Physics 20 Problem Set 6

Harry Nelson

due Monday, November 8, by 5pm
to the Physics 20 Boxes in Broida Hall's Lobby

Course Announcments: These problems pertain to the sixth week's lectures, and the corresponding reading is 75-95 of KK, Chapter 6 of RHK4.

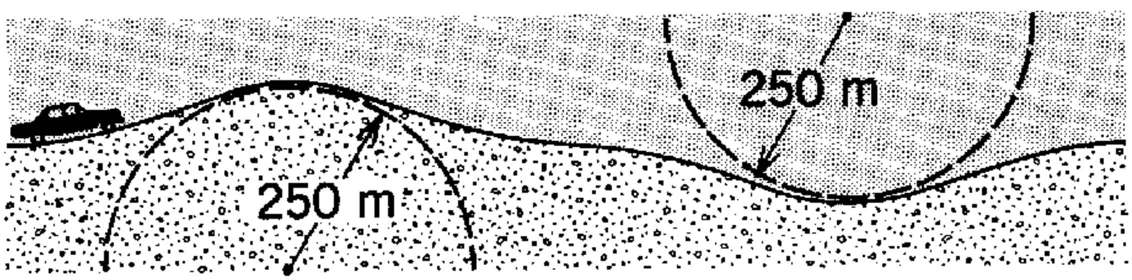

Figure 1: Problem 3.

1. When in 1640 Broida Hall, we are always accelerating because we are rotating the Earth's axis. We are latitude $\phi = 34.41°$, and our distance from the Earth's center is 6371 km. This is a numerical problem. Work to 4 significant digits, just for fun. In that spirit, take the duration of one Earth rotation to be not $24 \times 60 \times 60 = 86,400\,\mathrm{s}$, which includes the extra few minutes needed for the Earth to face the Sun, but $86,164\,\mathrm{s}$.

   (a) Numerically evaluate ϕ in radians. It is very near a round number when expressed in radians.

   (b) Numerically evaluate the minimum distance from 1640 Broida to the Earth's axis.

   (c) What is our speed in meters/second?

   (d) What is the magnitude of our acceleration, in meters/second^2? Assume that gravity and the normal force cancel.

   (e) Make a clear diagram showing the Earth, our latitude, and the direction of our acceleration.

   (f) What percentage of $g = 9.807\,\mathrm{m/s^2}$ is that acceleration?

   (g) Suppose a bathroom scale indicates you have a mass of 60 kg. By how many kilograms should you doubt the scale, given part 1f? Only need 2 significant figures here.

   (h) Make an educated guess as to why the radius of the Earth at the equator is 6378 km, while at the poles the radius is only 6357 km? That is, the Earth is shaped a little like a flying saucer. Consider evaluating the percentage difference of the two radii relative to their average, and comparing it to the percentage of the part 1f.

2. A conical pendulum (like Example 2.8 on page 77 of KK) is formed by attaching a 53-g pebble to a 1.4-m string. The pebble swings around with a radius of 25 cm.

(a) What is the speed of the pebble?

(b) What is the acceleration?

(c) What is the tension in the string? (RHK4 6.36)

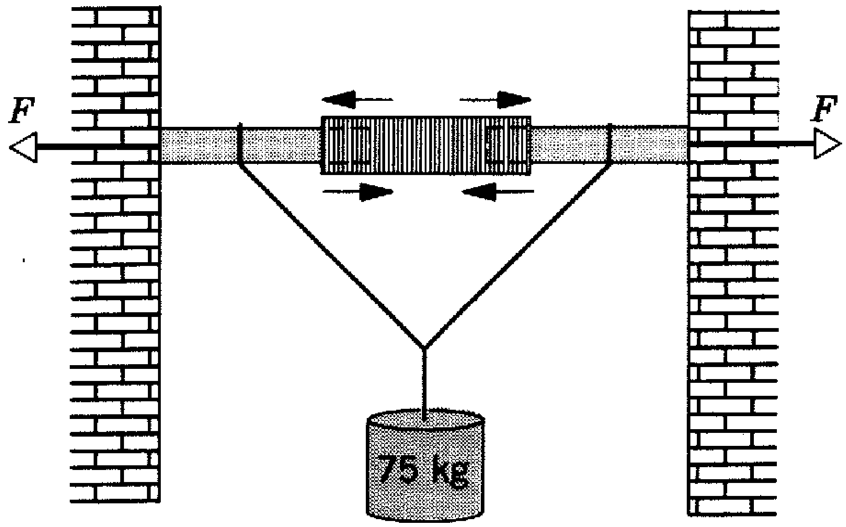

Figure 2: Problem 5.

3. A car moves at a constant speed on a straight but hilly road. Once section has a crest and a dip of the same 250 m radius; see Fig. 1.

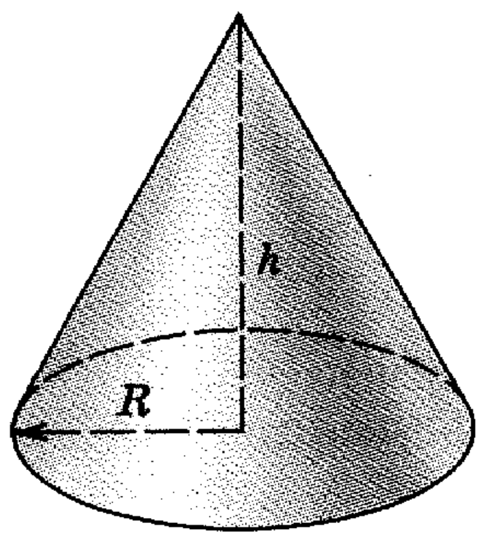

Figure 3: Problem 6.

(a) As the car passes over the crest, the normal force on the car is one-half the 16-kN weight of the car. What will be the normal force on the car as it passes through the bottom of the dip?

(b) What is the greatest speed at which the car can move without leaving the road at the top of the hill?

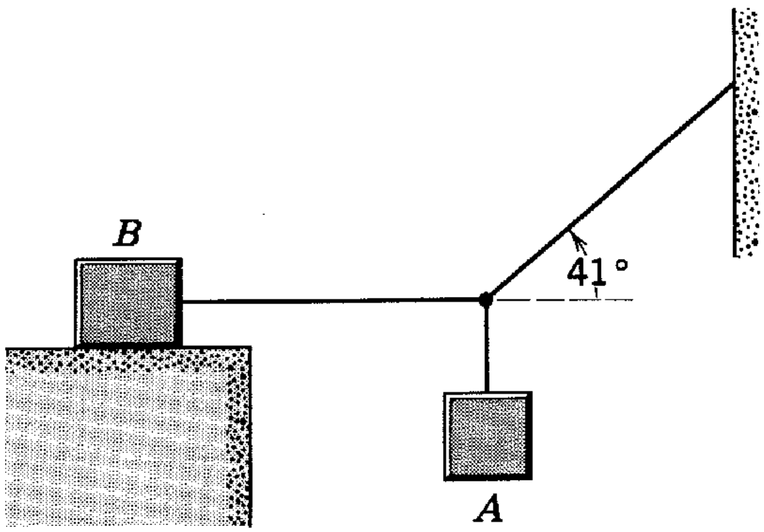

Figure 4: Problem 7.

(c) Moving at the speed found in (b), what will be the normal force on the car as it moves through the bottom of the dip? (RHK4 6.44)

4. KK 2.9

5. A horizontal bar is used to support a 75-kg object between two walls, as shown in Fig. 2. The equal forces F exerted by the bar against the walls can be varied by adjusting the length of the bar. Only friction between the ends of the bar and the walls support the system. The coefficient of static friction between bar and walls is 0.41. Find the minimum value of the forces F for equilibrium. (RHK4 6.5)

6. You want to pile sand onto a circular area in the yard. The radius of the circle is R. No sand is to spill on to the surrounding area; see Fig. 3. Show that the greatest volume of sand that can be stored in this manner is $\pi \mu_s R^3/3$, where μ_s is the coefficient of static friction of sand on sand. (The volume of a cone is $Ah/3$, where A is the base area and h is the height). (RHK4 6.13)

7. Block B in Fig. 4 weights 712 N. The coefficient of static friction between the block B and the table is 0.25. Find the maximum weight of block A for which the system will be in equilibrium. (RHK4 6.24)

8. KK 2.28. This problem is most easily done if you choose a coordinate system that is rotated with respect to horizontal/vertical by an angle θ.