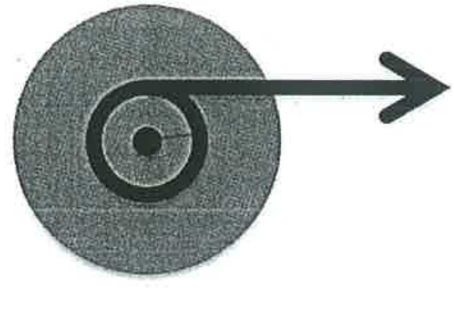
Excellent.

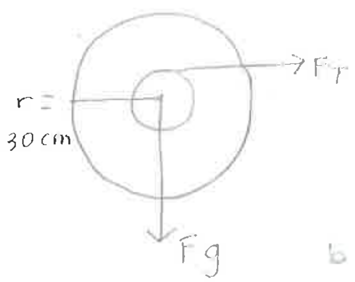
Big Exam #6 Nam ________

#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. We will find everything in this problem by starting with energetics!



a) Section 10.3 of your text is about moment of inertia with a nice table showing the moments of inertia for different shapes. 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 $\omega_0 = 0$, 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

Energy lens - $PE_i + KE_i + W_{in} = PE_f + KE_f + W_{out}$ (Heat)



a) we can use $I = \frac{1}{2}mr^2$ to find the moment of inertia

$I = \frac{1}{2}(3kg)(.3m)^2 = \boxed{.135\ kgm^2}$

b) $W = F \cdot d = (100N)(2m) = \boxed{200\ Nm}$

c) $W = KE = \frac{1}{2}I\omega^2$ Energy lens because $W \Rightarrow KE$

$200J = \frac{1}{2}(.135\ kgm^2)\omega^2$

$\boxed{\omega = 54\ rad/s}$

d) $\theta = \frac{l}{R} = \frac{2m}{.1m} = 20$ radians

$\vec{\omega}_{avg} = \frac{d\theta}{dt} \rightarrow dt = \frac{d\theta}{\omega_{avg}}$

e) $\omega_0 = 0$ $\vec{\omega}_f = 54\ rad/s$

$dt = \frac{20\ rad}{27\ rad/s} = \frac{20}{27}s$

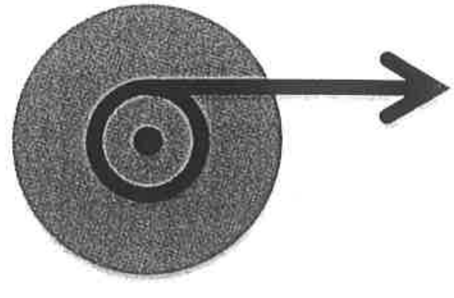
$\omega_{avg} = \frac{54\ rad/s - 0}{2} = \boxed{27\ rad/s}$

$\boxed{dt = 0.74s}$

f) $\vec{\alpha} = \frac{d\omega}{dt} = \frac{54\ rad/s}{.74s} \approx \boxed{73\ rad/s^2}$

g) $\Sigma\vec{\tau} = I\vec{\alpha} = (.135\ kgm^2)(73\ rad/s^2) \approx \boxed{9.9\ Nm} \approx 10\ Nm$

#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? It is more straight-forward

Dynamics · force cause the wheel to accelerate

$I = .135 \text{ kg m}^2 \qquad T = 100 \text{ N} = F_\perp$

a) $\vec{\tau} = r\vec{F}_\perp = (.1\text{m})(100\text{N}) = \boxed{10 \text{ N}\cdot\text{m}}$

b) $\vec{\tau} = I\vec{\alpha} \rightarrow \vec{\alpha} = \frac{\tau}{I} = \frac{10 \text{ Nm}}{.135 \text{ kgm}^2} \approx \boxed{74 \text{ rad/s}^2}$

c) $W = F \cdot d = \tau \cdot \theta$

$W = (100\text{N})(2\text{m}) = 200 \text{ Nm}$

$\theta = \frac{l}{r} = \frac{2\text{m}}{.1\text{m}} = 20 \text{ rad}$

$W = (10 \text{ N}\cdot\text{m})(20 \text{ rad}) = 200 \text{ Nm}$

$\boxed{\text{linear W = rotational W done on the wheel}}$