3.11 Acceleration of point A is a_A.

Velocity of point A is V_A

$V_C = \frac{V_A}{2}$ $\quad m_L$ has velocity $V_L = V_C = \frac{V_A}{2}$

$$F > \left(\frac{m_L + m_c}{2}\right) g$$

$$F - \left(\frac{m_L + m_c}{2}\right) g = m_e a_A = m_e \dot{V}_A$$

$$KE = \frac{1}{2} m_e V_A^2 = \frac{1}{2} I_B \omega_B^2 + \frac{1}{2} I_c \omega_c^2 + \frac{1}{2} m_c V_c^2 + \frac{1}{2} m_L V_c^2$$

String velocity $= V_A$

Tangential velocity on pulley B and C $= V_A$

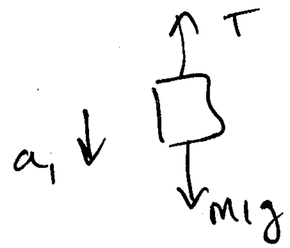
$V_A = r_B \omega_B \qquad V_A = r_c \omega_c$

$\omega_B = \frac{V_A}{r_B} \qquad \omega_c = \frac{V_A}{r_c}$

$$KE = \frac{1}{2} m_e V_A^2 = \frac{1}{2} I_B \left(\frac{V_A}{r_B}\right)^2 + \frac{1}{2} I_c \left(\frac{V_A}{r_c}\right)^2 + \frac{1}{2} m_c \left(\frac{V_A}{2}\right)^2 + \frac{1}{2} m_L \left(\frac{V_A}{2}\right)^2$$

$$= \frac{1}{2} \underbrace{\left[\frac{I_B}{r_B^2} + \frac{I_c}{r_c^2} + \frac{m_c}{4} + \frac{m_L}{4}\right]}_{m_e} V_A^2$$

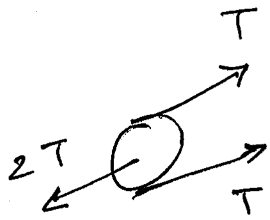
3.12

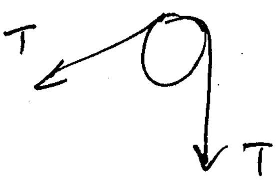


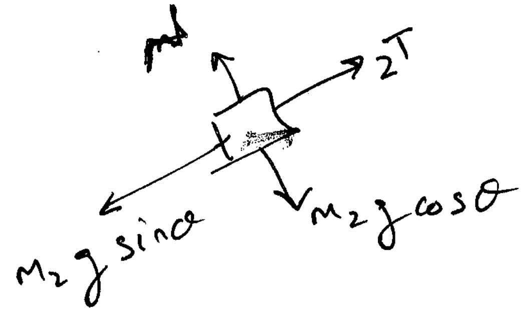
$m_1 g > T$

$m_1 g - T = m_1 a_1$

$T = m_1 g - m_1 a_1$







$2a_2 = a_1$

$\nearrow a_2$

$2T - m_2 g \sin\theta = m_2 a_2$

$2(m_1 g - m_1 a_1) - m_2 g \sin\theta = m_2 a_2$

$2m_1 g - 2m_1 a_1 - m_2 g \sin\theta = m_2 a_2$

Under static conditions.

$a_1 = a_2 = 0.$

$2m_1 g - m_2 g \sin\theta = 0$

$2m_1 g = m_2 g \sin\theta.$

$m_1 = \frac{m_2 \sin\theta}{2}$

a) To lift m_2 $\quad m_1 > \frac{m_2 \sin\theta}{2}$

b) $N = m_2 g \cos\theta$

with friction.

$$f_f = \mu_d N = \mu_d m_2 g \cos\theta$$

$$2 m_1 g - m_2 g \sin\theta - \mu_d m_2 g \cos\theta = 0$$

$$m_1 = \frac{m_2}{2}$$

$$\cancel{m_2} g - \cancel{m_2} g \sin\theta - \mu_d \cancel{m_2} g \cos\theta = 0$$

$$g - g \sin\theta = \mu_d g \cos\theta$$

$$\mu_d = \frac{g(1 - \sin\theta)}{g \cos\theta} = \frac{1 - \sin\theta}{\cos\theta}.$$

3.19 3rd edition, 4th edition.

$$\frac{1}{2} I_e \omega^2 = \frac{1}{2} I_1 \omega_1^2 + \frac{1}{2} I_2 \omega_2^2 + \frac{1}{2} m_2 V^2 + \frac{1}{2} m_3$$

$$= \frac{1}{2} I_1 \omega_1^2 + \frac{1}{2} \frac{1}{N^2} I_2 \omega_1^2 + \frac{1}{2} m_2 \frac{R^2 \omega_1^2}{N^2} + \frac{1}{2} m_3 \frac{R^2}{N}$$

$$\frac{\omega_1}{\omega_2} = N \qquad \omega_2 = \frac{\omega_1}{N}$$

$$V = R\omega_2 = R\frac{\omega_1}{N}$$

$$\frac{1}{2} I_e \omega_1^2 = \frac{1}{2} \underbrace{\left[I_1 + \frac{I_2}{N^2} + \frac{m_2 R^2}{N^2} + \frac{m_3 R^2}{N^2} \right]}_{I_e} \omega_1^2$$

T_1 is aided by $\underbrace{m_3 g R}_{\text{Torque}}$ and opposed by $\underbrace{m_2 g R}_{\text{Torque}}$

Since I_2 rotates slower we divide

$$\frac{m_3 g R}{N} \qquad \frac{m_2 g R}{N}$$

$\omega_2 N = \omega_1$

$\omega_2 2 = \omega_1$

$N = 2$

(given)

$$T_1 + \frac{m_3 g R}{2} - \frac{m_2 g R}{2} = I_e \alpha_1$$

3.24

$T = I_e \alpha_1 = I_e \dot{\omega}_1$

$\omega_1 = 1.8\,\omega_2$ $\qquad \omega_2 = \dfrac{\omega_1}{1.8}$

$\omega_2 = 1.8\,\omega_3 = \dfrac{\omega_1}{1.8}$ $\qquad \omega_3 = \dfrac{\omega_1}{(1.8)^2}$

$$KE = \frac{1}{2} I_e \omega_1^2 = \frac{1}{2} I_4 \omega_1^2 + \frac{1}{2} I_1 \omega_1^2 + \frac{1}{2} I_2 \omega_2^2 + \frac{1}{2} I_3 \omega_3^2 + \frac{1}{2} I_5 \omega_3^2$$

use ω_1 because driving Torque is applied to I_4 ~~that~~ has ω_1

$$KE = \frac{1}{2} I_e \omega_1^2 = \frac{1}{2} I_4 \omega_1^2 + \frac{1}{2} I_1 \omega_1^2 + \frac{1}{2} I_2 \left(\frac{\omega_1}{1.8}\right)^2 + \frac{1}{2} I_3 \left(\frac{\omega_1}{1.8^2}\right)^2 + \frac{1}{2} I_5 \left(\frac{\omega_1}{1.8^2}\right)^2$$

$$\frac{1}{2} I_e \omega_1^2 = \frac{1}{2} \left\{ I_4 + I_1 + \frac{I_2}{1.8^2} + \frac{I_3}{1.8^4} + \frac{I_5}{1.8^4} \right\} \omega_1^2$$

$I_e = 00478$

$T = 0.478\,\dot{\omega}_1 = 0.0478\,(1.8)^2\,\dot{\omega}_3$

$\dot{\omega}_3 = \dfrac{T}{0.1548} = 6.45\,T$

3.30

m_1 displacement is x

m_1 velocity is $\dot{x} = v$

m_1 acc is $\ddot{x} = a$

wheel m_2 has $2v$, $2a$

Assume No friction

$m_1 g = M_e a$ [Nothing to oppose $m_1 g$]

$$KE = \frac{1}{2} M_e v^2 = \frac{1}{2} m_1 v^2 + \frac{1}{2} m_2 (2v)^2 + \frac{1}{2} I_2 (\omega)^2$$

$$\omega \text{ of wheel} = \frac{2v}{r}$$

$$\frac{1}{2} M_e v^2 = \frac{1}{2} m_1 v^2 + \frac{1}{2} m_2 4v^2 + \frac{1}{2} I_2 \frac{4v^2}{r^2}$$

$$I_2 = \frac{1}{2} m_2 r^2 \text{ (solid wheel)}$$

$$\frac{1}{2} M_e v^2 = \frac{1}{2} m_1 v^2 + \frac{1}{2} m_2 4v^2 + \frac{1}{2} \left(\frac{1}{2} m_2 \cancel{r^2}\right) \frac{4v^2}{\cancel{r^2}}$$

$$= \frac{1}{2} [m_1 + 4m_2 + 2m_2] v^2$$

$$= \frac{1}{2} [\underbrace{m_1 + 6m_2}_{M_e}] v^2$$

$$\boxed{m_1 g = (m_1 + 6m_2)\ddot{x}}$$