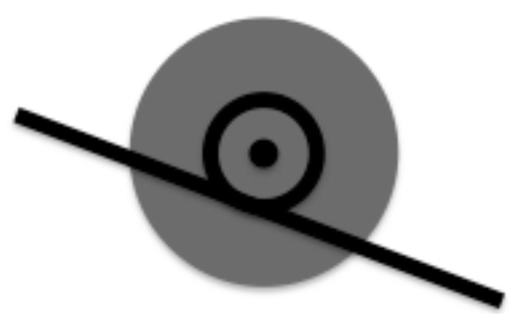
PS#11 Due Thursday, Dec. 6 in class. Remember to start each question with a description of the lens and method.

1) A bicycle is a beautiful thing to me! Imagine that I can put a constant force (perpendicular to the radius of rotation) of 200 N onto the pedal that is 20 cm long, and am able to maintain that force for some time as I pedal along. Let's say that I am rotating the pedals at 60 rotations per minute. Imagine that I am riding up at constant speed against wind friction.

A) Find the torque my legs put on the pedals and the omega of the pedals.
B) Find the power I'm putting out.
C) I'm in my highest gear, the diameter of the pedal gear is 20 cm, and the diameter of the gear driving the rear wheel is 4 cm. Please find the tension in the chain, and the torque the chain produces on the rear wheel.
D) Given the speed of the chain and the tension in the chain, what is the power I deliver to the chain?
E) What is omega of the rear wheel? What is the power the torque of the chain delivers to the rear wheel?
F) If the diameter of the rear wheel is 700 mm, what is the force that the torque on the rear wheel delivers to the road (assume that there is no slipping).
G) What must be the speed of the surface of the rear tire surface (which is equal to the speed of the bike)? And what is the power that this surface delivers to the bicycle?
H) At some time, I change gears, putting the chain on a rear gear cluster on a gear that is 8 cm in diameter (doubling the diameter of the rear gear), and I am able to continue putting the *same amount of force* on the pedals. What change to I experience? What do I notice in my pedaling? what would be the new:
   i) The torque on the rear wheel?
   ii) The power to the rear wheel?
   iii) The speed of the chain?
   iv) Omega of my legs?
   v) What will happen to the motion of my bike?
   vi) What will happen to the feeling in my body? (will I relax or do I have to work harder?)

2) Remember the flywheel from the first problem in PS #6?, 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?

3) The classic "notorious ladder problem": why does a ladder not slip when you stand on it at the bottom, but then it slips as you go higher? *Please don't attempt this problem until you thoroughly understand the diving board problem from previous problem sets.* A 30 kg 5 m ladder leans up against a frictionless wall at an angle of 53° with respect to the ground. You are 50 kg, and the coefficient of static friction with the floor is a dangerous 0.50. At first, you are standing at the base of the ladder on the bottom rung, essentially 0 meters from the bottom.

a) I hope you already drew a great diagram! … and labeled all the forces? And thought about all the torques? Do you have a lens? Can you group all the horizontal forces and make a statement about them? Can you do the same with all the vertical forces?

b) How much force can we depend on the friction to provide for us? Is this the actual force friction is providing, or don't we know? The actual amount of frictional force is going to depend on how hard we push on it. What forces are competing with this frictional force to keep the ladder in equilibrium?

c) We may notice that there's a normal force provided by the wall the ladder is leaning against? Why is this force necessary? Does this normal force supply a necessary torque to keep the ladder in equilibrium?

d) Please set up the torques. Which point to you use to be the center of rotation? Why do you choose that point? Can you use this equation to find the normal force of the wall on the ladder. How do you calculate the torque when the forces are not perpendicular to the radius?

e) Can you use this information to show that the ladder does not slip when you are on the bottom rung of the ladder? Can you show that you can "test" the ladder by bouncing up and down on it and it won't slip?

f) Now that you are confident about the security of the ladder, you start walking up the ladder. Which of the equations does this change? How does it change them? How does the situation become more dangerous?

g) Will I make it to the top of the ladder? Find out by doing an analysis with me at the top of the ladder, and see if the ladder will slide.

h) Please find my location when the ladder slides. Is it bad for me?

i) If we were to do this problem again, and we changed the inclination angle of the ladder to 60°, would this make the situation safer, or more dangerous? How do you know?

4) In class I give you two ways to find a coefficient of friction between the masses and the spinning turntable: by measuring how far the disks move horizontally as they fall, and by measuring the inclination when the disks slip. Please get the measurements in class and do both calculations and see if you get reasonably close answers for the two different ways.

5) Hit a baseball off a cliff: Exercise 6, section 7.6