Discussion 2 - Oscillators

Problem 1. An apple weighs mg. When you hang it from the end of a long spring of force constant k and negligible mass, it bounces up and down in simple harmonic motion. If you stop the bouncing and let the apple swing from side to side through a small angle, the frequency of this simple pendulum is half the bounce frequency. (Because the angle is small, the back-and-forth swings do not cause any appreciable change in the length of the spring.) What is the unstretched length of the spring with the apple removed?

Problem 2. A block of mass m rests in a tray of mass M which is attached to a spring with force constant k. The spring is below the tray, so it can oscillate up and down. Define $y = 0$ as the equilibrium position (where the net force is zero). The force of gravity acts in the $-y$ direction. Assume that at time $t = 0$, the system is set into motion from its equilibrium position by giving the tray and block an initial speed v_0 in the $-y$ direction. Determine $y(t)$ in terms of k, m, M, and v_0. Assume v_0 is small enough that the block remains on the tray at all times.

Problem 3. A block of mass m, moving on the end of a spring with force constant k, is acted on by a damping force $\vec{F} = -b\vec{v}$.

a. If the constant b has the value $\sqrt{mk}$, what is the frequency of oscillation of the block?

b. For what value of the constant b will the motion be critically damped?

c. Is energy conserved?

Problem 4. A block with mass M rests on a frictionless surface and is connected to a horizontal spring of force constant k. The other end of the spring is attached to a wall. A second block with mass m rests on top of the first block. The coefficient of static friction between the blocks is μ_s. Find the *maximum* amplitude of oscillation such that the top block will not slip on the bottom block.

Problem 5. A compound physical pendulum consists of a disk or radius R fixed at its center to one end of a rod of length L whose other end is attached to a pivot as shown in the figure.

a. Find the torque about the pivot due to gravity in terms of the angle θ the pendulum makes with the vertical.

b. Find the moment of inertia of the compound object about the pivot.

c. Find the period and angular frequency of small oscillations.

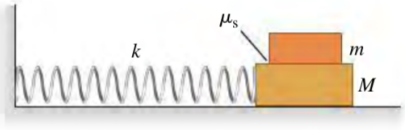

Figure 1: Problem 4

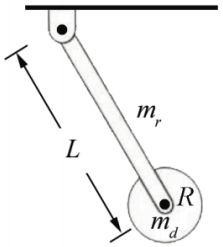

Figure 2: Problem 5