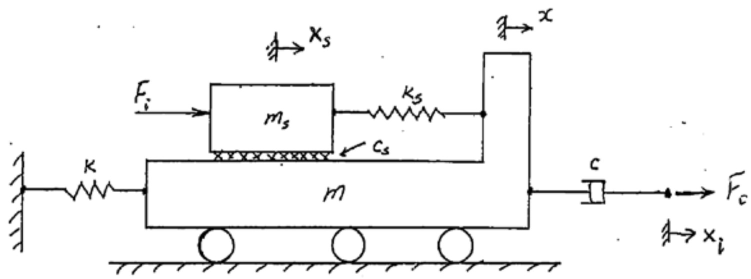
ME 370.1 Fall 2018 Name(s)

Homework 4

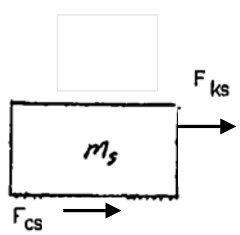
Due: *In class*, Friday, 9/21

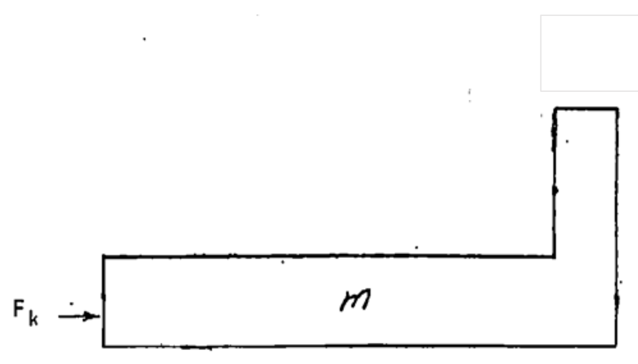
1. (12 pts) A 2DOF geometric model of a mechanical system is shown below. The system is driven by two inputs: force F_i on mass m_s and force F_c on the right part of damper *c*. The mass m_s can slide on the surface of mass *m*. The sliding surface is lubricated with oil so that the friction may be modeled using a viscous damper of damping coefficient c_s.

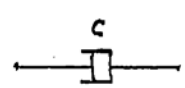


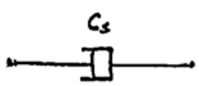
Draw the FBDs of all the model elements given below with ***force and motion variables***. Make sure all FBDs are ***complete*** and ***consistent*** with the forces, F_{cs}, F_{ks} and F_k, labelled on the incomplete FBDs of the two masses. Pay attention to action/reaction pair of forces between two connected elements.

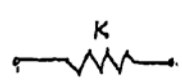
2 pts for each of the 6 FBDs.



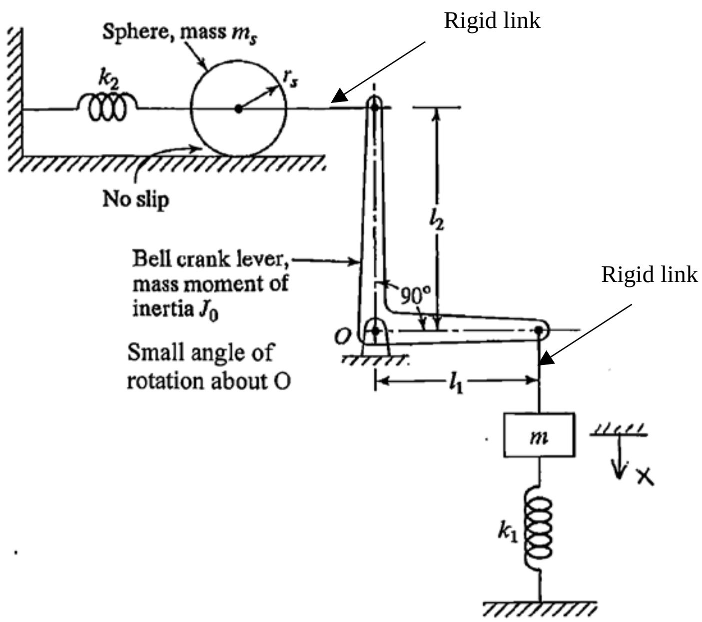


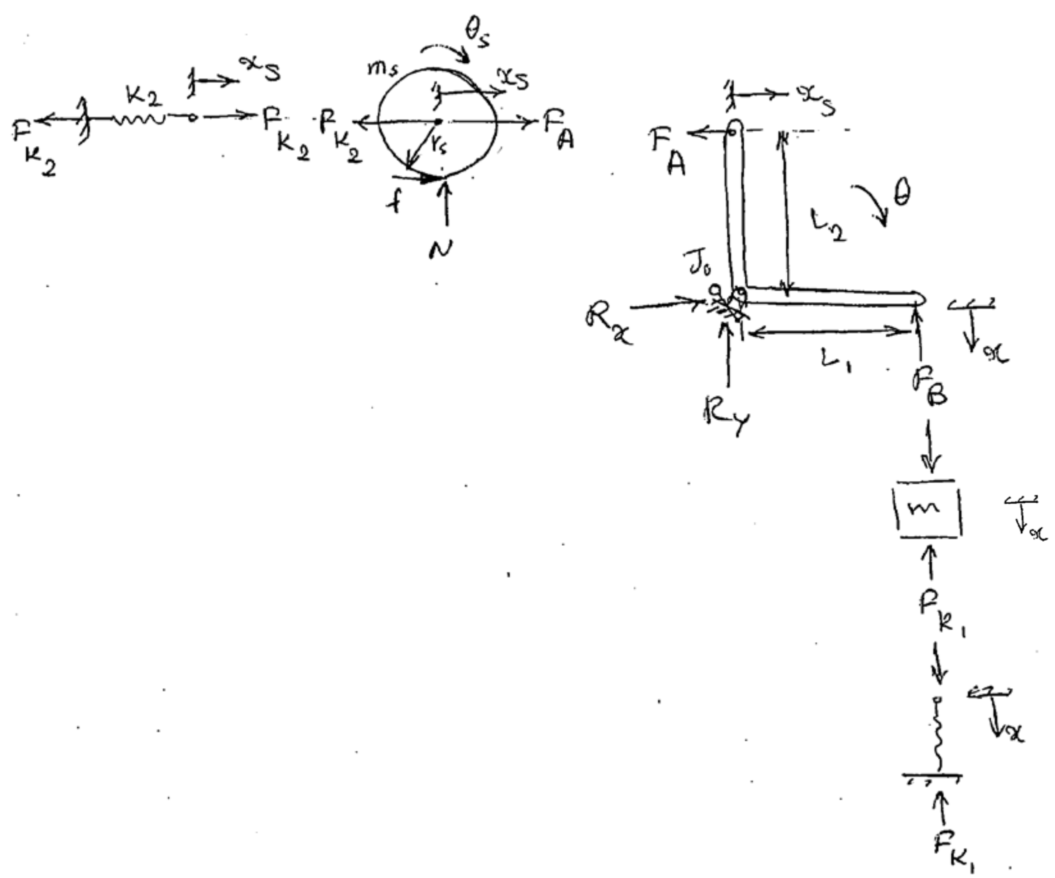






2. (15 pts) Examine the SDOF geometric model and the FBDs below, where J_o is the moment of inertia of the crank with respect to the pivot "O".





(1) (9 pts) Write a complete set of elemental equations (1 pt each, no partial credit)

a) The ele eq. for k_1 is: $F_{k1} =$

b) The ele eq. for m is: $m\ddot{x} =$

c) The ele eq. for J_o is: $J_o\ddot{\theta} =$

d) The ele eq. for m_s is: $m_s\ddot{x}_s =$

e) The ele eq. for J_s is: $J_s\ddot{\theta}_s =$
(J_s is the sphere moment of inertia about the center of sphere)

f) The ele eq. for k_2 is: $F_{k2} =$

g) The motion relation between θ and x is: $\theta =$

h) The motion relation between x_s and x is: $x_s =$

i) The motion relation between θ_s and x is: $\theta_s =$

(2) (6 pts) The governing equation of the system in x variable is

a) $\left(m + \frac{J_o}{l_1^2} + \frac{J_s + m_s r_s^2}{r_s^2}\right)\ddot{x} + (k_1 + k_2)x = 0$

b) $\left(m + \frac{J_o}{l_1^2} + \frac{l_2^2}{l_1^2}\frac{J_s + m_s r_s^2}{r_s^2}\right)\ddot{x} + \left(k_1 + \frac{l_2^2}{l_1^2}k_2\right)x = 0$

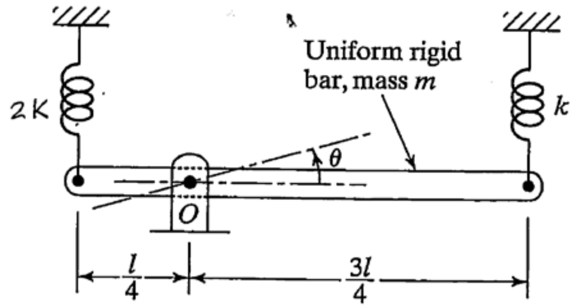
c) $\left(m + \frac{J_o}{l_1^2} + \frac{l_2^2}{l_1^2}\frac{J_s + m_s r_s^2}{r_s^2}\right)\ddot{x} + (k_1 + k_2)x = 0$

d) $\left(m + \frac{J_o}{l_1^2} + \frac{J_s + m_s r_s^2}{r_s^2}\right)\ddot{x} + \left(\frac{l_2^2}{l_1^2}k_1 + k_2\right)x = 0$

e) $\left(m + \frac{J_o}{l_1^2} + \frac{l_2^2}{l_1^2}\frac{J_s + m_s r_s^2}{r_s^2}\right)\ddot{x} + \left(\frac{l_2^2}{l_1^2}k_1 + k_2\right)x = 0$

f) $\left(m + \frac{J_o}{l_1^2} + \frac{J_s + m_s r_s^2}{r_s^2}\right)\ddot{x} + \left(k_1 + \frac{l_2^2}{l_1^2}k_2\right)x = 0$

3. (10 pts) Examine the SDOF geometric model below:



(1) (3 pts) The moment of inertia of the bar about the pivot point O is

a) $J_o = \frac{1}{12}ml^2$

b) $J_o = \frac{7}{48}ml^2$

c) $J_o = \frac{5}{24}ml^2$

d) $J_o = \frac{1}{3}ml^2$

e) $J_o = ml^2$

(2) (7 pts) The governing equation of the system is

a) $7m\ddot{\theta} + 24k\theta = 0$

b) $7m\ddot{\theta} + 33k\theta = 0$

c) $7m\ddot{\theta} + 48k\theta = 0$

d) $5m\ddot{\theta} + 24k\theta = 0$

e) $5m\ddot{\theta} + 33k\theta = 0$

f) $5m\ddot{\theta} + 48k\theta = 0$