Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

M. E. - SEMESTER – II • EXAMINATION – WINTER • 2013

Subject code: 1720906 **Date: 02-01-2014**

Subject Name: Robotics

Time: 10.30 am – 01.00 pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** (i) State any five applications of robots beyond the capability of the human kind. **03**

(ii) Find the values of the missing elements and complete the matrix representation of the frame **04**

$$\begin{bmatrix} ? & 0 & ? & 5 \\ 0.707 & ? & ? & 3 \\ ? & ? & 0 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

(b) Derive Euler angles formulation considering rotation of ϕ about Z-axis followed by rotation of θ about Y-axis and finally by rotation of ψ about Z-axis. The desired final orientation of the hand of a Cartesian-Euler robot is given as ${}^{R}T_{H}$, determine the necessary Euler angles. **07**

$${}^{R}T_{H} = \begin{bmatrix} 0.527 & -0.574 & 0.628 & 4 \\ 0.369 & 0.819 & 0.439 & 6 \\ -0.766 & 0 & 0.643 & 9 \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

Q.2 **(a)** Name and describe the various components of industrial robotic system. **07**

(b) The end point of a link of manipulator is at [2 2 6 1]. The link is rotated by 90° about X-axis, then by -180° about its own Z-axis and finally by -90° about its own Y-axis. Find the resulting homogeneous transformation matrix and final location of the end point. **07**

OR

(b) A vector $P = 3\hat{i} - 2\hat{j} + 5\hat{k}$ is first rotated by 90° about X-axis, then by 90° about Z-axis. Finally, it is translated by $-3\hat{i} + 2\hat{j} - 5\hat{k}$. Determine the new position of the vector. **07**

Q.3 **(a)** Explain Roll, Pitch and Yaw angle for wrist configuration with a sketch. **07**

(b) (i) List different types of robotic actuators. **03**

(ii) An end-effector is rotated by 60° about an axis whose unit vector is $\hat{k} = [0.707 \quad 0.707 \quad 1 \quad 1]^{T}$. Find the homogeneous transformation matrix representing this rotation. **04**

OR

Q.3 **(a)** Derive the Denavit and Hartenberg (DH) formulation with illustration. **07**

(b) Obtain the forward kinematic equation of a 4-DoF SCSRA robot shown in Figure 1. **07**

Q.4	**(a)**	Write different motion control methods used in robotics stating its industrial applications.	**07**
	(b)	The gripper as shown in Figure 2, is required to hold the work piece. An actuating force of 490 N is acting vertically downwards resulting in a gripping force F_g. Compute the maximum gripping force that can be applied. (All dimensions are in mm)	**07**

OR

Q.4	**(a)**	State the characteristics of robotic sensors. Explain rotary incremental optical Encoder with neat sketch.	**07**
Q.4	**(b)**	Calculate the velocity of the tip of the two-link, planar RR-manipulator arm shown in Figure 3.	**07**
Q.5	**(a)**	Differentiate the following: (i) Path and Trajectory (ii) Joint space and Cartesian space trajectory planning	**06**
	(b)	A joint of a robot manipulator traverses from an initial position of 20˚ to a final position of 80˚ in 6 seconds. Assume a fifth degree polynomial and a starting acceleration of 5 deg/sec^2 and final retardation of 10 deg/sec^2. Derive the expression for $\theta(t)$ and also compute the angular position at end of 4 seconds.	**08**

OR

Q.5	**(a)**	Differentiate between online and offline robot programming. List any four robot programming languages.	**07**
	(b)	Derive the equation of motion of 2-DoF system shown in Figure 4, using LE method.	**07**

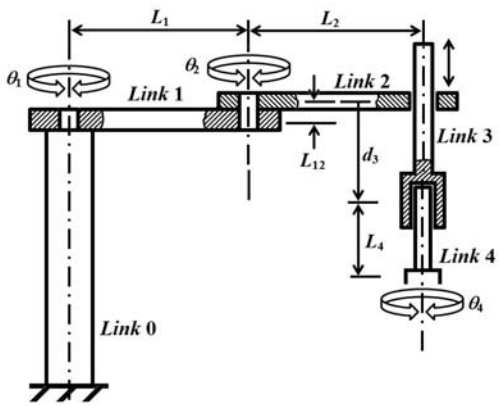

Figure 1 (Q.3 (b) (OR))

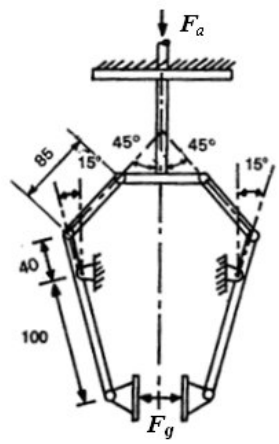

Figure 2 (Q.4 (b))

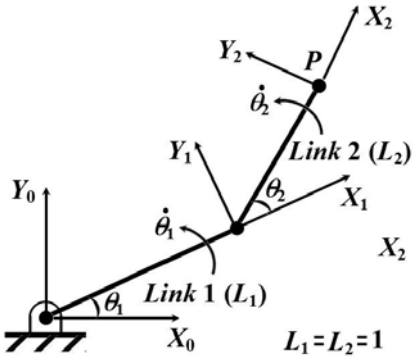

Figure 3 (Q.4 (b) (OR))

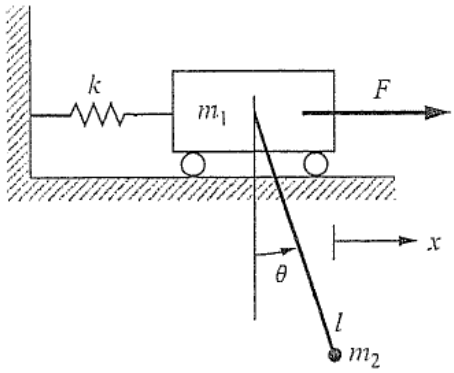

Figure 4 (Q.5 (b) (OR))

****