SEMESTER S8

INDUSTRIAL ROBOTICS

Course Code	PEEIT865	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	5/3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PEAET527 Introduction to Robotics	Course Type	Theory

Course Objectives:

1. To familiarize robot structures and distinguish between different sensors and drives.
2. To develop skills in performing spatial transformations and kinematic analysis of robot manipulator.
3. To develop knowledge installing and commissioning the robot..

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SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to robotics Robot definition, applications, Industrial robot anatomy, robot classifications, Understanding its technical specifications, serial robots and parallel robots. Electrical Actuators and Drives: DC Motors, Stepper motors, BLDC Motor, and Synchronous AC servo motors, Industrial Servo drives, hardware controllers and interfaces, Selection of motors. Understanding Manufacturer's Technical datasheet.	8
2	Robot sensors and its interfaces Robot sensors and its interfaces: Contact and non-contact sensors; position, velocity, acceleration, proximity, and force sensors. Characteristics of Sensors Grubler-Kutzbach Criterion; DOF of a Robot Manipulator. Kinematic Transformations: Homogeneous Transformation, Denavit-Hartenberg (DH) Parameters; Forward Kinematics.. Inverse Kinematic Model – Manipulator Workspace-Solvability-Solution	10

	techniques-Closed form solution.	
3	Industrial Robot Installation and Commissioning, Mastering a Robot, Tool Center Point Calibration: 4-Point method, External reference method, Orientation calibration: World frame method, Two-point method. Calibration of Industrial Robot system: External fixed tool, Workpiece calibration: Direct and Indirect.	**9**
4	Imaging components-image representation-picture coding-object recognition and categorization-visual inspection.Robot cell-design and control layouts. Industrial Applications – Material Handling, Process, Assembly, Inspection.Non-Industrial Applications.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

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Criteria for Evaluation(Evaluate and Analyse): 20 marks

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- Each student should Design, simulate, and analyze a robotic arm with three or more degrees of freedom (DoF) for a pick and place system, operating within a defined work volume.
- Computational tools such as MATLAB or Octave can be utilized for for simulation and analysis.
- Find below the details of the project and the outcomes to be evaluated.

Project: Design, simulate, and analyze a robotic arm with three or more degrees of freedom (DoF) for a pick and place system, operating within a defined work volume.

Project Components:

1. Design Specifications and Simulation
    - Develop comprehensive arm specifications, including: a) Link dimensions b) Joint movement parameters c) Actuator specifications d) Sensor requirements

- Ensure design enables full access to the specified work volume
- Create a detailed 3D model for simulation purposes

2. Kinematic Analysis

- Derive kinematic equations using Denavit-Hartenberg (DH) parameters
- Construct homogeneous transformation matrices
- Implement and validate forward as well as inverse kinematics

3. Path Planning and Motion Simulation

- Define an efficient path for pick and place operations
- Simulate arm movements along the planned path
- Analyze motion profiles for optimization opportunities

4. Actuator Modeling and Dynamic Analysis

- Develop an electric motor models for joint actuation
- Simulate joint torques and forces during movement under a fixed load condition

5. Control System Implementation and Evaluation

- Simulate arm movement along the predefined path under load for each control strategy
- Evaluate and compare performance metrics for each control method

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Project Deliverables:

1. Detailed design specifications and 3D model
2. Kinematic and dynamic analysis reports
3. Identify and address technical challenges encountered
4. Simulation results and performance comparisons
5. Comprehensive project report including methodology, results, challenges, and recommendations

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Compare, evaluate and choose sensors/drives for robots	**K2**
CO2	Understand the kinematic model of a manipulator and the inverse kinematics	**K2**
CO3	Understand the steps for installation and commissioning of industrial robots	**K2**
CO4	Choose appropriate image processing techniques for robotic applications	**K3**
CO5	llustrate the various indsurial applications of robotics systems .	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										
CO2	2	3										
CO3		1				1			2		3	
CO4	2	2										
CO5	2	2										2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

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Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	"Introduction to Robotics .	S. K. Saha	McGraw Hill Education, (India) Pvt. Ltd.	2nd Edition,. 2008.
2	Introduction to Robotics: Mechanics and Control"	John J. Craig,	Pearson Publishers	3rd edition,2008
3	Robot Modeling and Control	Mark W. Spong, Seth Hutchinson, M. Vidyasagar	Wiley (India)	2nd Edition, , 2020.

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Modern Robotics: Mechanics, Planning, and Control	Kevin M. Lynch, Frank C. Park	Cambridge University Press	1st Edition, 2017
2	Robotics: Modelling, Planning and Control	Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo	Springer	1st Edition, 2009
3	'Robotics: Control, Sensing, Vision, and Intelligence'	Fu, K.S., Gonzalez, R.C. and Lee C.S.G	McGraw Hill, New York, NY	1987

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Video Links (NPTEL, SWAYAM…)	
Module No.	**https://onlinecourses.nptel.ac.in/noc24_me117/preview**
NPTEL	Industrial Robotics : Theories for Implementation By Prof. Arun Dayal Udai | IIT-ISM Dhanbad