# BACHELOR OF ENGINEERING (MECHANICAL ENGINEERING) 2$^{ND}$ YEAR 1$^{ST}$ SEM EXAM 2019 (Old)

## (2$^{nd}$ year 1$^{st}$ semester)

### Sub: Advanced Kinematics and Robotics

Time:3hrs       (Answer any five from the following)       Full marks: 100
Assume relevant data

1. (a) The $[q]^1 = [0, 0, 100, 10]^T$ represents the homogeneous coordinates of a point in a mobile frame 1. If initially 1 is coincident with a fixed coordinate frame 2 and is rotated by $\pi/3$ radians about the first unit vector of 2, find the resultant homogeneous transformation matrix.    10

   (b) For the above problem if it is required to translate the mobile coordinate frame 1 relative to the fixed 2 coordinate frame by 50 units along the X-axis and – 30 units along the Y-axis and 60 units along the Z-axis, find the coordinates of the point q in the 2.    10

2. A point P in space is rotated by an angle $\pi/3$ about z-axis, and then translated by 2 units along x-axis and finally – 2 units along y-axis. Pictorially show the transformation of the vector. If the coordinates of P are $\begin{bmatrix} 2.0 & 4.0 & 6.0 \end{bmatrix}^T$, find the coordinates in its new location.    20

3. Describe the Denavit-Hartenberg Representation and defined the different parameters of a revolute joint. Determine the D-H transformation matrix for adjacent coordinate frames, i and i-1 for a revolute and prismatic joints, and also determine the inverse of this transformation.    20

4.
   a) $T = \begin{bmatrix} R & p \\ 0 \ 0 \ 0 & 1 \end{bmatrix}$ is a transformation matrix. State its significance.    8

   b) Use this equation to determine the degrees of freedom of the linkages.

(a)

(b)

(c)

(d)

12
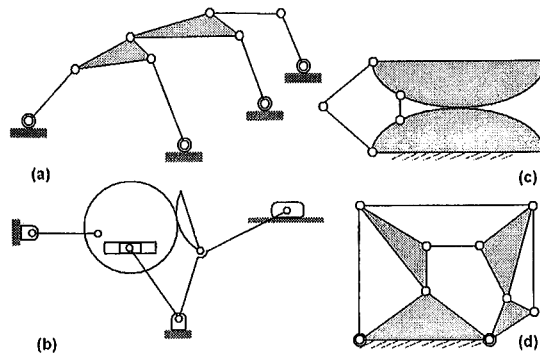
5.    Synthesize a slider crank mechanism so that the displacement of the slider is proportional to the square of the crank rotation in the internal $45^0 \leq \theta \leq 135^0$. Use three precision points with Chebyshev,s spacing. Assuming the starting displacement of the slider (s$_S$) = 100 mm and final displacement of the slider (s$_F$) = 30 mm.

20

6.    An automatic device requires generating a function $y = \log_{10} x$ in an interval of $10 \leq x \leq 20$ with 3 accuracy points. Assuming $\Delta \theta_2 = 75^0$ for input and $\Delta \theta_4 = 110^0$ for output, design a 4-bar linkage that can generate the function. For a length of 10 cm of the smallest link, draw the linkage you have designed.

20

7.    Any four from following below:

I.      What is Chebyshev spacing? If a function varies from 10 to 20, find the Chebyshev spacing for 2, 3, 4 and 6 precision positions.

5

II.     What is least-square technique? How is it useful in synthesis of constrained linkages?

5

III.    Inverse composite homogeneous rotation matrix;

5

IV.    Robot and its classification;

5

V.     Precision Points for Function Generation

5