B.E. MECHANICAL ENGINEERING SECOND YEAR SECOND SEMESTER (Old) – 2017

ADVANCED KINEMATICS AND ROBOTICS

Time: 3 hours, Full Marks: 100

Answer any five questions

1. Deduce the Freudenstein equation for a 4R linkage. With the help of this equation synthesize the following mechanism:

A 4R linkage is required to generate the function $y = x^{1.5}$ for $1 \le x \le 5$. The crank rotates from an angle of π to $2\pi/3$, whereas the follower rotates from an angle of $\pi/3$ to $5\pi/6$. Assume that the length of the largest link is 25 cm. Find the lengths of all the links using 3-point Chebyshev spacing. (5+15)

2. A 4R linkage is required to coordinate three positions of the input and output links for the following angular displacements: $\theta_{12} = 50^0$, $\theta_{13} = 80^0$, $\phi_{12} = 30^0$ and $\phi_{13} = 80^0$. Here θ is for input link and ϕ is for output link. Design the mechanism graphically using the principles of inversion. 20

X

3. Use the least square technique for the synthesis of a 4R linkage for four precision points. This linkage is to generate a function of $y=\log x$. If the range of the function is given by $2.5 \le x \le 5.5$, $45^0 \le \theta \le 150^0$ and $75^0 \le \phi \le 150^0$ and the minimum link length is of 20 mm, determine the lengths of other links. The four precision points are to be determined by the Chebyshev equation. 20

4. Use Denavit-Hartenberg algorthim to do the forward kinematic analysis of the robotic manipulator shown in Fig. Q(4). Find out the overall transformation matrix of the

manipulator. Draw the necessary link coordinate diagram and prepare the kinematic parameter table.

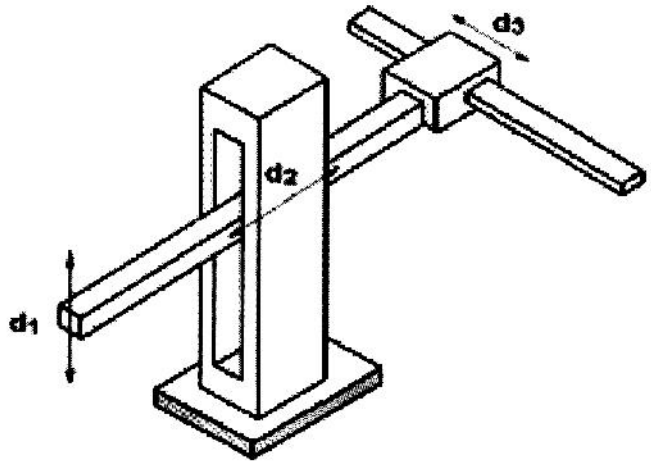

Fig. Q(4)

5. (a) Two coordinate frames A and B are initially coincident. If A is translated along B^2-axis by 20 units, then rotated about B^3–axis by $\pi/2$ radians and finally translated along B^1-axis by -10 units, find the new coordinates of the point $P_A = [15\ 10\ -25]^T$ after completing all of the above transformations.

(b) A planar 2R manipulator is shown in Fig. Q(5). Do the forward kinematics analysis and determine the base to tip overall transformation matrix. Draw the necessary link coordinate diagram. Also prepare the kinematic parameter table. (5+15)

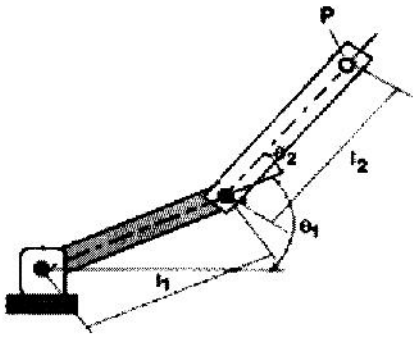

Fig. Q(5)

6. Table Q(6) is a kinematic parameter Table for a 3-axis robotic manipulator. The manipulator is subjected to a series of motion as mentioned in the Table and assumes the position and orientation expressed by the matrix T. Determine the unknown parameters by inverse kinematics analysis. 20

Axes	a	α	d	θ
1	3	90	2	θ_1
2	6	90	2	θ_2
3	0	0	0	θ_3

Table Q6

$$T=\begin{bmatrix} 0.04 & -0.93 & -0.37 & 3.9 \\ -0.98 & 0.04 & -0.21 & 1.68 \\ 0.21 & 0.37 & -0.91 & -0.27 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

7. Write notes on any four of the following: 4x5

a) Number synthesis,

b) Path generation and motion generation,

c) Necessity of accuracy point method in synthesis,

d) Reach and stroke of a robotic manipulator,

e) Shape-memory-effect Actuators,

f) Sensors in robots.