INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

MECHANICAL ENGINEERING

TUTORIAL QUESTION BANK

Course Name	:	**ROBOTICS**
Course Code	:	**A70355**
Class	:	IV B. Tech I Semester
Branch	:	**MECHANICAL ENGINEERING**
Year	:	2018 – 2019
Course Faculty	:	Mr. A. Anudeep Kumar, Assistant Professor

COURSE OBJECTIVES:

The subject makes understand the underline concepts used in design and building robot and make it working. The course covers kinematics and dynamics of motion robot arms. It covers feedback control systems, sensors, programming to make robotic work finally it undertakes to explain work in principles involved in industrial applications of robot.

S. No.	Question	Blooms Taxonomy Level	Course Outcomes
	UNIT-I		
Part - A (Short Answer Questions)			
1	Define Fixed automation.	Understand	1
2	Explain the Magnetic grippers.	Remember	1
3	Define Flexible automation.	Understand	1
4	Explain the Vacuum cups.	Remember	1
5	Draw the four basic configurations of robot.	Remember	1
6	List the different types of joints used in robots.	Remember	1
7	List the factors in gripper’s selection.	Understand	1
8	Define the position and orientation of robot.	Understand	1
9	Differentiate types of joints used in robots	Remember	1
10	List the factors in gripper’s design.	Remember	1
11	Define manipulator.	Understand	1
12	List the applications of programmable automation.	Understand	1
13	Define a Robot.	Understand	1
14	Define industrial automation.	Remember	1
15	List types of industrial automation.	Remember	1
Part - B (Long Answer Questions)			
1	Explain the different types of joints used in robots with neat sketch.	Remember	1
2	Explain RPY representation of orientation.	Remember	1
3	Discuss the advantages and disadvantages of using robots in industry?	Understand	1
4	Compare hard automation with soft automation?	Understand	1
5	Explain how the performance of robotic system is studied?	Remember	1

S. No.	Question	Blooms Taxonomy Level	Course Outcomes
6	Write a detailed note about programmable automation.	Understand	1
7	What are the various factors in gripper's selection and design? Explain.	Remember	1
8	Discuss the gripper design considerations in robotics.	Remember	1
9	Define repeatability, resolution and accuracy.	Understand	1
10	Describe the types of manipulators generally adopted for basic motions	Understand	1
Part - C (Problem Solving and Critical Thinking Questions)			
1	Establish the mathematical expressions of forward transformation of a spatial 2 degree of freedom arm. With two revolute joints.	Understand	1
2	An industrial robot with a prismatic joint has a telescoping range of 0.6m. The robots control memory has the following bit storage capacity. i. 10 bit storage capacity ii. 12 bit storage capacity Determine the control resolution for the two cases separately.	Remember	1
UNIT – II			
Part - A (Short Answer Questions)			
1	Explain about Homogeneous coordinates.	Understand	2
2	A vector v=2i+5j+3k is rotated by 60^0 about the z-axes and translated by 3,4 and 5 unit in the x, y and z directions respectively. Find the vector with reference to reference frame.	Remember	2
3	Write short notes on inverse transforms.	Understand	2
4	Explain the importance of homogenous transformations.	Remember	2
5	Explain Direct kinematics.	Understand	2
6	Write short notes on DH convention.	Remember	2
7	Define inverse kinematics.	Remember	2
8	Define joint coordinates of a robot.	Understand	2
9	Define world coordinates of a robot.	Understand	2
10	Explain about Homogenous Transformation	Remember	2
Part - B (Long Answer Questions)			
1	Give Euler angles representation for the RPY system and derive the rotation matrix.	Understand	2
2	Explain the homogeneous transformation matrix and interprete the partitioning with application.	Remember	2
3	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	2
4	Draw any two Euler angle systems and show rotation and angles.	Remember	2
5	Explain co-ordinate frame assignment of DH representation.	Understand	2
6	Find the transformation matrices for the following operations on the point $2\hat{i} - 8\hat{j} + 3\hat{k}$ i. Translate 2 units along y-axis and rotate 60^0 about z-axis	Remember	2
7	Derive the kinematic equations for the SCARA robot giving co-ordinate frame diagram and the kinematic parameters.	Understand	2
8	For the point 3*i*+7*j*+5*k* perform the following operation: Translates 6 units along *Y* then rotate 30^0 about *X*.	Remember	2

S. No.	Question	Blooms Taxonomy Level	Course Outcomes
9	Define and illustrate the link and joint parameters. Explain their uses.	Remember	2
10	Derive the kinematic equation for the elbow manipulator with co-ordinate frame diagram and kinematic parameters.	Understand	2
11	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	Remember	2
12	List the steps involved in DH convention.	Understand	2
13	Derive the arm matrices for a cylindrical robot. Hence obtain the kinematic equations for the same.	Remember	2
14	Explain and derive inverse kinematic solution for the variables of a cylindrical robot.	Understand	2
15	Get Euler angles for system I representation by applying inverse kinematic solution.	Remember	2
Part - C (Problem Solving and Critical Thinking Questions)			
1	Compute the homogeneous transformation representing a translation of 3 units along the x-axis followed by a rotating of $\pi/2$ about the current z-axis followed by a translation of 1 unit along the fixed y-axis. Sketch the frame. What are the coordinates of the o_1 with respect to the original frame in each case.	Understand	2
2	A Cartesian co-ordinate robot of configuration L L L is to move its three axes from position (x,y,z)=(0,5,5) to position (x,y,z)=(20,35,15). All distance measures are given in mm the maximum velocities for the three joints are respectively 20mm/sec 15 mm/sec and 10mm sec determine the time required to move each joint if slew motion is used.	Remember	2
3	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 anling 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	2
4	Find an expression for general rotational transformation that rotates a body about arbitrary direction 1≤ k x i k y j +k z k by an angle ϴ.	Remember	2
5	Using DH method and by symbolic sketch, write down the transformation matrices for each link and determine the position and orientation of end effector with respect to the base in a Cartesian robot configuration.	Understand	2
6	Discuss about direct and inverse kinematics	Understand	2
7	Arrive at the rotation matrices for the angle of rotations α, β and ϴ about x,y and z axes respectively.	Remember	2
UNIT – III			
Part - A (Short Answer Questions)			
1	Define Jacobian of a robot system.	Understand	3

S. No.	Question	Blooms Taxonomy Level	Course Outcomes
2	List the steps involved in kinematics model.	Remember	3
3	Name a method to solve Forward Kinematics.	Understand	3
4	Define degree of freedom of a robot manipulator.	Understand	3
5	Compute the Jacobian J_{11} for the three linked spherical manipulator.	Remember	3
6	Define Lagrange Euler's formulation for robot arm.	Understand	3
7	Find the total differential transformation caused by small rotation about three axes of dx=0.1, dy =0.05 and dz=0.02 rad.	Remember	3
8	Name a method to solve Forward Kinematics.	Remember	3
9	Define Lagrangian method of approach a robot manipulator.	Understand	3
10	Name the manipulator in which all the links perform spherical motions about a common stationary point.	Remember	3
11	List out forces to be considered in Newton Euler method.	Understand	3
12	Write the kinetic energy of Euler-Lagrange Formulation.	Remember	3
13	List out the advantages of Lagrange Formulation.	Understand	3
14	Write the potential energy of Euler-Lagrange Formulation.	Understand	3
15	List out moments to be considered in Newton Euler method.	Understand	3
16	Define the Dynamics of a two-link planar robot.	Remember	3
17	Name the manipulator which consists of open loop and closed loop chains.	Understand	3
18	Define Homogeneous Transformation Matrix of a manipulator.	Remember	3
19	Sketch a two-link planar manipulator.	Understand	3
20	Define position of any point in space, relative to a reference frame.	Remember	3
Part - B (Long Answer Questions)			
1	The hand frame of a robot with five degrees of freedom, its numerical jacobian for the instant and a set of differential motion are given. Find the new location of the hand after differential motion. $T=\begin{bmatrix}1 & 0 & 0.1 & 5\\ 0 & 0 & 1 & 3\\ 0 & 1 & 0 & 2\\ 0 & 0 & 0 & 1\end{bmatrix}, B=\begin{bmatrix}3 & 0 & 0 & 0 & 0\\ -2 & 0 & 1 & 0 & 0\\ 0 & 4 & 0 & 0 & 0\\ 0 & 1 & 0 & 1 & 0\\ -1 & 0 & 0 & 0 & 0\end{bmatrix} \text{ and } dq=\begin{Bmatrix}0.1\\ -0.1\\ 0.05\\ 0.1\\ 0\end{Bmatrix}$	Remember	3
2	As a result of applying a set of differential motion to frame T is given and it has changed about dT is also given. Find the magnitude of the differential changes made (dx, dy, dz, dx, dy, dz) and the differential operator with respect to T. $T=\begin{bmatrix}1 & 0 & 0 & 5\\ 0 & 0 & 1 & 3\\ 0 & -1 & 0 & 8\\ 0 & 0 & 0 & 1\end{bmatrix} \text{ and } dT=\begin{bmatrix}0 & -0.1 & -0.1 & 0.6\\ 0.1 & 0 & 0 & 0.5\\ -0.1 & 0 & 0 & -0.5\\ 0 & 0 & 0 & 0\end{bmatrix}$	Remember	3
3	Derive the Jacobian matrix for the to2-link planer manipulator.	Remember	3

S. No.	Question	Blooms Taxonomy Level	Course Outcomes
4	Explain the Lagrange Euler's formulation for robot arm.	Understand	3
5	Derive the dynamic equation of motion for a Revolute-Prismatic (RP) robot arm manipulator.	Remember	3
6	Differentiate clearly with reference to 2-jointed manipulator of RR type and LL type.	Remember	3
7	Establish the dynamic model of a one axis robot (inverted pendulum) with Newton-Euler formulation.	Understand	3
Part - C (Problem Solving and Critical Thinking Questions)			
1	Explain Newton-Euler formulation of a robotic system.	Understand	3
2	Derive the equation of motion for a single link manipulator given mass and length of link.	Remember	3
3	Derive Lagrangian-Euler formulation of joining force/torque for single link manipulator of given length and mass.	Remember	3
4	Explain the following briefly as applied to robot arm dynamics analysis. i. Kinematic energy ii. Potential energy iii. Joint velocities	Remember	3
5	Derive the equation of motion for a single link manipulator given the mass and length of the link.	Understand	3
6	Give the derivation of Lagrange-Euler formulation for the joint force/torque.	Understand	3
UNIT – IV			
Part - A (Short Answer Questions)			
1	Classify actuators used in robots.	Understand	4
2	Explain inductive type proximity sensors.	Understand	4
3	Explain ultrasonic proximity sensors.	Understand	4
4	Explain construction of inductive type proximity sensors.	Understand	4
5	Define the Joint space trajectory planning.	Understand	4
6	Explain Manual programming.	Understand	4
7	Explain Lead through teaching.	Remember	4
8	Explain the working of DC servo Motor.	Understand	4
9	Discuss the principle of a Resolver.	Understand	4
10	Explain principle of inductive type proximity sensors.	Understand	4
11	Explain the constructions of ultrasonic proximity sensors.	Understand	4
12	List the parameters involved in path planning with 3^{rd} degree polynomial.	Remember	4
13	Define the Trajectory planning.	Understand	4
14	Explain the operation of ultrasonic proximity sensors.	Remember	4
15	List the advantages and disadvantages of joint space scheme .	Remember	4
16	List the advantages and disadvantages of Cartesian-space scheme.	Understand	4
Part - B (Long Answer Questions)			
1	Find expressions for the joint motion parameters by using cubic polynomial fit in joint space scheme. Use the following data: Θ_0=20, Θ_f=70 t=3seec.	Understand	4
2	Enumerate trajectory generation of polynomial type.	Remember	4

S. No.	Question	Blooms Taxonomy Level	Course Outcomes
3	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. Using 3rd degree polynomials calculate joint angles at one, two, three seconds.	Understand	4
4	A single link robot with a rotary joint is motionless at $\Theta_0=15^0$ it is desired to move the joint in a smooth manner to $\Theta_f=75^0$ in 3sec. Find the coefficients of a cubic which accomplishes this motion and brings the arm to rest at the goal.	Remember	4
5	Explain trajectory planning with respect to PTP robot considering modified constant velocity of joint.	Understand	4
6	Describe different path control modes in robotics.	Remember	4
7	Explain the parameters involved in the path planning with 3rd degree polynomial.	Understand	4
8	Compare the features of most commercially used electrical actuators in robots.	Remember	4
9	Explain various types of touch sensors with neat sketch.	Understand	4
10	Explain features and application of hydraulic actuators in robotics	Understand	4
11	With a neat sketch explain the following hydraulic actuator. i. Rotary actuator ii. Linear actuator.	Understand	4
12	Compare the features of most commonly used electric actuators in robotics.	Remember	4
13	Explain the performance and selection criteria of electric motors in robotics.	Remember	4
14	With a neat sketch explain the tactile sensors and the range sensors.	Understand	4
15	Explain the types of touch sensors with neat sketches.	Understand	4
16	Enlist the main elements of a hydraulic system used in robot and explain their functions briefly.	Understand	4
Part - C (Problem Solving and Critical Thinking Questions)			
1	A hydraulic rotary vane actuator is used to drive the revolute joint of cylindrical robot with power source delivery of 27 cc/sec of oil at a pressure of $705N/cm^2$ the outer and inner vane radius are 10cm and 5cm respectively. Thickness of vane is 1cm. Determine angular velocity of motion and torque in the motor shaft.	Understand	4
2	A stepper motor is used to drive a prismatic joint of Cartesian robot. Motor shaft is connected to a screw shaft with a pitch of 3mm. The control resolution 0.6mm is desired for the controller. Determine i. Number of step angles in motor to achieve this resolution. ii. Pulse rate required to drive the joint with a linear speed 75mm per second.	Understand	4
3	Determine the time required for each joint of a three-axis RRR manipulator to travel the following distances using slew motion; joint 1, 100^0; joint 2, 30^0; and joint 3, 60^0. All joints travel at a rotation velocity of 15^0/s.	Understand	4
4	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	4

S. No.	Question	Blooms Taxonomy Level	Course Outcomes
5	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	4
	UNIT – V		
	Part - A (Short Answer Questions)		
1	List the applications of robots.	Understand	5
2	Define interlock in robotic workcell design.	Understand	5
3	What are the features of robot in machine loading applications?	Remember	5
4	List out material transfer applications	Understand	5
5	What are the features of robot in machine unloading applications?	Remember	5
6	List out advantages of robot arc welding.	Understand	5
7	List out advantages of robot spray coating.	Remember	5
8	Define work volume of a robot.	Understand	5
9	Classify the robot cell layouts	Understand	5
10	List out considerations in workcell design.	Understand	5
11	Classify workcell control.	Understand	5
12	What are the considerations of Robots in material handling?	Remember	5
13	Define pick-and-place operation performed by robot.	Understand	5
14	List out problems encountered in applying robots to arc welding.	Remember	5
	Part - B (Long Answer Questions)		
1	Explain spray painting by robots.	Understand	5
2	Explain function of robots in assembly and inspection	Understand	5
3	Explain various methods of part presentation in assembly process	Remember	5
4	Explain pick-and-place robots for machining operation die costing.	Understand	5
5	Explain automation in inspection.	Understand	5
6	Explain pick-and-place robots for machining operation of plastic moulding.	Understand	5
7	Explain compliances device for assembly operations.	Understand	5
8	Describe the features of welding robot.	Remember	5
9	Explain use of Robots in the fields of welding and painting.	Understand	5
10	Explain with the neat diagram how Robot can be gainfully employed in the inspection methods of component made in large number.	Remember	5
11	Describe sensors used in robotic arc welding.	Remember	5
12	Explain various assembly systems configuration.	Understand	5
13	Explain remote control compliance device for assembly operations.	Remember	5

Prepared by:

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