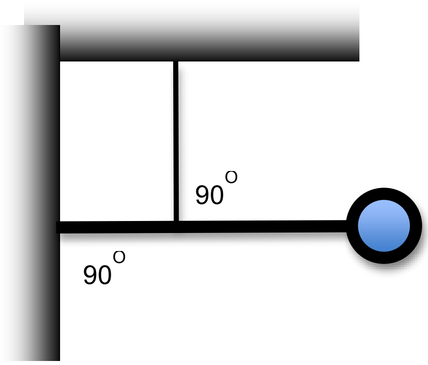
Problem Set #8 due beginning of class, Monday, Nov 17. 100 pts. total

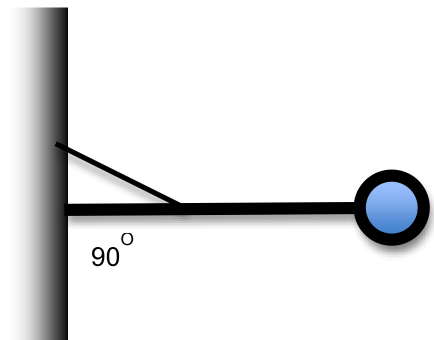
2 pts extra credit per extra person in the group – up to 8 points possible!

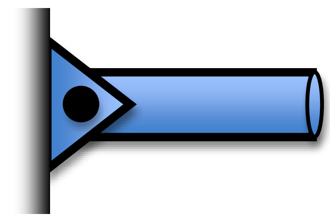
3 pts extra credit if you don't use a calculator: if so, write and sign a statement at the top of the problem set: "I [your name] did not use a calculator for any part of this problem set."



#1 A 30 kg sphere is suspended in front of a store as a sign. It is at the end of a 1.5 m bar and a cable is connected just 50 cm along the bar from the store front as shown. *Read 9.1 - 9.4 in your text to learn how to do this.* Where the bar meets the wall there is a pivot, as illustrated at bottom, so the bar is free to rotate about this point, but not move translationally

a) We want to find the tension in the cable (right, top), what concept of physics is used here? State which of the 4 concepts and if it's linear or rotational, and state why you know it.
b) Label all the forces on the bar.
c) Which point do you use as the center for calculating torques? Why do you use this point?
d) Find the tension in the cable.
e) Find the force supplied to the bar by the store front. – indicate direction.
f) If the mass of the bar was 100 kg as well, what would be the tension then? This mass can be treated as being a point mass at the center of mass of the bar. *Section 9.4 of your text demonstrates how to use center of mass (they call center of gravity, CG).*
g) What would happen if we moved the cable's connection point on the bar closer and closer to the store front? How do you know?
h) How about if instead of being vertical, the line made a 30 degree angle with the bar as shown in the middle? What would this do to the tension in the string *and the force supplied by the wall*? How do you know?





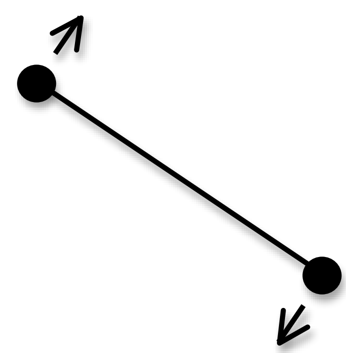
#2 A child's carousel has a mass of 100 kg and a diameter of 3 meters, and is spinning at clockwise as viewed from above at 1.5 revolutions per second. Assume that the mass is uniformly distributed over the circular area. Two kids, 30 kg point masses, each are dropped from rest simultaneously on opposite sides of the carousel, 1 meter from the center.

a) Find the moment of inertia of the carousel and the moment of inertia of the two children.
b) Find the initial angular velocity, ω_o, please include direction using the right hand rule.
c) What happens to the rotation rate of the carousel after the kids are dropped onto the surface? Why is this? Please identify the appropriate physics concept in your answer.
d) Please find the final angular velocity, ω_f.
e) Please find the initial and final kinetic energy of the carousel + children system before and after the stationary kids were dropped onto the carousel's surface. Was kinetic energy conserved? If not where did it go, and how?
f) What was the change of angular momentum, $\Delta\vec{L}$ of the carousel itself? What was the change in angular momentum, $\Delta\vec{L}$ of the two kids? These are vectors, please include direction.
g) If it took 0.05 s for the kids to get moving at the same speed as the carousel (the vertical bars holding them pushed them along abruptly, but without hurting them), what was the average torque supplied to the carousel when their bodies were added?
h) If the two kids then moved out to the edge of the carousel, stationing themselves at a radius of 2 m (yes, they can do that by hanging onto the vertical bars and reaching out past the surface, but we don't endorse this behavior), what is the new angular velocity of the carousel?

#3 You see a 10 kg rock in space moving with constant speed of 10 m/s in a circle of radius 20 meters. I wonder what force is acting on this rock.

a) Find the angular velocity, ω of the rock.
b) Why you know the rock is accelerating if it is moving with constant speed?
c) Find the acceleration of the rock, including direction of the acceleration.
d) Calculate the force necessary to accelerate this rock.
e) What kind of force is this? – if you say, "it is centripetal force!" you will receive zero points. You will receive full credit if you say, "I have no idea what force is acting on it, because I can't see anything that the rock is interacting with, so I have to look around at what object must be applying a force of_____(put answer from d) on the rock to make it accelerate at______(put answer from c)."
f) Then you see a string attached to my arm as I spin the rock in a circle. What kind of force is it? Find the tension in the string.
g) Then the string breaks – what happens to the rock? Please Draw a Picture
h) ….instead of me and a string, you see a large sphere in the middle of the rock's circular path. What kind of force might be acting on the rock now? If this force is gravity, what must be the mass of the large sphere in the center? If the mass at the center has the largest possible radius of 20 m, what would be the density of the object? Is there any known substance with this density?
i) ….instead, you notice that the 10 kg rock is actually a small 10 kg toy car driving around in a 20 m circle on a flat parking lot at 10 m/s. Now what force is acting on the car? Please find the coefficient of friction necessary to keep the car moving in this circle.

#4 You see two equal masses tied together with a string spinning in space at constant angular speed, w_o, when a motor at the center pulls them both inward such that the final diameter of their paths is 1/3 the original diameter, or, d => 1/3 d_O.



a) In this process, what do we know is conserved? What may not be conserved?

Please state how each of the following changes during this process and show your work, or explain reasoning:

b) The moment of inertia of the system, I => ___ I_O,
c) The angular momentum of the system, L => ___ L_O,
d) The rotational velocity, ω => ___ ω_O,
e) The tension in the string connecting the masses
g) The kinetic energy, KE => ___ KE_O,
h) Is kinetic energy conserved in this interaction? If so, how do you know? If not, where did the kinetic energy go, or come from?
i) now please go back and ask yourself if these answers make sense. Is this like the figure skater spinning on near frictionless ice?

#5 extra credit: OMG! That woman was spinning at 308 rpm! Can you DO that? Please do some kind of analysis as to whether a normal person could hold their arms in toward their body while spinning at such a high rotational velocity.