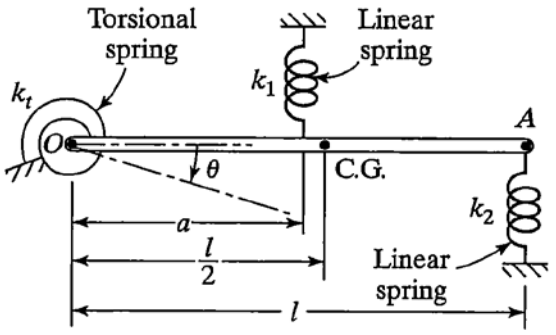
ME 370.1 Fall 18 Name(s)

Homework 5

Due: *In class*, Friday, 9/28

1. (10 pts) For the system shown below, let $l = 1.0$ m , $a = 0.45l$, $k_t = 500$ N-m/rad and $k_1 = k_2 = 1000$ N/m. Also, the mass of the bar is $m = 10$ kg and gravity excluded.



(1) (3 pts) The moment of inertia of the bar in kg-m^2 with respect to the pivot *O* is:

a) $J_o = 3.33$

b) $J_o = 3.97$

c) $J_o = 4.71$

d) $J_o = 5.82$

e) $J_o = 6.65$

(2) (7 pts) The natural frequency of the system in rad/s is:

a) $\omega_n = 12.3$

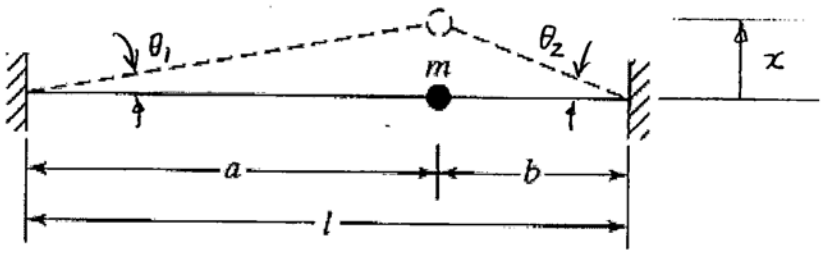
b) $\omega_n = 22.6$

c) $\omega_n = 33.1$

d) $\omega_n = 41.5$

e) $\omega_n = 54.2$

2. (10pts) A ball of mass is attached to an elastic cord as shown below. The cord is stretched with a tension T. Assume the tension remains the same as the mass is pulled up by a small amount (ie. $\sin\theta = \tan\theta = \theta$). Furthermore, gravity is neglected.



(1) (3 pts) The magnitude ***and direction*** of the vertical force, F_m, on the mass by the cord tension as a function of the displacement of the mass, x, is given by:

a) $F_m = -\left(\frac{Tl}{ab}\right)x$

b) $F_m = -\left(\frac{2Tl}{ab}\right)x$

c) $F_m = -\left(\frac{0.7Tl}{ab}\right)x$

d) $F_m = \left(\frac{Tl}{ab}\right)x$

e) $F_m = \left(\frac{2Tl}{ab}\right)x$

f) $F_m = \left(\frac{0.7Tl}{ab}\right)x$

(2) (7 pts) Let $l = 1.0$ m, $a = 0.7l$, $b = 0.3l$, $m = 0.1$ kg and $T = 100$ N. If the ball is pulled up by an amount of $x_o = 1.0$ cm and then let go, the number of times the ball will bounce up and down in one second is equal to:

a) $N = 11$

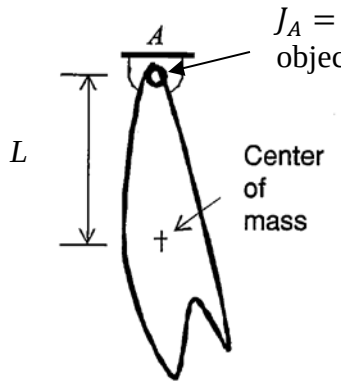
b) $N = 21$

c) $N = 31$

d) $N = 41$

e) $N = 51$

3. (25 pts) A complex-shaped object of mass *m* is shown below. When it is suspended like a pendulum at point *A*, it swings 60 times in one minute.



(1) (2pts) The natural frequency of the system in rad/s is

a) $\omega_n = \pi / 2$ b) $\omega_n = \pi$

c) $\omega_n = 2\pi$ d) $\omega_n = 4\pi$

e) $\omega_n = 1.0$

(2) (4 pts) The governing equation for the pendulum in free swing motion is

a) $J_A\ddot{\theta} + mgL\theta = 0$

b) $L\ddot{\theta} + g\theta = 0$

c) $2J_A\ddot{\theta} + mgL\theta = 0$

d) $2L\ddot{\theta} + g\theta = 0$

e) $J_A\ddot{\theta} + 2mgL\theta = 0$

(3) (5 pts) Let $m = 2.0$ kg and $L = 0.2$ m. The moment of inertia of the object ***about its center of mass*** in kg-m^2 is about equal to

a) $J_{cg} = 0.009$

b) $J_{cg} = 0.019$

c) $J_{cg} = 0.038$

d) $J_{cg} = 0.076$

e) $J_{cg} = 0.098$

As worked out in class, the free vibration (ie. pendulum swing) is given by $\theta(t) = A\sin(\omega_n t + \phi)$. Suppose the pendulum is displaced by an angle of $\theta_o = 0.1$ rad and is released with a velocity of $\dot{\theta}_o = -0.5$ rad/s.

(4) (2pts) The amplitude of the pendulum swing in rad is about equal to

a) $A = 0.050$

b) $A = 0.098$

c) $A = 0.128$

d) $A = 0.187$

e) $A = 0.245$

(5) (2pts) The phase angle in rad of the pendulum swing is about equal to

a) $\phi = \pi / 4$

b) $\phi = 0.94$

c) $\phi = 2.24$

d) $\phi = -1.54$

e) $\phi = -2.76$

(5) (10pts) Write a simple matlab program to calculate θ vs. t and plot the pendulum swing for two periods of pendulum swing. Make sure your plot shows a smooth curve. Also, make sure your plot matches the given ICs to be correct. Label your plot including units. Submit your matlab program along with results. (the class website has a simple matlab guide)