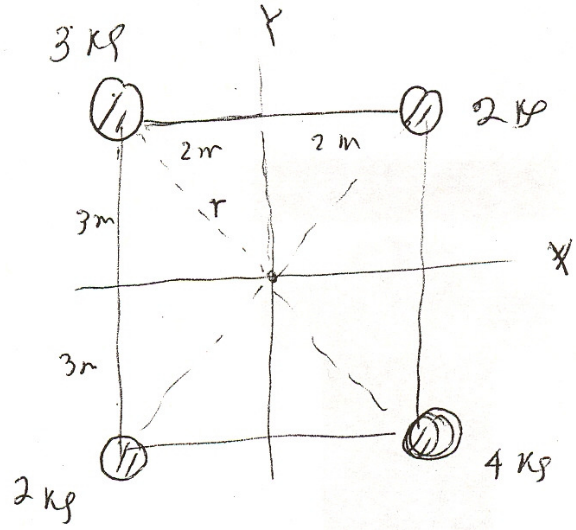
(21)



$$r = \sqrt{2^2 + 3^2} = \sqrt{4+9} = 3.6$$

$$r^2 = 13$$

(a) $I = (3\,kg)(13) + 2\,kg\,(13) + 2\,kg\,(13) + 4\,kg\,(13)$

$= 13(11) = 143\ kg\ m^2$

(b) $K.E. = \frac{1}{2} I \omega^2$

$= \frac{1}{2} \times 143 \times (6\ rad/s)^2 = 2574\ J = 2.57\ kJ$

ch. 10

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$$I(x) = Mx^2 + m(L-x)^2$$

Minimum $I(x)$:

$$\frac{\partial I(x)}{\partial x} = 0 .$$

ie., $2Mx + 2m(L-x)(-1) = 0$

$$2Mx - 2mL + 2mx = 0$$

$$\therefore \quad x(2M+2m) = 2mL$$

$$\therefore \boxed{x = \frac{mL}{M+m}}$$

$$\therefore I_{min} = M\left(\frac{mL}{M+m}\right)^2 + m\left(L - \frac{mL}{M+m}\right)^2$$

$$= \frac{L^2}{(M+m)^2}\left\{Mm^2 + mM^2\right\}$$

$$= \frac{mM}{(M+m)}L^2 = \mu L^2$$

where, $\mu = \dfrac{mM}{(m+M)}$

(33)

$\tau_1 = (10N)\, b$

$= 10 \times 0.25$ Nm clockwise

$\tau_2 = 9N \times b$

$= 9 \times 0.25$ Nm clockwise

$\tau_3 = 12N \times a$

$= 12 \times 0.1$ Nm Counterclockwise

net torque : clockwise = -ve
Counter clockwise = +ve

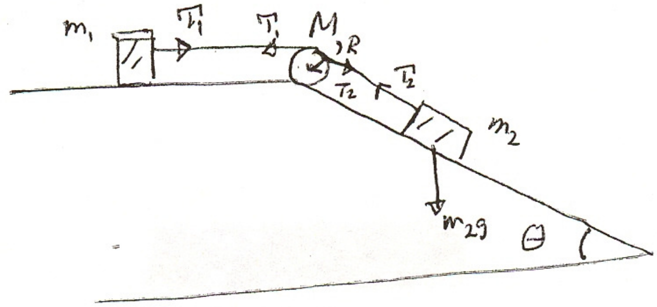
= [illegible]

$= -19 \times 0.25 +$

$= -4.75 \text{ Nm} + 1.2 \text{ Nm}$

$\boxed{\tau_{net} = -3.55 \text{ Nm}}$

(37)



$m_1 = 2$ kg

$m_2 = 6$ kg

$M = 10$ Kg

$R = 0.25$ m

$\mu_k = 0.36$

Motion of m_1 : $T_1 - \mu_k m_1 g = m_1 a$

$\therefore T_1 - 7.05 = 2a \quad (1)$

Motion of m_2 :

$m_2 g \sin\theta - T_2 - \mu_k m_2 g \cos\theta = m_2 a$

or $29.4 - T_2 - 18.32 = 6a \quad (2)$

Motion of Pulley :

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

$\therefore T_2 - T_1 = \frac{1}{2} M a \quad (3)$

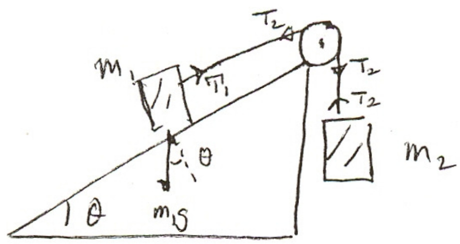
Adding (1) + (2) and using (3) :

$29.4 - 7.05 - 18.32 + \underbrace{T_1 - T_2} = 8a$

$\therefore 29.4 - 7.05 - 18.32 = 13a \quad \therefore \boxed{a = 0.31 \ m/s^2}$

Substituting $\boxed{T_1 = 7.6\cancel{7} \ N, \ T_2 = 9.22 \ N}$

(71)



$a = 2\ m/s^2$

$m_1 = 15\ Kg$

$m_2 = 20\ Kg$

$\theta = 37^\circ$

$R = 0.25\ m$

To find T_1, T_2, I

Motion of m_1 :

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

$$\therefore T_1 = m_1 g \sin\theta + m_1 a = 15\,(9.8 \times \sin 37^\circ + 2)$$

$$\therefore \boxed{T_1 = 118.4\ N}$$

Motion of m_2 :

$$m_2 g - T_2 = m_2 a$$

$$\therefore T_2 = m_2 (g - a) = 20\,(9.8 - 2) = 156\ N$$

$$\therefore \boxed{T_2 = 156 N}$$

Motion of the Pulley :

$$(T_2 - T_1) R = I\alpha = I \frac{a}{R}$$

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

$$\therefore I = \frac{(156 - 118.4)(0.25)^2}{2} = 1.175\ Kg\ m^2$$

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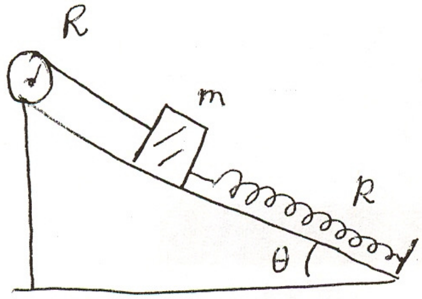

L = length of the unstretched spring.

Initially,

Stretch of the spring $= d$

Finally, the spring is unstretched.

$$E_i = \frac{1}{2}kd^2 + mg(L+d)\sin\theta$$

$$E_f = \frac{1}{2}I\omega^2 + \frac{1}{2}mv_{cm}^2 + mgL\sin\theta$$

$\therefore$ Conservation of E gives

$$\frac{1}{2}kd^2 + mg\cancel{L\sin\theta} + mgd\sin\theta = \frac{1}{2}I\omega^2 + \frac{1}{2}mv_{cm}^2 + mg\cancel{L\sin\theta}$$

$v_{cm} = R\omega$

$$\frac{1}{2}kd^2 + mgd\sin\theta = \frac{1}{2}I\omega^2 + \frac{1}{2}mR^2\omega^2$$

$$\therefore \quad \omega^2 = \frac{2\left[\frac{1}{2}kd^2 + mgd\sin\theta\right]}{(I + mR^2)}$$

$$\omega = 1.74 \text{ rad/s}$$