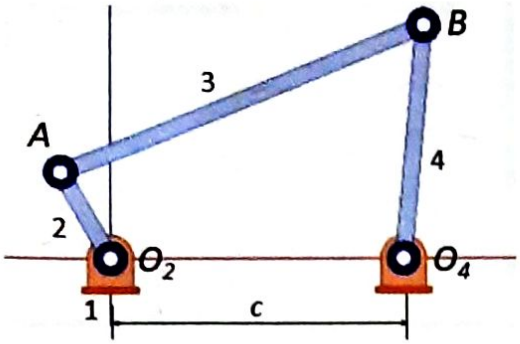
Kafi Mahardika / 13119033 / Programming Assignment



Input : $L^2 = 50 + 033 + 83$ mm

$L^3 = 2L^2 = 166$ mm

$\omega^2 = 15$ rad/s

$L^4 = 1{,}5L^2 = 124{,}5$ mm

$c = 1{,}7L^2 = 141{,}1$ mm

$\theta_0^2 = \frac{\pi}{4}$ rad.

Position of O in X^2Y^2 $\bar{U}_0^2 = \left[-\frac{L^2}{2} \quad 0\right]^T$

Position of A in X^2Y^2 $= \bar{U}_A^2 = \left[\frac{L^2}{2} \quad 0\right]^T$

Position of A in X^3Y^3 $\bar{U}_A^3 = \left[-\frac{L^3}{2} \quad 0\right]^T$

Position of B in X^3Y^3 $\bar{U}_B^3 = \left[\frac{L^3}{2} \quad 0\right]^T$

Position of B in X^4Y^4 $\bar{U}_B^4 = \left[-\frac{L^4}{2} \quad 0\right]^T$

Position of O in X^4Y^4 $\bar{U}_O^4 = \left[\frac{L^4}{2} \quad 0\right]^T$

equations.

1. eq for joint O

$$R_x^2 - \frac{L^2}{2}\cos\theta^2 = 0$$

$$R_y^2 - \frac{L^2}{2}\sin\theta^2 = 0$$

2. eq for joint A

$$R_x^2 + \frac{L^2}{2}\cos\theta^2 - R_x^3 + \frac{L^3}{2}\cos\theta^3 = 0$$

$$R_y^2 + \frac{L^2}{2}\sin\theta^2 - R_y^3 + \frac{L^3}{2}\sin\theta^3 = 0$$

3. eq for joint B

$$R_x^3 + \frac{L^3}{2}\cos\theta^3 - R_x^4 + \frac{L^4}{2}\cos\theta^4 = 0$$

$$R_y^3 + \frac{L^3}{2}\sin\theta^3 - R_y^4 + \frac{L^4}{2}\sin\theta^4 = 0$$

4. eq for joint O

$$R_x^4 + \frac{L^4}{2}\cos\theta^4 - c\cos\theta^1 = 0$$

$$R_y^4 + \frac{L^4}{2}\sin\theta^4 - c\sin\theta^1 = 0$$

5. Driving constraint

$$\theta^2 - \theta_0^2 - \omega^2 t = 0$$

C. Coordinates vector

$$q = [R_x^1 \; R_y^1 \; \theta^1 \; R_x^2 \; R_y^2 \; \theta^2 \; R_x^3 \; R_y^3 \; \theta^3 \; R_x^4 \; R_y^4 \; \theta^4]^T$$

D. Constraint Matriks equation.

$$C(q,t) = \begin{bmatrix} C_1(q,t) \\ C_2(q,t) \\ C_3(q,t) \\ C_4(q,t) \\ C_5(q,t) \\ C_6(q,t) \\ C_7(q,t) \\ C_8(q,t) \\ C_9(q,t) \\ C_{10}(q,t) \\ C_{11}(q,t) \\ C_{12}(q,t) \end{bmatrix} = \begin{bmatrix} R_x^1 \\ R_y^1 \\ \theta^1 \\ R_x^2 - \frac{L^2}{2}\cos\theta^2 \\ R_y^2 - \frac{L^2}{2}\sin\theta^2 \\ R_x^2 + \frac{L^2}{2}\cos\theta^2 - R_x^3 + \frac{L^3}{2}\cos\theta^3 \\ R_y^2 + \frac{L^2}{2}\sin\theta^2 - R_y^3 + \frac{L^3}{2}\sin\theta^3 \\ R_x^3 + \frac{L^3}{2}\cos\theta^3 - R_x^4 + \frac{L^4}{2}\cos\theta^4 \\ R_y^3 + \frac{L^3}{2}\sin\theta^3 - R_y^4 + \frac{L^4}{2}\sin\theta^4 \\ R_x^4 + \frac{L^4}{2}\cos\theta^4 - c\cos\theta^1 \\ R_y^4 + \frac{L^4}{2}\sin\theta^4 - c\sin\theta^1 \\ \theta^2 - \theta_0^2 - \omega^2 t \end{bmatrix}$$

E. For Acceleration Analysis.

$$C_{qq} = \begin{bmatrix} \dot{R}_x^1 \\ \dot{R}_y^1 \\ \dot{\theta}^1 \\ \dot{R}_x^2 + \frac{\dot{\theta}^2 L^2}{2}\sin\theta^2 \\ \dot{R}_y^2 - \frac{\dot{\theta}^2 L^2}{2}\cos\theta^2 \\ \dot{R}_x^2 - \frac{\dot{\theta}^2 L^2}{2}\sin\theta^2 - \dot{R}_x^3 - \frac{\dot{\theta}^2 L^3}{2}\sin\theta^3 \\ \dot{R}_y^2 + \frac{\dot{\theta}^2 L^2}{2}\cos\theta^2 - \dot{R}_y^3 + \frac{\dot{\theta}^3 L^3}{2}\cos\theta^3 \\ \dot{R}_x^3 - \frac{\dot{\theta}^3 L^3}{2}\sin\theta^3 - \dot{R}_x^4 - \frac{\dot{\theta}^4 L^4}{2}\sin\theta^4 \\ \dot{R}_y^3 + \frac{\dot{\theta}^3 L^3}{2}\cos\theta^3 - \dot{R}_y^4 + \frac{\dot{\theta}^4 L^4}{2}\cos\theta^4 \\ \dot{R}_x^4 - \frac{\dot{\theta}^4 L^4}{2}\sin\theta^4 + \dot{\theta}^1 c \sin\theta^1 \\ \dot{R}_y^4 + \frac{\dot{\theta}^4 L^4}{2}\cos\theta^4 - \dot{\theta}^1 c\cos\theta^1 \\ \dot{\theta}^2 \end{bmatrix}$$

$$(C_{q\dot{q}})_{\dot{q}} = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{\dot{\theta}^2 L^2}{2}\cos\theta^2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{\dot{\theta}^2 L^2}{2}\sin\theta^2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -\frac{\dot{\theta}^2 L^2}{2}\cos\theta^2 & 0 & 0 & -\frac{\dot{\theta}^3 L^3}{2}\cos\theta^2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -\frac{\dot{\theta}^2 L^2}{2}\sin\theta^2 & 0 & 0 & -\frac{\dot{\theta}^3 L^3}{2}\sin\theta^3 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\dot{\theta}^3 L^3}{2}\cos\theta^3 & 0 & 0 & -\frac{\dot{\theta}^4 L^4}{2}\cos\theta^4 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\dot{\theta}^3 L^3}{2}\sin\theta^3 & 0 & 0 & -\frac{\dot{\theta}^4 L^4}{2}\sin\theta^4 \\ 0 & 0 & \dot{\theta}^1 c\cos\theta^1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\dot{\theta}^4 L^4}{2}\cos\theta^4 \\ 0 & 0 & \dot{\theta}^1 c\sin\theta^1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -\frac{\dot{\theta}^4 L^4}{2}\sin\theta^4 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$