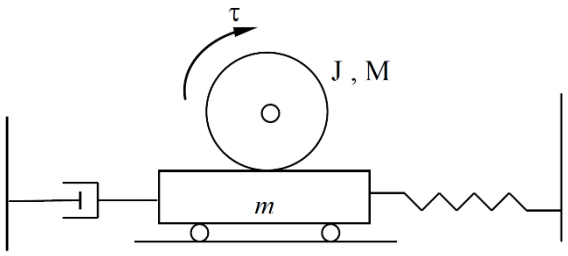
MECH 3140 Homework #7

Problems to be worked by Friday, 10/13/2023

Palm, Chapter 8, Problems #20, 23, 35, 36



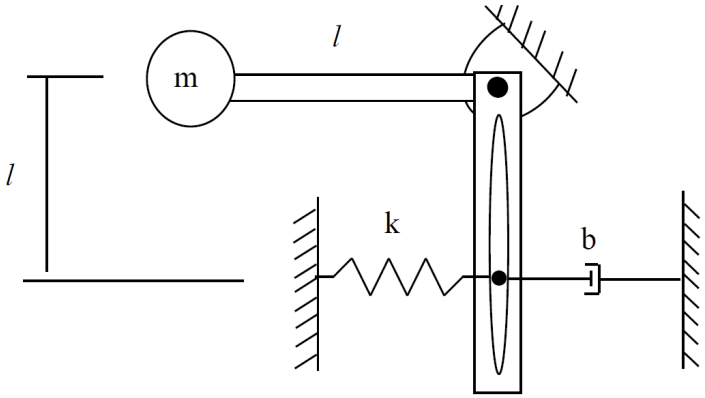
1) Find the eigenvalues for rack and pinion with non-linear spring $\left(F_{spring} = kx^3\right)$ (linearize about x=x0 and v=0). Assume no slip between the rack and pinion.

2) A system oscillates at 5 Hz and takes 10 s to settle to within 5% of its final value.
   a. Sketch the roots on the s-plane
   b. Write out the differential equation
   c. Write out the transient response for the system

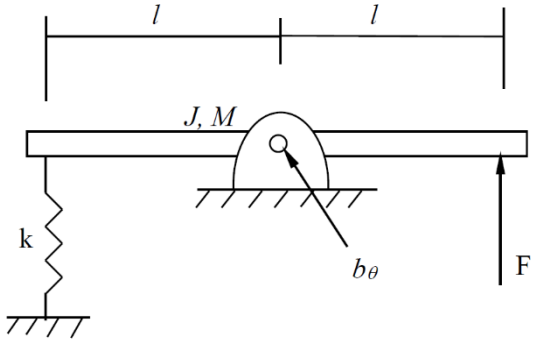
3) A second order system does not oscillate. The system has a 5 s and 10 s time constant.
   a. Sketch the roots on the s-plane
   b. Write out the differential equation
   c. Write out the transient response for the system

Supplemental Problems:

4) Find the eigenvalues for a regular pendulum and inverted pendulum assuming small angles.



5) Derive the non-linear equations of motion for the system to the right. Assume the spring and damper forces remain horizontal and neglect the inertia of the beam. Linearize the equations about θ=0 and about $\theta=\theta_{ss}$



6) For the system to the right, size/design/find the maximum spring value without allowing the transient response to oscillate.

7) Design the suspension (k and b) for the rack and pinion (problem 1 schematic) to have a 1 second settle time (1%) and a rise time (10%-90%) of 0.2 second.