Department of Mechanical Engineering
Indian Institute of Technology Madras

ME 5233 Multi-body Dynamics & Applications

End Semester Examination

Date: November 25, 2023 Maximum Marks: **80**
Time: 24 hours

Instructions

- You need to attach your MATLAB/GNU Octave or any other code with your results
- You must clearly state how you validated or verified the accuracy of the results presented

1. Figure 1 shows a six-bar mechanism, with all required dimensions marked in the figure. Establish that the loop involving $ABCD$ corresponds to a Grashof mechanism. For one full rotation of the crank AB plot the displacement, velocity and acceleration of E, given that AB rotates clockwise at a constant rate of 300 rpm. Also plot the angular position, velocity and acceleration of link EF. You can modify or use the code you had written earlier for kinematically driven systems. **You should justify why you think the computational results are correct**. (30)

2. A single-cylinder 4-stroke slider-crank mechanism has the following dimensions: crank radius $r = 110$ mm, connecting rod length $l = 440$ mm. The cylinder bore diameter is 180 mm. The mass of the crank is $m_{cran} = 89.5$ kg and the center of mass is at a radial distance of 27.5 mm from the crankshaft bearing. The mass of the connecting rod, m_{crod} is 30.1 kg and the centre of mass is at a distance of 120 mm from the crank-pin. The piston mass, m_p is 24.3 kg. *Assume only for calculation of mass moments of inertia that the crank and connecting rods are uniform bars.*

   The piston is acted upon by gas pressure, which is periodic in time. Its mean and first 4 half-order magnitues (in bar) are given in the table below. The fundamental frequency associated with the gas pressure fluctuations is 10 Hz.

Order	Cosine Term	Sine Term
0	108.22	0
0.5	57.54	-18.73
1	22.23	-6.97
1.5	17.28	-7.03
2	13.66	-6.55

   Use the embedded formulation, with R_x of the piston as the independent variable. Modifying your existing code written for the computational dynamics assignment, simulate the dynamics of the mechanism from time, $t = 0$ to $t = 0.6$ seconds. Include the loads due to weight of the links in your simulation.

   The **initial conditions** are $R_x = 330$ mm and $\dot{R}_x = 0$ mm/s at time $t = 0$ seconds.

   Plot the displacement and velocity of the piston for the entire simulation time; *we are assuming that the piston moves along the horizontal axis.* Also plot the orientation and angular velocity of the crank for the same time duration. **You should justify why you think the computational results are correct**. (50)

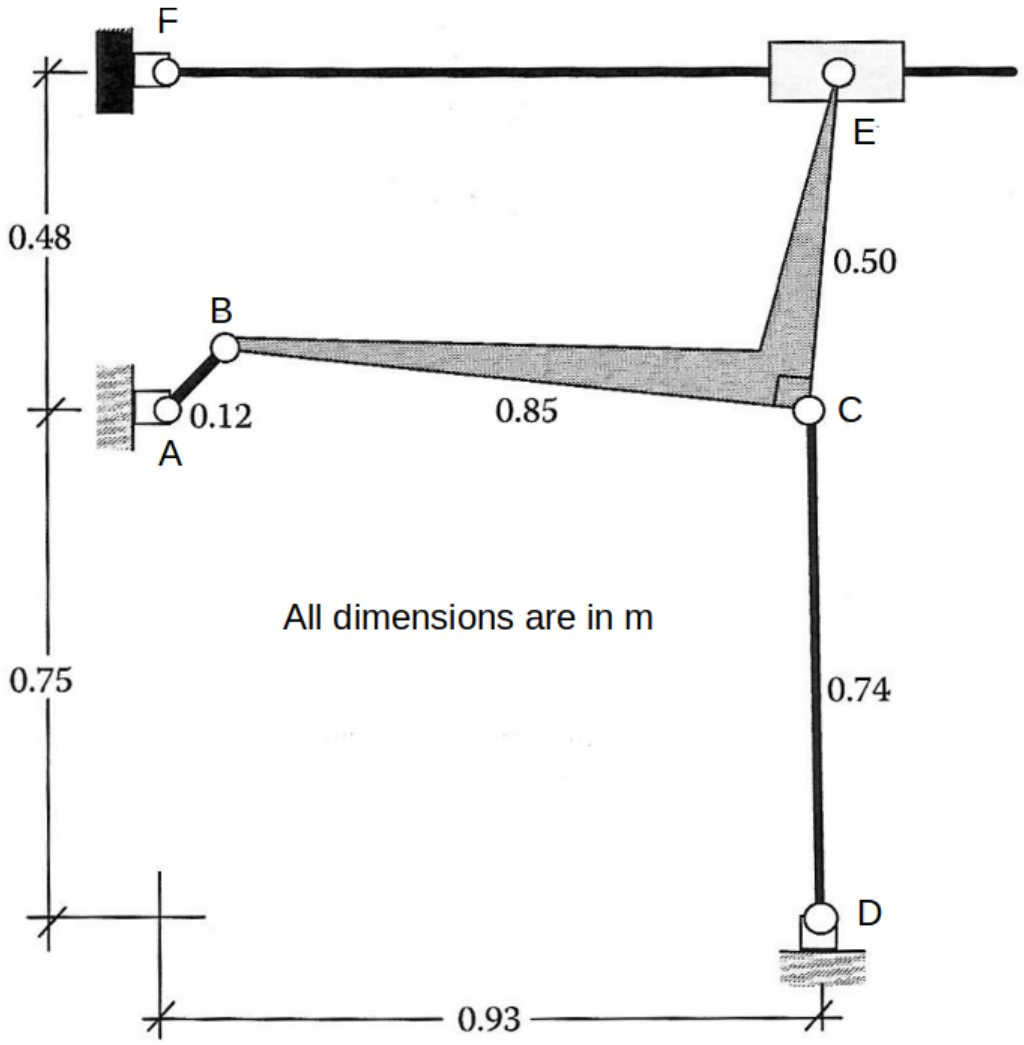

Figure 1: