Department of Mechanical Engineering
Indian Institute of Technology Madras

ME 5233 Multi-body Dynamics & Applications

Assignment 1

Due on: **September 17, 2022**

1. For the slider-crank mechanism discussed in class (see Figure 1a), assume length of the crank $l^2 = 2.5$ cm, connecting rod length to be $l^3 = 10$ cm and slider upward vertical offset to be $h = 2$ cm.

   (a) Use the computational kinematics approach by assigning a body-coordinate system to links 2, 3 and 4. Assume that for body 1, $R_x^1 = R_y^1 = \theta^1 = 0$ explicitly, so that the number of co-ordinates is reduced to 9 rather than 12. Identify the joints and write down the constraint equations for each joint.

   (b) Assume that the driving constraint is given by $\theta^2 = \theta_0^2 + \omega^2 t$, with $\theta_0^2 = 0$ and $\omega^2 = 40\pi$ rad/s which is <u>constant</u>. For $t = 0$ to $t = \frac{4\pi}{\omega^2}$, solve the set of constraint equations using Newton-Raphson method; Use an appropriate Δt. Plot R_x^4 as a function of time as well as R_y^3 vs. R_x^3. Comment on your results. This can be done using GNU/Octave or MATLAB or any other programming language.

   (c) Based on the position analysis, calculate the angular velocity $\dot{\theta}^3$ and velocity $\dot{R}_x^4$ as a function of the crank angle θ^2.

   (d) From the position and velocity results, now calculate the angular acceleration $\ddot{\theta}^3$ and acceleration $\ddot{R}_x^4$ as a function of crank angle θ^2.

   (e) Using **Adams** software model the slider-crank mechanism and generate the results. Compare with your own codes written for the earlier steps.

2. A two link manipulator as shown in Figure **??** has $l^2 = 15$ cm and $l^3 = 25$ cm. Link 2 rotates ACW (anti-clockwise) at a constant angular velocity $\omega^2 = 0.25\pi$ rad/s and link 3 CW (clockwise) with a constant angular velocity $\omega^3 = 0.4\pi$ rad/s. The initial configuration corresponds to $\theta_0^2 = 30°$ and $\theta_0^3 = 60°$.

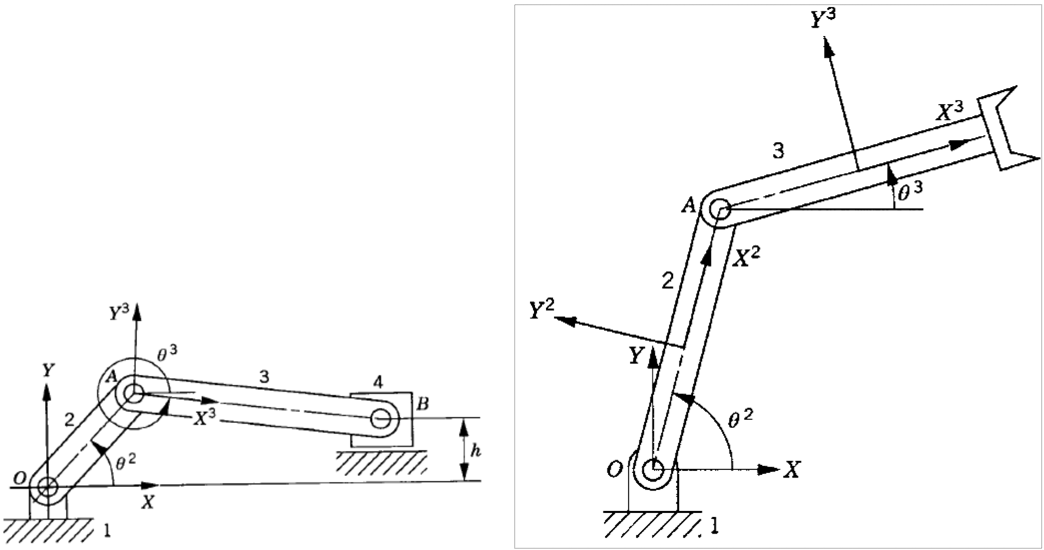
   (a) Using the computational kinematics approach, assign a body co-ordinate system to links 1, 2 and 3. Write down the constraint equations for body 1 which is fixed. Identify the joints and write down the constraint equations in terms of the co-ordinates.

   (b) For $t = 0$ to $t = \frac{4\pi}{\omega^2}$ s, solve the set of constraint equations (including the driving constraints) using Newton-Raphson method; use $\Delta t = 0.16$ s. Plot the x and y co-ordinates of the end-effector vs. time as well as x vs. y co-ordinates of the end effector.

   (c) From the position results, calculate and plot the end-effector x and y components of the velocity from $t = 0$ to $t = \frac{4\pi}{\omega^2}$ s.

   (d) Using the position and velocity results, calculate and plot the end-effector x and y components of acceleration from $t = 0$ to $t = \frac{4\pi}{\omega^2}$ s.

   (e) Using **Adams** software model the two-link manipulator and generate the results. Compare with your own codes written for the earlier steps.



(a) (b)

Figure 1: Figures for Problems 1 and 2.