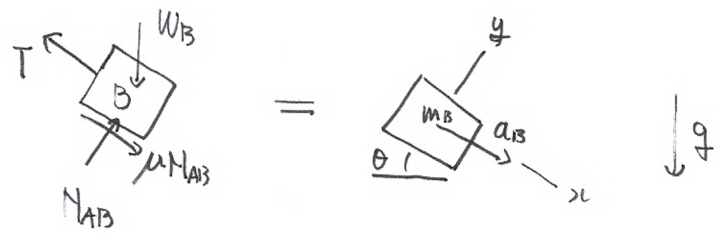
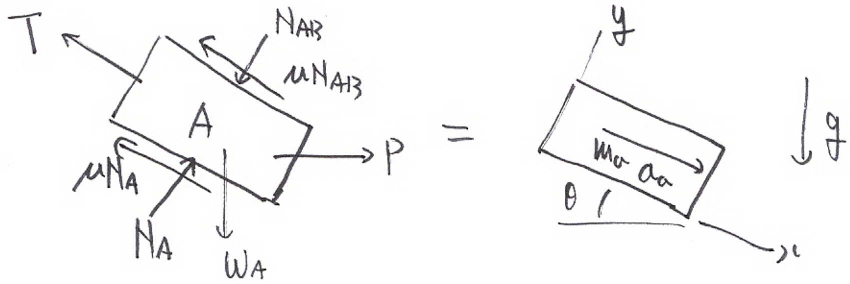
12.16(17)

FBD





Constraint of cable: $x_A + x_B = const$

$$a_A + a_B = 0 \qquad a_B = -a_A$$

Block B: $+\nearrow \Sigma F_y = 0$: $N_{AB} - W_B \cos\theta = 0$ —— ①

$+\searrow \Sigma F_x = ma_x$: $-T + \mu N_{AB} + W_B \sin\theta = \frac{W_B}{g} a_B$ —— ②

① - ② $\quad -T + W_B(\sin\theta + \mu\cos\theta) = W_B \frac{a_B}{g} = -W_B \frac{a_A}{g}$

Block A: $+\nearrow \Sigma F_y = 0$: $N_A - N_{AB} - W_A \cos\theta + P\sin\theta = 0$ —— ③

$+\searrow \Sigma F_x = m_A a_A$: $-T + W_A \sin\theta - N_{AB} - N_A + P\cos\theta = \frac{W_A}{g} a_A$ —— ④.

③ → $N_A = N_{AB} + W_A\cos\theta - P\sin\theta$

$= (W_B + W_A)\cos\theta - P\sin\theta$

④ → $-W_B(\sin\theta + \mu\cos\theta) - W_B \frac{a_A}{g} + W_A \sin\theta - \mu W_B \cos\theta$

$-\mu(W_B + W_A)\cos\theta + \mu P \sin\theta + P\cos\theta = W_A \frac{a_A}{g}$

→ $(W_A - W_B)\sin\theta - \mu(W_A + 3W_B)\cos\theta + P(\mu\sin\theta + \cos\theta) = (W_A + W_B)\frac{a_A}{g}$

i) static condition

$\mu = \mu_s = 0.2 \quad a_A = a_B = 0 \ , \ \theta = 25^\circ$

$(W_A - W_B)\sin\theta - \mu_s(W_A + 3W_B)\cos\theta + P_s(\mu_s \sin\theta + \cos\theta) = 0.$

$$P_s = \frac{(0.2)(64)(9.81)\cos 25^\circ - (32)(9.81)}{0.2\sin 25^\circ + \cos 25^\circ} = -19.04\text{N}.$$

$P = 50\text{N} > -19.04\text{ N}$

$\therefore P = 50\text{N} \rightarrow$ Block move.

ii) moving condition

$\mu = \mu_k = 0.15 \quad \theta = 25^\circ \quad P = 50\text{N}$

$$\frac{a_A}{g} = \frac{(W_A - W_B)\sin\theta - \mu_k(W_A + 3W_B)\cos\theta + P(\mu_k \sin\theta + \cos\theta)}{W_A + W_B}$$

$$= \frac{(32)(9.81)\sin 25^\circ - (0.15)(64)(9.81)\cos 25^\circ + (50)(0.15\sin 25^\circ + \cos 25^\circ)}{(48)(9.81)}$$

$= 0.203449.$

$a_A = (0.203449)(9.81) = 1.995\ \text{m/s}^2$

$a_B = -a_A = \underline{\underline{-1.995\ \text{m/s}^2}}$ // (a)

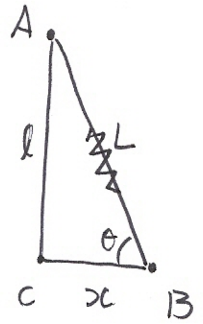
①-② $T = W_B(\sin\theta + \mu\cos\theta) + W_B \frac{a_A}{g}$

$= 8(9.81)(\sin 25^\circ + 0.15\cos 25^\circ) + (8)(9.81)(0.203449)$

$= 59.8$

$T = \underline{\underline{59.8\text{ N}}}$ // (b)

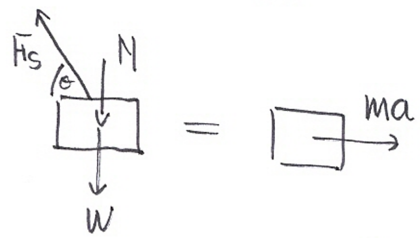
12.27 (29)



$L = \sqrt{l^2 + x^2}$ (l : unstretched length)

elongation of spring $e = L - l$

FBD of a collar



$F_s = ke = k(\sqrt{l^2 - x^2} - l)$

$\xrightarrow{+} \Sigma F_x = -F_s \cos\theta = ma.$

$-k(\sqrt{l^2 - x^2} - l)\cos\theta = ma. \quad \left(\cos\theta = \frac{x}{L} = \frac{x}{\sqrt{l^2 + x^2}}\right)$

$a = -\frac{k}{m}\left(x - \frac{lx}{\sqrt{l^2 + x^2}}\right)$

To express v with function of x

$a = \frac{dv}{dt} = \frac{dv}{dx}\frac{dx}{dt} = v\frac{dv}{dx}$

$\rightarrow \int_0^v v\,dv = \int_{x_0}^{x} a\,dx \quad (\because v_0 = 0 \text{ initial condition}).$

$\int_0^v v\,dv = \int_{x_0}^{0} a\,dx \quad (\because \text{We want to know } v \text{ at } x = 0)$

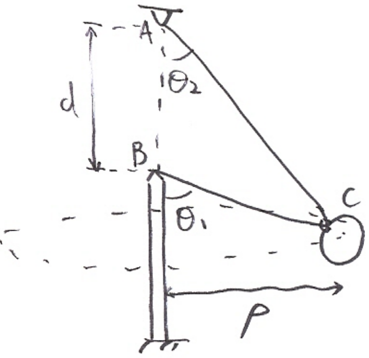
$\frac{1}{2}v^2 = \int_{x_0}^{0} -\frac{k}{m}\left(x - \frac{lx}{\sqrt{l^2 + x^2}}\right)dx$

$= -\frac{k}{m}\left[\frac{1}{2}x^2 - l\sqrt{l^2 + x^2}\right]_{x_0}^{0} = -\frac{k}{m}\left[-l^2 - \frac{1}{2}x_0^2 + l\sqrt{l^2 + x_0^2}\right]$

$v^2 = \frac{k}{m}\left(2l^2 + x_0^2 - 2l\sqrt{l^2 + x_0^2}\right)$

$$\underline{\underline{v = \sqrt{\frac{k}{m}}\left(\sqrt{l^2 + x_0^2} - l\right)}} \quad //$$

12.34 (37)



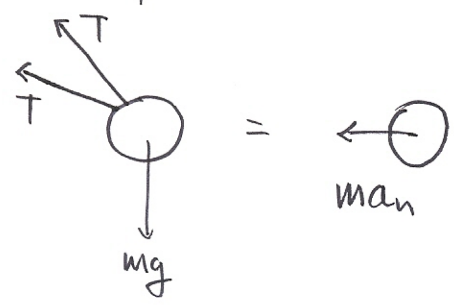
wire ACB length = 2m = L

horizontal constant speed of sphere C = v

radius of the horizontal circle : ρ

$\theta_1 = 60°$, $\theta_2 = 30°$

FBD of sphere C.



$$L = \frac{\rho}{\sin\theta_1} + \frac{\rho}{\sin\theta_2} \longrightarrow \rho = \frac{L\sin\theta_1\sin\theta_2}{\sin\theta_1 + \sin\theta_2}$$

$$\uparrow + \Sigma F_y = 0 \ : \ T\cos\theta_1 + T\cos\theta_2 - mg = 0$$

$$T = \frac{mg}{\cos\theta_1 + \cos\theta_2} \quad \text{——— ①}$$

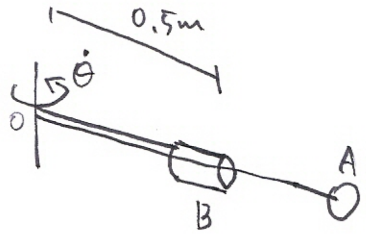
$$\overset{+}{\leftarrow} \Sigma F_x = ma_x \ : \ T\sin\theta_1 + T\sin\theta_2 = ma_n = m\frac{v^2}{\rho} \quad \text{——— ②}$$

$$①, ② \quad \frac{mg(\sin\theta_1 + \sin\theta_2)}{\cos\theta_1 + \cos\theta_2} = \frac{mv^2(\sin\theta_1 + \sin\theta_2)}{L\sin\theta_1\sin\theta_2}$$

$$v^2 = Lg\frac{\sin\theta_1\sin\theta_2}{\cos\theta_1 + \cos\theta_2} = 2\cdot(9.8)\frac{\sin 60 \sin 30}{\cos 60° + \cos 30°} = 6.22 \ m^2/s^2$$

$$\underline{\underline{v = 2.49 \ m/s}}$$

12.71 (71)

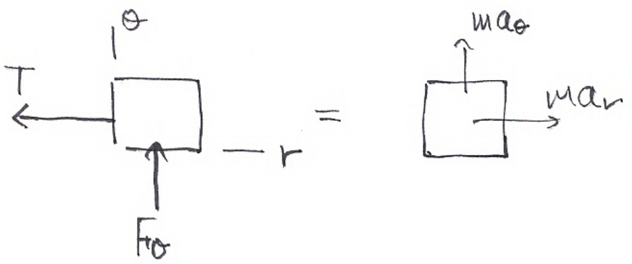


$\dot{\theta} = 10t$ rad/s

$m_B = 250g$

A breaking strength of wire = 18 N

FBD (top view)



Before wire breaking $T = -18\,N$, $\ddot{r} = 0$, $r = 0.5\,m$

$$T = ma_r = m(\cancel{\ddot{r}}^{\,0} - r\dot{\theta}^2)$$

$$\dot{\theta}^2 = \frac{-T}{mr} = \frac{18}{(0.25)(0.5)} = 144$$

$$\dot{\theta} = 12 \text{ rad/s}$$

Immediately after wire breaks : $\dot{\theta} = 12$ rad/s , $T = 0$.

$$T = ma_r = m(\ddot{r} - r\dot{\theta}^2) = 0$$

$$\ddot{r} = r\dot{\theta}^2 = 0.5(12)^2 = 72 \text{ m/s}^2$$

$$a_{r/rod} = \ddot{r} = \underline{\underline{72 \text{ m/s}^2}} \quad (a)$$

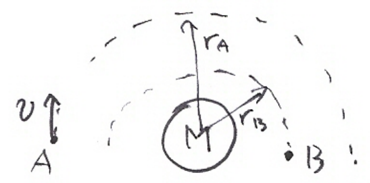
(b) $F_\theta = ma_\theta = m(r\ddot{\theta} + 2\dot{r}\dot{\theta}) \quad (\ddot{\theta} = \frac{d\dot{\theta}}{dt} = 10),\ \dot{r} = 0$

$$= 0.25(0.5\cdot(10) + 2\cdot(0)\cdot(12))$$

$$= 1.25$$

$$F_\theta = \underline{\underline{1.25\,N}} \quad (b)$$

12.90 (8th Edition)



$r_A = 2243$

$r_B = 2083$

FBD (A)

$$\xrightarrow{F_{rA}} \;=\; \underset{m}{\bullet}\xrightarrow{a_n} \quad (\overset{r}{\leftarrow} +)$$

$$F_{rA} = -\frac{GMm}{r_A^2} = m(\cancel{\ddot{r}} - r\dot{\theta}^2) \quad \left(\dot{\theta} = \frac{v_A}{r_A}\right)$$

$$= m\left(-\frac{v_A^2}{r_A}\right)$$

$$\underline{\underline{v_A = \sqrt{\frac{GM}{r_A}}}}$$

$$v_A = \sqrt{\frac{(6.224\times10^{-11})(2.28\times10^{21}\,kg)}{2243\times10^{3}\,m}} = 2.515\times10^{2}\,m/s.$$

If B is circular motion

$$v_B = \sqrt{\frac{(6.224\times10^{-11})(2.28\times10^{21}\,kg)}{2083\times10^{3}\,m}} = 2.61\times10^{2}\,m/s.$$

(a) $v_A' = v_A - 25.8 = 225.7\ m/s$

(mometum conserve) $m r_A (v_A') = m r_B (v_B')$

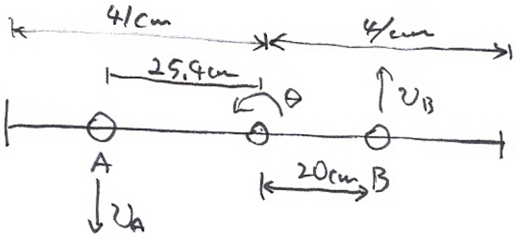
$$v_B' = \frac{r_A v_A'}{r_B} = \frac{(2243\times10^3)(225.7)}{2083\times10^3} = 243\ m/s$$

$$\underline{\underline{v_B' = 243\ m/s}}\ //$$

(b) v_B' change to v_B for circular motion

$$\therefore \Delta v_B = v_B - v_B' = 261 - 243 = \underline{\underline{18\ m/s\ \uparrow}}\ //$$

12.134 (8th Edition)



$v_A = 2.4$ m/s

$m_A = 0.$

$\theta_B = \theta_A + \pi$

$\dot\theta_B = \dot\theta_A$

$\ddot\theta_B = \ddot\theta_A$

(a) immediately after the pin is removed

B have no radial direction force ($F_r = 0$)

- $F_{B,r} = m_B a_{B,r} = 0$ $\qquad \underline{\underline{a_{B,r} = 0}}$ // (radial direction accel.)

- Transverse direction ($a_{B,\theta}$)

$$(a_A)_\theta = r_A\ddot\theta + 2\cancel{\dot r_A}^{\,0}\dot\theta = r_A\ddot\theta$$

$$(a_B)_\theta = r_B\ddot\theta + 2\dot r_B\dot\theta$$

$$\circlearrowleft + \sum M = r_A F_{A,\theta} + r_B F_{B,\theta} = r_A \cdot m_A \cdot a_{A\theta} + r_B \cdot m_B \cdot a_{B,\theta} = 0$$

$$r_A m_A r_A \ddot\theta + r_B \cdot m_B \cdot (r_B\ddot\theta + 2\dot r_B\dot\theta) = 0$$

$$\ddot\theta = \frac{-2\dot r_B\dot\theta}{r_A^2 m_A + r_B^2 m_B}$$

immediately after pin is removed $\underline{\dot r_B = 0}$.

$\therefore \ddot\theta = 0$

$\therefore \underline{\underline{(a_B)_\theta = 0}}$ // (transverse accel.)

(b) Acceleration of B relative to the rod ($= \ddot{r}_B$)

$$a_{B,r} = \ddot{r}_B - r_B\dot{\theta}^2 = 0.$$

$$v_{A,\theta} = 2.4 = r_A\dot{\theta}$$

$$\dot{\theta} = \frac{2.4}{0.254} = 9.6 \text{ rad/s}$$

$$\therefore \ddot{r}_B = r_B\dot{\theta}^2 = 0.2 \cdot (9.6)^2 = \underline{\underline{18.4 \text{ m/s}^2}}$$

(c) There are no external force.

$$\therefore \frac{d}{dt}(H) = 0.$$

$$\frac{d}{dt}(m_A r_A^2\dot{\theta} + m_B r_B^2\dot{\theta}) = 0$$

$$(m_A r_A^2 + m_B r_B^2)\dot{\theta} = (m_A r_A^2 + m_B r_C^2)\dot{\theta}_f$$

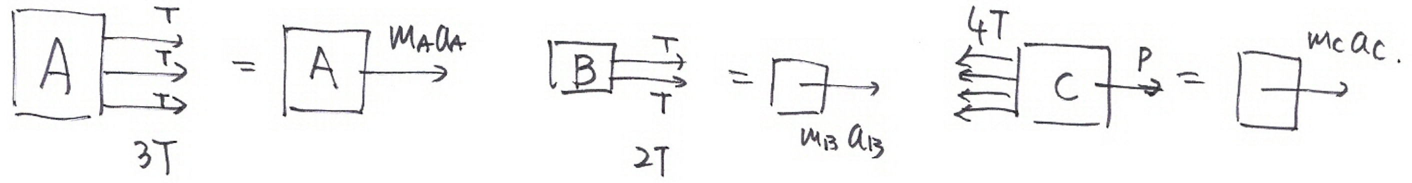
$$\dot{\theta}_f = \frac{m_A r_A^2 + m_B r_B^2}{m_A r_A^2 + m_B r_C^2}$$

$$= \frac{(0.45)(0.254)^2 + (0.9)(0.2)^2}{(0.45)(0.254)^2 + (0.9)(0.4)^2} = 3.5765 \text{ rad/s}$$

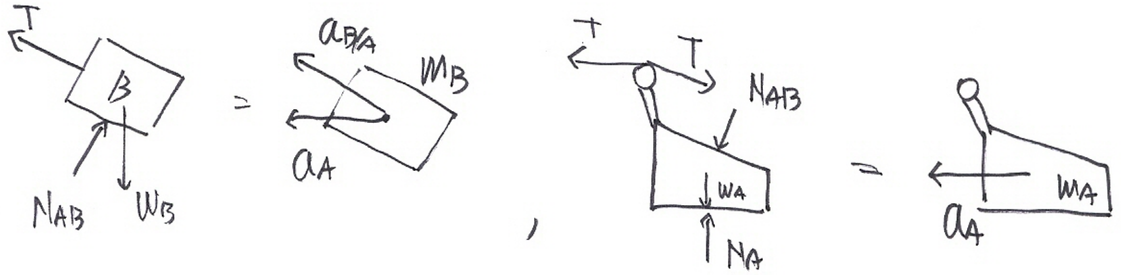
$$(v_A)_f = r_A\dot{\theta}_f = (0.25)(3.5765) = \underline{\underline{0.89 \text{ m/s}}}$$

FBD

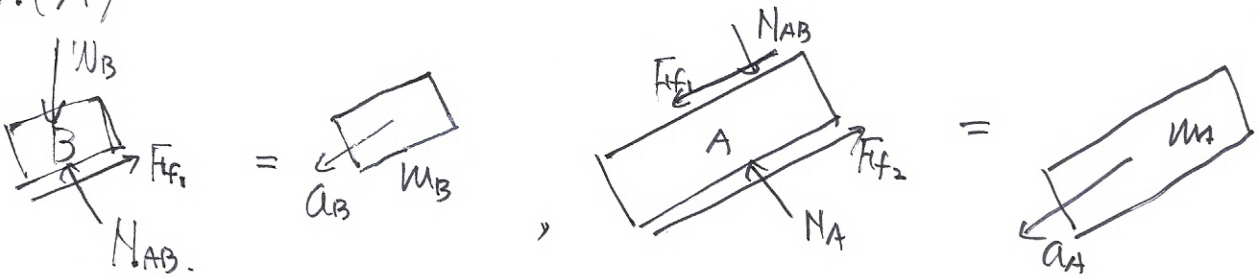
12.28(32)



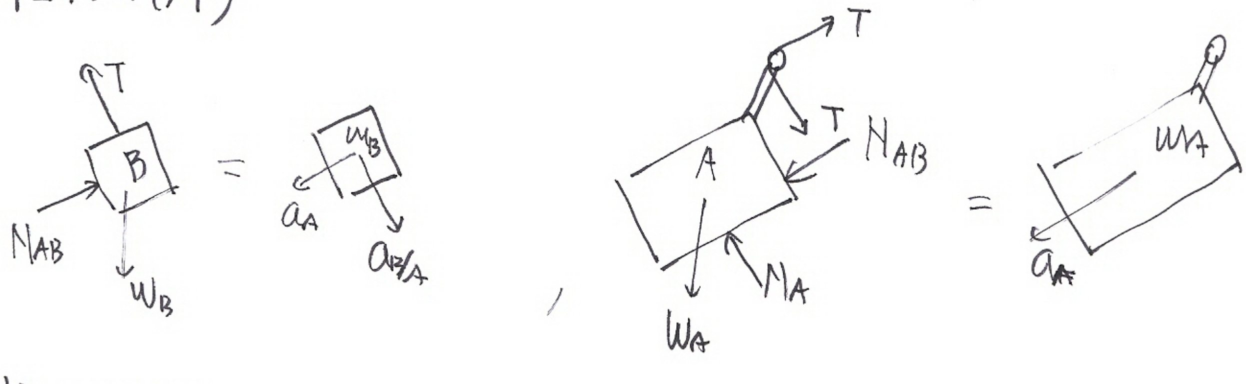
12.30(126)



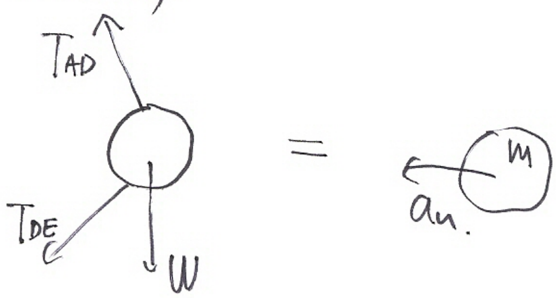
12.31(31)



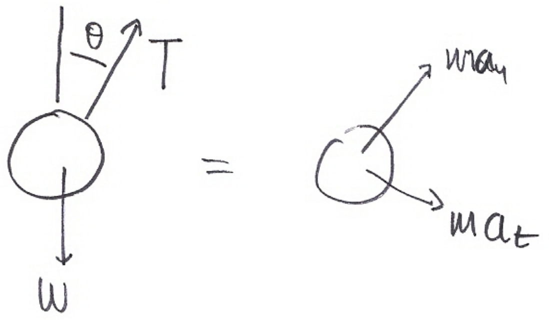
12.32(34)



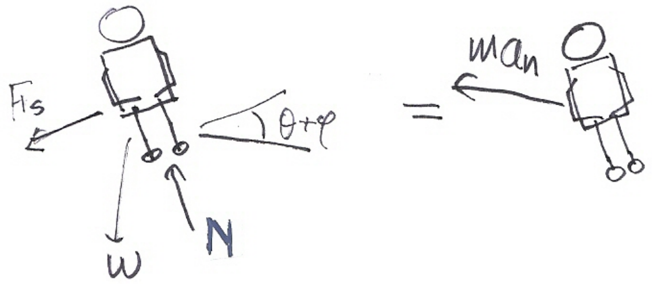
12.40(42)



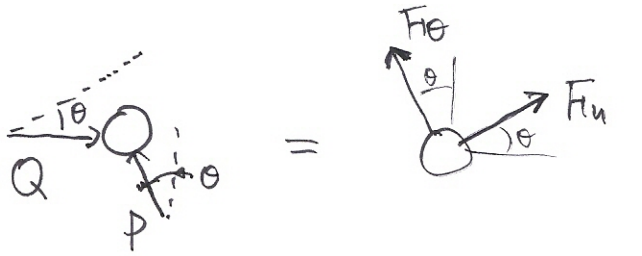
12.45 (127)



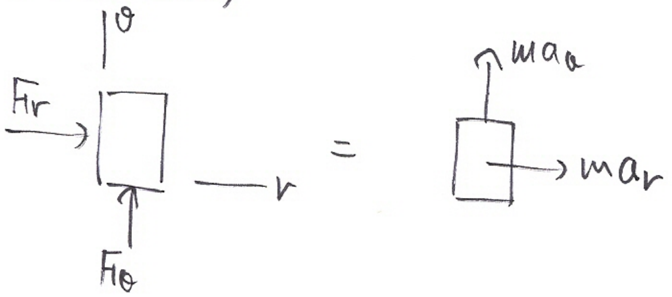
12.52 (54)



12.69 (131)



12.70 (72)



12.92 (92)