parallel plate capacitors, Applications, Interdigitated Finger capacitor, Comb drive devices, Micro Grippers, Micro Motors , Thermal Sensing and Actuation , Thermal expansion ,Thermal couples , Thermal resistors , Thermal Bimorph ,Applications , Magnetic Actuators , Micromagnetic components , Case studies of MEMS in magnetic actuators, Actuation using Shape Memory Alloys	7	CO2
4	Unit IV: Sensors and actuators II Piezoresistive sensors , Piezoresistive sensor materials , Stress analysis of mechanical elements , Applications to Inertia, Pressure, Tactile and Flow sensors ,Piezoelectric sensors and actuators , piezoelectric effects, piezoelectric materials , Applications to Inertia , Acoustic, Tactile and Flow sensors.	7	CO3
5	Unit V: Polymer and Optical MEMS Polymers in MEMS, Polimide ,SU-8 , Liquid Crystal Polymer (LCP), PDMS, PMMA, Parylene , Fluorocarbon, Application to Acceleration, Pressure, Flow and Tactile sensors. Optical MEMS ,Lenses and Mirrors , Actuators for Active Optical MEMS.	7	CO4

References Books

1. Chang Liu, 'Foundations of MEMS', Pearson Education Inc., 2012.
2. Stephen D Senturia, 'Microsystem Design', Springer Publication, 2000.
3. Tai Ran Hsu, "MEMS & Micro systems Design and Manufacture" Tata McGraw Hill, New Delhi, 2002.

Text Books

1. Nadim Maluf," An Introduction to Micro Electro Mechanical System Design", Artech House, 2000.
2. Mohamed Gad-el-Hak, editor, " The MEMS Handbook", CRC press Baco Raton, 2001.
3. Julian w. Gardner, Vijay K. Varadan, Osama O.Awadelkarim, Micro Sensors MEMS and Smart Devices, John Wiley & Son LTD, 2002.
4. James J.Allen, Micro Electro Mechanical System Design, CRC Press Publisher, 2005.
5. Thomas M.Adams and Richard A.Layton, "Introduction MEMS, Fabrication and Application," Springer, 2010.

e Resources

2. https://pchats.tripod.com/int_manu.pdf

Useful websites / Video

2. https://www.youtube.com/watch?v=De8MQWbhu3k

Strength of CO - PO/PSO Mapping (Sample): Attainment of a PO/PSO depends both on the attainment levels of associated COs of courses and the strengths to which it is mapped
• Each Course Outcome addresses a sub-set of POs and PSOs to varying levels (strengths: 1-Low,2 – Medium, 3 - Strong).

Strength of CO-PO/PSO Mapping

Strength of COs	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	2	2	2										1	
CO 2	2	2	3		2				2	2	1		2	
CO 3	2	2	2	3	2	1	1				2	2	1	
CO 4	2	2	3	3	2	1	1		1		2	2	1	

GuidelinesforContinuousComprehensiveEvaluationofTheoryCourse		
Sr. No.	**ComponentsforContinuousComprehensiveEvaluation**	**MarksAllotted**
1	Tests on each unit using LMS (Each test for 20 M and total will be converted out of 10 M)	5
2	Timely Assignment Submission	10
3	Real life case studies to solve real life problems using evolutionary computing	5
	Total	

Name and Sign of Academic Coordinator **Name and Sign of BoS Chairperson**

Course Code	2312405D						
Course Name	**Control System**						
Type of Course	PEC						
Teaching Scheme and Credits Weekly Working Hrs	TH(Hrs.)		TU(Hrs.)		PR(Hrs.)		Total Credits
	03		--		--		03
Assessment Scheme	CCE	TW	PR	OR	ISE	ESE	Total (Marks)
	20	--	--	--	20	60	100

Prerequisites for the Course: Basic Electrical and Electronics Engineering , Mathematics

The course aims to:

Course Objectives	Description
1	**Understand the fundamentals of control systems** including open-loop and closed-loop configurations, modeling, and representation of dynamic systems used in robotics.
2	**Analyze time-domain behavior of control systems** and evaluate performance parameters such as stability, transient response, and steady-state error for robotic applications.
3	**Apply stability analysis techniques** such as Routh–Hurwitz criterion and Root Locus to assess and improve the stability of robotic systems.
4	**Interpret frequency-domain characteristics** using Bode plots, Nyquist plots, and gain/phase margins for effective control of robotic systems.
5	**Design and implement controllers** (P, PI, PID) and develop state-space models to achieve desired performance in robotic manipulators and mobile robots.

On completion of the course, learner will be able to–

Course Outcomes	Description
CO1	**Define and explain** basic concepts of control systems, types of control systems, and mathematical models of electrical, mechanical, and electromechanical systems used in robotics.
CO2	**Apply** time-domain analysis techniques to **evaluate** transient and steady-state performance parameters of first- and second-order control systems in robotic applications.
CO3	**Analyze** the stability of control systems using **Routh–Hurwitz criterion** and **Root Locus** methods for robotic manipulators and mobile robots.
CO4	**Analyze and assess** frequency-domain characteristics of control systems using **Bode plots, Nyquist plots, and stability margins** to judge system performance.

CO5	**Design and develop P, PI, and PID controllers** and **formulate state-space models** to achieve desired control objectives in robotic systems.

Course context, Relevance, Practical Significance:

The course builds upon prior knowledge of **engineering mathematics, basic electrical and mechanical systems**, and serves as a prerequisite for advanced courses such as **Robotics Dynamics and Control, Autonomous Systems, Mechatronics, Industrial Automation, and AI-based Control**.

Robotic systems operate in dynamic and uncertain environments where **precision, stability, and robustness** are critical. This course equips students with essential tools to: Understand how feedback improves accuracy and stability in robotic systems, Analyze system behavior in time and frequency domain, Ensure stability and desired performance of robotic joints, wheels, and end-effectors, Design controllers that enable smooth motion, trajectory tracking, and disturbance rejection. The concepts covered are directly relevant to modern applications including **industrial robots, autonomous mobile robots (AMRs), drones, humanoid robots, and medical robots**.

This course forms the **technical backbone** for robotics laboratories, internships, final-year projects, and careers in **robotics, automation, control engineering, and autonomous systems development**.

Course Contents:

Unit and Chapter	Contents	Lecture Hours
1	**Introduction to Control Systems:** Definition and classification of control systems, Open-loop and closed-loop control systems, Examples of control systems in robotics (servo motors, robot arms, mobile robots), Mathematical modeling of physical systems, Electrical systems, Mechanical translational and rotational systems, Electromechanical systems, Transfer function concept, Block diagram representation and reduction, Signal flow graphs and Mason's gain formula	7
2	**Time Domain Analysis:** Standard test signals (step, ramp, impulse), Time response of first-order and second-order systems, Performance specifications, Rise time, peak time, settling time, overshoot, Steady-state error and error constants, Type of control systems, Time-domain analysis of robotic joint control systems	7
3	**Stability Analysis:** Concept of stability, Characteristic equation and roots, Routh–Hurwitz stability criterion, Root locus technique, Rules for construction, Effect of gain variation, Stability analysis of robotic manipulators and mobile robots.	7

4	**Frequency Domain Analysis:** Frequency response concepts, Bode plots, Magnitude and phase plots, Gain margin and phase margin, Nyquist stability criterion, Polar plots, Application of frequency domain methods in robotic motion control	7
5	**Controller Design and State Space Analysis:** Controllers in control systems, P, PI, and PID controllers, Design and tuning of PID controllers, Introduction to state-space modeling, State variables and state equations, State transition matrix, Controllability and observability, State-space control in robotic systems	7

Course Mapping

Unit and Chapter	Bloom's Taxonomy Level	CO Mapped	PO Mapped	PSO Mapped
1	Remember Understand	1	PO1, PO2, PO5, PO10	1,2
2	Understand, Apply	2	PO1, PO2, PO3, PO4, PO5, PO12	1,2
3	Analyse	3	PO1, PO2, PO3, PO4, PO5, PO12	1,2
4	Analyse, Evaluate	4	PO1, PO2, PO3, PO4, PO5, PO11, PO12	1,2
5	Apply, Create	5	PO1, PO2, PO3, PO4, PO5, PO10, PO11, PO12	1,2

References Books

1] K. Ogata, *Modern Control Engineering*, Pearson

2] **I.J. Nagrath & M. Gopal**, *Control Systems Engineering*, New Age

3] **Norman S. Nise**, *Control Systems Engineering*, Wiley

Text Books

1] Dorf & Bishop, *Modern Control Systems*
2] Katsuhiko Ogata, *Discrete-Time Control Systems*

e Resource

NPTEL / SWAYAM Control Systems

NPTEL Control Systems (IIT Madras) — full video lecture series with assignments and transcripts, great for core theory and examples.

SWAYAM Control Systems course — another structured course with assessments and certification options.

e-Yantra MOOC on Control Systems

A beginner-level online course focusing on control theory, state-space, and controller design with tasks and Python assignments — useful for robotics context.

Useful websites / Video

Channel Name	Useful For	Link

Strength of CO - PO/PSO Mapping (Sample): Attainment of a PO/PSO depends both on the attainment levels of associated COs of courses and the strengths to which it is mapped
• Each Course Outcome addresses a sub-set of POs and PSOs to varying levels (strengths: 1-Low, 2 – Medium, 3 - Strong).

Strength of CO-PO/PSO Mapping														
Strength of COs	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	3	2	-	-	-	-	-	-	-	1	-	1	2	1
CO 2	3	2	-	-	1	-	-	-	-	1	-	2	2	2
CO 3	3	3	2	-	3	-	-	-	2	2	2	2	3	3
CO 4	2	2	3	-	3	-	-	-	2	2	2	2	2	3
CO5	2	3	3	2	3	2	1	1	3	2	2	2	3	3

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for CCE	Marks Allotted
1	Tests on each unit using LMS (Each test for 10 M and total will be converted out of 5 M)	05
2	Quiz on each topic of having 3 marks and total marks is converted into 5marks	05
3	Timely Assignment Submission	10
	Total	20

Name and Sign of Academic Coordinator **Name and Sign of BoS Chairperson**

K. K. Wagh Institute of Engineering Education and Research, Nashik
(Autonomous from Academic Year 2022-23)

Final Year B. Tech. Robotics and Automation **Pattern 2023, Semester: VII** **2312406B: Name of Subject: Elective IV (B) Additive Manufacturing**		
Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Theory :03hrs/week	**03**	**In Sem Exam: 20 Marks** **End Sem Exam: 60 Marks** **CCE: 20 Marks**

Prerequisite Courses: - Manufacturing Technology, Reverse Engineering, Engineering Mechanics

Course Objectives:
Understand the Additive Manufacturing
Understand Light and LASER based Techniques
Understand Extrusion and energy based Techniques
Analyze the Hardware and Software for AM

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	Bloom's Level
CO1	Explain the principles, methods, possibilities and limitations as well as environmental hazards of Additive Manufacturing technologies	2. Understand
CO2	Identify the characteristics of the different materials used in Additive Manufacturing technologies.	2. Understand
CO3	Explore the potential of additive manufacturing technologies in real life applications	2. Understand

COURSE CONTENTS

Unit I	**Additive Manufacturing (AM) Overview**	**(07 hrs)**	**COs Mapped: CO1, CO2**

Introduction to AM, Historical Development, Additive v/s Conventional Manufacturing, Role of AM in Product development cycle, Rapid prototyping, Relevance of AM in Industry 4.0, Current industry and manufacturing trends driving AM, AM Process-Chain, Reverse engineering, Advantages, Types of materials, Classification of AM Processes (Process-based, material form based, application-based – direct and indirect processes and Micro- and Nano-additive processes), Process Planning for Additive Manufacturing.

Unit II	**Light and LASER based Techniques**	**(07 hrs)**	**COs Mapped: CO2, CO3**

Introduction, Process and mechanism, Materials, Process Physics, Parameters, Benefits, Drawbacks,
Limitations and Applications. Light-Based Photo-curing: Stereolithography (SLA), Digital Light Processing (DLP), Direct Laser Writing (DLW), Continuous Liquid Interface Production (CLIP) Laser-Based Melting: Selective Laser Sintering (SLS), Direct Metal Laser Sintering (DMLS), Selective Laser Melting (SLM), Electron-Beam Melting (EBM), Laser Blown Powder, Laser Wire Deposition, Laser Engineered Net Shaping (LENS), 3D Laser Cladding.

Unit III	**Extrusion and energy based Techniques**	**(07 hrs)**	**COs Mapped: CO2, CO3**

Introduction, Process and mechanism, Materials, Process Physics, Parameters, Benefits, Drawbacks,
Limitations and Applications. Extrusion-Based Deposition: Fused Deposition Modeling (FDM), Fused Filament Fabrication (FFF), Direct Ink Writing (DIW), Robocasting, Bio-printing Inkjet(droplet)-Based Deposition and Fusion: Multi-jet Modeling (MJM), Polyjet Printing, Nanoparticle Jetting, Binder Jetting, Multi-Jet Fusion, Color-jet Printing (CJP), Energy Deposition Techniques: Plasma/TIG/MIG/Arc Deposition, Electron Beam-based DED, Direct Metal Deposition (DMD).

Unit IV	**Materials and Design for AM**	**(07 hrs)**	**COs Mapped: CO3**

Introduction, Materials: Metals, Polymers, Ceramics & Bio-ceramics, Composites, Hierarchica Materials, Biomimetic Materials, Shape-Memory Alloys, 4D Printing & Bio-active materials, Materia selection, AM Material Specific Process Parameters: Processes, Heat or Chemical Treatments, Phase Transformations, Process Selection for various applications, DfAM: Process specific strategies, Rules and Recommendations, Quality considerations and Post-Processing techniques: Requirements and Techniques, Support Removal, Sanding, Acetone treatment, Polishing, Heat treatments, Hot isostatic pressing, Materials science, Surface enhancement Techniques and its Material Science Analysis of AM's error sources

Unit V	**Hardware and Software for AM**	**(07 hrs)**	**COs Mapped: CO3**

Construction of Basic AM Machines: Equipment Layout and sub-system Design, Construction, Working, Equipment Topology/Layout Frame Designs, 3D Printer Design Considerations (Filament, Frame, Build Platform, Extruder Design, Nozzles, Print Bed, Heated build/Base Plate, Heater, Dispenser, Optical system, Cooling system, Gas Recirculation System, Laser controller, Gas Filtration, Inert Gas Cooling system, Powder Handling System, Loading/unloading System.
Software and Controller: Types of In-fill, Types of slicing, Software Integration (with Process, Slicing etc), Control system (PLC and safety PLC, micro control/ Microcontroller, Micro-processor control) CAD Software and Controller Interfacing, CURA Software, Relevant G/M Codes, Standard firmware (Merlin Software, etc), In-process Monitoring, Calibration

Reference Books

1. L. Lu, J. Y. H. Fuh and Y.S. Wong, “Laser-Induced Materials and Processes for Rapid Prototyping”, Springer, 2001
2. Andreas Gebhardt and Jan-Steffen Hötter, "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing" Hanser Publishers, Munich, 2016.
3. Ben Redwood, FilemonSchöffer& Brian Garret, "The 3D Printing Handbook: Technologies, design and applications", 3D Hubs B.V. 2017
4. Ehsan Toyserkani, Amir Khajepour, Stephen F. Corbin, “Laser Cladding”, CRC Press, 2004
5. Andreas Gebhardt, “Understanding Additive”, Hanser Publishers, Munich, 2011
6. Ben Redwood, Filemon Schöffer & Brian Garret, “The 3D Printing Handbook – Technologies,
7. Design and Applications” Part One:3D Printing Technologies and Materials, 3D Hubs, 2017
8. Chee Kai, Kah Fai, Chu Sing, ‘Rapid Prototyping: Principles and Applications”, 2nd Ed., 2003
9. D. T. Pham and S.S. Dimov, “Rapid Manufacturing” Springer, 2001
10. Rupinder Singh J. Paulo Davim, “Additive Manufacturing - Applications and Innovations” CRC Press, 2019
11. I. Gibson, D. W. Rosen, B. Stucker, “Additive Manufacturing Technologies” Springer, 2010
12. L. Jyothish Kumar, Pulak M. Pandey, David Ian Wimpenny, “3D Printing and Additive Manufacturing Technologies” Springer, 2019

Strength of CO-PO Mapping

	PO											
	1	2	3	4	5	6	7	8	9	10	11	12
CO1	1	-	1	-	-	-	1	-	-	-	-	-
CO2	1	-	1	-	-	-	2	-	-	-	-	-
CO3	2	2	-	1	-	-	-	-	-	-	-	-
CO4	-	-	1	-	1	-	-	-	-	-	-	-
CO5	3	3	3	2	1	-	3	-	-	-	-	-

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Tests on each unit using LMS (Each test for 20 M and total will be converted out of 10 M)	10
2	Timely Assignment Submission	10

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Course Code	**2312406C**						
Course Name	**Industry 4.0**						
Type of Course	PEC						
Teaching Scheme and Credits Weekly Working Hrs	TH(Hrs.)		TU(Hrs.)		PR(Hrs.)		Total Credits
	02		--		--		02
Assessment Scheme	CCE	TW	PR	OR	ISE	ESE	Total
	--	--	--	--	20	30	50

Prerequisites for the Course: Manufacturing Technology

The course aims to:

Course Objectives	Description
1	Understand the core concepts, technologies, and enablers of Industry 4.0.
2	Explore the role of IoT, cyber-physical systems, cloud computing, and data analytics in smart manufacturing.
3	Analyse how Industry 4.0 transforms conventional production systems into smart factories.
4	Familiarize with the standards, protocols, challenges, and applications of Industry 4.0 in the robotics and automation domain.

On completion of the course, learner will be able to–

Course Outcomes	Description
CO1	Explain the fundamental concepts, history, and scope of Industry 4.0
CO2	Illustrate the application of IoT, CPS, and smart sensors in manufacturing.
CO3	Analyse the role of big data, AI, cloud, and digital twin technologies in industrial automation.
CO4	Examine case studies and applications of Industry 4.0 in robotic and automation systems.

Course context, Relevance, Practical Significance:

The **Industry 4.0 course** provides an interdisciplinary foundation on the fourth industrial revolution driven by **digital transformation**, **cyber-physical systems**, **artificial intelligence**, **big data**, and **smart manufacturing**. It aims to equip students with knowledge of intelligent systems, interconnected devices, and data-driven decision-making, which are central to modern industrial environments.

Course Contents:

Unit and Chapter	Contents	Lecture Hours
1	**Introduction to Industry 4.0** Evolution of Industry: Industry 1.0 to Industry 4.0,Key technologies of Industry 4.0,Smart Factory and Smart Manufacturing, Need for Industry 4.0,Pillars of Industry 4.0.	5
2	**Cyber-Physical Systems and IoT in Industry 4.0** Concepts of CPS,Architecture and Components of CPS,Industrial Internet of Things (IIoT),Communication protocols (MQTT, OPC UA),Role of smart sensors and actuators.	5
3	**Big Data Analytics and Cloud Computing** Introduction to Industrial Big Data, Data acquisition and storage, Cloud platforms and computing models, Edge vs. Cloud Computing, Real-time analytics in manufacturing.	6
4	**Artificial Intelligence, Digital Twin, and Simulation** Machine learning and AI in manufacturing, Digital Twin: Architecture and applications, Simulation for virtual commissioning, Predictive maintenance and anomaly detection	6
5	**Introduction to Industry 5.0** Introduction**,** Key Features of Industry 5.0, Enabling Technologies, Applications, Case Studies, Challenges and Ethical Considerations.	6

Course Mapping

Unit and Chapter	Bloom's Taxonomy Level	CO Mapped	PO Mapped	PSO Mapped
1	Remember, Understand	CO1	PO1, PO6, PO12	PSO1
2	Understand ,Apply	CO2	PO1, PO2, PO3, PO5	PSO1, PSO2
3	Understand ,Apply	CO3	PO1, PO2, PO4, PO5	PSO2
4	Understand ,Apply	CO4	PO1, PO2, PO3, PO5, PO12	PSO1, PSO2
5	Understand ,Apply	CO5	PO6, PO7, PO8, PO11, PO12	PSO1, PSO2

References Books

1. **Alasdair Gilchrist**, *Industry 4.0: The Industrial Internet of Things*, Apress, 2016. ISBN: **9781484220467**
2. **Klaus Schwab**, *The Fourth Industrial Revolution*, World Economic Forum, 2017. ISBN: **9780241300756**

K.K.Wagh Institute of Engineering Education and Research, Nasik
B. Tech. (Autonomous Syllabus 2023 Pattern)

Course Code	2312406D						
Course Name	Modelling & Simulation						
Type of Course	PEC						
Teaching Scheme and Credits	TH(Hrs.)		TU(Hrs.)		PR(Hrs.)		Total Credits
Weekly Working Hrs	2 hrs/week		---		---		2
Assessment Scheme	CCE	TW	PR	OR	ISE	ESE	Total (Marks)
(Marks)	---	---	---	---	20	30	50

Prerequisites for the Course:

1. Applied Mathematics (ODEs, Laplace Transforms, Probability),
2. Engineering Physics, Programming Concepts
3. Mechatronics and Control Systems.

The course aims to:

Course Objectives	Description
1	To introduce students to the fundamental principles of modeling physical systems.
2	To develop understanding of various simulation techniques for dynamic systems.
3	To apply mathematical models for analysis and prediction of system behavior.
4	To explore simulation tools used in robotics and automation systems.

On completion of the course, learner will be able to–

Course Outcomes	Description	Bloom's Level
CO1	Describe the principles and types of modeling and simulation of Physical systems.	2 –Understand
CO2	Develop mathematical models of mechanical, electrical, thermal, and fluid systems.	3 – Apply
CO3	Implement dynamic simulations of control systems using tools such as MATLAB/Simulink	3 – Apply
CO4	Analyze and evaluate simulation results for robotic and automation systems	4 – Analyse

Course Contents:

Unit	Contents	Lecture Hours	Cos Mapped

1	**Introduction to Modelling and Simulation:** Definition and scope of modeling and simulation; types of models – physical, mathematical, static, dynamic, deterministic, stochastic, discrete, and continuous; role of simulation in design and control; steps involved in modeling; simulation life cycle; overview of simulation tools and their applications in engineering.	**(7hrs)**	**CO1**
2	**Modelling of Physical Systems:** Mathematical modelling of mechanical, electrical, thermal, and fluid systems; representation of translational and rotational dynamics; analogies between physical domains and conversion techniques useful for unified modelling.	**(7hrs)**	**CO2**
3	**Dynamic System Modelling using State-Space and Transfer Functions:** Transfer function and state-space representations of dynamic systems; block diagram algebra and signal flow graphs; linearization of nonlinear systems; time-domain response and stability analysis; application of Laplace transforms in system analysis.	**(7hrs)**	**CO2**
4	**Simulation of Dynamic Systems:** Simulation of dynamic systems using MATLAB and Simulink; modeling of mechanical and electrical subsystems; simulation of robotic arms, control loops, and joint behavior; introduction to offline and real-time simulation with comparison of features and use-cases.	**(7hrs)**	**CO3**
5	**Simulation Software and Applications in Robotics** Simulation environments such as Simulink, Simscape, Gazebo, and RobotStudio; implementation of offline simulation for industrial robots; case studies including mobile robot navigation, manipulator path planning, and automated system performance analysis; model verification and validation techniques.	**(7hrs)**	**CO3**

References Books

1. Katsuhiko Ogata, *System Dynamics*, Pearson Education.
2. William J. Palm III, *System Dynamics*, McGraw-Hill.

Text Books

1. W. Bolton, *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*, Pearson.
2. Robert L. Norton, *Design of Machinery*, McGraw-Hill.
3. Nise, Norman S., *Control Systems Engineering*, Wiley.

e Resources

1. NPTEL – Modelling and Simulation of Dynamic Systems

Useful websites / Video

1. https://www.geeksforgeeks.org/introduction-to-modeling-and-simulation/
2. https://www.tutorialspoint.com/discrete_event_simulation/index.htm

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	--NA--	---
2	--NA--	---
	Total	**---**

Name and Sign of Academic Coordinator **Name and Sign of BoS Chairperson**

Course Code	2312407						
Course Name	Innovation, Entrepreneurship & IPR						
Type of Course	RM						
Teaching Scheme and Credits	TH(Hrs.)		TU(Hrs.)		PR(Hrs.)		Total Credits
Weekly Working Hrs	3		-		-		3
Assessment Scheme	CCE	TW	PR	OR	ISE	ESE	Total (Marks)
(Marks)	20	-	-	-	20	60	100

Prerequisites for the Course:
No pre-requisite

The course aims to:

Course Objectives	Description
1	Identify and evaluate innovative ideas.
2	Develop prototypes and test their feasibility.
3	Understand the different types of innovation and their potential impact
4	Develop entrepreneurial skills and mindset

On completion of the course, learner will be able to–

Course Outcomes	Description	Bloom's Level
CO1	Understand the different types of innovation and their potential impact.	Understand
CO2	Protect their intellectual property.	Understand
CO3	Think creatively and come up with innovative ideas.	Apply
CO4	Develop prototypes and test their feasibility.	Apply
CO5	Apply entrepreneurial principles to solve real-world problems.	Apply

Course context, Relevance, Practical Significance:
This course prepares students to become innovative entrepreneurs capable of navigating uncertainty, solving complex problems, and creating sustainable value. It covers a wide range of topics including idea generation, prototyping, technological and non-technological innovation, entrepreneurship, social innovation, intellectual property rights, commercialization, and startup development. By exploring the innovation ecosystem, pre-incubation and incubation stages, and various entrepreneurial opportunities, students gain the knowledge, skills, and mindset needed to launch impactful ventures and drive positive change in society.

Course Contents:

Unit	Contents	Lecture Hours	COs Mapped
1	**Introduction to Innovation and Entrepreneurship:** Defining innovation, Types of innovation: incremental, radical, disruptive, The innovation process, Factors that drive innovation, Defining entrepreneurship, The entrepreneurial process, Characteristics of successful entrepreneurs, Brainstorming, Design thinking process.	7	CO1

2	**Idea Generation and Prototyping:** Techniques for brainstorming and generating ideas - Criteria for evaluating innovative ideas, Market research and feasibility analysis, Identifying potential customers and partners. Developing and Testing Prototypes - The purpose and importance of prototyping, Different prototyping methods and tools, Creating low-fidelity and high-fidelity prototypes, User testing and feedback collection, Iterating and refining prototypes based on feedback.	7	CO3, CO4
3	**Entering into market and Understanding the process:** Attaining Market-Product Fit: Prototype Designing Process and Tools for Development of Minimum Viable Product (MVP), Application of Design Thinking Tools and Approach for Right Problem Identification and Solution Development. Understanding Technology Readiness Level (TRL), Manufacturing Readiness Level (MRL) and Investment Readiness Level (IRL) Stages & Implications in Innovation Development, Innovation Management Process, Types of IPR, Patents, patent requirements, what is not patentable, general procedure for filing patents in India, KAPILA scheme.	7	CO2, CO3
4	**Business plans and execution:** Business Plan Development: Components and Stages in Business Plan Development, Validation of Business Opportunity: Application of Market Research Tools at the Early Stage of Startup. Generation and Management of IP at the Early Stage of Innovation and Startup Development, Legal Structures and Ethical Steps in Establishing Startups. Social Entrepreneurship, Blue Ocean Strategy-I, Blue Ocean Strategy-II	7	CO2, CO3
5	**Start-up and its working:** Start-ups, Definition, requirements, company act, opportunities and schemes, benefits of start-up formation, start-up registration process., funding opportunities, incubators and accelerators- roles, responsibilities and partnership, infrastructure. Funding, government schemes, Investments – need, sources, VC, angel investments. Start-up life cycle., documentation and recording., NISP and its features.	7	CO5

References Books

1. Innovation and Entrepreneurship, Peter F. Drucker, Harper Business; Reprint, 2006, ISBN: 9780060851132.
2. The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses, Crown Currency; Illustrated, 2011. ISBN: 9780307887894.

3. Innovator's DNA, Updated, with a New Preface: Mastering the Five Skills of Disruptive Innovators, Harvard Business Review Press; Revised, 2019. ISBN: 1633697207.
4. Wiley Innovation Black Book Enterprise 4.0, 2020.
5. Problem-Solving", Penguin Random House India Pvt. Ltd. 2020, ISBN: 9780670094097
6. HBS series on Innovation and Entrepreneurship.

Text Books

1. 8 Steps To Innovation: Going From Jugaad To Excellence, Collins India, 2013. ISBN: 9789350293584
2. Pavan Soni, "Design Your Thinking - The Mindsets, Toolsets and Skill Sets For Creative Problem Solving", Penguin Random House India Pvt. Ltd. 2020, ISBN: 9780670094097..

e Resources

1. Innovation, Business Models and Entrepreneurship, By Prof . Rajat Agrawal and Prof. Vinay Sharma | IIT Roorkee nptel.ac.in/courses/110107094
2. Design Thinking - A Primer, By Prof. Ashwin Mahalingam & Prof. Bala Ramadurai | IIT Madras, nptel.ac.in/courses/110106124
3. Innovation and Start-up Policy By Prof. Rahul K. Mishra | IILM Institute for Higher Education https://onlinecourses.swayam2.ac.in/imb20_mg22/preview
4. Introduction to Intellectual Property By KAPILA IPR committee | IIT Kharagpur, https://onlinecourses.swayam2.ac.in/aic21_ge20/preview

Useful websites / Video

1. https://www.startupindia.gov.in/
2. https://kapila.mic.gov.in

Strength of CO - PO/PSO Mapping (Sample): Attainment of a PO/PSO depends both on the attainment levels of associated COs of courses and the strengths to which it is mapped
• Each Course Outcome addresses a sub-set of POs and PSOs to varying levels (strengths: 1-Low,2 – Medium, 3 - Strong).

Strength of CO-PO/PSO Mapping

Strength of COs	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	2	2	1	1	1	2	2	1	1	1	2	2	2	2
CO 2	2	1	1	1	1	3	1	3	1	1	2	2	2	2
CO 3	2	2	3	2	2	2	2	2	2	2	2	3	2	2
CO 4	2	3	3	3	3	2	1	2	2	2	3	2	2	2
CO 5	2	3	3	2	2	3	2	2	3	3	3	3	2	2

Guidelines for Continuous Comprehensive Evaluation of Theory Course		
Sr. No.	**Components for Continuous Comprehensive Evaluation**	**Marks Allotted**
1	Test on each unit using LMS	10
2	Assignment on each unit	10
	Total	**20**

Name and Sign of Academic Coordinator **Name and Sign of BoS Chairperson**

K.K.Wagh Institute of Engineering Education and Research, Nasik
Final Year B. Tech. (Autonomous 2023 Pattern)

Course Code	**2312408**						
Course Name	**Supply Chain Management**						
Type of Course	HSSM-EEM						
Teaching Scheme and Credits Weekly Working Hrs	TH(Hrs.)		TU(Hrs.)		PR(Hrs.)		Total Credits
	02		--		--		02
Assessment Scheme	CCE	TW	PR	OR	ISE	ESE	Total (Marks)
	50	--	--	--	--	--	50

Prerequisites for the Course: Manufacturing Technology

The course aims to:

Course Objectives	Description
1	Understand the fundamental concepts and strategies of supply chain management.
2	Learn how SCM integrates with manufacturing, automation, and robotics in industries.
3	Analyse the role of logistics, inventory, and information systems in supply chains.
4	Gain insights into modern technologies like IoT, AI, and automation in SCM.
5	Understand optimization and risk management within supply chains.

On completion of the course, learner will be able to–

Course Outcomes	Description
CO1	Explain the structure and components of a supply chain.
CO2	Analyze supply chain strategies and performance metrics.
CO3	Apply forecasting, inventory, and logistics planning in SCM.
CO4	Evaluate the role of IT, AI, and automation in modern supply chains.
CO5	Assess supply chain risks and propose mitigation strategies.

Course context, Relevance, Practical Significance:

This course introduces students to the fundamental and advanced concepts of supply chain management with a strong focus on how automation, robotics, and emerging technologies are transforming supply chains globally. It covers design, forecasting, logistics, inventory, digital technologies, and sustainability — all tailored to the applications and needs of robotics and automation engineers.

Course Contents:

Unit and Chapter	Contents	Lecture Hours
1	**Introduction to Supply Chain Management** Definition and Importance of SCM, Supply Chain Drivers and Metrics, Process View of Supply Chains, Decision Phases in Supply Chains, Strategic Fit and Scope, SCM in the context of Robotics and Automation	5
2	**Supply Chain Network Design** Network Design in the Supply Chain, Facility Location and Capacity Planning, Role of Robotics in Warehouse Automation, Global Supply Chain Networks, and Case Studies: Amazon Robotics, Flipkart Warehouse Automation.	5
3	**Demand Forecasting and Inventory Management** Forecasting Methods (Qualitative and Quantitative), Role of Forecasting in Supply Chain, Inventory Management Techniques (EOQ, JIT, Safety Stock), Push vs Pull Strategies, Vendor-Managed Inventory (VMI)	6
4	**Logistics, Transportation, and Warehousing** Modes of Transportation and Optimization, Distribution Network Design, Role of AGVs and Drones in Logistics, Cross-Docking and Last-Mile Delivery, Packaging and Material Handling Automation	6
5	**Digital Supply Chain and Risk Management** Role of IoT, AI, and Blockchain in SCM, Supply Chain Visibility and Analytics, ERP and SCM Software (SAP, Oracle SCM Cloud), Risk Identification and Mitigation Strategies, Sustainable and Green Supply Chains.	6

Course Mapping

Unit and Chapter	Bloom's Taxonomy Level	CO Mapped	PO Mapped	PSO Mapped
1	Understand, Apply	CO1	PO1, PO2, PO10	PSO1, PSO2
2	Analyse, Apply	CO1,CO2	PO2, PO3, PO5	PSO1, PSO2
3	Apply, analyse	CO2,CO3	PO4, PO5, PO11	PSO1, PSO2
4	Apply, Evaluate	CO3,CO4	PO3, PO5, PO9, PO12	PSO1, PSO2
5	Evaluate, Create	CO4,CO5	PO6, PO7, PO12	PSO1, PSO2

References Books

- **"Supply Chain Management: Strategy, Planning, and Operation"** – Sunil Chopra ISBN: 9780134731889

Text Books

1. **"Logistics and Supply Chain Management"** – Martin Christopher ISBN: 9781292083797
2. **"Designing and Managing the Supply Chain"** – David Simchi-Levi ISBN: 9780073341521

e Resources

1. https://www.youtube.com/playlist?list=PLUl4u3cNGP63EdVPNLG3ToM6LaEUuStEY
2. https://www.youtube.com/watch?v=77rgtVhHT50
3. https://www.youtube.com/watch?v=elK8bspXK4o

Useful websites / Video

1) https://www.youtube.com/watch?v=Rh1EC7FfD4E
2) https://www.youtube.com/watch?v=dLIabZc0O4c

Strength of CO - PO/PSO Mapping (Sample):

Attainment of a PO/PSO depends both on the attainment levels of associated COs of courses and the strengths to which it is mapped

• Each Course Outcome addresses a sub-set of POs and PSOs to varying levels (strengths: 1-Low,2 – Medium, 3 - Strong).

Strength of CO-PO/PSO Mapping														
Strength of COs	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	3	-	-	-	-	-	-	-	-	-	2	2	2	2
CO 2	3	3	-	2	-	-	-	-	-	-	2	2	2	2
CO 3	3	2	3	-	2	-	-	-	-	-	3	2	3	3
CO 4	3	2	3	2	3	-	-	-	-	-	3	3	3	3
CO5	3	2	3	2	2	2	2	-	-	2	3	3	3	3

Guidelines for Continuous Comprehensive Evaluation of Theory Course

Sr. No.	Components for CCE	Marks Allotted
1	Tests on each unit using LMS	20
2	Timely Assignment Submission	30
	Total	20

Name and Sign of Academic Coordinator **Name and Sign of BoS Chairman**

Course Code	2312409						
Course Name	Project Stage						
Type of Course	PROJ						
Teaching Scheme and Credits	TH(Hrs.)		TU(Hrs.)		PR(Hrs.)		Total Credits
Weekly Working Hrs	-		-		8		4
Assessment Scheme	CCE	TW	PR	OR	ISE	ESE	Total (Marks)
(Marks)	-	100	50	-	-	-	150

Pre-requisite:

1. Students are required to undergo 3 to 4 weeks industrial training / implant training /in-house project based learning/project related skill development course/ industrial survey report before Commencement of first semester of Final year.
2. Submit detailed report of 10-15 pages of the same.
3. Project registration will be based on completion of above activities.

The course aims to:

Course Objectives	Description
1	To Apply the knowledge for solving realistic problem
2	To develop problem solving ability
3	To Organize, sustain and report on a substantial piece of team work over a period of several months
4	To Evaluate alternative approaches, and justify the use of selected tools and methods
5	To Reflect upon the experience gained and lessons learned
6	To Consider relevant social, ethical and legal issues
7	To find information for yourself from appropriate sources such as manuals, books, research journals and from other sources, and in turn increase analytical skills.
8	To Work in Team and learn professionalism

On completion of the course, learner will be able to–

Course Outcomes	Description	Bloom's Level
CO1	Solve real life problems by applying knowledge.	
CO2	Analyze alternative approaches, apply and use most appropriate one for feasible solution.	
CO3	Write precise reports and technical documents in a nutshell.	
CO4	Participate effectively in multi-disciplinary and heterogeneous teams exhibiting team work	
CO5	Inter-personal relationships, conflict management and leadership quality.	

The student shall take up a suitable project, the scope of the project shall be such as to complete it within the time schedule, and the term work shall consist of:

Fabrication of models, machines, prototypes based on new ideas, robots and machine based on hi-tech systems and automation, experimental set-up, fabrication of testing equipment, renovation of machines, etc. Students shall submit the project phase – II plan. Above work shall be taken up

individually or in groups. The group shall not be more than 4 students, (If project work is more than group members may be increased by permission of guide)

OR

Extensive analysis of some problems done with the help of a computer individually or in a group not exceeding two students.
A detailed report on the work done shall include project specification, design procedure, drawings, process sheets, assembly procedure and test results etc. Project may be of the following types:

(i) Manufacturing / Fabrication of a prototype machine' including selection, concept, design, material, manufacturing the components, assembly of components, testing and performance evaluation
(ii) Improvement of existing machine / equipment / process.
(iii) Design and fabrication of robots for specialized applications,
(iv) Computer aided design, analysis of components such as stress analysis.
(v) Problems related to Automated Storage and retrieval system
(vi) Design of a test rig for performance evaluation of machine devices.
(vii) Design and development. of non-standard robots
(viii) Analysis, evaluation and experimental verification of any engineering problem
(ix) Design and development of service robots
(x) Hardware system development to ingrate robotics operations
(xi) Low cost automation, Computer Aided Automation in Manufacturing.
(xii) Development of prototypes for new concepts in robotics such as biological robots, swarm robotics, drones, humanoids
(xiii) Development of artificial intelligence systems for humanoids and robots OR
Computer based design / analysis or modelling / simulation of robot(s), mechanism(s) or system (s) and its validation or comparison with available benchmarks / results. When a group of students is doing a project, names of all the students shall be included on every certified report copy. Two copies of project Report shall be submitted to the college. The students shall present and submit their Project Phase-I report to the internal and external examiner from college/Industry.

Name and Sign of Academic Coordinator **Name and Sign of BoS Chairperson**

SEMESTER-VII

K.K.Wagh Institute of Engineering Education and Research, Nasik
Final Year B. Tech. (Autonomous Syllabus 2023 Pattern)

Course Code	2312411						
Course Name	Wireless Sensor Network (Online)						
Type of Course	PCC						
Teaching Scheme and Credits	TH(Hrs.)		TU(Hrs.)		PR(Hrs.)		Total Credits
Weekly Working Hrs	03		--		--		03
Assessment Scheme	CCE	TW	PR	OR	ISE	ESE	Total (Marks)
(Marks)	--	--	--	--	--	100	100

Prerequisites for the Course: NA

The course aims to:

Course Objectives	Description
1	Introduce the fundamental concepts and architecture of Wireless Sensor Networks (WSN).
2	Familiarize students with sensor node design, communication protocols, and energy-efficient networking.
3	Provide understanding of various WSN standards, protocols, and network stacks.
4	Equip students with knowledge of localization techniques and routing algorithms.
5	Enable students to explore data aggregation, security challenges, and real-world applications of WSN in robotics and automation.

On completion of the course, learner will be able to–

Course Outcomes	Description	Bloom's Level
CO1	Explain various concepts, architectures, and protocols used in wireless sensor networks.	Understand
CO2	Describe radio communication techniques and link management strategies in WSN.	Understand
CO3	Analyse localization schemes and routing techniques relevant to WSN deployments.	Analyse
CO4	Apply data aggregation and evaluate the importance of security in WSN.	Apply

Course context, Relevance, Practical Significance:

Wireless Sensor Networks (WSNs) represent a foundational technology for enabling intelligent, context-aware, and responsive systems in modern robotics and automation. This course covers the principles of WSNs, including sensor node architecture, communication protocols, networking standards, localization, routing, data aggregation, and security. Students will gain insights into how WSNs are integrated with robotic systems for real-time data acquisition, control, and environment interaction.

Course Contents:

Unit	Contents	Lecture Hours	Cos Mapped
1	**UNIT I – Introduction to Wireless Sensor Networks (WSN)**	7	CO1

	Overview and Applications of WSN**,**Sensor Nodes: Architecture and Types**,** Anatomy of a Sensor Node**,** Network Architecture: Layered and Clustered Architecture**,** Communication Architecture: Single-hop and Multi-hop**,** Performance Metrics: Energy Efficiency, Latency, Throughput, Scalability, Reliability		
2	**UNIT II – Wireless Communication and Link Management** Fundamentals of Wireless Communication, Radio Wave Propagation and Modulation/Demodulation, Signal Attenuation, Interference, and Multipath Fading, Medium Access Control (MAC) Protocols for WSN,Error Detection and Correction Techniques, Wireless Link Characteristics and Management.	7	CO2
3	**UNIT III – Standards and Protocol Stack in WSN** IEEE 802.15.4 Standard for Low-Rate WPAN, Overview of ZigBee, Wireless HART, ISA100.11a, 6LoWPAN,Bluetooth, Protocol Stack for WSN: Physical, MAC, Network, Transport, Application, Cross-layer Design Approaches in WSN.	7	CO1, CO2
4	**UNIT IV – Localization and Routing in WSN** Need for Localization in WSN, Location, Deployment and Topology Control, Routing Protocols: Flat, Hierarchical, Location-Based, Directed Diffusion, LEACH, Gradient-Based Routing, ZigBee Routing.	7	CO3
5	**UNIT V – Data Aggregation, Security, and Applications** Clustering Techniques for Scalability and Energy Efficiency, In-Network Data Processing and Aggregation, Aggregation Strategies: Tree-Based, Cluster-Based, Compressive Sensing and its Role in Data Reduction, Security in WSN: Applications of WSN:	7	CO4, CO5

Course Mapping

Unit	Mapped CO(s)	Mapped POs	Mapped PSOs
Unit I	CO1	PO1, PO2, PO3, PO5, PO10, PO12	PSO1, PSO2
Unit II	CO2	PO1, PO2, PO3, PO5, PO10, PO12	PSO1, PSO2
Unit III	CO1, CO2	PO1, PO2, PO3, PO5, PO10, PO12	PSO1, PSO2
Unit IV	CO3	PO1, PO2, PO3, PO4, PO5, PO10, PO12	PSO1, PSO2
Unit V	CO4, CO5	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO9, PO10, PO11, PO12	PSO1, PSO2

References Books

1. **"Sensors Handbook"** by **Sabrie Soloman**, ISBN: 9780071465743
2. **"Wireless Sensor Network Designs"** by **Anna Hac**, ISBN: 9780471793717
3. **"Wireless Sensor Networks"** edited by **C. S. Raghavendra, Krishna M. Sivalingam, and Taieb Znati**, ISBN: 9780387265295

Text Books

1. **"Protocols and Architectures for Wireless Sensor Networks"** by **Holger Karl to**, ISBN: 9780470095102
2. **"Wireless Sensor Network"** by **Feng Zhao and Leonidas Guibas**, ISBN: 9781558609143

e Resources

1. https://nptel.ac.in/courses/106/105/106105160/
2. IEEE Xplore
3. coursera.org/learn/wireless-sensor-networks

Useful websites / Video

1. https://www.tutorialspoint.com/wireless_sensor_networks/
2. https://nptel.ac.in/courses/106/105/106105160/

Strength of CO - PO/PSO Mapping (Sample): Attainment of a PO/PSO depends both on the attainment levels of associated COs of courses and the strengths to which it is mapped
• Each Course Outcome addresses a sub-set of POs and PSOs to varying levels (strengths: 1- Low, 2 – Medium, 3 - Strong).

Strength of CO-PO/PSO Mapping

Strength of COs	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	3	2	1	1	2	-	-	-	-	1	-	2	3	2
CO 2	3	2	2	2	3	-	-	-	-	1	-	2	3	2
CO 3	2	3	3	2	3	-	-	-	-	2	-	3	3	3
CO 4	2	2	3	2	2	-	2	2	-	1	-	3	2	3
CO 5	3	3	3	3	3	-	1	2	1	2	1	3	3	3

Name and Sign of Academic Coordinator **Name and Sign of BoS Chairperson**

Course Code	2312412						
Course Name	Material handling systems and Robotics (Online)						
Type of Course	PEC						
Teaching Scheme and Credits	TH(Hrs.)		TU(Hrs.)		PR(Hrs.)		Total Credits
Weekly Working Hrs	3		-		-		3
Assessment Scheme	CCE	TW	PR	OR	ISE	ESE	Total (Marks)
(Marks)	-	-	-	-	-	100	100

Prerequisites for the Course:

1. Engineering Mechanics
2. Fundamentals of Electrical and Electronics Engineering
3. Introduction to Manufacturing Processes
4. Engineering Mathematics

The course aims to:

Course Objectives	Description
1	To introduce the fundamentals of material handling systems used in automation and manufacturing environments.
2	To explain various storage systems and data capturing technologies relevant to automated operations.
3	To familiarize students with the basic components, configurations, and classifications of industrial robots.
4	To enable learners to evaluate and select appropriate robots based on specific industrial applications and requirements.
5	To provide insights into the diverse applications of robotics, including justification, integration, and implementation strategies in real-world scenarios.

On completion of the course, learner will be able to–

Course Outcomes	Description	Bloom's Level
CO1	Understand about material handling system	Understand
CO2	Understand storage and data capturing system	Understand
CO3	Describe the basic concepts, parts of robots and types of robots.	Understand
CO4	Select the robots according to its usage.	Apply
CO5	Describe various applications of robots, justification and implementation of robot.	Understand

Course context, Relevance, Practical Significance:

This course provides foundational knowledge of automation systems with a focus on material handling, storage, data capturing, and robotics. It introduces students to the essential components, types, and applications of robots, enabling them to understand, select, and justify the use of robots in various industrial scenarios. The course is highly relevant in today's automation-driven industries, where efficient handling and robotic integration are key to productivity and innovation. Practically, students gain the ability to analyze system requirements, choose suitable robotic solutions, and evaluate their implementation and societal impact—skills that are crucial for careers in manufacturing, logistics, and smart automation systems.

Course Contents:

Unit	Contents	Lecture Hours	COs Mapped
1	**Introduction to Material handling:** Principles of Material Handling, Unit load concept, Material Handling equipment, Material transport systems: AGVs, Monorails, Conveyor systems, Cranes and hoists, Analysis of material transport systems: Charting technique, analysis of vehicle based systems, Conveyor analysis	7	CO1
2	**Storage and Data capturing systems:** Conventional storage methods and equipments Storage system performance, Analysis of Automated storage/retrieval systems (ASRS) and Carousel Storage system. Automatic data capturing system (ADC), Bar coding, Radio frequency identification (RFID), Optical character recognition, Magnetic stripes	7	CO2
3	**Introduction to Industrial Robots:** Types of industrial robots, Load handling capacity, general considerations in Robotic material handling, material transfer, machine loading and unloading, CNC machine tool loading, Robot centered cell.	7	CO3
4	**End Effectors:** Classification, Design consideration, Materials for hostile operation. Cylindrical Cam type; Grippers using pneumatic, hydraulic and electrical motor for transmission; Vacuum Grippers, Ultrasonic grippers. Gripper force analysis and gripper design, design of multiple degrees of freedom, active and passive grippers. Selection of Robot: Factors influencing the choice of a robot, robot performance testing, economics of robotization, Impact of robot on industry and society.	7	CO4
5	**Applications of Robots** Application of robots in Manufacturing: Pick and place Robot, Application of Robots in Arc Welding Robots, Assembly and mega-assembly Robots continuous arc welding, Spot welding, Spray painting, assembly operation, Other industrial applications: Coating, Deburring, cleaning, Die Casting, Moulding, Material handling, Picking, Palletizing, Packaging Robots For Inspection :Robotic vision systems, image representation, object recognition and categorization, depth measurement Advanced applications of robots: Military and medical applications, robot for underwater applications Robots, Climbing Robots, Machine mounted Robots. Interfacing Robots with computers. Obstacle Avoidance: Lee's Algorithm; Counter Path Defining using 'via' point, blending	7	CO5

References Books

1. M. P. Groover, “Automation, ProductionSysytems, and Computer –Integrated Manufacturing”, Pearson Education,ISBN-81-7808-511-9.
2. Deb S.R., “Robotics”, Tata McGraw Hill Publications, New Delhi.
3. Yoram Koren, "Robotics for Engineers", McGraw Hill Book Co.
4. Groover M.P., Weiss M., Nagel R.N., Odrey N.G., "Industrial Robotics Technology - Programming and Applications", McGraw Hill Book Co.
5. Fu K.S., Gonzalex R.C., Lee C.S.G., "Robotics Control Sensing, Vision and intelligence", McGraw Hill Book Co.
6. Hartenberg and Denavit, "Kinematics and Synthesis of Linkages", McGraw Hill Book Co.
7. Hall A.S., "Kinematics and Linkage Design", Prentice Hall.
8. Hirchhorn J., "Kinematics and Dynamics of Machinery", McGraw Hill Book Co.
9. Todd D.J., “Fundamentals of Robot Technology”, Wiley Publications
10. Paul R., “Robots - Manipulators, Mathematics, Programming and Control”, MIT Press.
11. Janakiraman P.A., “Robotics and Image Processing”, Tata McGraw Hill 1995.
12. Rudenko N., “Material, Handling equipment”, MIR Publications, Moscow.
13. Jacob Fruchlboum, “Bulk Material Handling Handbook”, 1st Edition, Springer, 1988
14. Monkman, G. J.; Hesse, S.; Steinmann, R.; Schunk, H. (2007). Robot Grippers. Wiley-VCH. p. 62. ISBN 978-3-527 40619-7

e Resources

1. Material Handling Automation: A Comprehensive Guide for Engineers

Useful websites / Video

1. Material Handling Robots | FANUC America
2. Material Handling | Industrial Robots by Kawasaki Robotics
3. Material Handling Robots: A Practical Introduction - RoboDK blog

Strength of CO - PO/PSO Mapping (Sample): Attainment of a PO/PSO depends both on the attainment levels of associated COs of courses and the strengths to which it is mapped

• Each Course Outcome addresses a sub-set of POs and PSOs to varying levels (strengths: 1-Low,2 – Medium, 3 - Strong).

Strength of CO-PO/PSO Mapping

Strength of COs	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO 1	2	1	-	-	-	-	-	-	-	-	-	2	2	2
CO 2	2	1	-	-	2	-	-	-	-	-	-	2	2	2
CO 3	2	-	-	-	1	-	-	-	-	-	-	1	2	2
CO 4	2	2	2	-	2	-	-	-	2	2	2	2	2	2
CO 5	2	2	2	-	1	2	-	-	2	2	2	2	2	2

Name and Sign of Academic Coordinator Name and Sign of BoS Chairperson

Final Year B. Tech.
Pattern: 2023 Semester VII
2312414: Internship with Project Work

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**
Practical: 24 Hours	**PR: 12**	**Termwork: 200 Marks** **Oral: 100 Marks**

Prerequisite Courses:

Course Objectives: The objectives of the course are

1. To encourage and provide opportunities for the students to acquire professional learning experiences.
2. Provide exposure to handling and using various tools, measuring instruments, meters, and technologies used in industries.
3. Enable students to develop professional and employability skills and expand their professional network.

Course Outcomes: On completion of the course, students will be able to–

	Course Outcomes	**Bloom's Level**
CO1	**Describe** the organisational structure, safety protocols, and key operational processes of the industry	2-Understand
CO2	**Apply** electrical engineering knowledge to operate, troubleshoot, or maintain equipment/systems used in the industry.	3-Apply
CO3	**Analyse** real-world engineering problems and suggest feasible solutions based on observed practices.	4-Analyze
CO4	**Demonstrate** professional skills such as communication, teamwork, punctuality, and ethical responsibility in an industrial setting.	3-Apply

Internship Guidelines for Students

A. Before Joining the Internship

1. Look for internships in the industries provided by the department.
2. The internship duration should be 16 weeks.
3. Ask for the internship request letter from the respective class coordinator. He/she will appoint a guide for you.
4. Monitoring and Mentoring of the internship activity will be done through your Guide. You are informed to report to your guide from time to time.

B. During Internship

1. Keep the internship record book with you.
2. Note down all the details date-wise in the internship record book. Take the signature of your industry mentor daily.
3. The internship record book will help you write your final internship report. Simultaneously, you can start writing internship reports.
4. Maintain an institutional culture while working in the industry.

C. After Internship

1. Submit the Internship Record book and Internship report. Both are in hard copy.
2. Submit all your details within 15 days of completion of the Internship.
3. After the internship, the presentation schedule will be displayed.
4. The internship course will be assumed to be completed only after the final presentation. The date of presentation will be declared at least 10-15 days before the actual date.

Internship Record Book

Maintain all the records as per the sample given to you. This should be handwritten and submitted in hard copy. It will be evaluated based on

1. Proper and timely documented entries
2. Adequacy and quality of information
3. Data, observations, and discussions recorded
4. Thought process and recording techniques used
5. Organisation of the information

Internship Report

Submit your report as per the guidelines. It should have

1. Starting pages: Certificates, declaration, abstract, table of contents, figures, tables, etc.
2. Chapter 1: Introduction: A Brief about the company, industry or organisation, objectives, motivation, and organization of the report
3. Chapter 2: Problem Identification/Problem statement/objectives and scope/expected outcomes
4. Chapter 3: Methodological details
5. Chapter 4: Results / Analysis /inferences and conclusion
6. Chapter 5: Suggestions/Recommendations for improvement to the industry, if any
7. End Pages: Acknowledgement and references