M.E. MECHANICAL ENGINEERING FIRST YEAR FIRST SEMESTER – 2018

ADVANCED DESIGN OF MECHANISM

Time 3 Hours Full Marks 100

Use separate answer script for each group

Group A

Answer any two questions

1. (a) What is structural error in connection with synthesis of linkages? State a process for minimizing the error. 5

(b) An offset slider-crank mechanism is to be synthesized when the displacement of the slider is proportional to the square of the crank rotation in the interval $45^0 \leq \theta_2 \leq 135^0$. The distance of the slider from the crank-shaft, *s*, should be 15 cm for $\theta_2 = 45^0$ and 5 cm for $\theta_2 = 135^0$. Use 3 accuracy points. Suggest modification of your solution for synthesis of the same using 4 accuracy points. 20

2. (a) Determine the maximum number of hinges on one link in a constrained mechanism with 'n' number of links. Applying Grubler criterion on planar kinematic chains show the minimum number of binary links in a chain is 4. 10

(b) What are the kinematic representations of 6 link Watt's mechanism and Watt's walking beam mechanism. Apply Gruebler's criterion to find the Stephenson mechanism and its inversions. 15

3. (a) Describe an optimization method for synthesis of multi-precision point (more than 4-point) function generation by planar linkages. 10

(b) Synthesize a 4R linkage for the purpose of generating a function $y = \log_{10}x$ using Freudenstein's method, for 3-accuracy points, with $\theta^i_2 = 60^0$, $\theta^i_4 = 150^0$ corresponding to $x^i = 2$ and $y^i = 0$. 15

Group B

Answer any two questions

4. Draw a 2R-2spheric pair spatial linkage. Identify the necessary axes and link parameters. Deduce the Freudenstein equation for the linkage. Compare this equation with that for a 4R planar linkage and show if there is any similarity between the equations. (4+4+15+2)

5. (a) Draw line diagrams of (i) P-P-P, (ii) R-P-P, (iii) R-R-P and (iv) R-R-R robots. (4x1)

(b) It is required to rotate a point through $\pi/4$ radian about the *OX* axis, followed by a translation of *25* unit along the same axis, followed by a translation of *-30* unit along the *OZ* axis, all belonging to

the fixed coordinate system and finally followed by a rotation of $\pi/3$ radian about the OZ of the body coordinate frame. Find the resultant homogeneous transformation matrix. 6

(c) Reference to Fig. Q5(b), apply D-H algorithm to find the 4x4 homogeneous transformation matrices ${}^{i-1}T_i$ and ${}^{0}T_i$ for $i = 1,2,...,4$. 15

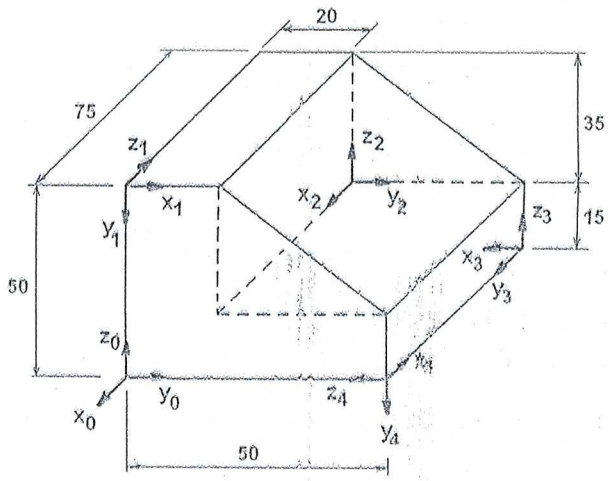

Fig. Q5(b)

6. (a) Define forward and inverse kinematics in connection with robotics.

(b) State three systems of Euler angle representation.

(c) The Fig. Q6(c) shows a cylindrical robot arm. Applying D-H algorithm (i) identify the axes, (ii) construct the Table for kinematic parameters and (iii) find out the overall transformation matrix from base to tool. Given that base rotation is $\pi/3$ radian in CCW direction looking from the top, a vertical translation of 20 unit and horizontal translation of 30 unit. (4+3+18)

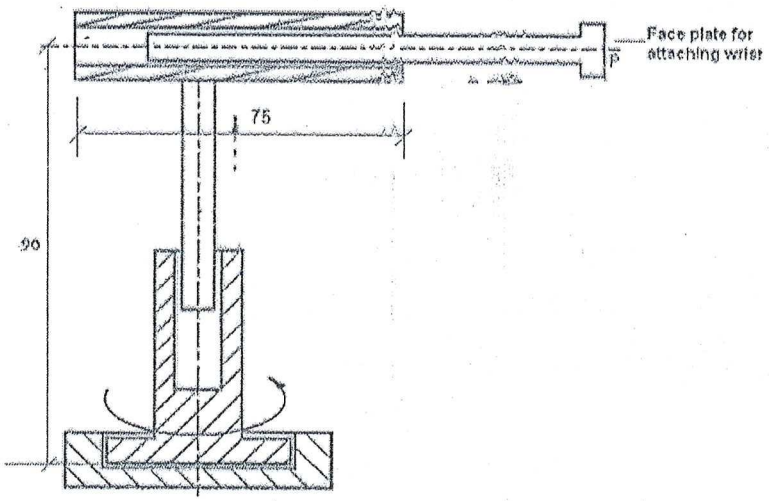

Fig. Q6(c)