ME41055
Multibody Dynamics B

Spring Term 2019

Homework Assignment 7 (HW7)

Consider the quick-return mechanism from Figure 1. The crank 2 drives via a slider 3 the rocker 4, and finally the connecting bar 5 moves the slider 6. The centre of mass of link i is denoted by G_i. The specification of the mechanism is as follows: $O_2A = 0.2$ m, $O_4B = 0.7$ m, $BC = 0.6$ m, $O_4O_2 = 0.3$ m, $O_4G_4 = 0.4$ m, $BG_5 = 0.3$ m, $y_c = 0.9$ m, $m_3 = 0.5$ kg, $m_4 = 6$ kg, $m_5 = 4$ kg, $m_6 = 2$ kg, $J_4 = 10$ kgm^2, $J_5 = 6$ kgm^2, $F = 1$ kN, $T = 0$. The reduced mass moment of inertia at the balanced crank ($G_2 = O_2$) is $J_2 = 100$ kgm^2. The initial angular velocity of the crank is $\omega_2 = 75$ rpm CCW at $\theta_2 = 0$ deg. We assume no friction and zero gravity.

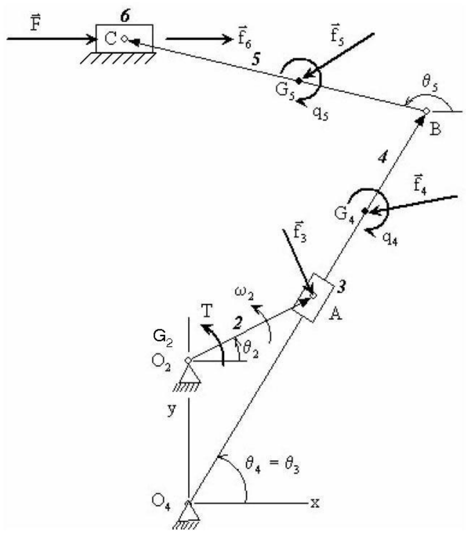

Figure 1 A Quick-Return Mechanism

Determine the motion of the mechanism by numerical integration of the equations of motion. Derive these equations in terms of generalised coordinates and use the cut loop method for this closed loop system. Use the Coordinate Projection Method from Ch. 16.1 from the course book, to make the solutions fulfill the constraints.

Use symbolic software to derive the various elements in the constrained equations of motion, like the jacobians $T_{i,l}$ and $C_{c,l}$, and the convective terms $T_{j,rs}\dot{q}_r\dot{q}_s$ and $C_{c,kl}\dot{q}_k\dot{q}_l$, and then copy and paste these expressions in an m-file to use for numerical evaluation. Do not use the symbolic expression "as is" and use `subs` to get numerical expressions, since this will slow down your calculation speed tremendously.

Please address the following questions:

a. Describe your algorithm in words.

Show and discuss for two revolutions of the crank as a function of time:

b. - The angular speed of crank 2, rocker 4 and connecting bar 5.

c. - The sliding speed of slider 3 with respect to rocker 4.

d. - The horizontal position, speed and acceleration of slider 6.

e. - The normal force exerted by the slider 3 on the rocker 4.

f. - The normal force exerted by slider 6 on the ground.

Looking at the plots we see that the motion is clearly periodic.

g. Determine the period T of the motion in seconds with at least 3 significant digits. For this you might use event detection in your Matlab odesolver. Info on event detection can be found in the online Matlab documentation, look for "matlab ode event location". Describe your method and show your code.

Finally,

h. Which checks did you use in order to be sure that you have the correct answers? Mention at least three.