

- N.B. :** (1) Question No. 1 is **compulsory**.
 (2) Attempt any **four** questions out of remaining **six** questions.
 (3) Assume **suitable** data if **necessary** with proper **justification**.

1. (a) State whether the following statement is **true** or **false** and justify your answer :-
 - (i) Robots are better suited to 'Flexible Automation' compared to CNC machines. **4**
 - (ii) Gross motion planning is robot independent and Fine motion planning is robot dependent. **4**
- (b) Compile a list of sensors that might be used in robotic systems. For each sensor give an application. **4**
- (c) Define total work envelope, joint space work envelope, Dexterous work envelope with their relevant formulae and explain the term involved in them. **8**
2. (a) Consider an Adept 1 SCARA robot 4 axes having axes B, E, VE, TR. Write a note on its physical construction. Explain its kinematic configuration (LCD, KPT using pass 1 and pass 2 of DH algorithm) with neat sketch and obtain the arm matrix and verify it by substituting the last column of the KP table. **12**
- (b) Compute, sketch and label the minimum and maximum horizontal and vertical reach of a five axis Rhino XR-3 Robot. **8**
3. (a) Explain the conditions for existence of inverse kinematics solution. Obtain inverse kinematics solution for two axis planar articulated robot arm. **10**
- (b) (i) Explain how do you simulate a planar motion of a robot between the two points (x_1, y_1) and (x_2, y_2) . **6**
- (ii) How will you determine the direction of intensity gradient while detecting the edges? **4**

4. (a) An (8×8) grey level image with 16 grey levels as shown in figure below :- **15**

7	3	0	4	3	4	3	5
3	14	14	13	14	11	13	3
3	7	10	13	13	10	11	4
3	4	8	12	13	5	3	3
5	5	3	13	12	5	0	6
5	10	13	15	14	14	12	3
5	12	13	14	10	13	10	4
1	5	3	3	5	4	7	4

Construct the histogram of the image. Convert the image into a binary image using suitable threshold value. Compute $m_{00}, m_{01}, m_{10}, \mu_{02}, \mu_{11}, \mu_{20}, v_{00}, v_{01}, v_{10}, v_{02}, v_{20}$, principal angle, centroid, run length code.

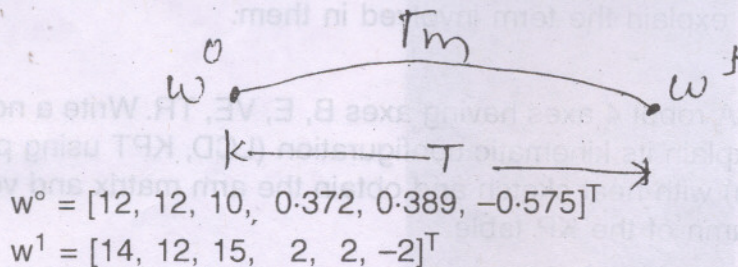
- (b) Explain position uncertainty and velocity uncertainty. **5**

5. (a) Derive the three fundamental rotation matrices $R_1(\theta)$, $R_2(\theta)$ and $R_3(\theta)$ with the help of neat sketch and prove that – 10

$$R_{YPR} = R_{RPY}$$

about fixed axis about mobile axis.

- (b) (i) Explain Shrink and Swell operators. 5
(ii) Write an algorithm that finds the corner points in a $m \times n$ binary image $I(k, j)$ using the eight corner point template. 5
6. (a) Find the cubic interpolating polynomial $w(t)$ which will smoothly move the robot between the following two points in TCS as shown in **figure** below over the time interval $(0, T) = (0, 2)$. Assume zero velocity at each end of the trajectory. 10



Also calculate $w(t)$ over the interval $(0, T)$ for any five pts.

- (b) (i) Write short note on 'Image Segmentation'. 6
(ii) Explain the significance of $\left[\exp\left(\frac{qn}{\Pi}\right) r^3 \right]$ in root configuration vector. 4
7. (a) (i) Analyse a conceptual robot for teaching in a classroom. 6
(ii) Describe how do you use motion heuristics in gross motion planning. 4
- (b) Write short notes on :- 10
- (i) Inverse Perspective Transformation
- (ii) Computer Integrated Manufacturing.