

(3 Hours)

- N.B. (1) Question No. 1 is compulsory.
(2) Attempt any three questions from remaining.
(3) All questions carry equal marks.
(4) Assume suitable data wherever necessary.

1. Answer any four of the following:

- (a) Explain why inverse kinematic solution is not unique for generic robots. 5
- (b) Define joint and link parameters. 5
- (c) Differentiate between the robots direct and inverse dynamics problem. 5
- (d) Explain Reach and Stroke of a robot. 5
- (e) Define pixel function, shrink operator and swell operator. 5

2. a) Find the position of the tool tip of the Adept one robot when the joint variables are 10

$$q = \left[\frac{\pi}{4}, -\frac{\pi}{3}, 120, \frac{\pi}{2} \right]^T$$

$$\text{Given } d = [877, 0.0, d_3, 200]^T \text{ mm and } a = [425, 375, 0.0, 0.0]^T \text{ mm.}$$

- b) Obtain the inverse kinematics analysis of a 3 axis planar articulated robot 10
- 3. a) Formulate the dynamic model of a simple one axis robot. 10
- b) Consider a 3 axis planar articulated robot. The tool configuration function 10

of this robot is as follows:

$$W(q) = \begin{bmatrix} a_1c_1 + a_2c_{12} \\ a_1s_1 + a_2s_{12} \\ d_3 \\ 0 \\ 0 \\ \exp\left(\frac{q_3}{\pi}\right) \end{bmatrix}$$

Find the tool configuration Jacobian matrix $V(q)$.

4. a) Explain robot motion planning using Bug 1 and Bug 2 algorithm. 10
b) What is a GVD? Sketch all the GVD's resulting due to the basic interactions of the obstacle. Derive the necessary equations. 10
5. a) What are moments of an image? How the moments are used in the shape analysis of objects? 10
b) Explain the 4 point minimal PNP trajectory for pick and place of objects by using a robot manipulator. 10
6. Write short notes on any **four** of the following: 20
(a) Potential functions.
(b) Wave front planner.
(c) Template matching.
(d) Cartesian space trajectory
(e) Edge detection