INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad-500043

MECHANICAL ENGINEERING

TUTORIAL QUESTION BANK

Course Title	**ROBOTICS**				
Course Code	AME533				
Programme	B.Tech				
Semester	VI	ME			
Course Type	PROFESSIONAL ELECTIVE				
Regulation	**IARE - R16**				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	4	-	3	-	-
Chief Coordinator	Mr. A Anudeep Kumar, Assistant Professor				
Course Faculty	Mr. A Anudeep Kumar, Assistant Professor				

COURSE OBJECTIVES:

The course should enable the students to:	
I	Develop the knowledge in various robot structures and their workspace.
II	Develop the skills in performing kinematics analysis of robot systems.
III	Provide the knowledge of the dynamics associated with the operation of robotic systems.
IV	Provide the knowledge and analysis skills associated with trajectory planning.
V	Understand material handling and robot applications in industries.

COURSE OUTCOMES (COs):

CO 1	Understand characteristic features of robots and usage of different grippers for industrial applications.
CO 2	Understand direct and inverse kinematics of robot structure.
CO 3	Illustrate Differential Kinematics of planar and spherical manipulators.
CO 4	Understand classification of robot actuators and trajectory planning.
CO 5	Remember material handling and applications in manufacturing.

COURSE LEARNING OUTCOMES (CLOs):

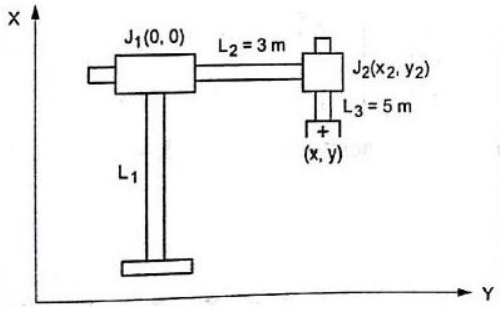
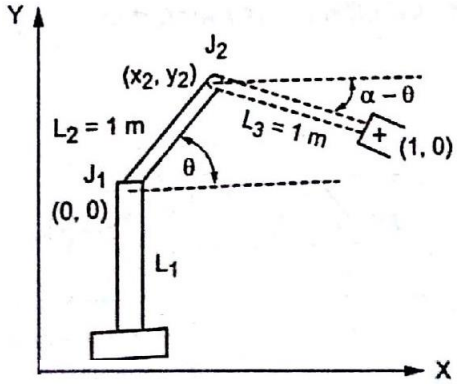
AME533.01	Differentiate between automation and robotics.
AME533.02	Classify robots and describe its anatomy.
AME533.03	Specify various types of industrial sensors.
AME533.04	Classify various grippers.
AME533.05	Discuss about motion analysis of robot.
AME533.06	Understand methods for calculating the kinematics and inverse kinematics of a robot manipulator.
AME533.07	Describe D-H notations, joint coordinates and. world coordinates.
AME533.08	Discuss about homogeneous transformation.
AME533.09	Describe the differential kinematics of planar manipulators.
AME533.10	Illustrate Lagrange-Euler formulation.
AME533.11	Discuss jacobian and robot dynamics.
AME533.12	Illustrate Newton-Euler formulation.
AME533.13	Describe Joint space scheme.
AME533.14	Illustrate cubic polynomial fit.
AME533.15	Classify types of motion.
AME533.16	Explain actuators and classify them.
AME533.17	Illustrate various robot applications in manufacturing.
AME533.18	Discuss the role of robots in material handling.
AME533.19	Explain work cell design.
AME533.20	Discuss the role of robots in assembly and inspection.

TUTORIAL QUESTION BANK

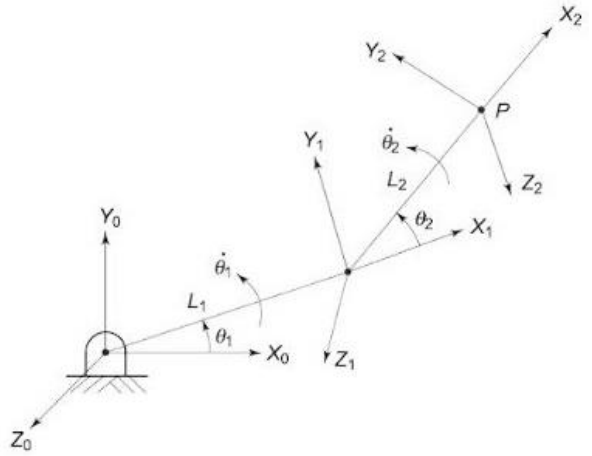
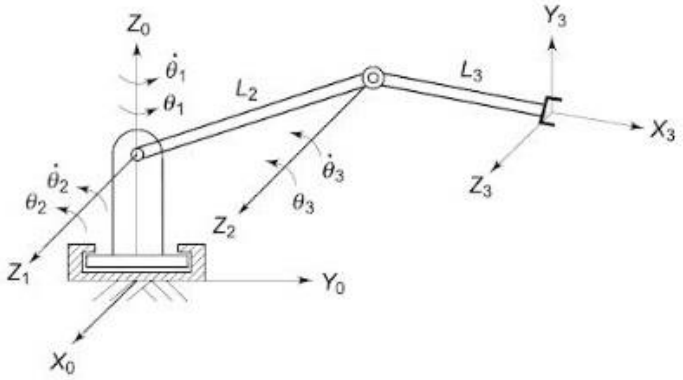
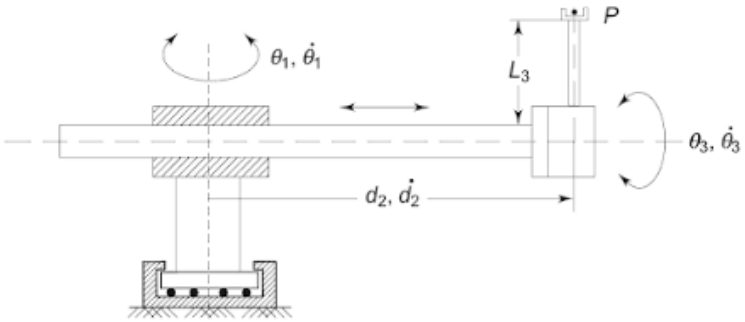
UNIT- I				
INTRODUCTION TO ROBOTICS				
Part - A (Short Answer Questions)				
S No	**QUESTIONS**	**Blooms Taxonomy Level**	**Course Outcomes**	**CLO Code**
1	Define Fixed automation.	Remember	CO 1	AME533.01
2	Explain the working principle of Magnetic grippers.	Understand	CO 1	AME533.04
3	Define Flexible automation.	Remember	CO 1	AME533.01
4	Define a Robot.	Remember	CO 1	AME533.01
5	Define the anatomy of robot.	Remember	CO 1	AME533.01
6	List the different types of joints used in robots.	Understand	CO 1	AME533.01
7	List the factors in gripper's selection.	Remember	CO 1	AME533.04
8	Define the position and orientation of robot.	Remember	CO 1	AME533.02
9	Differentiate types of joints used in robots	Understand	CO 1	AME533.02
10	List the factors in gripper's design.	Remember	CO 1	AME533.04
11	Define manipulator.	Understand	CO 1	AME533.02
12	List the applications of programmable automation.	Remember	CO 1	AME533.01
13	Explain the Vacuum cups used in vacuum gripper.	Understand	CO 1	AME533.04
14	Define industrial automation.	Understand	CO 1	AME533.01
15	List types of industrial automation.	Remember	CO 1	AME533.01

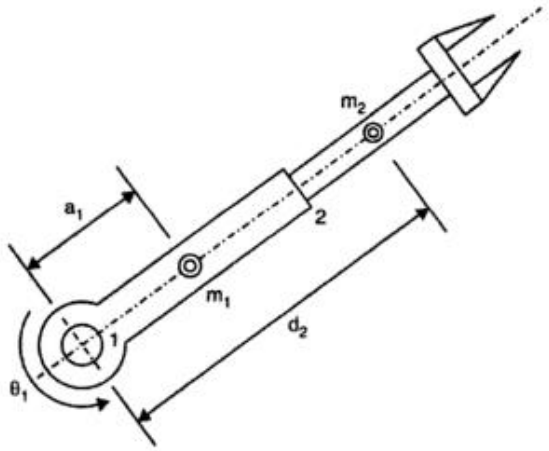
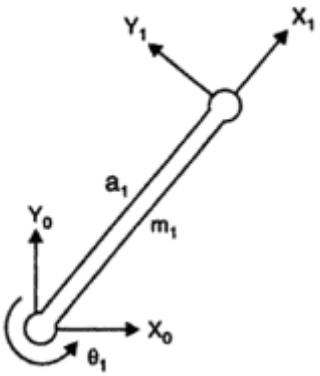
16	Define mechanical gripper.	Understand	CO 1	AME533.04
17	List out the disadvantages of mechanical gripper.	Understand	CO 1	AME533.04
18	Define the role of sensor in robot.	Remember	CO 1	AME533.03
19	Classify end effectors.	Understand	CO 1	AME533.04
20	Define SCARA robot.	Remember	CO 1	AME533.02
Part - B (Long Answer Questions)				
1	Explain the different types of joints used in robots with neat sketch.	Understand	CO 1	AME533.02
2	Explain RPY representation of orientation.	Understand	CO 1	AME533.02
3	Discuss the advantages and disadvantages of using robots in industry.	Remember	CO 1	AME533.01
4	Compare hard automation with soft automation.	Understand	CO 1	AME533.01
5	Discuss in detail about programmable automation.	Remember	CO 1	AME533.01
6	Describe the role of automation in industries and classify automation.	Understand	CO 1	AME533.01
7	Discuss fixed automation in detail and illustrate one example.	Remember	CO 1	AME533.01
8	Illustrate Cartesian coordinate configuration robot with a neat sketch.	Understand	CO 1	AME533.02
9	Discuss programmable automation in detail and illustrate one example.	Understand	CO 1	AME533.01
10	Illustrate cylindrical configuration robot with a neat sketch.	Remember	CO 1	AME533.02
11	Discuss fixed automation in detail and illustrate one example.	Understand	CO 1	AME533.01
12	Describe polar configuration robot with a neat sketch.	Understand	CO 1	AME533.02
13	Explain hydraulic drive used in industrial robot.	Remember	CO 1	AME533.03
15	Differentiate between cartesian coordinate and cylindrical robot.	Understand	CO 1	AME533.02
16	Explain electric drive used in industrial robot.	Remember	CO 1	AME533.03
17	Discuss mechanical grippers used in robots and list out its advantages.	Understand	CO 1	AME533.04
18	Explain vacuum gripper with a neat sketch and list out its disadvantages.	Understand	CO 1	AME533.04
19	Discuss the benefit of using pneumatic drive used in robots.	Remember	CO 1	AME533.03
20	Differentiate between vacuum gripper and magnetic gripper.	Understand	CO 1	AME533.04
Part - C (Problem Solving and Critical Thinking Questions)				
1	Explain the various factors in gripper's selection and design.	Understand	CO 1	AME533.04
2	Classify sensors used in robots and explain each of them in detail.	Remember	CO 1	AME533.03
3	At time t the excitation voltage to a resolver is 24V and Vs_1 = 17V and Vs_2 = -17V. What is the angle?	Understand	CO 1	AME533.03
4	What is the resolution, in degrees, of an encoder with 10 tracks?	Understand	CO 1	AME533.03
5	What is the output value of an absolute encoder if the shaft angle is 1 rad and the encoder has 8 tracks?	Remember	CO 1	AME533.03
6	Describe magnetic gripper in detail with a neat sketch.	Understand	CO 1	AME533.04
7	Describe resolvers used in robots with a neat sketch.	Understand	CO 1	AME533.03
8	Explain four types of robot controls in detail.	Remember	CO 1	AME533.03
9	Describe potentiometer used in robots with a neat sketch.	Understand	CO 1	AME533.03
10	Differentiate between polar configuration robot and jointed-arm configuration robot.	Remember	CO 1	AME533.02
UNIT-II				
MOTION ANALYSIS				
Part – A (Short Answer Questions)				
1	Define forward kinematics of a robot.	Understand	CO 2	AME533.05
2	Define manipulator kinematics of a robot.	Understand	CO 2	AME533.05
3	Define inverse kinematics of a robot.	Understand	CO 2	AME533.05
4	Write about transformations used in robot kinematics.	Understand	CO 2	AME533.05
5	State a method to solve forward kinematic problems.	Remember	CO 2	AME533.05
6	Write homogeneous transformation matrix.	Understand	CO 2	AME533.08
7	State a method to solve inverse kinematic problems.	Remember	CO 2	AME533.08
8	Define composite rotation matrix.	Understand	CO 2	AME533.08
9	Write homogeneous representation.	Understand	CO 2	AME533.08
10	State the D-H notations.	Understand	CO 2	AME533.07
11	State how many linear and rotary joints are present in LRL robot.	Remember	CO 2	AME533.05
12	Define position control of a robot.	Remember	CO 2	AME533.05
13	State singularity of a robot manipulator.	Understand	CO 2	AME533.05
14	Define force control of a robot.	Understand	CO 2	AME533.05
15	Define redundancy of a robot.	Understand	CO 2	AME533.05
16	Classify location of the end effector of a robot manipulator.	Remember	CO 2	AME533.06

17	Define joint space of a robot manipulator.	Understand	CO 2	AME533.06
18	Define world space of a robot manipulator.	Remember	CO 2	AME533.06
19	State how many linear and rotary joints are present in LL robot.	Understand	CO 2	AME533.06
20	State how many linear and rotary joints are present in RR robot.	Remember	CO 2	AME533.06
Part - B (Long Answer Questions)				
1	Explain Direct kinematics of a manipulator with a neat sketch.	Understand	CO 2	AME533.06
2	Discuss inverse kinematics of a manipulator with a neat sketch.	Remember	CO 2	AME533.06
3	Explain about homogenous transformation used in robot manipulator kinematics.	Understand	CO 2	AME533.08
4	Describe composite rotation matrix of a robot manipulator in detail.	Remember	CO 2	AME533.08
5	Explain joint space of a robot manipulator.	Understand	CO 2	AME533.06
6	Describe world space of a robot manipulator.	Understand	CO 2	AME533.06
7	Discuss Denavit - Hartenberg convention in detail.	Remember	CO 2	AME533.06
8	Explain the forward kinematics transformation of a LL robot of 2 D.O.F with a neat sketch.	Understand	CO 2	AME533.06
9	Describe the forward kinematics transformation of a RR robot of 2 D.O.F with a neat sketch.	Understand	CO 2	AME533.06
10	Explain the inverse kinematics transformation of a LL robot of 2 D.O.F with a neat sketch.	Remember	CO 2	AME533.06
11	Describe the inverse kinematics transformation of a RR robot of 2 D.O.F with a neat sketch.	Understand	CO 2	AME533.06
12	Differentiate between joint space and world space of a robot manipulator.	Understand	CO 2	AME533.06
13	Find the resultant rotation matrix that represents a rotation of Φ angle about the OY axis followed by a rotation of θ angle about the OZ axis followed by a rotation of α angle about the OX axis.	Remember	CO 2	AME533.06
14	$P_{uvw}(4,3,2)^T$ with respect to rotated O,U,V,W coordinate system corresponding points P_{xyz} with respect to reference coordinate system, if it has been rotated about OZ axis.	Understand	CO 2	AME533.06
15	q(u,v,w) are given by $(4,3,2)^T$ which are rotated about X-axis of the reference frame by angle of 45^0. Determine the point q_{xyz}.	Understand	CO 2	AME533.06
16	One point $p_{uvw} = (6,5,4)^T$ are to be translated a distance +6 units along OX axis and -4 units along the OZ axis using appropriate homogeneous matrix, determine the new points p_{xyz}.	Remember	CO 2	AME533.06
17	Determine the translated vector for the given vector v = 25i+10j+20k perform a translation by a distance of 8 units in "x" direction, 5 units in "y" direction and 0 units in "z" direction.	Understand	CO 2	AME533.06
18	The coordinates of point P in frame {1} are $[3.0\ 2.0\ 1.0]^T$. The position vector P is rotated about the Z – axis by 45^0. Find the coordinates of point Q, the new position of point P.	Remember	CO 2	AME533.06
19	Frame {1} and {2} have coincident origins and differ only in orientation. Frame {2} is initially coincident with frame {1}. Certain rotations are carried out about the axis of the fixed frame {1}: first rotation about x- axis by 45^0 then about y-axis by 30^0 and finally about x-axis by 60^0. Obtain the equivalent rotation matrix ${}^1R_2$.	Understand	CO 2	AME533.06
20	Two coordinate frames {1} and {2} are initially coincident. Frame {2} is rotated by 45^0 about a vector $k = [0.5\ 0.866\ 0.707]^T$ passing through the origin. Determine the new description of frame {2}.	Understand	CO 2	AME533.05
Part - C (Problem Solving and Critical Thinking Questions)				
1	Determine the inverse kinematic solution of a RRR robot configuration with three DOF with 2D manipulator.	Understand	CO 2	AME533.06
2	Determine the forward kinematic solution of a RRR robot configuration with three DOF with 2D manipulator.	Understand	CO 2	AME533.06

3	An LL robot has two links of variable length. Assume that the origin of the global coordinate system is defined at joint J_1, determine the following: a) The coordinate of the end-effector point if the variable link length are 3m and 5m. b) Variable link lengths if the end-effector is located at (3,5).  Fig: LL Robot	Understand	CO 2	AME533.06
4	An RR robot has two links of length 1m. Assume that the origin of the global coordinate system is at J_1. a) Determine the coordinate of the end-effector point if the joint rotations are 30^0 at both joints. b) Determine joint rotations if the end-effector is located at (1,0).  Fig: RR Robot	Remember	CO 2	AME533.06
5	For the point $a_{uvw}= (6,2,4)^T$ perform following operations. a. Rotate 30^0 about the *X* axis, followed by translation of 6 units along *Y* axis. b. Translate 6 units along *Y* axis, followed by rotation of 30^0 about *X* axis. c. Rotate 60^0 about *Z* axis followed by translation of 10 units along the rotated *U* axis.	Understand	CO 2	AME533.06
6	For the vector v=25i+10j+20k, perform a translation by a distance of 8 in the x-direction, 5 in the y-direction and 0 in the z-direction.	Understand	CO 2	AME533.06
7	For the point $3i+7j+5k$ perform the translation of 6 units along *Y* axis and then rotate 30^0 about *X* axis.	Remember	CO 2	AME533.06
8	Find the transformation matrices for the following operations on the point $2\hat{i}-8\hat{j}+3\hat{k}$ Rotate 30^0 about x-axis and then translate -5 units along y-axis	Understand	CO 2	AME533.06
9	Determine the forward kinematic solution of a spherical robot RRL configuration with three DOF with 2D manipulator.	Understand	CO 2	AME533.06
10	Determine the inverse kinematic solution of a spherical robot RRL configuration with three DOF with 2D manipulator.	Remember	CO 2	AME533.06
UNIT -III				
DIFFERENTIONAL KINEMATICS				
Part - A (Short Answer Questions)				
1	Define jacobian in robots.	Remember	CO 3	AME533.11
2	Define differential kinematics of a robot manipulator.	Remember	CO 3	AME533.09

3	List the steps involved in kinematics model.	Understand	CO 3	AME533.09
4	Define spherical manipulator.	Remember	CO 3	AME533.09
5	Name a method to solve Forward Kinematics.	Remember	CO 3	AME533.09
6	Define degree of freedom of a robot manipulator.	Understand	CO 3	AME533.09
7	Define planar manipulator.	Understand	CO 3	AME533.09
8	Define lagrangian method of approach a robot manipulator.	Remember	CO 3	AME533.10
9	Name the manipulator in which all the links perform spherical motions about a common stationary point.	Understand	CO 3	AME533.10
10	State the lagrangian function.	Understand	CO 3	AME533.10
11	List out forces to be considered in Newton Euler method.	Understand	CO 3	AME533.12
12	Write the kinetic energy of Lagrange- Euler Formulation.	Remember	CO 3	AME533.10
13	List out the advantages of Lagrange Formulation.	Remember	CO 3	AME533.10
14	Write the potential energy of Lagrange- Euler Formulation.	Understand	CO 3	AME533.10
15	List out moments to be considered in Newton-Euler method.	Remember	CO 3	AME533.11
16	Define the dynamics of a two-link planar robot.	Remember	CO 3	AME533.09
17	Name the manipulator which consists of open loop and closed loop chains.	Understand	CO 3	AME533.11
18	Define Homogeneous Transformation Matrix of a manipulator.	Remember	CO 3	AME533.11
19	Sketch a two-link planar manipulator.	Remember	CO 3	AME533.11
20	Define position of any point in space, relative to a reference frame.	Understand	CO 3	AME533.11
	Part – B (Long Answer Questions)			
1	Derive the Jacobian matrix for the 2-link planar manipulator.	Understand	CO 3	AME533.11
2	Differentiate clearly with reference to 2-jointed manipulator of RR type and LL type.	Understand	CO 3	AME533.09
3	Explain the differential kinematics of planar manipulators.	Remember	CO 3	AME533.09
4	Differentiate between planar manipulators and spherical manipulators	Understand	CO 3	AME533.09
5	Explain the differential kinematics of spherical manipulators.	Understand	CO 3	AME533.09
6	Explain the Lagrange Euler's formulation for robot arm.	Remember	CO 3	AME533.10
7	Explain Newton-Euler formulation of a robotic system.	Understand	CO 3	AME533.12
8	Derive the equation of motion for a single link manipulator given the mass and length of the link.	Understand	CO 3	AME533.12
9	Derive Lagrange-Euler formulation for the joint force/torque.	Understand	CO 3	AME533.10
10	Explain the Kinematic energy applied to robot arm dynamics analysis.	Understand	CO 3	AME533.10
11	Derive Lagrangian-Euler formulation of joining force/torque for single link manipulator of given length and mass.	Remember	CO 3	AME533.10
12	Explain the Potential energy as applied to robot arm dynamics analysis.	Understand	CO 3	AME533.11
13	Derive Newton-Euler formulation of joining force/torque for single link manipulator of given length and mass.	Remember	CO 3	AME533.12
14	Explain the joint velocities as applied to robot arm dynamics analysis.	Understand	CO 3	AME533.12
15	Differentiate between Newton-Euler formulation and Lagrange-Euler formulation.	Understand	CO 3	AME533.12
	Part – C (Problem Solving and Critical Thinking)			
1	A moving frame {1} is represented by the following rotation matrix R, where α is the angle of rotation of the frame {1} with respect to the base frame. If α is a function of time, find the angular velocity of frame {1}. $${}^{0}\boldsymbol{R}_{1} = \begin{bmatrix} C\alpha & -S\alpha & 0 \\ S\alpha & C\alpha & 0 \\ 0 & 0 & 1 \end{bmatrix}$$	Understand	CO 3	AME533.09

2	Calculate the velocity of the tip of the two-link, planar, RR- manipulator arm shown in below fig.  Fig: A two-link, RR planar manipulator.	Remember	CO 3	AME533.09
3	Determine the manipulator jacobian matrix for the 3-DOF articulated shown in below fig.  Fig: 3-DOF articulated manipulator arm.	Understand	CO 3	AME533.09
4	For the manipulator shown in figure below, obtain the jacobian to express the cartesian velocities in terms of the joint velocities. Obtain the singularities of the manipulator.  Fig: A 3-DOF RPR arm of a manipulator.	Remember	CO 3	AME533.09
5	Derive the equation of motion for a single link manipulator given the mass and length of the link.	Understand	CO 3	AME533.10
6	Using the L-E formulation determine the equation of motion for a Revolute-Prismatic (RP) robot arm manipulator shown in below fig.	Understand	CO 3	AME533.10

	 Fig: RP manipulator.			
7	Compute the effective inertia, coupling inertia for a single link manipulator of mass m_1 and length 'a_1' as shown in below fig.  Fig: Single link manipulator.	Remember	CO 3	AME533.11
8	Explain following as applied to a robot arm, and also discuss their importance. a) Centrifugal force. b) Gravity term.	Understand	CO 3	AME533.12
UNIT -IV				
TRAJECTORY PLANNING				
Part – A (Short Answer Questions)				
1	Define the Trajectory planning.	Remember	CO 4	AME533.13
2	List the disadvantages of joint space scheme in trajectory planning.	Remember	CO 4	AME533.13
3	List the parameters involved in path planning with 3rd degree polynomial.	Remember	CO 4	AME533.13
4	Classify types of motions used in robot manipulator.	Remember	CO 4	AME533.13
5	List the advantages of joint space scheme in trajectory planning.	Understand	CO 4	AME533.13
6	Define straight line motion in robot manipulator.	Remember	CO 4	AME533.15
7	Define joint interpolated motion in robot manipulator.	Understand	CO 4	AME533.13
8	List the advantages of Cartesian-space scheme in trajectory planning.	Understand	CO 4	AME533.13
9	List the disadvantages of Cartesian-space scheme in trajectory planning..	Understand	CO 4	AME533.13
10	Define the Joint space trajectory planning.	Understand	CO 4	AME533.13
11	Classify actuators used in robot manipulator.	Remember	CO 4	AME533.16
12	Define inductive type proximity sensors.	Understand	CO 4	AME533.16
13	Define ultrasonic proximity sensors.	Understand	CO 4	AME533.16
14	Explain the working of DC servo Motor.	Understand	CO 4	AME533.16
15	Define the principle of a Resolver.	Remember	CO 4	AME533.16
16	List the characteristics of actuators used in robot manipulator.	Understand	CO 4	AME533.16
17	Define the pneumatic actuator used in robot manipulator.	Understand	CO 4	AME533.16
18	List out the components used in pneumatic actuators.	Remember	CO 4	AME533.16
19	Mention the advantages of pneumatic actuators.	Remember	CO 4	AME533.16

20	List out the disadvantages of pneumatic actuators.	Understand	CO 4	AME533.16
	Part – B (Long Answer Questions)			
1	Describe different path control modes in robotics.	Understand	CO 4	AME533.13
2	Briefly explain trajectory planning for robotics.	Understand	CO 4	AME533.13
3	Explain trajectory planning with respect to PTP robot considering modified constant velocity of joint.	Remember	CO 4	AME533.13
4	Explain the parameters involved in the path planning with 3rd degree polynomial.	Understand	CO 4	AME533.13
5	Discuss the general considerations in trajectory planning.	Understand	CO 4	AME533.13
6	Explain path planning with a block diagram.	Understand	CO 4	AME533.13
7	Differentiate between joint-space and cartesian space.	Remember	CO 4	AME533.13
8	Discuss the general considerations of joint interpolated trajectory.	Understand	CO 4	AME533.13
9	Explain trajectory planning with 5^{th} order polynomial.	Understand	CO 4	AME533.16
10	Explain the working principle of proximity sensor with a neat sketch.	Understand	CO 4	AME533.16
11	Discuss the role of feedback in robots and classify robot components.	Remember	CO 4	AME533.16
12	Compare between DC motors and Stepper motors used in robot manipulator.	Understand	CO 4	AME533.16
13	Explain features and application of hydraulic actuators in robotics	Understand	CO 4	AME533.16
14	Explain the performance and selection criteria of electric motors in robotics.	Understand	CO 4	AME533.16
15	Enlist the main elements of a hydraulic system used in robot and explain their functions briefly.	Remember	CO 4	AME533.16
16	Briefly classify actuators used in robot manipulator.	Understand	CO 4	AME533.16
17	Explain stepper motor with a neat sketch and list out its advantages and disadvantages.	Remember	CO 4	AME533.16
18	Enlist the main elements of a pneumatic system used in robot and explain their functions briefly.	Understand	CO 4	AME533.16
19	Explain the types of touch sensors with neat sketches.	Understand	CO 4	AME533.16
20	Explain tactile sensors and the range sensors with a neat sketch.	Understand	CO 4	AME533.16
	Part – C (Problem Solving and Critical Thinking)			
1	Determine the time required for each joint of a three-axis RRR manipulator to travel the following distances using slew motion; joint 1, 1000; joint 2, 300; and joint 3, 600. All joints travel at a rotation velocity of 150/s.	Understand	CO 4	AME533.14
2	Explain trajectory planning and show how trajectory planning is done in case of PTP (Point-to-point) robot having constant maximum velocity and finite acceleration and deceleration.	Remember	CO 4	AME533.14
3	A single link rotary robot is required to move from $\Theta(0)=45^0$ to $\Theta(2)=90^0$ in two seconds. Joint velocity and acceleration are zero at initial and final positions. What is the highest degree polynomial that can be used to accomplish the motion?	Understand	CO 4	AME533.14
4	Find expressions for the joint motion parameters by using cubic polynomial fit in joint space scheme. Use the following data: $\Theta(0)=2^0$, $\Theta(f)=7^0$ t=3sec.	Remember	CO 4	AME533.14
5	One of the joints of articulated robot has to travel from initial angle of 20^0 to final angle of 84^0 in 4 seconds. Using3rd degree polynomials calculate joint angles at one, two, three seconds.	Understand	CO 4	AME533.14
6	A single cubic trajectory given by $q(t) = 30 + t^2 – 6t^3$ is used for a period of 3s determine the start and goal positions, velocity and acceleration of the end effector.	Understand	CO 4	AME533.14
7	Design a single polynomial trajectory which starts from the initial position of $\Theta(0)=10^0$, passes through a via point $\Theta(1)=5^0$ and then stops at final angular position $\Theta(2)=50^0$. The velocities of start and stop positions are 0.	Remember	CO 4	AME533.14
8	A single-link robot with a rotary joint is motionless at $\Theta(o) = 15^0$. It is desired to move the joint in a smooth manner to $\Theta(f) = 75^0$ in 3 seconds. Find the coefficients of a cubic that accomplishes this motion and brings the manipulator to rest at the goal.	Understand	CO 4	AME533.14
	UNIT -V			
	ROBOTIC APPLICATIONS			
	Part - A (Short Answer Questions)			
1	List out the industrial applications of robots.	Understand	CO 5	AME533.17
2	State the features of robot in machine unloading applications.	Remember	CO 5	AME533.17
3	What are the features of robot in machine loading applications?	Understand	CO 5	AME533.17

4	List out material transfer applications.	Remember	CO 5	AME533.17
5	Define pick-and-place operation performed by robot.	Remember	CO 5	AME533.17
6	List out advantages of robot arc welding.	Remember	CO 5	AME533.17
7	Sate the considerations of robots in material handling	Understand	CO 5	AME533.18
8	List out advantages of robot spray coating.	Understand	CO 5	AME533.17
9	State the considerations of Robots in material handling.	Understand	CO 5	AME533.18
10	List out problems encountered in applying robots to arc welding.	Understand	CO 5	AME533.18
11	Classify various methods of part presentation in assembly process.	Remember	CO 5	AME533.18
12	Define automation in inspection.	Understand	CO 5	AME533.20
13	List out the features of welding robot.	Remember	CO 5	AME533.18
14	Classify various assembly systems configuration	Understand	CO 5	AME533.20
15	List out the sensors used in robotic arc welding.	Remember	CO 5	AME533.18
16	Define work volume of a robot.	Understand	CO 5	AME533.18
17	Define remote control compliance device for assembly operations	Remember	CO 5	AME533.18
18	Classify workcell control.	Understand	CO 5	AME533.20
19	List out considerations in workcell design.	Remember	CO 5	AME533.20
20	Define interlock in robotic workcell design.	Understand	CO 5	AME533.20
Part - B (Long Answer Questions)				
1	Explain spray painting by robots and list out the advantages.	Understand	CO 5	AME533.17
2	Discuss various methods of part presentation in assembly process.	Remember	CO 5	AME533.17
3	Explain function of robots in assembly and inspection.	Understand	CO 5	AME533.20
4	Explain pick-and-place robots for machining operation of die casting.	Understand	CO 5	AME533.17
5	Describe the features of welding robot and list out its advantages.	Remember	CO 5	AME533.17
6	Explain pick-and-place robots for machining operation of plastic moulding.	Understand	CO 5	AME533.17
7	Explain compliance devices used for assembly operations with a neat sketch.	Understand	CO 5	AME533.18
8	Explain use of robots in the fields of welding and painting.	Remember	CO 5	AME533.17
9	Discuss with the neat diagram how robot can be gainfully employed in the inspection methods of component made in large number.	Understand	CO 5	AME533.17
10	Briefly explain various sensors used in robotic arc welding.	Understand	CO 5	AME533.17
11	Classify various assembly systems configuration.	Understand	CO 5	AME533.20
12	Briefly explain the role of robot in machine loading applications.	Remember	CO 5	AME533.20
13	Discuss the importance of work cell design for industrial application.	Understand	CO 5	AME533.19
14	Briefly explain peg-in-hole assembly with a neat sketch.	Remember	CO 5	AME533.17
15	Discuss the steps involved in assembly operations.	Understand	CO 5	AME533.20
16	Explain sensor based inspection.	Understand	CO 5	AME533.17
17	Discuss the role of robots in non-industrial applications.	Remember	CO 5	AME533.20
18	Explain vision based inspection.	Understand	CO 5	AME533.20
19	Explain arc welding robot requirements.	Understand	CO 5	AME533.17
20	Discuss the importance of robot in assembly task.	Remember	CO 5	AME533.20
Part – C (Problem Solving and Critical Thinking)				
1	Explain the principles for robot application and application planning.	Understand	CO 5	AME533.17
2	Differentiate between sensor based inspection and visual based inspection.	Understand	CO 5	AME533.20
3	Explain the importance of robot safety in industrial applications.	Understand	CO 5	AME533.17
4	Classify robot workcell and explain any two types with neat sketches.	Remember	CO 5	AME533.19
5	Differentiate between intermittent transfer and continuous transfer.	Understand	CO 5	AME533.18
6	Classify in-line robot work cell in detail.	Understand	CO 5	AME533.18
7	Differentiate between non-synchronous transfer and continuous transfer.	Remember	CO 5	AME533.18
8	Explain mobile robot workcell with a neat sketch.	Understand	CO 5	AME533.19
9	Explain automated guided vehicle and list out its applications in detail.	Understand	CO 5	AME533.18
10	Discuss the robot qualitative justification in detail.	Remember	CO 5	AME533.17

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