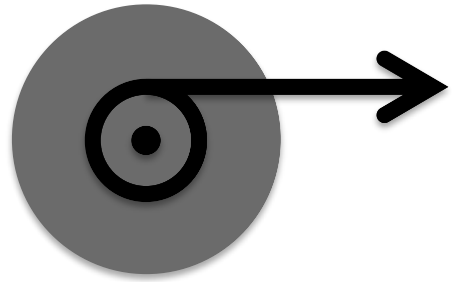
I found these problems on 2 problem sets from last quarter. I changed the problem numbers

#1 You spin up a flywheel by pulling 2 m of string with a tension of 100 N as shown at right. The flywheel is 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.



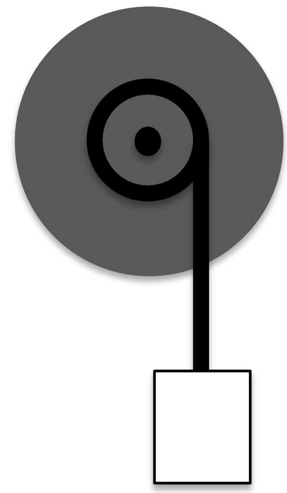
a) Find the moment of inertia of the flat disk flywheel.
b) Find the work I do pulling the string. Where did this work go?
c) Find the final angular velocity, ω. Which lens are we using to solve this problem?
d) Find the total angle, θ the wheel turns through while I am pulling the string.
e) If $\omega_o = 0$, and assuming there is constant angular acceleration, what is the average ω during the time I'm pulling the string, and how long does it take me to pull the string?
f) What is the angular acceleration α, of the wheel while I am pulling the string?
g) Find the torque, τ, that I must apply to accelerate the wheel as I did

#2 We repeat the above problem using rotational dynamics! Start with the same problem and assume you have so far only calculated moment of inertia and nothing else.
a) Please find the torque, τ provided by the tension of the string pulling on the pulley.
b) Calculate the angular acceleration, α, of the wheel as you are pulling it. What is necessary to have constant angular acceleration while you are pulling the string?
c) We will learn that rotational work is rotational force times rotational distance, or $W = \tau*\theta$. Is the linear work you did pulling the string = the rotational work done on the wheel?
d) Which way, *energy* lens or *rotational dynamics* lens, do you like best? Why?

#3 For the problem above, image that we use the same flywheel, but the hub radius is 20 cm; that is the radius of the pulley is doubled. We want to see which other things change and by what factor. Please provide proof. If r_{pulley} => 2_ r_o, then:
a) How does this change the total angle θ that the wheel turns while I am pulling the string? θ => __ θ_o
again, please show reasoning for each question.
b) How does the final angular speed change? ω => __ ω_o
c) How does the Torque change? τ => __ τ_o
d) How does the angular acceleration change? α => __ α_o
e) How does this change the time it takes to pull the string? t => __ t_o

#4 For problem #1 and #2 above, imagine that you have the *same pulley*, but instead you attach a flywheel that is twice the radius, made of the same metal, of the same thickness, but has a radius of 60 cm. That is, we double the radius of the flywheel (we have to add more material in the process): $R_{flywheel}$ => 2_ R_o,
a) How does this change the mass of the flywheel? $m_{flywheel}$ => __ m_o,
again, please show reasoning for each question.
b) How does the moment of inertia of the wheel change? $I_{flywheel}$ => __ I_o,
c) How does this change the torque that I apply by pulling the string? τ => __ τ_o
d) How does the final angular speed change? ω => __ ω_o
e) How does the angular acceleration change? α => __ α_o
f) How does the total angle θ that the wheel turns while I am pulling the string change? θ => __ θ_o
g) How does this change the time it takes to pull the string? t => __ t_o

#5 Remember the flywheel on question #1 above? 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! Please explain why you know this is *not* the case and 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?
iii) What happens in the limit that the falling mass has way more mass than the wheel?
iv) What happens in the limit that the falling mass has way less mass than the wheel?

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.