Homework 8

Due Wednesday, 24 April

1. Rotational motion introduces many new terms, and in order to make sense of conversations about rotation, you should be familiar with them. In your own words and using *no mathematics*, define the following and give the dimensions of each of the following:

   (a) Angular velocity

   (b) Angular acceleration

   (c) Tangential velocity

   (d) Radial acceleration

   (e) Tangential acceleration

   (f) Torque

2. Suppose that you want to hold a meter stick horizontal to the ground by touching it with only two fingers. One finger is at the 10 cm mark, while the other finger is at the 20 cm mark. The meter stick has a mass of 100g. What must you do with your fingers, and what normal forces do they exert on the meter stick? What if your fingers are at the 10 cm and 12 cm marks?

   If you are having trouble with this problem, go get a meter stick and physically play with it.

3. In Exam 2, we saw a story involving aircraft during the Second World War that were shot down by damage to their engines. However, this sort of thing didn't automatically result in the loss of an aircraft.

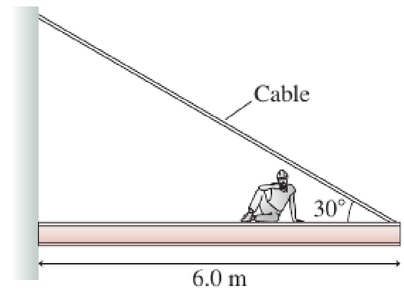
   Both the Americans and British built large aircraft driven by four engines turning propellers mounted along the wings. Two inner engines were located closer to the fuselage, and two outer engines were mounted further out along the wings.

   (a) One such aircraft, the Flying Fortress, was known for its ability to still fly despite extensive damage. In particular, they were able to fly with only one of their four engines working. Would it be easier to fly such an aircraft with (1) only an outer engine remaining, or (2) only an inner engine remaining? Why?

   (b) There is another report of an aircraft of this sort losing hydraulic control, eliminating its ability to steer using normal means. However, the pilot was able to steer by altering the power supplied to the engines and landed safely. How was he able to do this? Explain using concepts from our class.

4. A construction worker takes a break for lunch, resting on a steel beam.

The steel beam has a mass of 1450 kg, and the construc- tion worker shown has a mass of 80 kg. They sit 3.2 meters from the end of the beam. The cable is rated to transmit a tension of 15 kN.



Should they be worried that the cable might fail?

5. The pendulum in a large clock is swinging back and forth. For one complete cycle (left to right and back to left again), sketch graphs of its angle, angular velocity, and angular acceleration on the same set of axes. Label the left and right endpoints of its swing on your graph.

   It will be most convenient if you choose the origin for your angle (*i.e.* the point at which $\theta = 0$) as the negative y-axis. Remember the convention that counterclockwise rotations are positive and clockwise ones are negative.

6. The CD-ROM drive in a computer accelerates a disk from rest to its full speed of 20000 revolutions per minute; it does so uniformly over 5 seconds. The disk is 6 cm in radius.

   (a) Is it correct to write $\alpha = 4000 \text{rev} \cdot \text{min}^{-1} \cdot \text{s}^{-1}$? Explain.

   (b) What is the maximum angular velocity in our conventional units of radians per second?

   (c) What is its angular acceleration?

   (d) How many times does it spin during this interval?

   (e) After four seconds, what is the *tangential velocity* of a point along the edge of the disk?

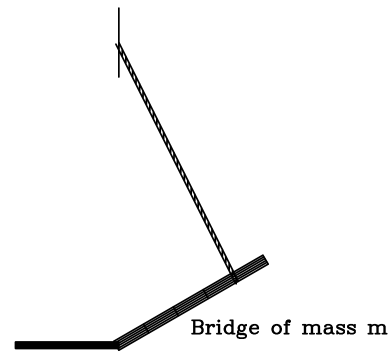
   (f) After four seconds, what is the *angular velocity* of a point along the edge of the disk?

   (g) After four seconds, what is the *tangential acceleration* of a point along the edge?

   (h) After four seconds, what is the *radial acceleration* of a point along the edge? Speculate on the engineering consequences of this figure; how large is it compared to other accelerations you know?

7. A castle's drawbridge consists of a heavy wooden plank that can be opened or closed using a rope, as shown below:

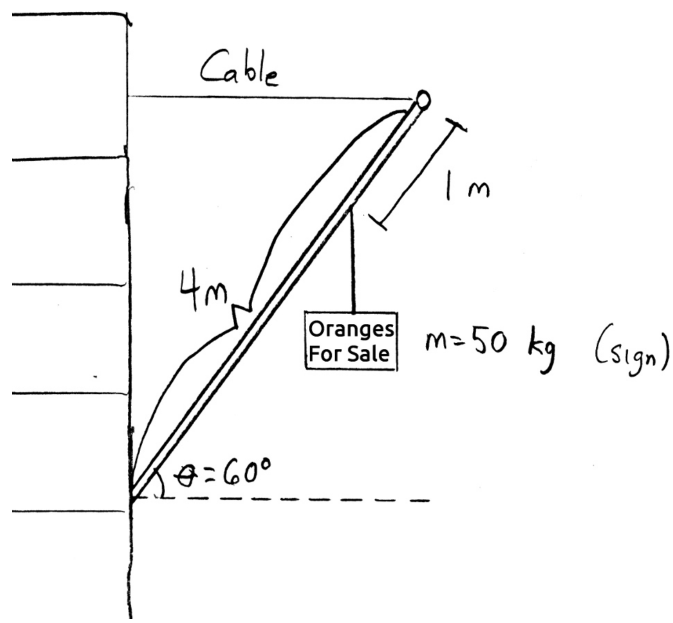
The rope is attached to the door 4/5 of the way down its length; the left side of the plank is attached to a hinge in the ground. The bridge is left in a partially-raised state by a careless sentry. It makes an angle of 30° with the horizontal; the rope that supports it is perpendicular to the bridge.



If the mass of the door is m, calculate the tension T in the rope in terms of θ, m, and g.

8. Otto decides to open a citrus shop to make some extra cash during a bad year for sportsball, and hangs a sign in front of his store.

A 4m-long pole of mass 50 kg extends from the side of a building, angled at 60 degrees above the horizontal. One meter from the end of the pole, a sign of mass 50 kg is attached. To support the pole, a horizontal cable runs from the end of the pole to the building.



(a) Calculate the tension in the support cable.

(b) Suppose that this cable eventually fails because the tension required was too high. Otto rebuilds the sign so it won't break this time, attaching a new cable at the same point to the pole, but to a different point on the building. (The building extends higher than is shown in the picture, so don't worry about that.) What should the angle between the support cable and the pole be to minimize the tension required?

(Note: If you completed this problem in recitation, just attach your recitation work to your homework.)