III B.Tech II Semester Examinations,APRIL 2011
ROBOTICS
Automobile Engineering
Time: 3 hours

## Answer any FIVE Questions <br> All Questions carry equal marks

1. (a) Explain the challenges of end effectors.
(b) Explain the requirements of end effectors.
2. Using Lagrange - Euler formulation, derive the expression for the joint Torques or forces of a planar RP Robotic manipulator.
[16]
3. (a) Discuss the position planning and orientation planning of Cartesian space Schemes.
(b) The motion of a joint of 3-DOF arm is constramed by an actuator that can produce a maximum acceleration of $0.35 \mathrm{rad} / \mathrm{sec}^{2}$ and maximum velocity of 15 $\mathrm{rad} / \mathrm{sec}$. If Trapezoidal velocity profile is assumed, determine the trajectory if the joint moves by $\pi$ radians in 10 seconds. $\quad[6+10]$
4. Derive the forward kinematics equation using the D-H convention for the three link palanar manipulator shown in figure 4.


Figure 4
5. (a) Explain the working of DC servo motors.
(b) What is the resolution, in degrees, of an encoder with 10 tracks?
6. Verify that the rotation matrices about the reference frame axes follow the required constraint equations set by orthogonality and length requirements of directional unit vectors.
7. (a) Discuss the single station Robotic Assembly system.
(b) Discuss the Robotic series Assembly system.
8. (a) What is precision of movement of a robot? Explain the terms special resolution, accuracy and repeatability?
(b) A robot with single degree of freedom has one sliding joint with a full range of 1.0 m . The robot's control memory has a 12-bit storage capacity. Determine the control resolution for this axis of motion.

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1. Why is the continuous-path system ideal for applications such as paint spraying and coating?
2. (a) Discuss the linear interpolation function with parabolic blends.
(b) The trajectory for a joint motion between start and goad position in a pick-nplace operation is determined by dividing the motion in two segments. The interpolating polynomial for each segment is cubic and the acceleration is continuous at via point. Determine the coefficients for the two cubics. [6+10]
3. (a) Discuss the robotic inspection in loading and unloading.
(b) What characteristics an arc - welding robotic system must have? Explain.
4. If an A matrix is given

where A describes a coordinate frame with respect to the base coordinate of a robot, determine the differential transformation dA that results if the coordinate frame is translated by $d$ and then differentially rotated by s such that
$\vec{d}=0.1 \mathrm{i}+0.2 \mathrm{j}+0.3 \mathrm{k}$
and $\overrightarrow{\mathrm{s}}=0.1 \mathrm{i}+0.2 \mathrm{j}+0.3 \mathrm{k}$
Find dA with respect to the base coordinate frame and the A frame itself.
5. Sketch any Four of the following robots indicating the joints and degrees of freedom:
(a) Polar robot
(b) Cylindrical robot
(c) Cartesian robot
(d) SCARA robot
(e) Gantry robot
(f) Jointed arm robot.
6. Write and explain the arm matrix of SCARA robot.
7. Consider the prism shown in figure 7. The positions of the prism vertices have been indicated relative to the reference axis system. Positions are given in meters. From its current position, the prism is rotated $90^{\circ}$ about the x axis, followed by a $90^{\circ}$ rotation about the y axis, followed by a translation of -2 m in the x direction.
(a) Define the transformation which describes the change in position of the prism. That is, determine the $4 \times 4$ homogeneous transform for the move.
(b) What are the new coordinates of the vertices of the prism after the move?
(c) What is the inverse transform and how should it be interpreted? $[6+5+5]$

8. (a) What are the functions of a resolver? Briefly explain.
(b) Using a block diagrams, differentiate between a clore-loop and an open loop robot control operation, with details of the actuator, encoders, and type of acutator, motion control-signals.

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1. (a) What are the features and capabilities of the second generation languages? Explain.
(b) Discuss the motion level languages.
$[10+6]$
2. (a) Explain about the D-H notation joint coordinate system.
(b) Explain about the world coordinate system.
3. (a) Explain the principles of stepper motor operation.
(b) What is the resolution of an absolute optical encoder that has six tracks?
4. (a) Discuss the major difference between servo-controlled and non-servo controlled robot.
(b) Define the following terms in relation to a robot:
i. Work envelop
ii. Work cell
iii. Speed
iv. Aceuracy
v. Cycle time.

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[6+10]
$$

5. Draw and explain the Composite homogeneous transformation algorithm.
6. (a) Explain various methods of transmitting power and control signals to the end effectors.
(b) Compare the electric, hydraulic and pneumatic types of locomotion devices.

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[7+9]
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7. (a) Explain the application of industrial Robots in stamping - press operation.
(b) What are the requirements of the Robot for spray painting applications? Explain.
8. (a) Discuss about the Jacobians in the force domain.
(b) Explain the determination of Jacobians with respect to frames attached to different links, when the Jacobian with respect to base frame is given. [8+8]

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1. (a) Why is the choice of end-of-arm tooling important to a robotics?
(b) What things might a robot hand be able to do that a human hand eannot do? $[8+8]$
2. (a) Explain the cubic polynomial fit of joint space scheme.
(b) Let the initial position of a joint is $15^{0}$ and final position is $75^{\circ}$. The duration to reach final position is 3 seconds. Design the joint trajectory considering the cubic polynomial fit.
3. (a) Discuss the features of Robots in Arc welding.
(b) Discuss the use of industrial Robots in Die -casting operation. [8+8]
4. Draw and explain the link-coordinate diagram of four-axis SCARA robot.
5. (a) What are the important items to be considered in deciding the use of robots in
i. Manufacturing operation
ii. Hazardous operation.
(b) What is meant by machine intelligence? What is AI? Illustrate a unified model of AI and Robotics.
[8+8]
6. For the point $3 \mathrm{i}+7 \mathrm{j}+5 \mathrm{k}$ perform the following operations.
(a) Rotate $30^{\circ}$ about the X-axis
(b) Rotate $45^{0}$ about the Y-axis
(c) Rotate $90^{\circ}$ about the Z-axis
(d) Translate 8 units along the Y axis
(e) Rotate $30^{\circ}$ about X , the translate 6 along Y
(f) Translate 6 along Y, then Rotate $30^{\circ}$ about X .
7. Determine the manipulator Jacobean matrix $\mathrm{J}(\mathrm{q})$ of five axis spherical co-ordinate robot.
8. A dc servometer is used actuate a robot joint. It has a torque constant of 1.25 N.m/A, and a voltage constant of $12 \mathrm{~V} / \mathrm{kr} / \mathrm{min}(1 \mathrm{kr} / \mathrm{min}=1000 \mathrm{r} / \mathrm{min})$. The armature resistance $=2.5 \Omega$. 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 the 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 the corresponding torque of the motor at 250 and $500 \mathrm{r} / \mathrm{min}$.

