#9 * (more difficult problem) Remember PS #7, question #1? 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. This is discussed in the rotational systems video. 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) How is this different from the situation in PS #7 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?

Please solve this problem 3 different ways.

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

c) 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.

d) 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?

e) 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.

#10. I spin a 2 kg rock over my head about a vertical axis (like David and Goliath) from a 2m string such that it makes an angle of 30° below the horizontal.

a) Find the radius of the rock's trajectory, the speed of the rock and the tension in the string.

*As I described in the video of sum of the forces = mass * $a_{centripetal}$, there are three different ways I can ask this same question. Are you ready for each one of them?*

b) Make the corresponding question for a (miniature) bicyclist rounding a corner. What must be the angle that the bicyclist's body makes with the pavement? What if I give you the angle and ask for something else?

c) Make the corresponding question for a toy car rounding a banked turn on a frictionless surface. What must be the bank of the curve? What if I give you the angle and ask for something else?

d) Make the corresponding question for a (toy) airplane baking a turn. What must be the bank of the wings?