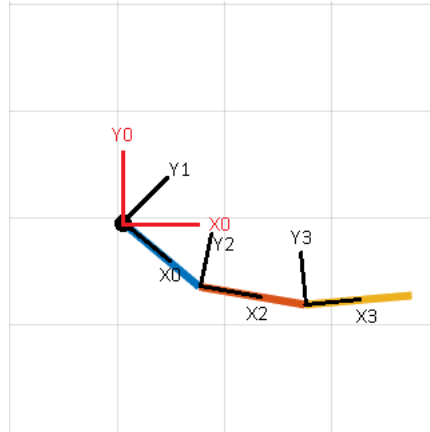


## Practical Assignment -4

### MEL3020: Kinematics and Dynamics of Machines

1. Simulate the following dynamic equations for 3R using MATLAB or Octave:



$$\mathbf{M} = \begin{pmatrix} 3 \cos(\theta_2(t)) + \cos(\theta_3(t)) + \cos(\theta_2(t) + \theta_3(t)) + 4 & \sigma_1 & \sigma_2 \\ \sigma_1 & \cos(\theta_3(t)) + \frac{5}{3} & \frac{\cos(\theta_3(t))}{2} + \frac{1}{3} \\ \sigma_2 & \frac{\cos(\theta_3(t))}{2} + \frac{1}{3} & \frac{1}{3} \end{pmatrix}$$

where

$$\sigma_1 = \frac{3 \cos(\theta_2(t))}{2} + \cos(\theta_3(t)) + \frac{\cos(\theta_2(t) + \theta_3(t))}{2} + \frac{5}{3}$$

$$\sigma_2 = \frac{\cos(\theta_3(t))}{2} + \frac{\cos(\theta_2(t) + \theta_3(t))}{2} + \frac{1}{3}$$

$$\mathbf{H} = \begin{pmatrix} \frac{981 \cos(\theta_1(t))}{40} + \sigma_1 + \frac{2943 \cos(\theta_1(t) + \theta_2(t))}{200} \\ \frac{991 \cos(\theta_1(t) + \theta_2(t) + \theta_3(t))}{200} + \frac{2973 \cos(\theta_1(t) + \theta_2(t))}{200} \\ \sigma_1 \end{pmatrix}$$

where

$$\sigma_1 = \frac{981 \cos(\theta_1(t) + \theta_2(t) + \theta_3(t))}{200}$$

C =

$$\begin{pmatrix} \sigma_2 \left( \sin(\theta_1(t)) + \frac{\sin(\sigma_6)}{2} + \sin(\sigma_{10}) \right) - \left( \cos(\theta_1(t)) + \frac{\cos(\sigma_6)}{2} + \cos(\sigma_{10}) \right) \sigma_1 - \left( \cos(\theta_1(t)) + \frac{\cos(\sigma_{10})}{2} \right) \sigma_4 + \left( \sin(\theta_1(t)) + \frac{\sin(\sigma_{10})}{2} \right) \sigma_3 \\ \left( \frac{\sin(\sigma_6)}{2} + \sin(\sigma_{10}) \right) \sigma_2 - \left( \frac{\cos(\sigma_6)}{2} + \cos(\sigma_{10}) \right) \sigma_1 + \frac{\sin(\sigma_{10}) \sigma_3}{2} - \frac{\cos(\sigma_{10}) \sigma_4}{2} \\ \frac{\sin(\sigma_6) \sigma_2}{2} - \frac{\cos(\sigma_6) \sigma_1}{2} \end{pmatrix}$$

where

$$\sigma_1 = \sigma_8 + \frac{\sin(\sigma_6) \sigma_5}{2} + \sin(\sigma_{10}) \sigma_9$$

$$\sigma_2 = \frac{\cos(\sigma_6) \sigma_5}{2} + \cos(\sigma_{10}) \sigma_9 + \sigma_7$$

$$\sigma_3 = \frac{\cos(\sigma_{10}) \sigma_9}{2} + \sigma_7$$

$$\sigma_4 = \sigma_8 + \frac{\sin(\sigma_{10}) \sigma_9}{2}$$

$$\sigma_5 = (\dot{\theta}_1(t) + \dot{\theta}_2(t) + \dot{\theta}_3(t))^2$$

$$\sigma_6 = \theta_1(t) + \theta_2(t) + \theta_3(t)$$

$$\sigma_7 = \cos(\theta_1(t)) \dot{\theta}_1(t)^2$$

$$\sigma_8 = \sin(\theta_1(t)) \dot{\theta}_1(t)^2$$

$$\sigma_9 = (\dot{\theta}_1(t) + \dot{\theta}_2(t))^2$$

$$\sigma_{10} = \theta_1(t) + \theta_2(t)$$

$$\ddot{\theta} = M^{-1}(\tau - C - G)$$

**m 1=1 kg, m2=1kg, m3 = 1kg, L1= 1m, L2= 0.75 m, L3 = 0.5m, g=9.8 m/s<sup>2</sup>, τ=0 Nm**, Simulate for 10 seconds with time step 0.05 s, with θ<sub>1</sub> initial pi/3, θ<sub>2</sub> initial pi/4, θ<sub>3</sub> initial pi/2. **initial  $\dot{\theta} = 0$**