## Set No: 1

III B.Tech. II Semester Regular Examinations, April/May -2013
ROBOTICS
(Mechanical Engineering)

## Time: 3 Hours

Max Marks: 75
Answer any FIVE Questions
All Questions carry equal marks
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1. What do you understand by degree of freedom (DOF)? How many DOFs are required to position an end-effector at any point in 3-D space? Discuss
2. An RR robot has two links of length 0.50 m and 1.0 m , respectively. Assuming that the global coordinate system is defined at joint $\mathrm{J}_{1}$, determine
(a) The coordinates of the end-effector point if the joint rotations are $45^{\circ}$ at both joints as shown in Figure
(b) Joint rotations if the end-effector is located at $(1,4.4,0.5)$


Fig
3. A double acting hydraulic rotary vane or bucket actuator is used for a twist joint in a robot. The outer and inner radius of the vane is 2.5 mm and 0.75 mm respectively. Thickness of the vane is 0.2 mm . The hydraulic power source can generate up to 1000 $\mathrm{kg} / \mathrm{mm}^{2}$ of pressure to delivery to the cylinder at the rate $100 \mathrm{~mm}^{3} / \mathrm{min}$, determine the angular velocity and torque generated by the actuator. Also find the power developed by the hydraulic actuator.
4. Most robots today are programmed by teaching. Why is this type of programming likely to be replaced by preprogramming (off-line programming)?
5. What are the basic rules and procedures followed in the use of robots in assembly?
[15]
6. Discuss why recessing the sensor inside the gripper's fingers eliminates the positionambiguity problem.
7. Determine (a) Jacobian (b) Singularities and (c) Joint velocities for a 3-DOF planar arm with the revolute joints.
8. What is Jacobian matrix? Explain its use in evaluating the velocity of robot. [ 15 ]
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## Set No: 2

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ROBOTICS
(Mechanical Engineering)

## Time: 3 Hours

## Max Marks: 75

Answer any FIVE Questions
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*****

1. Distinguish between servo and non-servo robots. What is the hierarchy of control for servo robots?
[ 15 ]
2. A point vector is translated in $x, y$, and z directions by a distance of 1,2 , and 1 , respectively. Write the transformation matrix for the translation. If the point is $(3,2,1)$, determine the position of this point after translation. Afterwards the point vector is rotated about the $x, y$, and z axes by angles of $30^{\circ}, 45^{\circ}$, and $60^{\circ}$, respectively. Write the transformation matrices for the rotations and also the total transformation matrix from the initial position of $(3,2,1)$. Also find the new position of this point. [ 15 ]
3. A permanent magnet DC motor is coupled to a load through a gearbox. If the polar moments of inertia of the rotor and load are $J r$ and $J_{\mathrm{i}}$, the gearbox has a $N$ : $M$ reduction from the motor to the load, the motor has a starting torque $T s$ and a no-load speed $\omega_{\max }$, and the load torque is proportional to its speed $(T i=k \omega)$,
(a). What is the maximum acceleration that the motor can produce in the load?
(b). What is the steady state speed of the motor and the load?
(c). How long will it take for the system to reach a steady state speed?
4. What are some advantage and disadvantages of teaching-by-building?
5. A vertical hollow cylinder is to be welded to a horizontal hollow cylinder at right angles. The set up is a $\mathrm{CO}_{2}$ MIG welding interfaced with a robot controller. Describe the robot task and indicate the programming for welding.
6. A new experimental strain gage is mounted on a 0.25 mm diameter steel bar in the axial direction. The gage has a measured resistance of $120 \Omega$ and when the bar is loaded with 500 kg in tension, the gage resistance increases by $0.01 \Omega$. What is the gage factor of the gage?
7. Compare pneumatic, magnetic and vacuum end effectors.
8. What is a skew symmetric matrix? How this matrix is related to the angular velocity of a link of an n-DOF manipulator.
[ 15 ]

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1. Bring the relationship between the following the parameters of the robot.
(a) Resolution
(b) Accuracy
(c) Repeatability
2. An LL robot has two links of variable length. Assuming that the global coordinate system is defined at joint $\mathrm{J}_{1}$, determine
(a) The coordinates of the end-effector point if the variable link lengths are 1 m and 2 m as shown in Figure .
(b) Variable link lengths if the end-effector is located at (1,2).

3. For each of the following applications, what is a good choice for the type of electric motor used? Justify your choice.
a. Robot arm joint
b. Ceiling fan
c. Electric trolley
d. Circular saw
e. NC milling machine
f. Electric crane
g. Disk drive head actuator
h. Disk drive motor
i. Windshield wiper motor
j. Industrial conveyor motor
k. Washing machine
4. clothes dryer
5. A robot is to be programmed to unload parts from one pallet and load them onto another pallet. The parts are located on the unload pallet in a 3 by 4 pattern in known fixed positions, 40 mm apart in both directions. The two directions of the pallet are assumed to be parallel to the ex and y world coordinate axes of the robot. The parts are to be placed on the load pallet to the x and y world coordinate axes of the robot. Make a sketch of the workstation setup before you begin programming.
[15]
6. If a linear stepper has a pitch of 0.040 mm and micro stepping is used to divide this distance into 400 micro steps (i.e., one micro step moves the motor 0.0001 mm .), what pulse frequency must be applied to the motor to achieve velocities from 0 to $60 \mathrm{~mm} / \mathrm{s}$ ?

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R10
Set No: 3
6. What is spot welding? Describe briefly the operations involved in robotic spot welding. What are the advantages of robotic welding over manual welding?
7. Explain the suitability of robots in automation and how they will be useful in reducing the manufacturing time.
8. Show that the three differential rotations of $\delta x, \delta y$ and $\delta z$ made in any order about the $\mathrm{x}-\mathrm{y}-\mathrm{y}$, and z - axes, respectively are equivalent to a differentional rotation of $\mathrm{d} \theta$ about axis K.

## Set No: 4

III B.Tech. II Semester Regular Examinations, April/May -2013

## ROBOTICS

(Mechanical Engineering)

## Time: 3 Hours

Max Marks: 75
Answer any FIVE Questions
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*****

1. What are the basic components of a robotic system? State the main function of each of the components.
2. Two Frames A \& B are initially coincident. Frame A is fixed, while Frame B moves according to the following sequence:
i) Rotation about $X_{A}$ of 30 degrees
ii) Rotation about $Y_{B}$ of 60 degrees
iii) Rotation about $Z_{A}$ of 90 degrees, and iv) Translation of $(1,2,3)$ along Frame B. Find the new position and orientation of Frame B in Frame A. (Express this as a homogeneous transformation matrix.)
3. A D.C servo motor is used to actuate speed of a robot joint. It has torque constant of $10 \mathrm{~mm}-\mathrm{kg} / \mathrm{A}$ and voltage constant of $12 \mathrm{~V} / \mathrm{Kr} / \mathrm{min}(1 \mathrm{Kr} / \mathrm{min}=100 \mathrm{r} / \mathrm{min})$ The armature resistance is $2.5 \Omega$. At a particular moment during the robot cycle, the joint is not moving and a voltage of 25 V is applied to the motor.
(a) Determine a torque of the motor immediately after the voltage is applied.
(b) As the motor accelerates, the effect of back-emf is to reduce the torque determine the back emf and corresponding torque at 250 rpm and 500 rpm .
(c) Sketch a graph between the torque and the speed
4. In a pallet objects protruding 50 mm from the face of the pallet are located in a number of rows and columns. The pallet has 4 rows that are 30 mm apart and 4 columns that are 50 mm apart. The plane of the pallet is assumed to be parallel to the X-Y plane. The rows are parallel to X -axis and the columns are parallel to Y -axis. The objects are to be picked up one after another from the pallet and placed in a location chute. The robot end effector should stop at 70 mm above the pickup point as safe position. Gripper should hold the object at 30 mm from base. Write the program in VAL to pickup the object at left top corner moving towards $y$ axis and then moving to the next columns. What are the basic rules and procedures followed in the use of robots in assembly?
5. A vertical hollow cylinder is to be welded to a horizontal hollow cylinder at right angles. The set up is a $\mathrm{CO}_{2}$ MIG welding interfaced with a robot controller. Describe the robot task and indicate the programming for welding.
6. A strain gage bridge used in a load cell dissipates energy. Why? Compare the power dissipated in a bridge circuit with equal resistance arms for gages of $350 \Omega$ and $120 \Omega$ when the excitation voltage is 10 V . What strategies can one employ if heating becomes a problem? Do these strategies have any deficiencies? Determine (a) Jacobian (b) Singularities and (c) Joint velocities for a 3-DOF planar arm with the revolute joints.

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7. What are the singularities of a manipulator? How are they classified and determined? Explain briefly.
8. Compare pneumatic, magnetic and vacuum end effectors.
