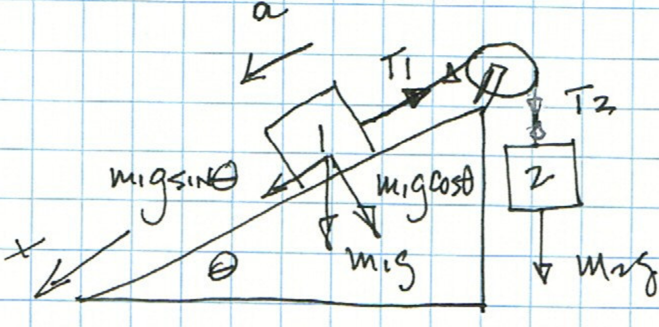
CHAPTER 8 #68



$m_1 = 8.0\ kg$
$m_2 = 3.0\ kg$
$\theta = 30°$

$R = 0.10\ m$ $M = 0.10\ kg$

a.) ACC = ? mass of string = 0, no friction

b.) FRIC TORQUE IN PULLEY $0.050\ N\cdot m$

$ACC' = ?$

3 SUB SYSTEMS: m_1, m_2, PULLEY

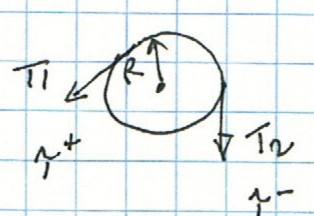
m_1

$$\Sigma F = m_1 g \sin\theta - T_1 = m_1 a$$

m_2

$$\Sigma F = T_2 - m_2 g = m_2 a$$

M (PULLEY)



$$\Sigma \tau = I\alpha = I\frac{a}{R} \qquad I = \frac{1}{2}MR^2$$

$$\Sigma \tau = \tau^+ - \tau^- = \frac{I a}{R}$$

$$= T_1 R - T_2 R = \frac{I a}{R} \rightarrow (T_1 - T_2)R^2 = \frac{1}{2}MR^2 a$$

$$T_1 - T_2 = \frac{1}{2}Ma$$

3 UNKNOWN T_1, T_2, a

$$m_1 g \sin\theta - T_1 = m_1 a \rightarrow T_1 = m_1 g \sin\theta - m_1 a$$
$$T_2 - m_2 g = m_2 a \rightarrow T_2 = m_2 g + m_2 a$$
$$T_1 - T_2 = \frac{1}{2}Ma$$

$$T_1 - T_2 = (m_1 g \sin\theta - m_1 a) - (m_2 g + m_2 a) = \frac{1}{2}Ma$$

$$= m_1 g \sin\theta - m_2 g - (m_1 + m_2)a = \frac{1}{2}Ma$$

$$= (m_1 \sin\theta - m_2)g = \left[\frac{1}{2}M + (m_1 + m_2)\right]a$$

$$a = \frac{(m_1 \sin\theta - m_2)}{\left[\frac{1}{2}M + (m_1 + m_2)\right]} g$$

Divide by m_2

$$a = \frac{\left(\frac{m_1}{m_2}\sin\theta - 1\right) g}{\left[\frac{1}{2}\frac{M}{m_2} + \left(\frac{m_1}{m_2} + 1\right)\right]}$$

$$\frac{m_1}{m_2} = \frac{8}{3} = 2.67\ ; \quad \frac{M}{m_2} = \frac{0.1}{3} = 0.0333$$

$$a = \frac{(2.67\sin 30 - 1)\,9.8}{\frac{0.0333}{2} + (2.67+1)} = \frac{(1.34-1)\,9.8}{0.0167 + 3.67}$$

$$a = \frac{(0.34)\,9.8}{3.68} = 0.905\ \frac{m}{s^2} \checkmark$$

PART B.

$$T_1 = m_1 g\sin\theta - m_1 a$$
$$T_2 = m_2 g + m_2 a$$
$$T_1 - T_2 - \frac{\tau_F}{R} = \frac{1}{2} M a$$

$$T_1 - T_2 = \frac{1}{2} M a + \frac{\tau_F}{R}$$

$$(m_1 g\sin\theta - m_1 a) - (m_2 g + m_2 a) = \frac{1}{2} M a + \frac{\tau_F}{R}$$

$$m_1 g\sin\theta - m_2 g - \frac{\tau_F}{R} = \left[\frac{1}{2} M + (m_1 + m_2)\right] a$$

$$\frac{(m_1\sin\theta - m_2) g - \frac{\tau_F}{R}}{\left[\frac{1}{2} M + (m_1 + m_2)\right]} = a$$

$$\frac{\left(\frac{m_1}{m_2}\sin\theta - 1\right) g - \frac{\tau_F}{m_2 R}}{\left[\frac{1}{2}\frac{M}{m_1} + \left(\frac{m_1}{m_2} + 1\right)\right]} = a = \frac{(0.34)\,9.8 - \frac{0.050}{3(0.10)}}{3.68}$$

$$= 0.905 - \frac{0.050}{3.68(3)(0.10)}$$

$$a = 0.905 - 0.045$$

$$a = 0.860\ {}^{m}/{}_{s^2} \checkmark$$

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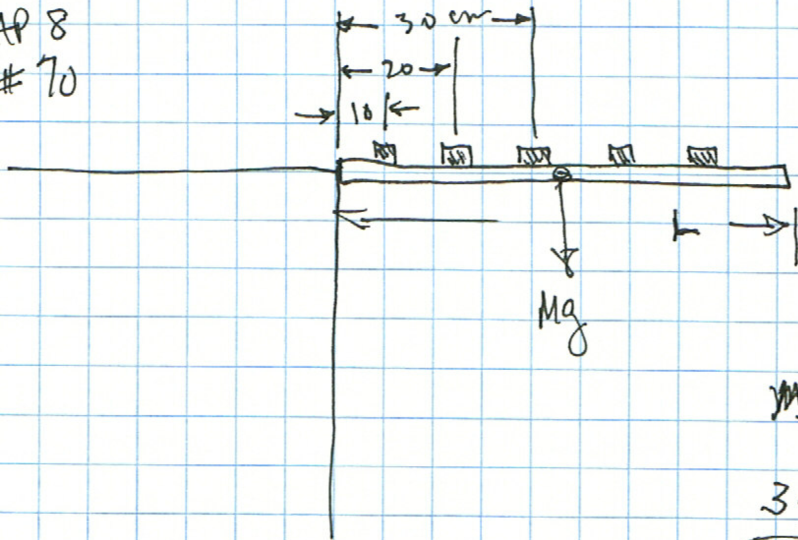


CENTER OF MASS

$$\tau = I\alpha$$

$$Mg\left(\frac{L}{2}\right)\sin\theta = I\alpha$$

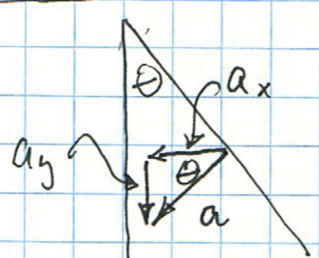
$$Mg\left(\frac{L}{2}\right)\sin\theta = \frac{1}{3}ML^2 \cdot \frac{a}{L/2}$$

$$3g\left(\frac{L}{2}\right)^2\sin\theta = L^2 a$$

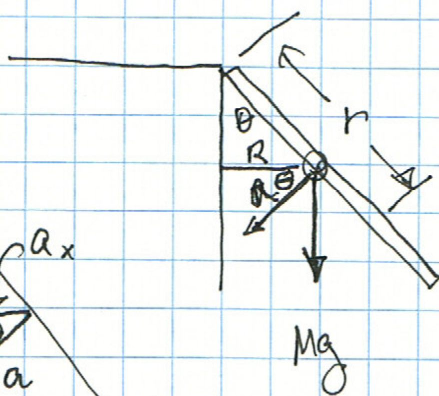
$$\boxed{\frac{3}{4}g\sin\theta = a}$$

MAGN OF ACC OF CM.

DETAIL



$a_y = a\sin\theta$



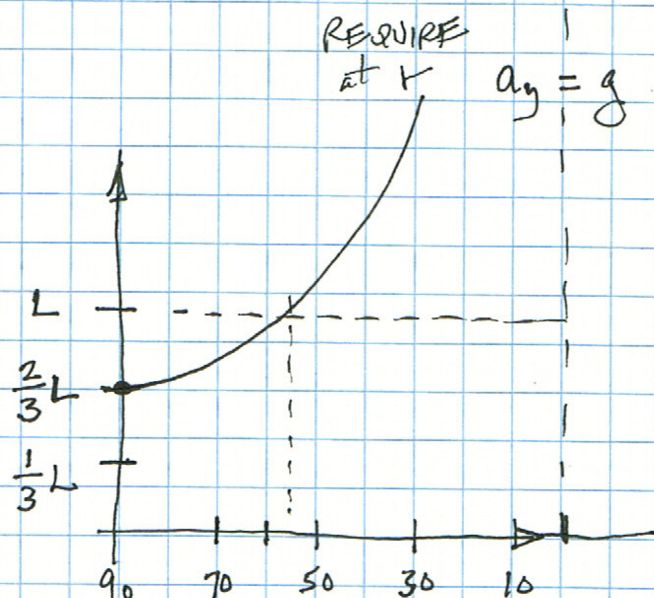
$$\tau = FR = mg\left(\frac{L}{2}\right)\sin\theta$$

τ_{max} AT $\theta = 90^\circ$ $= mg\frac{L}{2}$

τ_{min} at $\theta = 0$ $= 0$

$$a_y = a\sin\theta$$

At $\frac{L}{2}$ $\quad a_y = \frac{3}{4}g\sin^2\theta \qquad \theta : 90^\circ \to 0^\circ$



$a_y = g \longrightarrow \dfrac{r}{\left(\frac{L}{2}\right)}\dfrac{3}{4}g\sin^2\theta = g$

$$\frac{r}{L}\cdot\frac{3}{2}\sin^2\theta = 1$$

$$r = \frac{\frac{2}{3}L}{\sin^2\theta}$$

AT $\theta = 90^\circ$ $\quad r = \frac{2}{3}L$

$a_y = g$ REACHES END OF METERS.

$$\frac{r}{L} = 1 \to \frac{2}{3\sin^2\theta} = 1$$

$\sin^2\theta = \frac{2}{3} \qquad \sin\theta = \sqrt{\frac{2}{3}} = 0.816$

$\theta = 54.7^\circ$

[FOR PENNIES WHERE $a_y < g$ THE PENNIES REMAIN IN CONTACT WITH THE METERSTICK. THE PENNIES LOSE CONTACT WHERE $a_y > g$.]

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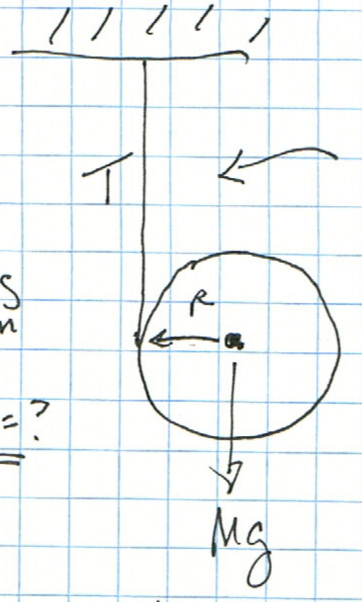

GIVEN:

$M = 2.0\,kg$

$R = 0.15\,m$

QUES: $a = ?$

ON CM

Two strings $\Sigma F_y = T + T - Mg = -Ma$

$2T - Mg = -Ma$.

a = ACCELERATION OF CM

ABOUT CM

$\Sigma \tau = 2T \cdot R = I\alpha = \frac{Ia}{R}$

$2T = \frac{Ia}{R^2}$

$$\left.\begin{aligned} 2T - Mg &= -Ma \\ 2T &= \frac{Ia}{R^2} \end{aligned}\right\}$$ UNKNOWNS: T, a

$$\frac{Ia}{R^2} - Mg = -Ma$$

$$\frac{Ia}{R^2} + Ma = Mg$$

$$\left(\frac{I}{R^2} + M\right) a = Mg$$

$$a = \left[\frac{M}{\frac{I}{R^2} + M}\right] g$$

$\rightarrow I = \frac{1}{2} MR^2$

$$a = \left[\frac{M}{\frac{1}{2}\frac{MR^2}{R^2} + M}\right] g$$

$$a = \left[\frac{M}{\frac{1}{2}M + M}\right] g$$

$$a = \frac{M}{+\frac{3M}{2}} g$$

$$a = +\frac{2g}{3} = \frac{2}{3}(9.8) = 6.53\,m/s^2$$