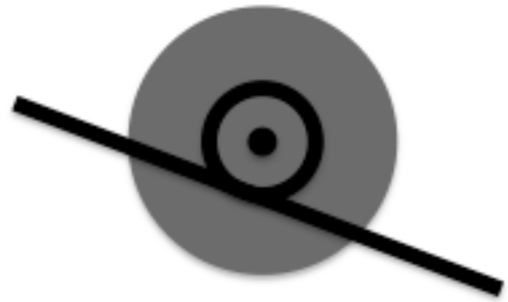
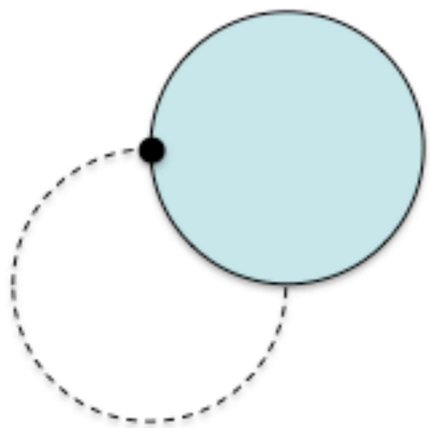
Problem Set #10 due beginning of class, Monday, Nov. 30

#1 Remember the flywheel from the first problem in PS #7?, now it has a hub on either side, rolling down two rails inclined at 30° as shown at right. The flywheel is a 3 kg flat disk of uniform thickness and has a radius of 30 cm. The hub is of radius = 10 cm.
The flywheel starts from rest and rolls without slipping along 4 m of rail.



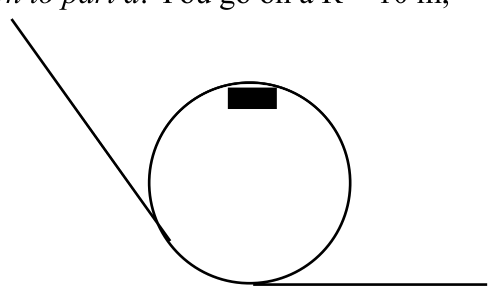
a) What is the loss of potential energy?
b) Find the final velocity and rotational velocity. *hint: you have two unknowns and only one equation! Poop! Ah, but there is a relationship between the speed of the disk and how fast it is spinning. Is this a helpful relationship?*
c) Use the above to find the average velocity, the time taken, and the angular and linear acceleration.
d) Use the above to find the torque on the wheel, and therefore find the frictional force that must have been applied by the rails.
e) Now that you know the frictional force on the wheel, and the force of gravity, can you find the acceleration the wheel should have and see if it matches your value for (c) above?

#2 A disk of uniform mass and radius, R is secured to a wall with a frictionless pivot that allows rotation as shown at right. It is started in the higher position where the center of the circle is at the same height as the pivot and allowed to drop and swing. When the disk is at the bottom of the swing (dotted line), please find:



a) Omega, the angular velocity of the disk about the pivot.
b) The angular momentum of the disk about the pivot.
c) The force that the pivot is providing to the disk. Include direction.

#3 *If you think you've already done this problem before, just skip down to part d*. You go on a R = 10 m, loop-de-loop ride at the carnival, but you have to choose how high to start the cart. Say you have a mass of 70 kg, like your instructor and you are sitting on a scale that reads in kg.



a) If you start from a vertical height of 40 m, what does the scale under you read as you are at the top of the loop? What does it read at the bottom of the loop as you enter the loop? Is this a good ride for pregnant women? How does it feel as you round the bottom of the loop?
b) What would happen if you decide to start the cart at the same height as the top of the loop? Why would this happen?
c) Please find the minimum vertical height, above the ground that you must start the ride.
d) Let's say that the object is instead a <u>*hollow*</u> sphere that is rolling without slipping. How would this change the problem? Can you do part a) and c) above for this scenario?

#4 Remember PS #8, question #4? We are doing a variation of this. Instead of pulling on the string with 100 N, we are putting a 10 kg mass on the end of the 2 m string and letting it fall. Again, the flywheel is a 3 kg flat disk of uniform thickness, is on a frictionless bearing, and has a radius of 30 cm. You have the string wrapped around the hub (or spindle, or pulley) of radius = 10 cm.

a) We know that the tension in the string is 100 N because it is an equal and opposite force to gravity, right? If this is the case, then the problem is the same as PS #8, and you are already done! If not, please continue with the rest of the problem

b) How is this different from the situation in PS #8 from a perspective of
   i) energetics? Where does the 200 J go?
   ii) dynamics? Is the tension on the string still 100 N? What would it mean if it was?

Now you are going to solve this problem 3 different ways.

c) Using energetics, please find the final angular velocity of the wheel after the block has fallen 2 m.

d) Using dynamics, please set up the torque and force equations on the wheel and mass respectively, to find the two unknowns: the tension in the string and the acceleration of the block.

e) Lastly there's a tricky way you can solve this as a system! Imagine that the length of the string is zero meters. Then the block is part of the wheel. This mass just adds to the wheel's moment of inertia. Because the block is offset, it provides torque. Use this to find the angular acceleration of the wheel at that moment. In reality, can you show that as the mass falls, it maintains this same rotational acceleration?

f) Verify that all three methods give you the same answers. You will need to use the velocity from b) to find accelerations and angular accelerations… or the other way around.

5. This is from class Week 10, Day 2:

You stand on a scale at the north pole and then on a scale at the equator. Assume that the earth is a perfect sphere. You find that at the equator, you weigh:

1) More because the normal force compensates for both gravity *and* centripetal force.
2) Less because the normal force at the equator is not enough to keep you in equilibrium.
3) The same because the normal force is always the same as gravity.
4) None of these.
5) Not enough information