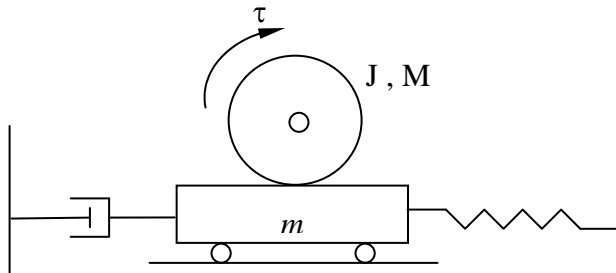


MECH 3140 Homework #4

(Problems should be worked by Monday, 2/13/12)

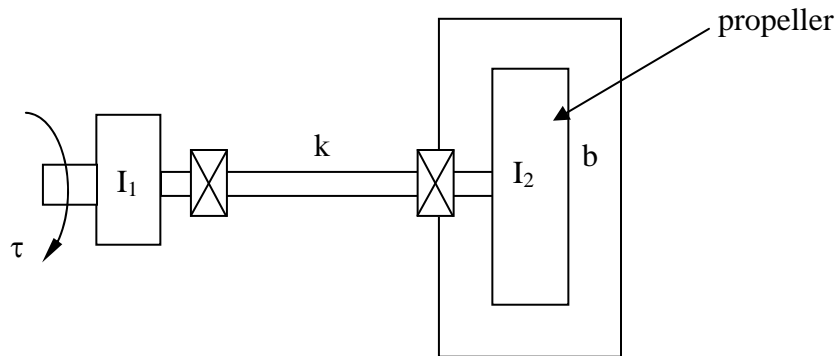
- 1) Chapter 1, problems 1.9-1.15 Place in State Space and practice obtaining Transfer Functions
- 2) Develop the Linear EOM (linearize about $x=x_0$ and $v=0$) for the rack and pinion



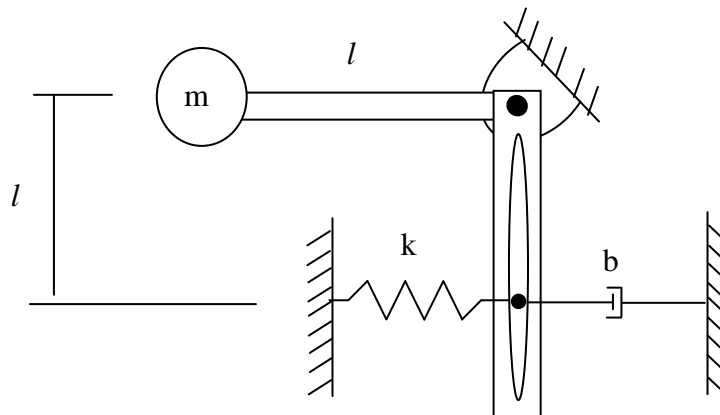
Assume no slip between
The rack and pinion

$$F_s = kx^3$$

- 3) A propeller a fluid coupler (like a torque converter). The damping losses of the propeller are of the form $b\omega^2$ and the shaft has a torsional stiffness of the form $k\theta^3$. Ignore the losses in the bearings. Develop the EOM and Linear EOM (linearize about the steady state - $\Delta\theta$ and ω) for the propeller problem given below

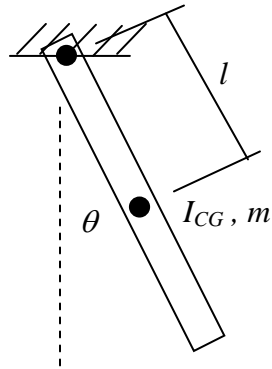


- 4) Derive the non-linear equations of motion for the following system. Assume the spring and damper forces remain horizontal and neglect the inertia of the beam. Linearize the equations about $\theta=0$ and about $\theta=\theta_{ss}$



Matlab Assignment (Due 2/15/12 in Class).

A non-uniform pendulum (a car) swings freely on a perfect pivot at a frequency equal to 1/4 Hz. The car weighs 15,000 Newtons and its CG is 1.5 meters from the pin.



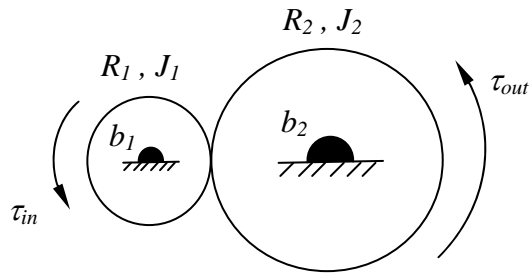
- Derive the non-linear equations of motion
- Linearize the EOM about $\theta=0$. Solve the linearized differential equation and calculate the yaw mass moment of inertia about the CG (I_{CG}) of the vehicle.
- Plot the analytical solution (of the linearized EOM) vs. the numerical integration (of the full non-linear equations of motion) on one plot with an initial angle offset of 10 degrees
- Repeat part (c) with an initial angle of 45 degrees. Why do the results not agree as well as in part (c)?
- Solve for and plot the reaction forces at the pin.

Note to linearize about $\theta=0$ use the relationships (known as the small angle approximation) shown below:

$$\sin(\theta) \approx \theta$$

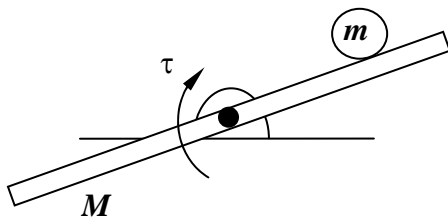
$$\cos(\theta) \approx 1$$

More Modeling Using Newton's Methods



Derive the EOM for the gear

Calculate the output torque as a function of the input torque



Neglect friction between the ball and beam

