Homework 9
Due Wednesday, 25 March

1. We saw in class that in a pendulum the string does no work. We also saw that the normal force does no work on an object sliding down a ramp.
   (a) Explain why the tension in the string of a pendulum does no work.
   (b) Explain why the normal force does no work on an object sliding down a ramp.
   (c) Give an example of a situation where tension *does* do work on an object.
   (d) Give an example of a situation where friction does positive work on something.

2. On a cold winter day, you might rub your hands together to warm them up. The kinetic friction as you rub your hands together does negative work on your hands. The law of conservation of energy (which we will study in more detail next week) says that energy is never lost, only converted from one form to another; in this case, this energy is dissipated as heat.
   (a) Estimate the amount of heat (in joules) that this will produce after ten seconds of rubbing your hands. You will need to make quite a few estimates here involving the parameters of rubbing your hands together; tell me what they are in your solution.
   (b) It requires about four joules of added heat to raise the temperature of one gram of tissue by one degree Celsius (1.8 degrees Fahrenheit). Is rubbing your hands together an effective way to keep your hands warm? What about your whole body? Again, tell me what approximations and assumptions you make here.

3. A lazy penguin slides down a snow-covered slope on its stomach. Suppose that the diagonal length of the slope is 12 m, and it is inclined at an angle of 10° above the horizontal. If the penguin is traveling at 4 m/s when it reaches the bottom of the slope, what is the coefficient of friction between the penguin and the slope?

   Do this problem twice: once with Newton's second law and kinematics, and once with energy methods. Write a few sentences comparing the approaches.

4. A person is sitting on a swing attached to a tree. The swing's ropes have a length L.

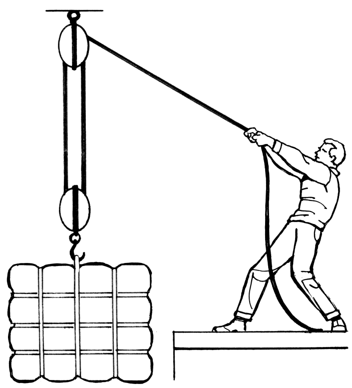
   Her dog runs into her lap, knocking her back. She swings up to an angle θ above the vertical, and then back down. If her dog has half her mass, determine the speed v_0 that her dog was running when he jumped into her lap.

   (This problem is an abbreviated version of the last problem in the recitation activities for Friday, April 13; that version contains some hints. You may submit those pages for your homework if you like, instead of writing it out on your own paper. If you don't have your paper from Friday, see `https://walterfreeman.github.io/phy211/recitation/recitation-momentum-energy.pdf`*.)*

5. A frog jumps horizontally off of a table of height h with an initial velocity v_0. What is the magnitude of its velocity when it lands? on the ground?

   Do this problem using both kinematics (that you already learned) and the work-energy theorem. It is much easier with the work-energy theorem; why? (There is a particular bit of mathematics you don't have to worry about here. What is it?)

6. A person uses a block-and-tackle system as shown below (from Wikimedia Commons) to lift a heavy load. Note that the string connects to the load twice.

   Suppose the load has a weight of 1250 N, and he lifts this load two meters slowly (at constant velocity).

   (a) How far must he pull the string he's holding in order to do this? (Hint: it is *not* two meters. Think about the previous double pulley problem you did.)

   (b) What force must he exert on the rope to do this?

   (c) It seems like he's getting something for nothing – that he's able to lift a larger weight with a smaller force. But is he? Calculate the work done by the rope on the load, and calculate the work he does on the rope.

   (d) If he lifts this load 2m and then holds it there, clearly its change in kinetic energy is zero: it started at rest and ended at rest. However, the rope did positive work on the load; the work-energy theorem thus says that its kinetic energy should increase unless some other force did an equal amount of negative work on it. What force was this?

   (e) Explain why, using the definition of work $W = \int \vec{F} \cdot d\vec{s}$, that force does negative work.