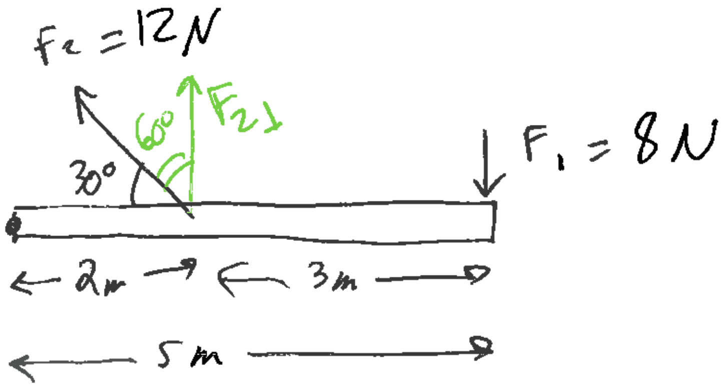
2)

A)



$$\vec{\tau} = \vec{r} \times \vec{F} \rightarrow \tau = r_{\perp} F = r F_{\perp}$$

CCW +

CW −

$$\tau_1 = 5m \cdot 8N = 40\ Nm \quad \text{CW} \ -$$

$$\tau_2 = 2m \cdot (\underbrace{12N \cos 60°}_{F_{\perp}}) = 12Nm \quad \text{CCW} \ +$$

$$\tau = -40Nm + 12Nm = \boxed{-28\ Nm}$$

CW

B) Forces thru the axis don't count!

$$\tau_1 = 0m \cdot 8N = 0$$

$$\tau_2 = 3m \cdot (12N \cos 60°) = \boxed{-18\ Nm}$$

CW

17) Energy to find V_f. Biggest V_f hits first

$$E_o = E_f$$

$$U_g = K_{Trans} + K_{rot}$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$mgh = \frac{1}{2}mv^2 + \frac{1}{2}(\# \cancel{m} r^2)\left(\frac{v}{r}\right)^2$$

$$\cancel{m}gh = \frac{1}{2}\cancel{m}v^2 + \frac{1}{2}\# \cancel{m}v^2$$

$$2gh = v^2 + \# v^2$$

$$\frac{2gh}{1+\#} = v^2$$

Biggest V for smallest $\#$ (in $I = \# mr^2$)

	Object Shape	I	$\#$
small V	Hoop	mr^2	1
empty can somewhere between Hoop & D-cell	tennis ball	$\frac{2}{3}mr^2$	$\frac{2}{3} = 0.\overline{6}$
↓	D-cell	$\frac{1}{2}mr^2$	$\frac{1}{2} = 0.5$
	marble	$\frac{2}{5}mr^2$	$\frac{2}{5} = 0.4$
Big V	Box	0	0

67 Approach:

Note! This one's a great review! Do it again before the final for practice. :)

① FBD for each object

② $\Sigma F = ma$ for A & B

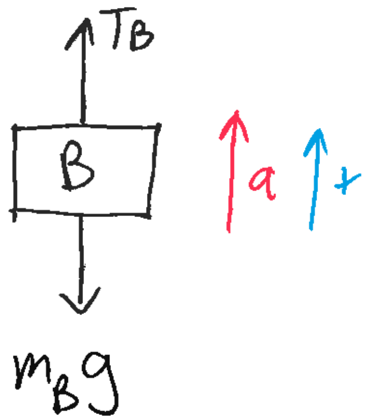
③ $\Sigma \tau = I\alpha$ (rotational equivalent) for C

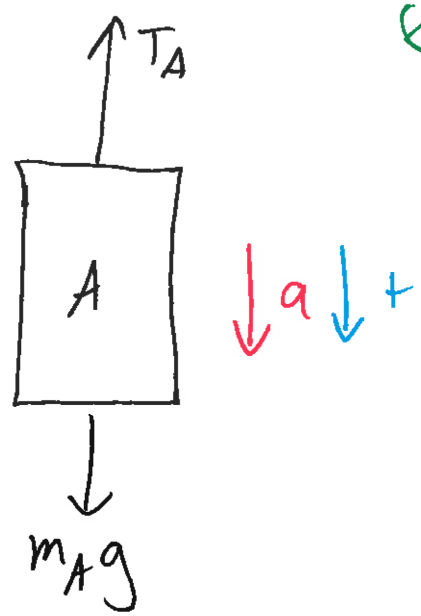
④ relate a & α

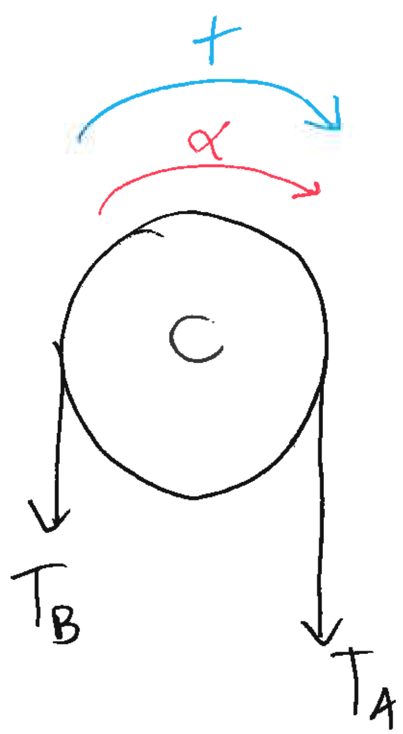
⑤ look for 3 eq^{n}s & 3 unknowns

Note: these steps are the same as for <u>any</u> force problem from Ch 4-5.

① FBDs







There's also gravity down and a rope up, but don't affect torque.

From this picture, T_A can't be equal to T_B, or else the pulley wouldn't speed up.

$\underline{A}$: $\Sigma F = ma$

① $+m_A g - T_A = m_A a$

These steps are similar to Disc 4, 5.15, except $T_A \neq T_B$

$\underline{B}$: $\Sigma F = ma$

② $+T_B - m_B g = m_B a$

$\underline{C}$: $\Sigma \tau = I\alpha$

$RT_A - RT_B = I_c \alpha$

R is $\perp$ to each T, so $\sin\theta = \sin 90° = 1$

③ $RT_A - RT_B = I_c a/R$

④ $\alpha = a/r$

② & ③ $\Sigma F = ma$

Three equations with 3 unknowns! ☺ (T_A, T_B, a)

① $m_A g - T_A = m_A a \rightarrow T_A = m_A g - m_A a$

② $T_B - m_B g = m_B a \rightarrow T_B = m_B a + m_B g$

③ $RT_A - RT_B = I_c \dfrac{a}{R} \Rightarrow T_A - T_B = I_c \dfrac{a}{R^2}$

$$(m_A g - m_A a) - (m_B a + m_B g) = \frac{I_c a}{R^2}$$

get a's all on same side.

$$m_A g - m_A a - m_B a - m_B g = \frac{I_c}{R^2} a$$

$$m_A g - m_B g = \frac{I_c}{R^2} a + m_A a + m_B a$$

$$(m_A - m_B) g = \left(\frac{I_c}{R^2} + m_A + m_B\right) a$$

$$\frac{(m_A - m_B) g}{\frac{I_c}{R^2} + m_A + m_B} = a$$

$$a = \left(\frac{m_A - m_B}{m_A + m_B + \frac{I_c}{R^2}}\right) g$$

if $I_c = \frac{1}{2} m_c R^2$, then

Part B Solved!

$$\boxed{a = \left(\frac{m_A - m_B}{m_A + m_B + \frac{1}{2} m_c}\right) g}$$

Part A) plug in

$m_A = 4\,kg$

$m_B = 2\,kg$

$I_c = 0.300\,kg\,m^2$

$R = 0.120\,m$

$g = 9.80\,m/s^2$

$$\boxed{a = 0.730\,m/s^2}$$

$$\alpha = \frac{a}{R} = \boxed{6.08\,rad/s^2} = \alpha$$

From 1

$$T_A = m_A g - m_A a = m_A(g-a) = \boxed{36.3\,N} = T_A$$

From 2

$$T_B = m_B(a+g) = \boxed{21.1\,N} = T_B$$

Part D) $I_{tot} = I_A + I_B + I_c$

$$= m_A R^2 + m_B R^2 + I_c$$

$$= 0.3864 = \boxed{0.386\,kg\,m^2}$$

Part E) This is Kinematics like Ch 2.

want V_f from a, t:

$$V_f = V_0 + at$$

$$= 0 + 0.730 \cdot 0.5 = \boxed{0.365\,m/s}$$

Part F) $\omega = \frac{V}{R} = 3.041\overline{6} = \boxed{3.04\,rad/s}$

Part G) $K_{tot} = K_A + K_B + K_C$

$$= \tfrac{1}{2} m_A V^2 + \tfrac{1}{2} m_B V^2 + \tfrac{1}{2} I \omega^2$$

$$= 1.78744 = \boxed{1.79\,J}$$

Part H) $L_{tot} = L_A + L_B + L_C$

Note: I wrote one of the relevant formulae wrong!

$\vec{L} = I\vec{\omega}$ is correct $\cancel{\vec{L} = m\vec{\omega}}$

Sanity check: $\vec{p} = m\vec{v}$ for linear momentum

$$\begin{array}{ccc} \vec{p} & m & \vec{v} \\ \downarrow & \downarrow & \downarrow \\ \vec{L} & I & \vec{\omega} \end{array}$$

$$L_{tot} = Rm_A v + Rm_B v + I_c \omega$$

all perpendicular so cross-product's $\sin\theta = 1$

$$= Rv(m_A + m_B) + I\omega$$

$$= 1.17530$$

$$= \boxed{1.18 \text{ kg}\cdot\text{m}^2/\text{s}}$$

Units: $R\,m\,v$

$\downarrow \quad \downarrow \quad \downarrow$

$m \quad kg \quad m/s \rightarrow kg\,m^2/s$