Physics 160

Extra Credit # 25

10.9   Flywheel with $I = 2.7\ \text{Kg}\cdot\text{m}^2$

a) What $^{\wedge}$constant TORQUE to $\omega = 390\text{RPM}$ in 7.8s?

Constant TORQUE ⇒ Constant $\alpha \Rightarrow \omega = \omega_0 + \alpha t$

$$\Rightarrow \omega = \frac{390\text{rev}}{\text{min}} \times \frac{2\pi\text{rad}}{\text{rev}} \times \frac{\text{min}}{60\text{s}} = 13\pi\ \text{rad/s}$$

$$\therefore \alpha = \frac{13\pi\ \text{rad/s}}{7.8\text{s}} = 5.236\ \text{rad/s}^2$$

$$\sum T = I\alpha \Rightarrow \sum T = (2.7\ \text{Kg}\cdot\text{m}^2)(5.236\ \text{rad/s}^2) = 14.1\ \text{N}\cdot\text{m}$$

INCONVENIENT

$$\text{Unit}: (\text{Kg}\cdot\text{m}^2)\left(\frac{\cancel{\text{rad}}}{\text{s}^2}\right) = \left(\frac{\text{Kg}\cdot\text{m}}{\text{s}^2}\right)\cdot\text{m} = \text{N}\cdot\text{m}$$

So HAVE to USE RAD/s²

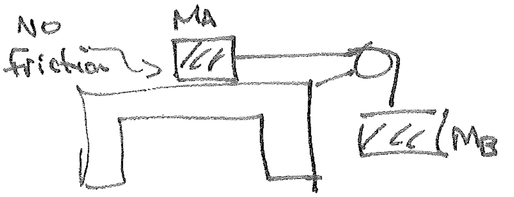
b) FINAL Kinetic? $K = \frac{1}{2}I\omega^2 = \frac{1}{2}(2.7\text{Kg}\cdot\text{m}^2)(13\pi\ \text{rad/s})^2$

$= 2251.75\text{J}$

$= 2250\text{J}$

YOU ALREADY KNEW we needed RAD/S there.

10.13



$M_A = 2.01\text{kg}$, $M_B = 2.91\text{kg}$

Pulley : Diameter $= 0.19\text{m}$

$\Rightarrow R = \frac{0.19\text{m}}{2} = 0.095\text{m}$

Books move 1.23m, in $t = 0.77\text{s}$

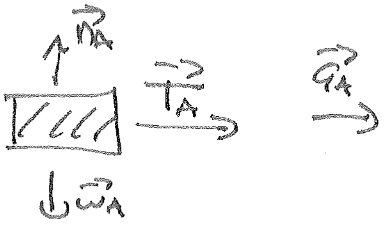
In the end, Gravity is responsible for all the motion. Gravity is constant $\Rightarrow$ Constant Acceleration

Look at M_A : $X_0 = 0$, $X = 1.23\text{m}$, $V_0 = 0$, $t = 0.77\text{s}$

$\Rightarrow X = X_0 + V_0 t + \frac{1}{2} a t^2$ can find acceleration

$1.23\text{m} = 0 + 0 + \frac{1}{2} a_A (0.77\text{s})^2 \Rightarrow a_A = \frac{2(1.23\text{m})}{(0.77\text{s})^2} = 4.149\text{m/s}^2$

Now draw fbd for A :



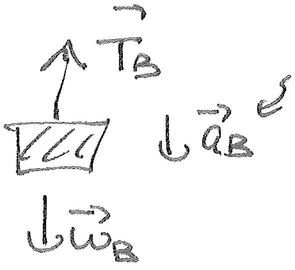
$\sum F_x = m a_x \Rightarrow T_A = M_A a_A$

$\Rightarrow T_A = (2.01\text{kg})(4.149\text{m/s}^2)$

$= 8.34\text{N}$

b) what is tension on M_B?

Now that the pulley isn't massless the tension on MB can be different. Luckily, ~~the~~ it still has to have the same magnitude of acceleration (since they are connected by a single rope)



B Accelera~~tes~~ down with $a_B = 4.149 m/s^2$

$\sum F_y = ma_y$

$\Rightarrow T_B - w_B = M_B a_{B,y}$

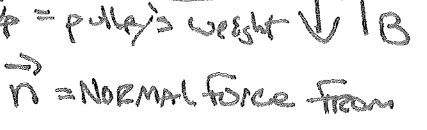
$\Rightarrow T_B - M_B g = M_B(-4.149 m/s^2)$

$\Rightarrow T_B = M_B(g - 4.149 m/s^2) = 2.91 kg\,(9.8 m/s^2 - 4.149 m/s^2) =$

$2.91 kg\,(5.651 m/s^2) = 16.4441 N = 16.4 N$

Part C: what is I for pulley.

Draw pulley's fbd being careful to include forces where they are applied



$\vec{w}_p$ = pulley's weight

$\vec{n}$ = normal force from pulley's support

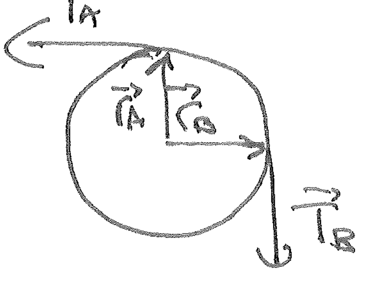
$\sum \tau = I\alpha$. $\vec{n}$ & $\vec{w}_p$ are both at $r = 0 \Rightarrow$ no torque. $\vec{T}_A$ trying to rotate counter-clockwise, $\vec{T}_B$ trying to rotate clockwise

$\Rightarrow \sum \tau = \tau_{T_B} - \tau_{T_A}$

I CHOSE clockwise to be positive BECAUSE I KNOW that's the direction it must be rotating.

$\vec{T_B}$ AND $\vec{T_A}$ BOTH Applied at edge $\Rightarrow$ at $R = 0.095\text{m}$

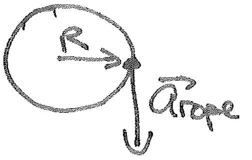
$\cancel{\Rightarrow}$ AND BOTH ARE perpendicular to their $\vec{r}$'s



so $\tau_{T_B} = RT_B$ $\quad \tau_{T_A} = RT_A$

$\Rightarrow \sum \tau = RT_B - RT_A = R(T_B - T_A)$

Finally α:



Rope's Acceleration must be the SAME As the pulley's a_{tan} at its edge. $\Rightarrow a_{Rope} = \alpha R$

Rope CONNected to B $\Rightarrow a_{Rope} = a_B = 4.149\text{m/s}^2$

$$\therefore \alpha = \frac{a_{Rope}}{R} = \frac{4.149\text{m/s}^2}{0.095\text{m}} = 43.67\text{rad/s}^2$$

$$\sum \tau = I\alpha \Rightarrow R(T_B - T_A) = I\alpha \Rightarrow I = \frac{R(T_B - T_A)}{\alpha} = \frac{0.095\text{m}(16.4 - 8.34)}{43.67}$$

$$\Rightarrow I = 0.0175\,\text{Kg}\cdot\text{m}^2$$

Unit: $\frac{\text{M}\cdot\text{N}}{\cancel{\text{rad}}/\text{s}^2} = \frac{\text{m}\cdot\text{Kg}\cdot\text{m}/\cancel{\text{s}^2}}{1/\cancel{\text{s}^2}} = \text{Kg}\cdot\text{m}^2$

inconvenient