MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Physics

Physics 8.01X Fall Term 2001

PROBLEM SET 7

Handed out: October 19
Due: October 26 at 5 pm in 4-339B.

Please write your name, subject, **recitation number**, and the name of the recitation instructor on the top right corner of the first page of your homework solutions. The solutions should be placed in the appropriate box in room 4-339B.

Problem 1: Fermi estimation problems

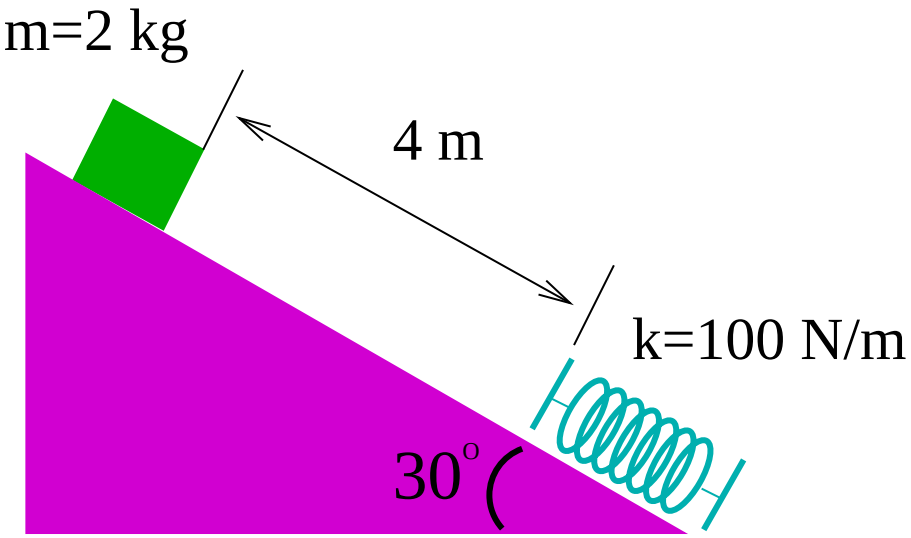
a. Estimate the work done by gravity when you drop a bowling ball on your toe. What happens to the energy?

b. If you drive in the Rocky Mountains, you will often see "runaway truck ramps" veering off the highway. These gravelly roads fork off from the main road and head up a sharp incline, so that trucks which have lost their brakes will be able to stop and avoid a crash. Design such a runaway truck ramp, i.e. select an angle of inclination and length of ramp such that most trucks will be able to stop. You may need to estimate such quantities as the maximum speed of a runaway truck, and the coefficient of friction between the truck and the road.

Problem 2:

A 2 kg mass is released on a frictionless incline 4 m from a spring of constant $k = 100$ N/m. The spring is fixed along the plane inclined at 30° with the horizontal.

a. Find the maximum compression of the spring, assumed to be ideal and massless.



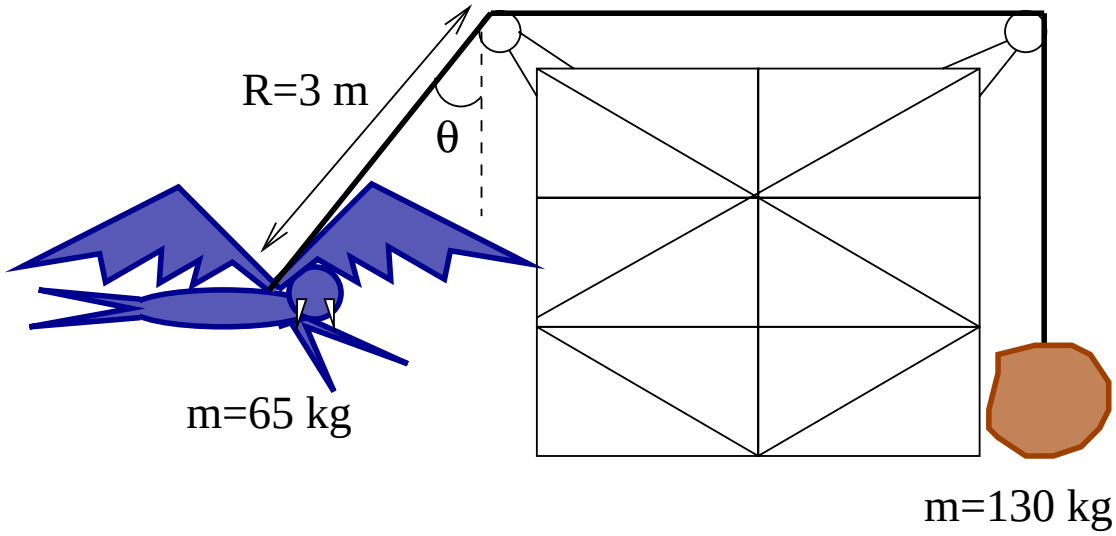
b. If the incline is not frictionless, but has a coefficient of kinetic friction $\mu_s = 0.2$ between it and the mass, find the maximum compression.

c. For the rough incline, how far up the incline will the mass travel after leaving the spring?

d. Describe qualitatively the subsequent motion of the mass for the rough incline.

Problem 3:

An 65 kg actor playing a vampire with giant bat wings in a Hallowe'en play must swoop down onto the stage from the sidelines, starting his swoop at a raised platform behind a side curtain. Your job as stage designer is to design an apparatus to support him. The vampire is supported by a harness to a 130 kg sandbag by means of a lightweight steel cable running smoothly over two frictionless pulleys. You need $R = 3.0$ m of cable between the harness and the nearest pulley so that the pulley can be hidden behind the curtains. For the apparatus to work, the sandbag must never lift above the floor while the actor swings from above the stage to the floor. The angle that the vampire's cable makes with the vertical is θ. Assume that the vampire starts from rest and that the cable remains taut throughout the swoop.



a. What is the maximum value that θ can have before the sandbag lifts from the floor?

b. If the initial angle is $\theta = 50°$, find the speed of the vampire and the tension in the cable just before he reaches the floor.

Problem 4:

The planet Mercury has a mass of 3.18×10^{23} kg, and a radius 2.43×10^{6} m.

a. What is the escape speed for Mercury?

b. A space probe that was sent to Mercury and landed there is to re-launch from its surface, such that it has a speed of 50 km/s when it is very far from Mercury. What speed must the probe have as it leaves the surface of Mercury?