Assignment IX, PHYS 101 (Introductory Physics I)
Fall 2020
Due via pdf upload to OAKS prior to *SATURDAY*, November 14th at 11:59 PM

General instructions:
Same instructions as usual. For this, and all other homework assignments, please turn in your solutions with all supporting work; answers without supporting work will not earn credit.

Suggested additional (ungraded) practice problems
Chapter 9: https://openstax.org/books/college-physics/pages/9-problems-exercises
Problems from all of chapter 9 (sections 9.2, 9.3, 9.4, 9.5, 9.6, 9.7)
Chapter 10: https://openstax.org/books/college-physics/pages/10-problems-exercises
Problems from sections 10.1, 10.2, 10.3, 10.4, and 10.5

1. This first problem should be reminiscent of a recent lab. A meter-stick is (surprise) 1.00 meter long and has a total mass of 80 g. Let us say that you put this meter-stick on a fulcrum with the pivot point being 22 cm from the left edge.

   a) Assuming the density of the meter-stick is constant (e.g. each cm of length has the same mass as every other cm of length), what is the net torque about the pivot point when the meter-stick is horizontally aligned?

   b) Again assuming the density of the meter-stick is constant, how much mass would you need to hang on the very left edge of the meter-stick to balance the torque to keep the meter-stick aligned horizontally on the fulcrum?

   c) Let us now assume that the meter-stick is still 80 g, but the left-hand half of the meter-stick only has a mass of 30 g while the right-hand half has a mass of 50 g. (Each half still has a uniform density, though, so the left hand half has a mass of 0.6 g for each cm and the right hand half has a mass of 1.0 g from each cm). How far from the left edge of the meter-stick is the center of mass of the meter-stick?

   d) Using the same irregular meter-stick as noted in part (c) above and with the fulcrum located 22 cm from the left edge as in parts (a) and (b), what is the net torque about the fulcrum when the meter-stick is aligned perfectly horizontally?

   e) Using the same irregular meter-stick as noted in part (c) above and with the fulcrum located 22 cm from the left edge as in all parts of the problem above, how much mass would you need to hang 12 cm from the left edge of the meter-stick in order to balance it horizontally on the fulcrum?

2. An Atwood machine has its two masses with mass $m_1 = 100$ g and $m_2 = 105$ g. However, in an attempt to be more realistic, we no longer will assume that the pulley that the string moves over is frictionless. Rather, now the pulley rotates as the masses move. (This means some of your old formulas for an Atwood machine that assumed the tension was the same on both sides won't work any longer!) Assume the pulley has a radius of 5 cm and is made out of a uniform disk with mass 20 g. Find:

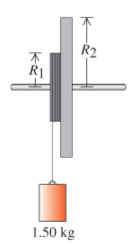
   a) The acceleration of the larger mass m_2.
   b) The tension of the string connected to m_1
   c) The tension of the string connected to m_2. (Note – because the pulley rotates and thus has a nonzero net torque, we know that this is *not* the same as the answer to part (b)!
   d) The moment of inertia of the pulley
   e) The angular acceleration of the pulley

   NOTE! You might need to keep a few more digits than normal when you write down your answers to this problem, because the effect of the pulley is important but – in some quantities above – changes the value only slightly.

3. A uniform cylinder of mass $M = 5$ kg and radius $R = 4$ cm *rolls* down a wedge of height $H = 2.3$ m and wedge-angle 23°. When the cylinder reaches the bottom of the wedge, what is the angular velocity of the wedge?

4. The moment of inertia of a compound object is equal to the sum of the moments of inertia of each piece. Two uniform metal disks with masses $m_1 = 1.35$ kg and $m_2 = 4.23$ kg and radii $R_1 = 7.0$ cm and $R_2 = 11.0$ cm (respectively) are welded together and mounted on a frictionless axis through their common center as shown in the figure below.

   a) What is the total moment of inertia of the two disks with respect to the axis shown?
   b) Let a massless, inextensible string be wrapped around the edge of the smaller disk and a 1.50 kg block is suspended from the free end of the string. If the block is released from rest a distance 10.00 m above the floor, what is the speed of the block just before it strikes the floor?
   c) Repeat your calculation in part (b) above if the string is wrapped around the edge of the larger disk instead.

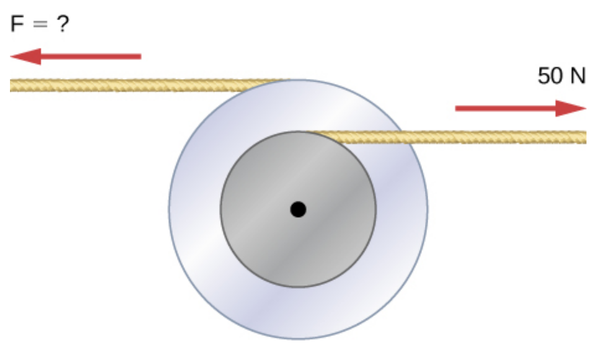


5. Consider the system displayed below. The mass distribution in both wheels is not uniform, but rather weighted towards the outside – so the moment of inertia of each of these wheels is not $\frac{1}{2}MR^2$ like it would be for a uniform disk, but rather $\frac{3}{4}MR^2$. The wheels are welded together and – as shown – a 50 N force is applied from a rope to the right connected to the smaller wheel. The mass and radius of the smaller wheel are 2.5 kg and 35 cm, respectively. The mass and radius of the larger wheel are 5.2 kg and 45 cm, respectively.

   a) How large must the force on the rope attached to the larger wheel be to hold the system from rotating?

   b) How large must the force on the rope attached to the larger wheel be if the system goes from rest to completing 5 full rotations counter-clockwise in 18.0 seconds?

   c) Continuing on from part (b) above, what would be the angular momentum of the system after 18.0 seconds?



6. A baseball (approximately a uniform sphere with mass = 145g and radius = 3.7 cm) is thrown from the pitcher's mound to home plate. On its path, it moves at an approximately constant speed of 45.151 m/s (aka 101 mph) and rotates about its axis at about 2000 rotations per minute (aka $\omega = 209.4$ rad/s).

   a) What fraction of the baseball's total kinetic energy as it moves towards home plate is in the form of rotational kinetic energy? (In other words, what is the baseball's rotational kinetic energy divided by the sum of its rotational and translational kinetic energies?)

   b) What is the angular momentum of this baseball about its axis during the throw?