Recitation Questions
Week of April 10

1. A ball of mass m is connected to one end of a rubber band and swung in a circle. The rubber band has spring constant k, and its unstretched length is r_0.

   If it is swung at an angular velocity ω, to what length will it stretch the rubber band?

2. A mad scientist has built a rocket-powered sled, and wants to show off by using it and a ramp made out of snow to jump through the air, much like a skier. She sets her sled a distance d in front of the ramp and fires the rocket. The rocket accelerates forward toward the ramp, ascends the ramp, then flies through the air before landing back on the ground.

   Suppose that:

   - The sled and rider together have mass m
   - The coefficient of friction between the snow and the sled is μ_k
   - The thrust force from the rocket is F_T
   - The overall (diagonal) length of the ramp is L
   - The ramp is inclined at an angle θ above the horizontal

   (a) Draw a cartoon of the situation, labeling interesting things (i.e. the trigonometry related to the ramp).

(b) Using energy methods, calculate how fast she is traveling when she leaves the top of the ramp.

(c) Using energy methods, calculate how fast she is traveling when she lands back on the ground. Think carefully about what your "initial" and "final" states are; there's a hard way and an easy way to do this.

(d) Can you use energy methods to figure out the horizontal distance she travels before landing back on the ground? If so, write down an equation you can solve for that distance. If not, explain what other techniques you need to use.

3. On a hot day in southern Arizona (air temperature 98° F/37° C), a hiker decides to climb Mt. Wrightson, ascending 1200m from the start of the trail to the summit. Suppose that she and her equipment have a mass of 100 kg.

   (a) How much mechanical work must her muscles do on her in order to climb the mountain?

   (b) Suppose that human muscle is 15% efficient – that is, of the chemical energy provided to it, 15% is converted into mechanical work, and the other 85% is converted to heat. We typically measure the chemical energy of food in kilocalories (often called just "calories", frustrating the scientists everywhere). 1 kilocalorie is 4180 J. How many kilocalories of food must our hiker consume to fuel her climb?

   (c) If 15% of her food energy gets converted into useful mechanical work, the other 85% is converted into heat. Since the air temperature is equal to her body temperature, the only way she can cool herself is by sweating.

   The evaporation of one kilogram (one liter) of water carries with it 2.3 MJ of heat energy. How many liters of water must the hiker drink as she climbs the mountain?

(d) If you have any experience hiking or climbing mountains, compare these numbers to your experience. Are they roughly correct? (One Clif Bar or similar contains about 250 kcal.)