CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET414	ROBOTICS	PEC	2	1	0	3

Preamble: This course provides an introduction to the robots types, Configurations and application; Coordinate frames and types, Transformations and types; Forward and Inverse Kinematics of manipulator's; all types of robotic sensors; Open loop and closed loop control systems

Prerequisite: NIL

Course Outcomes: After the completion of the course the student will be able to

CO 1	Identify the anatomy and specifications of robots for typical application
CO 2	Select the appropriate sensors and actuators for robots
CO 3	Identify robotic configuration and gripper for a particular application
CO 4	Solve forward and inverse kinematics of robotic manipulators
CO 5	Plan trajectories in joint space and Cartesian space
CO 6	Develop the dynamic model of a given robotic manipulator and its control strategy

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	1										2
CO 2	2	1										2
CO 3	2	1	2									2
CO 4	3	3	3									2
CO 5	3	3	3									2
CO 6	3	3	3									2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	20	20	40
Apply	20	20	40
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test (2 numbers) : 25 marks

Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the anatomy of a robot which is used for pick and place tasks. (K2, PO1, PO12)
2. What are the specifications of a typical spray painting robot? (DOF, specialties, control method etc.) (K1, PO2, PO12)

3. Which control method is used for a spot welding robot? (Continuous path control or point to point control) (K2, PO2, PO12)

Course Outcome 2 (CO2):

1. Choose a sensor as per robotic application.(K2, PO1, PO12)
2. Describe the functional differences of stepper motors and ac motors.(K1, PO1, PO12)
3. Pneumatic actuators are not suitable for heavy loads under precise control. Justify it.(K2, PO1, PO2, PO12)

Course Outcome 3 (CO3):

1. Explain the features of SCARA, PUMA Robots?(K1, PO1, PO12)
2. What are the different classification of robots based on motion control methods and drive technologies? Explain(K1, PO1, PO2, PO12)
3. What are the factors affecting the selection of grippers?(K1, PO1, PO3, PO12)

Course Outcome 4 (CO4):

1. What do you mean by forward kinematics?(K1, PO1, PO2, PO12)
2. Explain the inverse kinematics of robots.(K1, PO1, PO3, PO12)
3. What are the different coordinate systems used by industrial robots?(K1, PO1, PO3, PO12)

Course Outcome 5 (CO5):

1. Explain about planning the trajectory in Cartesian space and Joint space for robotic manipulators.(K1, PO1, PO2, PO12)
2. Explain about the third order polynomial trajectory planning in Joint space.(K1, PO1, PO2, PO12)
3. A two-degree-of-freedom planar robot is to follow a straight line in Cartesian space between the start (2,6) and the end (12,3) points of the motion segment. Find the joint variables for the robot if the path is divided into 10 segments. Each link is 9 inches long.(K2, PO1, PO3, PO12)

Course Outcome 6 (CO6):

1. Obtain the dynamic model of 1 DOF robot.(K2, PO1, PO2, PO12)
2. Explain the steps to design a PID controller for a single link manipulator.(K2, PO1, PO3, PO12)
3. Write short note on computed torque control.(K1, PO1, PO2, PO12)

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: EET414

Course Name: ROBOTICS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	Define reach and stroke of a robotic manipulator.	(3)
2	What are the characteristics of a spot welding robot?	(3)
3	A strain gauge of gauge factor 2 and resistance of the unreformed wire 100 Ω is used to measure the acceleration of an object of mass 3kg. If the strain is 10^{-6}, cross sectional area=10mm^2 and Young's modulus =6.9 x 10^{-10} N/m^2, compute the acceleration of the object.	(3)
4	Compare hydraulic and pneumatic actuators.	(3)
5	Explain the features of a SCARA robot.	(3)
6	What are the advantages and disadvantages of a pneumatic gripper?	(3)
7	If a point $P = [3\ 0\ -1\ 1\ ]^T$, find the new location of the point P, if it is rotated by π about the z-axis of the fixed frame and then translated by 3 units along the y-axis.	(3)
8	How will you compute the end effector position and orientation of a robotic arm?	(3)
9	What is the necessity of dynamic modelling of robotic manipulators?	(3)
10	Is a robotic system linear or nonlinear? Justify your answer.	(3)

PART B

Answer any one full question from each module, each carries 14 marks.

MODULE1

11 a) Explain in detail the specifications of a robotic manipulator. (10)

	b)	What is the typical anatomy of a robotic manipulator?	(8)
12	a)	Explain in detail any two industrial applications of Robots.	(10)
	b)	Compare point to point control and continuous path control.	(4)

MODULE II

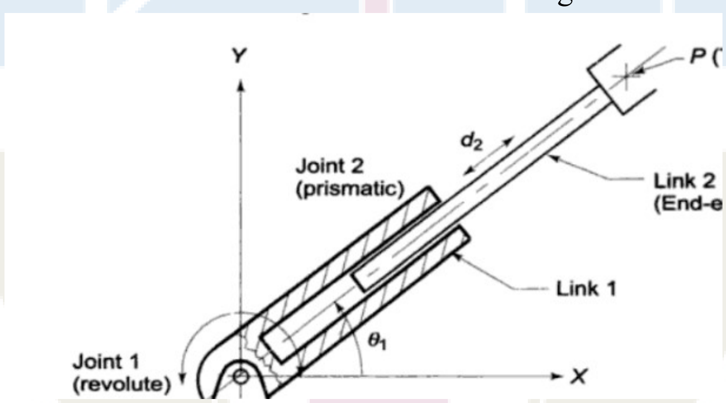
13	a)	How will you choose an appropriate sensor for a robotic application?	(8)
	b)	Mention the applications of vision sensor	(6)
14	a)	Outline the method of varying position using servo motor and stepper motor.	(8)
	b)	Explain the working of a typical hydraulic actuator.	(6)

MODULE III

15	a)	Explain in detail all robotic configurations.	(14)
16	a)	Describe the types of end effector & gripper mechanisms with simple sketches	(14)

MODULE IV

17	a)	Obtain the forward kinematic model of the following robot	(14)



18	a)	The second joint of a SCARA robot has to move from 15^0 to 45^0 in 3 sec. Find the coefficients of the cubic polynomial to interpolate a smooth trajectory. Also obtain the position, velocity and acceleration profiles	(8)
	b)	How will you plan a straight line trajectory in Cartesian space?	(6)

MODULE V

19	a)	Obtain the dynamic model of 1 DOF robot operated by electric motor.	(8)

b) How will you build a servo controlled robotic arm? (6)

20 a) Describe the schematic of PID controlled robotic manipulator and derive the closed loop transfer function. Explain how gains are computed for the PID controller? (10)

b) Comment on the stability of the above controller (4)

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SYLLABUS

Module 1

Definitions- Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots; Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom; Robot considerations for an application- number of axes, work volume, capacity & speed, stroke & reach, Repeatability, Precision and Accuracy, Operating environment, point to point control or continuous path control.

Robot Applications- medical, mining, space, defence, security, domestic, entertainment, Industrial Applications-Material handling, welding, Spray painting, Machining.

Case study- anatomy and specifications of a typical material handling robot

Module 2

Sensors and Actuators

Sensor classification- Touch, force, proximity, vision sensors.

Internal sensors-Position sensors, velocity sensors, acceleration sensors, Force sensors; External sensors-contact type, non-contact type; Vision - Elements of vision sensor, image acquisition, image processing; Selection of sensors.

Actuators for robots- classification-Electric, Hydraulic, Pneumatic actuators; their advantages and disadvantages; Electric actuators- Stepper motors, DC motors, DC servo motors and their drivers, AC motors, Linear actuators, selection of motors; Hydraulic actuators- Components and typical circuit, advantages and disadvantages; Pneumatic Actuators- Components and typical circuit, advantages and disadvantages.

Case study- sensors and actuators needed for a differential drive robot which is capable of autonomous navigation, study of sensors and actuators for an autonomous pick and place robot

Module 3

Robotic configurations and end effectors

Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots; Classification of robots based on motion control methods and drive technologies; 3R concurrent wrist;

Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, factors affecting selection of grippers.

Case study- typical robotic configuration for a pick and place robot capable picking objects from a moving conveyor

Module 4

Kinematics and Motion Planning

Robot Coordinate Systems- Fundamental and composite rotations, homogeneous coordinates and transformations, Kinematic parameters, D-H representation, Direct Kinematics. The Arm equation- forward and inverse Kinematics of typical robots upto 3 DOF.

Motion Planning- joint space trajectory planning-cubic polynomial, linear trajectory with parabolic blends; Cartesian space planning, Point to point vs continuous path planning.

Case study- Obtain the joint profiles of a 2 DOF planar manipulator, if the end effector is moving through an arc.

Module 5

Dynamics and Control of Robots

Dynamics- Dynamic model of a robot using Lagrange's equation, dynamic modelling of 1 DOF robot.

Control Techniques- Transfer function and state space representation, Performance and stability of feedback control, PID control of a single link manipulator, selection of PID controller gains; nonlinear nature of manipulators, and need for nonlinear control techniques, Computed torque control.

Case study: Closed loop PID control a typical 2 DOF planar robotic manipulator

Case Studies/Assignments: Any of the three case studies can be given as assignments.

Text Books

1. Introduction to Robotics by S K Saha, Mc Graw Hill Eduaction
2. Robert. J. Schilling, “Fundamentals of robotics – Analysis and control”, Prentice Hall of India 1996.
3. R K Mittal and I J Nagrath, “Robotics and Control”, Tata McGraw Hill, New Delhi, 2003.
4. Introduction to Robotics (Mechanics and control), John. J. Craig, Pearson Education Asia 2002.
5. Ashitava Ghosal, “Robotics-Fundamental concepts and analysis”, Oxford University press.
6. Robotics Technology and Flexible Automation, Second Edition, S. R. Deb.
7. Introduction to Robotics, Saeed B. Nikku, Pearson Education, 2001.
8. Rachid Manseur, ‘Robot Modeling and Kinematics’, Lakshmi publications, 2009.

Reference Books

1. D Roy Choudhury and shaail B. jain, ‘Linear Integrated circuits’, New age international Pvt.Ltd 2003
2. Boltans w. ”Mechatronics” Pearson Education , 2009

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction**	
1.1	Definitions- Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots;	1
1.2	Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom;	1
1.3	Robot considerations for an application- number of axes, work volume, capacity & speed, stroke & reach, Repeatability, Precision and Accuracy, Operating environment, point to point control or continuous path control.	1
1.4	Robot Applications- medical, mining, space, defence, security, domestic, entertainment	1
1.5	Industrial Applications-Material handling, welding, Spray painting, Machining.	1

2	**Sensors and Actuators**	
2.1	Sensor classification- touch, force, proximity, vision sensors	1
2.2	Internal sensors-Position sensors, velocity sensors, acceleration sensors, Force sensors;	1
2.3	External sensors-contact type, non-contact type;	1
2.4	Vision-Elements of vision sensor, image acquisition, image processing; Selection of sensors.	1
2.5	Actuators for robots- classification-Electric, Hydraulic, Pneumatic actuators; their advantages and disadvantages; Electric actuators- Stepper motors, DC motors, DC servo motors and their drivers, AC motors, Linear actuators, selection of motors;	2
2.6	Hydraulic actuators- Components and typical circuit, advantages and disadvantages; Pneumatic Actuators- Components and typical circuit, advantages and disadvantages.	2
3	**Robotic configurations and end effectors**	
3.1	Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots	2
3.2	Classification of robots based on motion control methods and drive technologies; 3R concurrent wrist;	2
3.3	Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, factors affecting selection of grippers.	3
4	**Kinematics and Motion Planning**	
4.1	Robot Coordinate Systems- Fundamental and composite rotations, homogeneous coordinates and transformations.	2
4.2	Kinematic parameters, D-H representation, Direct Kinematics. The Arm equation- forward Kinematic analysis of a typical robots up to 3 DOF.	4
4.3	Motion Planning- joint space trajectory planning-cubic polynomial, linear trajectory with parabolic blends; Cartesian space planning, Point to point vs continuous path planning.	2

5	**Dynamics and Control of Robots**	
5.1	Dynamics- Dynamic model of a robot using Lagrange's equation, dynamic modelling of 1 DOF robot	2
5.2	Control Techniques- Transfer function and state space representation, Performance and stability of feedback control.	3
5.3	PID control of a single link manipulator, selection of PID controller gains; nonlinear nature of manipulators, and need for nonlinear control techniques, Computed torque control.	2