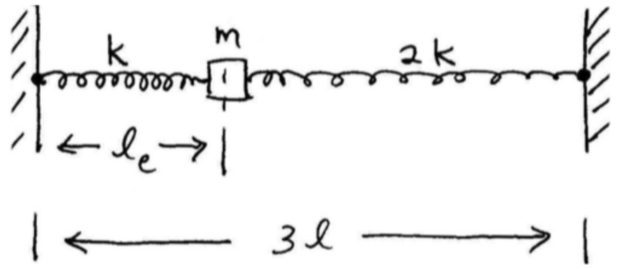
Ph1a - Flipped Section

Problem Set 11

November 11, 2019

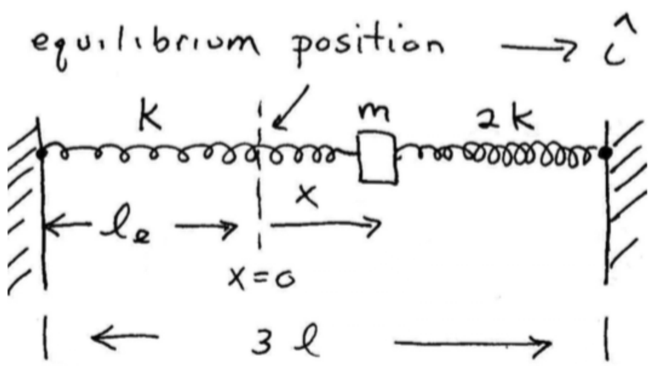
1. Two Oscillating Springs

The left side of an object of mass m is attached to a spring of spring constant k. The other side of the spring is fixed to a wall. The right side of the object is attached to a spring of spring constant $2k$. The other side of the spring is fixed to a wall a distance $3l$ from the first wall(as shown in the figure below). Both springs have equilibrium length $2l$. Express your answers to the following questions in terms of m, k, and l as needed.



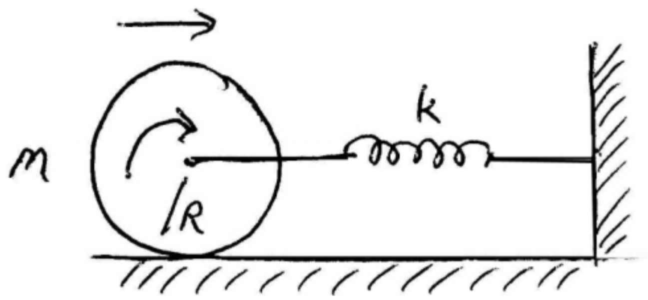
a. When the object is in equilibrium, what is the distance, l_e , between the object and the left wall?

b. Find the differential equation governing the horizontal displacement from the equilibrium position of the object $x(t)$. Assume that the block does not hit either wall.



c. At $t = 0$, the object is released at $x = x_0$ with an initial velocity $\vec{v} = -v_0\hat{\imath}$ with $v_0 > 0$. Find the subsequent location of the object from equilibrium as a function of time $x(t)$.

2. Oscillating and Rolling



Attach a solid cylinder of mass M and radius R to a horizontal massless spring with spring constant k so that it can roll without slipping along a horizontal surface. Let us try to find the period of the simple harmonic motion for the center of mass of the cylinder.

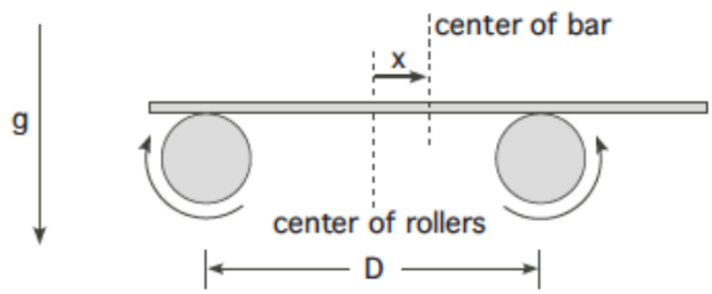
a. Write down the energy of the system.

b. Conservation of energy tells us that $dE/dt = 0$. Use this to write down the equation of motion for the position of the cylinder, and find the period.

c. We can also solve the problem using forces. Write down the force equation and the torque equation for the center of mass of the cylinder.

d. The condition of rolling without slipping tells us that $a = R\alpha$. Use this to obtain the equation of motion for the position of the cylinder, and find the period.

3. Oscillating Bar



A bar of mass m and negligible height is lying horizontally across and perpendicular to a pair of counter rotating rollers as shown in the figure. The rollers are separated by a distance D. There is a coefficient of kinetic friction μ between each roller and the bar. Assume that the bar remains horizontal and never comes off the rollers.

a. The bar is released from rest at $x = x_0$ at $t = 0$. Find the subsequent location of the center of the bar $x(t)$. (Hint: the net torque on the bar is zero.)

b. Now suppose the rollers roll in the opposite direction. Find $x(t)$ with the same initial conditions as part a).