Homework 9

Due Wednesday, May 4

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

   (g) Angular momentum

2. 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 $\alpha = 4000\ \mathrm{rev} \cdot \mathrm{min}^{-1} \cdot \mathrm{s}^{-1}$? 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?

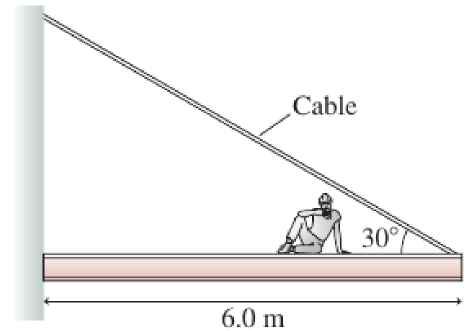
   (g) After four seconds, how many times has the disc rotated?

3. 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 weight of 1 N. 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. We will put a meter stick in the Physics Clinic for people to play with.

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. When very large stars reach the ends of their lives, their cores are made of solid iron. A supernova happens when the iron core can no longer support the weight of its own gravity; it collapses into a much smaller object (of essentially the same mass) called a neutron star.

   Suppose that before the core collapses, it has a radius of 6000 km. During the core collapse, it shrinks to a neutron star with a radius of 50 km.

   In both cases, you can model it as a uniform sphere with a moment of inertia of $I = \frac{2}{5}mR^2$.

   (a) Even if the core is rotating only very slowly before it collapses, it will be rotating quickly once it does. Explain briefly why.

   (b) Suppose that the neutron star rotates once every second. How quickly did the iron core rotate before it collapsed? (You can either describe its angular velocity in rotations per second, or tell me how many seconds it took to rotate before it collapsed.)

6. A person rolls a basketball ($I = \frac{2}{3}mr^2$) down a slope; the slope is inclined at an angle $\theta = 15°$. The basketball rolls without slipping down the slope.

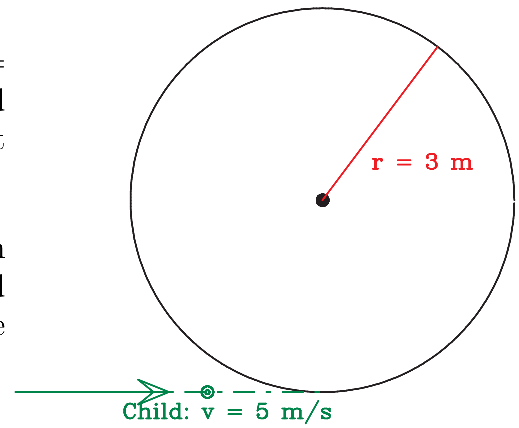
   At the same time, another person slides a piece of ice down the slope. There *is* friction between the ice and the slope – just not very much.

   What must the coefficient of kinetic friction μ_k between the ice and the slope be such that the piece of ice and the basketball have the same speed when they reach the bottom?

7. A “merry-go-round” is a large horizontal platform for children to play on that can rotate freely.

Imagine a certain merry-go-round has a radius of $r = 3$ m and a mass of 200 kg, and has been constructed out of fancy and well-lubricated bearings so that it rotates freely without friction.

Suppose a child of mass 40 kg runs and jumps on the edge of the platform at 5 m/s; when they land on the edge, they are moving tangent to it. (See the diagram.)



   (a) Once the child jumps on the platform, how will it move?
   (b) Now, imagine that the child walks to the center of the platform. How will it be moving now?

8. An large old iron wheel of mass m, still connected to its axle, has been abandoned by a roadside. A person wants to move it, so they tie a rope to the axle, set the wheel up on its edge, and pull horizontally with a tension T. The coefficient of static friction between the wheel and the ground is μ_s and the coefficient of kinetic friction is μ_k.

   They pull gently enough that the wheel rolls without slipping.

   (a) Determine, in terms of m, T, g, and μ, the acceleration of the wheel. (Your result may not depend on all of these.)
   (b) Determine, in terms of m, T, g, and μ, the frictional force between the wheel and the ground. (Your result may not depend on all of these.)