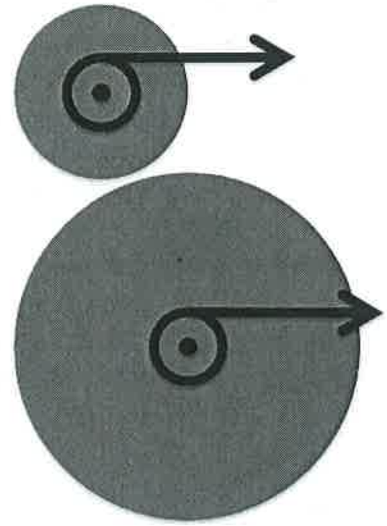
Big Exam #4, SUSTAIN, Schwartz Name Peter V Schwartz



1) Remember that we pulled 2 m on a string wrapped around the hub of a wheel in the problem set? Now we do the same thing, except that we do it with a flywheel made of the same material (same thickness) with twice the radius of the orginal wheel. The hub around which the string is wound is the same radius. That is, we double the radius of the flywheel (we have to add more material in the process): $R_{flywheel} \Rightarrow \underline{2}\ R_o$,

a) How does this change the mass of the flywheel? $m_{flywheel} \Rightarrow \underline{4}\ m_o$, *again, please show reasoning for each question.*
b) How does the moment of inertia of the wheel change? $I_{flywheel} \Rightarrow \underline{16}\ I_o$,
c) How does this change the torque that I apply by pulling the string? $\tau \Rightarrow \underline{1}\ \tau_o$
d) How does the final angular velocity change? $\omega \Rightarrow \underline{\frac{1}{4}}\ \omega_o$
e) How does the angular acceleration change? $\alpha \Rightarrow \underline{\frac{1}{16}}\ \alpha_o$
f) How does the total angle θ that the wheel turns while I am pulling the string change? $\theta \Rightarrow \underline{1}\ \theta_o$
g) How does this change the time it takes to pull the string? $t \Rightarrow \underline{4}\ t_o$

Just a scaling problem

a) $m \propto V$

$V = \text{Thickness} \cdot \text{Area} = \text{Thickness} \cdot \pi r^{2} \Rightarrow 2^2 V_o = 4 V_o$

b) $I = \frac{1}{2} m R^{2} \Rightarrow 4 \times 4\, I_o = 16\, I_o$

$\times 4$ $\times 2$

c) $\tau = F \times r_{\perp}$ remains unchanged

d) I'll use energy. $W = \vec{F} \cdot \vec{\Delta x}$ – it's the same for both

$KE = \frac{1}{2} I \omega^2$ must be the same for both

$16\, I_o$ $\frac{1}{16}(\omega_o^2)$ $\omega \Rightarrow \frac{1}{4}\omega_o$

e) I'll use dynamics $\tau = I \alpha$ must be $\frac{1}{16}\alpha_o$

same $16 \cdot I_o$

f) $\theta = \frac{l}{r}$ same, same → this isn't "R", it's the radius of the hub

g) Kinematics $\omega_{ave} = \frac{\theta}{\Delta t}$ $\Delta t = \frac{\theta}{\omega_{ave}}$ same, $\frac{1}{4}$ $\Delta t \Rightarrow 4 t_o$

2) A child's carousel has a mass of 100 kg and a diameter of 3 meters, and is spinning clockwise as viewed from above (what rotational direction is this?) 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) If the interaction took 0.05s, what was the average torque on the carousel? What lens will you use?
f) Do you think kinetic energy was conserved in this event? Why or why not?
g) Could there be some qualitative question. Like what if I dropped them closer to the middle or closer to the edge?

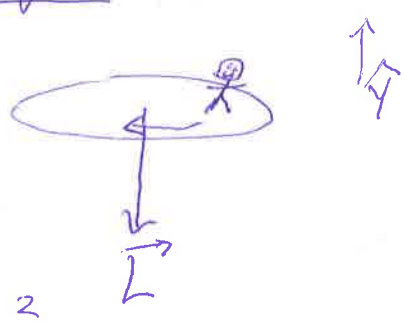
This is a "rotational collision". There are no external torques, so $\underline{\Delta \vec{L} = \vec{\tau} dt = 0}$ Conserve $\vec{L}$.
KE is lost to heat as the kids slide onto the moving surface.

$(2.25)50$ $\quad 1.5 \times 1.5$ $\quad 1.5 \times 1.5 = 75$

$$\vec{L}_o = I_o \vec{\omega}_o = I_f \omega_f = L_o$$

a) $I_{disk} = \left(\frac{1}{2}\right) MR^2 = \frac{1}{2}(100\,kg)(1.5\,m)^2 = \underline{112.5\,kg\,m^2}$ $\quad 2.25$

b) $\omega_o = \dfrac{1.5\,\cancel{rev}}{s} \dfrac{\overset{\sim 6.3}{2\pi}\text{ radians}}{\cancel{rev}} \approx 9.5/s\,(-\hat{y})$



c) $\omega \Downarrow$ $\quad L = I\omega$ ← must decrease; I ← increase

d) $I_f = I_{disk} + I_{kids}$ $\qquad I_{kids} = \overset{2\text{ kids}}{2}(30\,kg)(1m)^2 = 60\,kg\,m^2$

$= 112.5\,kg\,m^2 + 60\,kg\,m^2$

$\approx 172.5\,kg\,m^2$

$\vec{L} = I_o \omega_o = I_f \omega_f$

$\omega_f = \dfrac{I_o \omega_o}{I_f} \approx \dfrac{112.5\,\cancel{kg\,m^2}\; 9.5/s}{172.5\,\cancel{kg\,m^2}}$

$\approx 6.4/s\,(-\hat{y})$

angular momentum lens

e) $\vec{\tau} = \dfrac{d\vec{L}}{dt} = \dfrac{I\,\Delta\omega}{\Delta t} = \dfrac{112.5\,kg\,m^2(3.1/s)}{.05\,s}$

$\approx^+ 7000\,Nm\,\hat{y}$

f) see above statement at top

g) closer to the middle would have reduced I_{kids}, reducing $\Delta\omega$