Robotics & Artificial Intelligence

V SEMESTER

Robot Kinematics and Dynamics (PCC)

Course Code	**22RI51**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	45	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- The course will enable the students to
- Understand the functional elements of a robot and robotic workspace.
- Acquire a basic understanding of direct and inverse kinematics.
- Acquire the basic concepts of Robot dynamics.
- Understand the robotic motion planning techniques.

Course Outcomes: At the end of the course student will be able to

CO1: Explain position and orientation parameters for describing the pose of industrial robots.

CO2: Apply mathematical tools for solving robot kinematics problems.

CO3: Assign the coordinate frames to industrial robots and derive their forward and inverse kinematic equations.

CO4: Use software tools for obtaining solutions to forward and inverse kinematics problems.

Module-1

Introduction Introduction to Robotics, Elements of Robots: Joints, links, End effectors, Grippers, actuators and sensors, Fundamentals of Robot Degrees of Freedom, Robot Components, Rigid body motions, Concepts of Rigid Body, Robotic manipulator Frames, Euclidean Space, Inertial Frame, Fundamentals of Robotic Manipulator, Vectors, Matrices.	CO1

Module-2

Robot Kinematics: Pure Translation, Pure Rotation about an Axis, Representation of Combined Transformations, Transformations Relative to a Moving Frame, Homogeneous Transformations using MATLAB. Denavit-Hartenberg DH-representation of robotic arm equation, Forward and Inverse kinematics for 2 DOF and 3 DOF planar manipulators (Simple derivation and numerical exercises)	CO2

Module-3

Robot Dynamics: Lagrangian mechanics, Two degree of freedom manipulator – dynamic model, Lagrange–Euler formulation, Velocity of a point on the manipulator, The inertia tensor, the kinetic energy, The potential energy, Equation of motion, The LE dynamic model algorithm, Derivation of Dynamic equation of motion for 2DOF robot configuration.	CO3

Module-4	
Path Planning: Path Planning- Joint space planning, use of cubic polynomial, Cartesian space planning, Straight line and circular paths, position and orientation planning. Design Project: A 3-DOF Robot.	CO4
Module-5	
Trajectory Planning: Trajectory Planning- Joint space trajectory planning, Cartesian and operational space trajectory planning techniques. Offline and Online Simulation of Industrial Robots, Robotic applications such as pick-and-place, assembling, welding, painting, etc.	CO4

Suggested Learning Resources:

Books

1. S. K. Saha, "Introduction to Robotics", McGraw Hill Education (India) Pvt. Ltd., 2014.
2. John J. Craig, "Introduction to Robotics – Mechanics and Control", Pearson Education, 2004.
3. M.P.Groover,M.Weiss, R.N.Nageland, N.G.Odrej, Industrial Robotics, McGraw-Hill,1986.

Reference Books

1. Fu, K., Gonzalez, R. and Lee, C. S. G., Robotics: Control, Sensing, Vision and
2. Corke P. Robotics, Vision and Control. Springer; 2017.
3. Saeed B. Niku, "Introduction to Robotics – Analysis, Control, Applications", Wiley India Pvt. Ltd., 2010.

E Books / MOOCs/ NPTEL

1. https://onlinecourses.nptel.ac.in/noc20_me53/preview
2. https://www.classcentral.com/course/swayam-mechanics-and-control-ofrobotic-manipulators-43637

CO-PO Map:

3 – Strong, 2 Moderate, 1-Weak

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	1	2	1	1	–	3	3	–	2	2	–	–
CO2	3	3	1	1	2	1	1	–	3	3	–	2	2	1	–
CO3	3	3	2	1	2	1	1	1	3	3	–	2	3	2	1
CO4	3	3	3	3	3	1	1	1	3	3	–	3	1	1	1

Natural Language Processing (IPCC)

Course Code	**22RI52**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-2	SEE Marks	50
Total Hours of Pedagogy	52	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

At the end of this course, the students will demonstrate the ability to:

- Learn the importance of Natural Language Modelling.
- Understand the Applications of Natural Language Processing.
- Study spelling, error detection and correction methods and parsing techniques in NLP
- Illustrate the information retrieval models in natural language processing

Course Outcomes: At the end of the course student will be able to

CO1: Apply the fundamental concept of NLP, grammar-based language model and statistical-based language model.

CO2: Model morphological analysis using Finite State Transducers and parsing using context-free grammar and different parsing approaches.

CO3: Develop the Naïve Bayes classifier and sentiment analysis for Natural language problems and text classifications.

CO4: Apply the concepts of information retrieval, lexical semantics, lexical dictionaries such as WordNet, lexical computational semantics, distributional word similarity.

CO5: Identify the Machine Translation applications of NLP using Encode and Decoder.

Module-1

Introduction: What is Natural Language Processing? Origins of NLP, Language and Knowledge, The Challenges of NLP, Language and Grammar, Processing Indian Languages, NLP Applications. **Language Modeling**: Statistical Language Model - N-gram model (unigram, bigram), Paninion Framework, Karaka theory.	CO1

Lab Exercises

1. Write a Python program for the following preprocessing of text in NLP:
   - Tokenization
   - Filtration
   - Script Validation
   - Stop Word Removal
   - Stemming
2. Demonstrate the N-gram modeling to analyze and establish the probability distribution across sentences and explore the utilization of unigrams, bigrams, and trigrams in diverse English sentences to illustrate the impact of varying n-gram orders on the calculated probabilities.

Module-2

Word Level Analysis: Regular Expressions, Finite-State Automata, Morphological Parsing, Spelling Error Detection and Correction, Words and Word Classes, Part-of Speech Tagging. **Syntactic Analysis:** Context-Free Grammar, Constituency, Top-down and Bottom-up Parsing, CYK Parsing.	CO2

Lab Exercises

3. Investigate the Minimum Edit Distance (MED) algorithm and its application in string comparison and the goal is to understand how the algorithm efficiently computes the minimum number of edit operations required to transform one string into another.

- Test the algorithm on strings with different type of variations (e.g., typos, substitutions, insertions, deletions)
- Evaluate its adaptability to different types of input variations

4. Write a program to implement top-down and bottom-up parser using appropriate context free grammar.

Module-3

<table>
<tr><td colspan="2">Naive Bayes, Text Classification and Sentiment: Naive Bayes Classifiers, Training the Naïve Bayes Classifier, Worked Example, Optimizing for Sentiment Analysis, Naive Bayes for Other Text Classification Tasks, Naive Bayes as a Language Model.</td><td>CO3</td></tr>
<tr><td>Lab Exercises</td><td colspan="2">5. Given the following short movie reviews, each labeled with a genre, either comedy or action:
• fun, couple, love, love comedy
• fast, furious, shoot action
• couple, fly, fast, fun, fun comedy
• furious, shoot, shoot, fun action
• fly, fast, shoot, love action and
A new document D: fast, couple, shoot, fly
Compute the most likely class for D. Assume a Naive Bayes classifier and use add-1 smoothing for the likelihoods. Dynamic Response of a Second Order Pneumatic System.
6. Demonstrate the following using appropriate programming tool which illustrates the use of information retrieval in NLP:
• Study the various Corpus – Brown, Inaugural, Reuters, udhr with various methods like filelds, raw, words, sents, categories
• Create and use your own corpora (plaintext, categorical)
• Study Conditional frequency distributions
• Study of tagged corpora with methods like tagged_sents, tagged_words
• Write a program to find the most frequent noun tags
• ● Map Words to Properties Using Python Dictionaries
• ● Study Rule based tagger, Unigram Tagger
Find different words from a given plain text without any space by comparing this text with a given corpus of words. Also find the score of words.</td></tr>
<tr><td colspan="3">Module-4</td></tr>
<tr><td colspan="2">Information Retrieval: Design Features of Information Retrieval Systems, Information Retrieval Models - Classical, Non-classical, Alternative Models of Information Retrieval - Custer model, Fuzzy model, LSTM model, Major Issues in Information Retrieval.
Lexical Resources: WordNet, FrameNet, Stemmers, Parts-of-Speech Tagger, Research Corpora.</td><td>CO 4</td></tr>
<tr><td>Lab Exercises</td><td colspan="2">7. Write a Python program to find synonyms and antonyms of the word "active" using WordNet.</td></tr>
<tr><td colspan="3">Module-5</td></tr>
<tr><td colspan="2">Machine Translation: Language Divergences and Typology, Machine Translation using Encoder-Decoder, Details of the Encoder-Decoder Model, Translating in Low-Resource Situations, MT Evaluation, Bias and Ethical Issues.</td><td>C O 5</td></tr>
<tr><td>Lab Exercises</td><td colspan="2">8. Implement the machine translation application of NLP where it needs to train a machine translation model for a language with limited parallel corpora. Investigate and incorporate techniques to improve performance in low-resource scenarios.</td></tr>
</table>

Suggested Learning Resources:

Books

4. Tanveer Siddiqui, U.S. Tiwary, “Natural Language Processing and Information Retrieval”, Oxford University Press.
5. Daniel Jurafsky, James H. Martin, “Speech and Language Processing, An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition”, Pearson Education, 2023.

Reference Books

1. Akshay Kulkarni, Adarsha Shivananda, “Natural Language Processing Recipes – Unlocking Text Data with Machine Learning and Deep Learning using Python”, Apress, 2019.
2. T V Geetha, “Understanding Natural Language Processing – Machine Learning and Deep Learning Perspectives”, Pearson, 2024.
3. Gerald J. Kowalski and Mark.T. Maybury, “Information Storage and Retrieval systems”, Kluwer Academic Publishers.

E Books / MOOCs/ NPTEL

1. https://www.youtube.com/watch?v=M7SWr5xObkA
2. https://youtu.be/02QWRAhGc7g
3. https://www.youtube.com/watch?v=CMrHM8a3hqw
4. https://onlinecourses.nptel.ac.in/noc23_cs45/preview
5. https://archive.nptel.ac.in/courses/106/106/106106211/

CO-PO Map

PO/PSO / **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO 1	3	2	2	1	3	-	-	-	-	-	2	-	-	3	-
CO 2	3	3	2	1	3	-	-	-	-	-	-	-	-	**3**	-
CO 3	3	3	3	3	3	-	-	-	-	-	-	-	-	**3**	-
CO 4	3	2	2	3	3	-	-	-	-	-	-	-	-	**3**	-
CO 5	3	3	3	3	2	-	-	-	-	-	-	-	-	**3**	-

3 – Strong, 2 Moderate, 1-Weak

CONTROL SYSTEMS (IPCC)			
Course Code	**22RI53**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-2	SEE Marks	50
Total Hours of Pedagogy	52	Total Marks	100
Credits	04	Exam Hours	03

Course objectives:

- At the end of this course, the students will demonstrate the ability to:
- Appreciate the role of the control system.
- Analyze the mathematical model of the control system.
- Solve to get a time domain response.
- Analyze the stability of the system.
- Use Bode plot for frequency domain analysis.

Course Outcomes: At the end of the course student will be able to

CO1: Explain the basic structure of control systems and the role of sensors, actuators, and PID controllers using practical examples.

CO2: Develop mathematical models of mechanical, electrical, and electro-mechanical systems, and represent them using transfer functions, block diagrams, and signal flow graphs.

CO3: Analyze time response of first and second order systems, evaluate steady-state error, and examine the effects of parameter variations and feedback on system performance and stability.

CO4: Apply root-locus and Routh–Hurwitz stability criterion technique to analyse and design control systems.

CO5: Apply frequency domain methods to analyze control systems and design PID controllers to meet gain margin, phase margin, and bandwidth specifications.

Module-1

Introduction to Control System: Introduction to control system block diagram. Importance of Control Systems. Components of control systems. Explanation with the help of the liquid level control system. Significance of actuators and sensors. Types of actuators, Types of sensors. Open-loop and closed-loop control systems. PID Controllers: Basic idea of PID controllers.		CO1
Lab Exercises	9. To study the open loop characteristics of DC motor and experiment it with using Matlab simulation File 10. Closed-Loop Speed Control of a DC Fan Using PID Controller using Arduino.	

Module-2

Control system representation: Mathematical modelling of control systems: Mathematical modelling of Mechanical systems, Electrical systems, electro-mechanical systems. Laplace transforms, transfer functions, electrical analogues of other dynamical systems. Block diagram representation and reduction. Signal flow graph.		CO2
Lab Exercises	1. To model and simulate the dynamics of a mass-spring-damper system using Laplace transforms and transfer functions. 2. To represent a complex system using a block diagram and systematically reduce it to a single transfer function.	

Module-3

<table>
<tr><td colspan="2">Time domain analysis:
Time response of first order, second order systems. Analysis of steady state error, Type of system and steady state error, Time response specifications. Effect of parameter variation on open loop and closed loop system response, sensitivity. Effect of feedback on system response, stability and disturbance.</td><td rowspan="2">CO3</td></tr>
<tr><td>Lab Exercises</td><td>1. Simulate the step response of a first and second-order system and analyze its time-domain specifications.
2. Dynamic Response of a Second Order Pneumatic System.</td></tr>
<tr><td colspan="3">Module-4</td></tr>
<tr><td colspan="2">Stability:
Concept of stability, Effect of pole zero location on stability, Routh- Hurwitz criterion. Root Locus method for analysis of gain margin, phase margin and stability.</td><td rowspan="2">CO4</td></tr>
<tr><td>Lab Exercises</td><td>1. To determine the stability of given characteristic equations using the Routh-Hurwitz criterion in MATLAB/Simulink.
2. To plot the root locus of a system and analyze the effect of gain on poles’ location and stability.</td></tr>
<tr><td colspan="3">Module-5</td></tr>
<tr><td colspan="2">Control system analysis in frequency domain:
Concept of frequency domain behavior, Bode Plot for analyzing systems in frequency domain. Frequency domain performance specifications. Correlation between time domain and frequency domain specification. Nyquist Analysis. Design of PID Controllers with Frequency-Response Approach.</td><td rowspan="2">CO5</td></tr>
<tr><td>Lab Exercises</td><td>1. To obtain and analyze the Bode plot of a given transfer function and interpret gain/phase margins and bandwidth.
2. To experimentally tune a PID controller based on observed frequency response characteristics of a motor system</td></tr>
</table>

Suggested Learning Resources:

Books

1. Katsuhiko Ogata (2004) ” Modern Control Engineering” Prentice Hall of India.
2. I. J. Nagarath and M. Gopal,(2002) “Control system” New Age International.
3. Harrison H.L. and Bollinger J.G. (1968) “Automatic controls”, 2nd edition, International Text Book Co. U.S.A.

Reference Books

1. G Richard C. Dorf and Robert H. Bishop, “Modern Control Systems”, 12th Edition, Pearson Education, New Delhi, 2011
2. Benjamin.Kuo.C. (1995) “Automatic Control Systems”, EEE, 7th Edition Prentice Hall of India Ltd. New Delhi.
3. Appukuttan K. K. Control Engineering, Oxford university publication, 2009

E Books / MOOCs/ NPTEL

1. http://nptel.ac.in/courses/108101037/
2. Virtual Lab link- http://vlabs.iitkgp.ernet.in/rcs/
3. https://www.mathworks.com/solutions/control-systems.html

CO-PO Map

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO 7	PO8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO 1	3	2	1		-	-	-	-	-	-	-	-	3	2	-
CO 2	3	2	1		-	-	-	-	-	-	-	-	2	3	1
CO 3	3	2	2	1	-	-	-	-	-	-	-	-	1	1	2
CO 4	3	2	2		-	-	-	-	-	-	-	-	3	-	3
CO 5	3	2	2		-	-	-	-	-	-	-	-	3	-	-

3 – Strong, 2 Moderate, 1-Weak

ROBOT PROGRAMMING AND SIMULATION LABORATORY (PEC)			
Course Code	**22RIL54**	CIE Marks	50
Teaching Hours/Week (L:T:P)	0-0-2	SEE Marks	50
Total Hours of Pedagogy	-	Total Marks	100
Credits	01	Exam Hours	03

Course objectives:

- To learn robot program softwares and also gain experience with robot programming environment and simulation tools.
- To achieve Task-Specific Programming of robots.

Course Outcomes: At the end of the course student will be able to

CO1: Use of any robotic simulation software to model the different types of robots and calculate position, orientation and coordinate systems for different robots.

CO2: To simulate the robot for pick and place, colour identification applications.

CO3: To program the robot and simulate robot for applications like industrial process like assembly , packaging etc.

CO4: To simulate robot for kinematics.

Sl.No.	Course Contents
1	Determination of maximum and minimum position of links of robots.
2	Verification of transformation (Position and orientation) with respect to gripper and world coordinate system.
3	Estimation of accuracy, repeatability and resolution.
4	Robot programming and simulation for pick and place.
5	Robot programming and simulation for palletization and depalletization.
6	Robot programming and simulation for Colour identification.
7	Robot programming and simulation for Shape identification.
8	Robot programming and simulation for machining (cutting, welding, laser engraving etc.).
9	Robot programming and simulation for any industrial process automation (Packaging, Assembly).
10	Robot programming and simulation for Tool Center Point (TCP)
11	Robot programming and simulation for Robot Drawing
12.	Robot programming and simulation for Forward Kinematics using Virtual labs.
13.	Robot programming and simulation for Vision camera/inspection applications.
14	Demonstration: Integration of IOT to robots for execution of tasks.

Note: Students are required to program and simulate the different robots for specific applications using the softwares and same virtual robot environment are required to demonstrate practically using real time robots for hands-on experience of robots.

List of Softwares that can be utilized for robotic simulation:

- ABB robo studio Software
- Fanuc Software.
- Siemens Technomatix digital manufacturing software.
- Robo DK
- Coppeliasim software
- Dobot software
- ADAMS Software
- WorkspaceLT
- Virtual Labs ,IIT Bombay
- Verification of direct kinematics equations and inverse kinematics equations of 1DOF "R-configuration" robot. https://mr-iitkgp.vlabs.ac.in/exp/forward-kinematics/simulation.html
- Verification of direct kinematics equations and inverse kinematics equations of 2DOF"R-R configuration" robot. https://mr-iitkgp.vlabs.ac.in/exp/inverse-kinematics/simulation.html.

REFERENCE:

Suggested Learning Resources:

- https://www.coppeliarobotics.com/
- https://www.youtube.com/watch?v=MX3VXvZFk0U
- https://www.fer.unizg.hr/en/course/rpas
- https://www.hindawi.com/journals/jr/2018/2312984/
- https://unity.com/solutions/automotive-transportation-manufacturing/robotics

CO-PO Map:

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	3	2	-	-	-	-	-	-	-	-	-	1	2	3
CO 2	3	3	1	-	-	-	-	-	-	-	-	-	2	1	3
CO 3	3	2	2	-	-	-	-	-	-	-	-	-	2	2	3
CO 4	3	3	2	-	-	-	-	-	-	-	-	-	1	2	3

3 – Strong, 2 Moderate, 1-Weak

Professional Elective Course- I			
SMART MOBILE ROBOTS (PEC)			
Course Code	**22RI551**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To study fundamentals of mobile robotics like motion of mobile robots.
- To gain knowledge on mobile robot kinematics and constraints.
- To use AI, sensors and actuators for mobile robots.

Course Outcomes: At the end of the course student will be able to

CO1: Provide knowledge on the fundamentals of mobile robotics

CO2: Understand the Locomotion and mobile robot kinematics principles.

CO3: Learn the Sensorics and its perception of mobile robots towards environment.

CO4: Develop the control and simulation systems of mobile robotic systems.

CO5: Apply the knowledge to integrate and build the architecture of mobile robots.

Module	CO
Module-1	
INTRODUCTION TO MOBILE ROBOTICS :Overview of Mobile Robotics, Definition and classification of mobile robots, Historical development and current trends Types of Mobile Robots, Intelligence and embodiment, A roboticists' problem, Rats life: an example of autonomous mobile robotics, Autonomous mobile robots: some core challenges, Autonomous manipulation: some core challenges.	CO1
Module-2	
LOCOMOTION: Introduction, Key issues for Locomotion, Legged Mobile Robots, Leg configurations and stability, Examples of legged robot locomotion, Wheeled Mobile Robots, Wheeled locomotion: the design space, Wheeled locomotion: case studies. **MOBILE ROBOT KINEMATICS:** Introduction, Kinematic Models and Constraints, Mobile Robot Maneuverability.	CO2
Module-3	
PERCEPTION: Sensors for Mobile Robots, Sensor classification, Characterizing sensor performance, Wheel/motor sensors, Heading sensors, Ground-based beacons, Active ranging, Motion/speed sensors, Accelerometers, gyroscopes, Vision-based sensors, Representing Uncertainty, Feature Extraction.	CO3
Module-4	
PLANNING AND NAVIGATION: Introduction, Competences for Navigation: Planning and Reacting, Path planning, Obstacle avoidance, Navigation Architectures, Modularity for code reuse and sharing, Control localization, Techniques for decomposition, Case studies: tiered robot architectures.	CO4

Module-5	
MOBILE ROBOT LOCALIZATION: Introduction, The Challenge of Localization: Noise and Aliasing, To Localize or Not to Localize: Localization-Based Navigation versus Programmed Solutions, Single-hypothesis belief, Map Representation, Continuous representations, Decomposition strategies, Probabilistic Map-Based Localization, Markov localization, Kalman filter localization.	CO5

Text Books:

1. Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators, and Algorithms” by Nikolaus Correll et al.,2022, MIT Press.
2. “Robotics: Modelling, Planning and Control” by Bruno Siciliano et al., 2009, Springer.
3. "Mobile Robotics: Technology and Applications" by D. K. Pratihar, 2007 by Alpha Science. International Ltd.
4. “Fundamentals of Robotics - Manipulators, Wheeled and Legged Robots; Dilip K Pratihar, Narosa Publishing House, Third Reprint 2023.

Reference Books

1. Introduction to Autonomous Mobile Robots, Roland Siegwart and Illah R. Nourbakhsh,A Bradford Book Edition 2004, The MIT Press Cambridge, Massachusetts London, England.
2. "Probabilistic Robotics" by Sebastian Thrun et al., published by MIT Press on August 19, 2005, ISBN: 9780262201629.
3. "Robotics: Principles and Practice" by S.K. Saha, McGraw Hill Education (India) Private Limited, 2014, ISBN: 978-93-3290-280-0.

CO-PO Map

PO/PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO 1	3	2	1	-	-	-	-	-	-	-	-	-	1	2	3
CO 2	3	2	1	-	-	-	-	-	-	-	-	-	1	2	3
CO 3	3	2	2	-	-	-	-	-	-	-	-	-	1	2	3
CO 4	3	2	2	-	-	-	-	-	-	-	-	-	1	-	3
CO 5	3	2	2	-	-	-	-	-	-	-	-	-	2	-	-

3 – Strong, 2 Moderate, 1-Weak

INDUSTRIAL AUTOMATION (PEC)			
Course Code	**22RI552**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To understand the core concepts of Industrial automation technologies.
- To know the automated material handling devices and its applications.
- To analyze the higher end control technologies and its benefits.

Course Outcomes: At the end of the course student will be able to

CO1: To understand the fundamental concepts of industrial automation, strategies and its levels.

CO2: To analyse different material handling technologies and its applications.

CO3: To know the advanced automation technologies such as FMS integrated systems.

CO4: To understand the control strategies, discrete control systems.

CO5: To analyse the advanced industrial control systems such as SCADA and remote monitoring systems.

Module-1	
Introduction: Automation In Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations. Flow Lines & Transfer Mechanisms, Fundamentals of Transfer Lines, Analysis of Transfer Lines.	CO1
Module-2	
Material Handling and Identification Technologies: Overview of Material Handling Systems, Principles and Design Consideration, Material Transport Systems, Storage Systems, Overview of Automatic Identification Methods. Material Identification Methods.	CO2
Module-3	
Automated Manufacturing Systems: Components, Classification and Overview of Manufacturing Systems, Manufacturing Cells, GT And Cellular Manufacturing, FMS, FMS And Its Planning and Implementation. Quality Control Systems: Traditional And Modern Quality Control Methods, SPC Tools, Inspection Principles and Practices, Inspection Technologies.	CO3
Module-4	
Control Technologies in Automation: Industrial Control Systems, Process Industries Versus Discrete-Manufacturing Industries, Continuous Versus Discrete Control, Computer Process and Its Forms. Sensors, Actuators and Other Control System Components.	CO4

Module-5	
Computer Based Industrial Control: Introduction & Automatic Process Control, Building Blocks Of Automation Systems: LAN, Analog & Digital I/O Modules, SCADA Systems & RTU.PLC and its applications. Distributed Control System: Functional Requirements, Configurations & some popular Distributed Control Systems. Display Systems in Process Control Environment.	CO5

Text Books:

1. Automation, Production Systems and Computer Integrated Manufacturing- M. P. Groover, Pearson Education.5th edition, 2009.

Reference Books:

1. Computer Based Industrial Control- Krishna Kant, EEE-PHI,2nd edition,2010
2. An Introduction to Automated Process Planning Systems- Tiess Chiu Chang & Richard A. Wysk
3. Performance Modeling of Automated Manufacturing Systems,-Viswanandham, PHI, 1st edition, 2009.

<u>CO-PO Map</u>

PO/PSO CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO3
CO 1	3	2	2		-	-	-	-	-	-	-	-	3	3	-
CO 2	3	2	2		-	-	-	-	-	-	-	-	3	3	2
CO 3	3	2	2	-	-	-	-	-	-	-	-	-	2	1	2
CO 4	3	2	2		-	-	-	-	-	-	-	-	3	2	3
CO 5	3	2	2		-	-	-	-	-	-	-	-	3	-	-

3 – Strong, 2 Moderate, 1-Weak

MICRO AERIAL ROBOTS (PEC - 1)			
Course Code	22RI553	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To understand the basics of micro aerial robots
- To identify the different components used in an UAV
- To understand the working of UAV
- To understand the communication methodology used in UAV
- To understand various application of UAVs

Course Outcomes: At the end of the course student will be able to

CO1: Understand the basics of micro aerial robots

CO2: Identify the different components used in an UAV

CO3: Understand the working of UAV

CO4: Understand the communication methodology used in UAV

CO5: Understand various application of UAVs

Module-1	
Overview of Micro Aerial Robots Introduction, Historical Developments, Uses of UAVs, Technical Terms, Characteristics of UAVs, Working of a UAV, Advantages and Disadvantages of UAVs	CO1
Module-2	
Various Components of UAV Introduction, Basic Aerodynamics, Stability and Control of UAV, UAVs Classification, Components of a UAV	CO2
Module-3	
Autonomous UAVs: The Automatic and Autonomous UAVs, Architecture of an Autonomous System, The Concept of Autonomy, Various Measures of UAV Autonomy, Simulation of the Environment, Path Planning, Flight Safety Operation, Path Planning Algorithms	CO3
Module-4	
Communication Infrastructure of UAVs UAV Communication System, Types of Communication, Wireless Sensor Network (WSN) System, Free Space Optical (FSO) Approach, The FPV Approach, Cyber security Approach, Swarm Approach, Internet of Things (IoT)	CO4

Module-5	
Various Applications of UAVs Overview of UAVs/Drones Applications, Surveying and Mapping, Forestry, Agriculture, Smart Cities, Traffic Monitoring and Management, Swarm-based Applications, Search and Rescue (SaR) Operations, Military	CO5

Suggested Learning Resources:

Books

1. Andey Lennon, Basics of R/C Model Aircraft Design - Practical Techniques for building better models, Air AgeMedia Inc., 2005
2. Garg, P.K., Unmanned Aerial Vehicles - An Introduction, Mercury learning & Information LLC, 2021
3. Donald Norris, Building Your Own Quadcopter, McGraw-Hill Education, 2014
4. Paul Gerin Fahlstrom, Thomas James Gleason, Introduction to UAV Systems, Wiley Publication, 4th Edition, 2012

Reference Books

1. Randal W. Beard and Timothy W. McLain: Small Unmanned Aircraft: Theory and Practice, 2nd edition, Princeton University Press, 2012
2. Landen Rosen, Unmanned Aerial Vehicle, Alpha Editions, 201

CO-PO MAPPING

Course Outcomes	Program Outcomes												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2		3				3	2		2	3		
2	3	3	3		3				3	2		2	3		
3	3	3	3		3				3	2		2	3		
4	3	3	3		3				3	2		2	3		
5	3	3	3		3				3	2		2	3		

INTRODUCTION TO DIGITAL TRANSFORM AND DIGITAL TWIN (PEC - 1)			
Course Code	**22RI554**	CIE Marks	50
Teaching Hours/Week (L:T:P)	3-0-0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03

Course objectives:

- To understand the basics of digital twin
- To understand working of digital twin in manufacturing and production
- To understand the working of digital twin in Supply Chain and Warehousing
- To understand the working of digital twin in healthcare
- To understand various application of digital twin

Course Outcomes: At the end of the course student will be able to

CO1: Understand the basics of digital twin

CO2: Understand working of digital twin in manufacturing and production

CO3: Understand the working of digital twin in Supply Chain and Warehousing

CO4: Understand the working of digital twin in healthcare

CO5: Understand various application of digital twin

Module-1	
What is a Digital Twin? Introduction to technologies, applications, opportunities, and challenges influencing digital twin	CO1
Module-2	
Manufacturing and Production Introduction to the impact of the digital twin, cyber-physical systems, process automation and optimization, predictive maintenance and anomaly detection on the manufacturing ecosystem and its application	CO2
Module-3	
Supply Chain and Warehousing Introduction to digital twin-based operation and management, and simulation-based smart supply chain ecosystem, including quality assurance in the food and beverage sector, warehousing with machine learning and path planning, and warehousing with machine learning and pallet loading	CO3
Module-4	
Healthcare Introduction to healthcare and bioengineering applications of digital twins. The bioprocess and its potential, industrial-scale bioreactors and biomanufacturing, hospital administration in industry 4.0, epidermic control prediction, and cloud computing for radiotherapy systems are covered.	**CO 4**

Module-5	
Various Applications of digital twins: Discussion on the fundamental characteristics and applications of digital twins, the future of digital twins and forecast for industrial 5.0	CO5

Suggested Learning Resources:

Books

1. Digital Transformation: Survive and Thrive in an Era of Mass Extinction, Thomas M. Siebel, RosettaBooks
2. Digital Twin Driven Smart Manufacturing, Fei Tao, Qinglin Qi, Ang Liu, A.Y.C. Nee, Academic Press (Elsevier)
3. Digital Transformation: A Model to Master Digital Disruption, Jo Caudron and Dado Van Peteghem, Across Group

Reference Books

3. Digital Twin Technologies and Smart Cities, Maryam Farsi, Alireza Daneshkhah, Amnir Hadžić, Bahman Javadi, Springer
4. Industry 4.0: The Industrial Internet of Things, Alasdair Gilchrist, Apress

CO-PO MAPPING

Course Outcomes	Program Outcomes												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	3	2	2		3							2			3
2	3	3	3		3							2			3
3	3	3	3		3							2			3
4	3	3	3		3							2			3
5	3	3	3		3							2			3