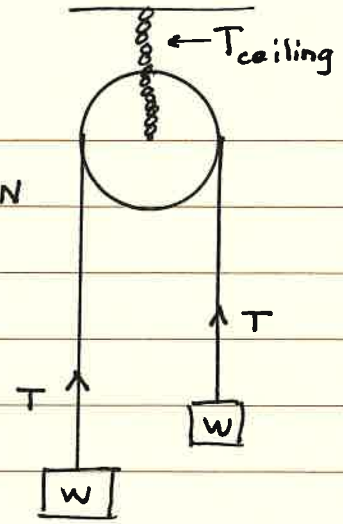
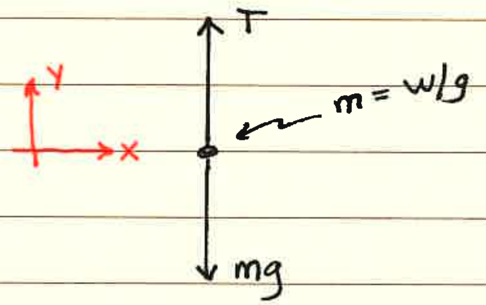
Chapter 5 In-Class Homework Solutions

Ex. 1 Two 25.0 N weights are suspended ....



a.) $T = ?$ $w = mg = 25\ N$

Pick one of the weights as the system

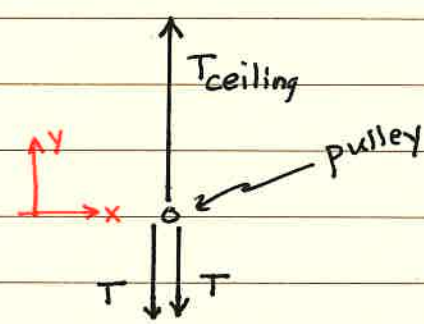


$\sum F_y = 0$ because $v = \text{constant}$

$T - mg = 0$ $\boxed{T = mg = w = 25.0\ N}$

b.) $T_{ceiling} = ?$

Pick the "massless" pulley as the system



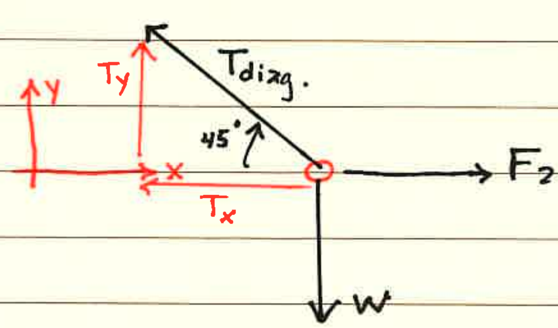
$\sum F_y = 0$ $T_{ceiling} - T - T = 0$

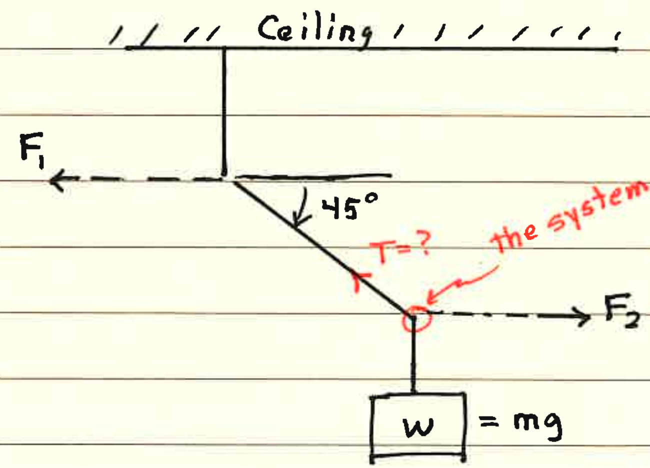
$\boxed{T_{ceiling} = 2T = 50.0\ N}$

Ex. 8 In the figure, the weight $w = 60.0\ N$

a.) $T_{diagonal} = ?$

Pick the ○ as the system





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Ex. 8 Cont'd $\sum F_y = 0 \Rightarrow T_y - w = 0 \quad T\sin 45^\circ = w$

$$T = \frac{w}{\sin 45^\circ} = \sqrt{2}\,(60.0\text{ N}) = 84.9\text{ N}$$

b.) Find F_1 and F_2

$\sum F_x = 0 \Rightarrow F_2 - T_x = 0 \quad F_2 - T\cos 45^\circ = 0$

$F_2 = T\cos 45^\circ \quad F_2 = \left(\frac{w}{\sin 45}\right)\cos 45^\circ \quad F_2 = \frac{w}{\tan 45^\circ} = w$

$$\boxed{F_2 = w = 60.0\text{ N}}$$

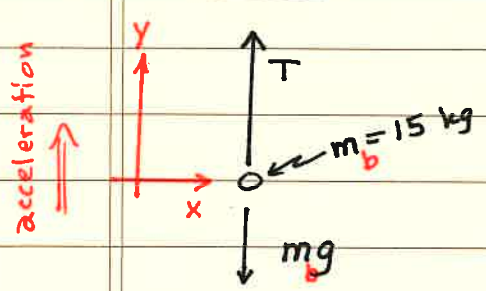
F_1 must equal F_2 such that the diagonal part of the string does not accelerate in the x-direction. $\sum F_x = 0$

$-F_1 + F_2 = 0$ Therefore, $\boxed{F_1 = F_2 = 60.0\text{ N}}$

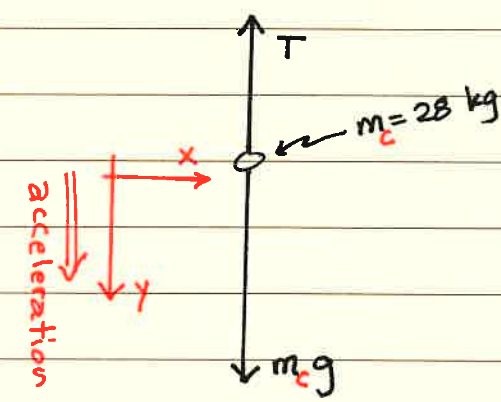
Ex. 15 Atwood's Machine

a.) Draw two free-body diagrams

Bricks



Counterweight



b.) acceleration = ?

Bricks: $\sum F_y = m_b a \quad T - m_b g = m_b a$

$$\boxed{T = m_b(g + a)}$$

Counterweight: $\sum F_y = m_c a \quad m_c g - T = m_c a \quad \boxed{T = m_c(g - a)}$

$T = T$

$m_b g + m_b a = m_c g - m_c a \quad (m_b + m_c)a = (m_c - m_b)g$

$$a = \frac{(m_c - m_b)}{(m_b + m_c)}\,g = \frac{28-15}{28+15}(9.8\text{ m/s}^2) \quad \boxed{a = 2.96\text{ m/s}^2}$$

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Ex. 15 Cont'd

c.) T = ? in the rope. Use either equation for T.

$T = m_b(g+a) = 15\text{ kg}\,(9.8 + 2.96)\,m/s^2$ $\quad T = 191.4\text{ N}$

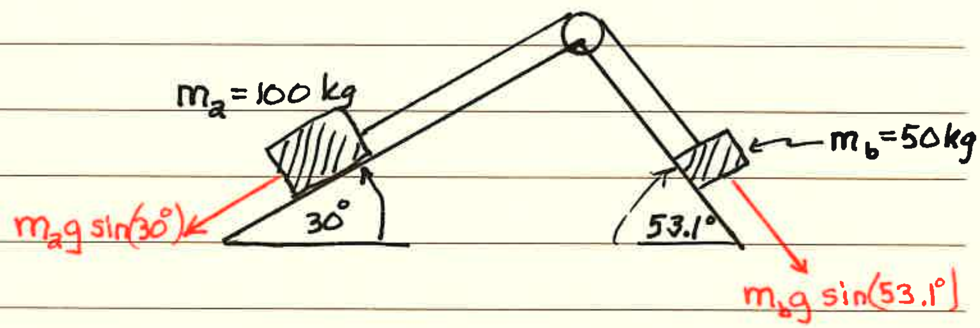
$T = m_c\,(g-a) = 28\text{ kg}\,(9.8 - 2.96)\,m/s^2$ $\quad T = 191.4\text{ N}$

$W_{bricks} = m_b g = 15\text{ kg}\,(9.8\,m/s^2) = 147\text{ N}$ ← $T = 191.4\text{ N}$

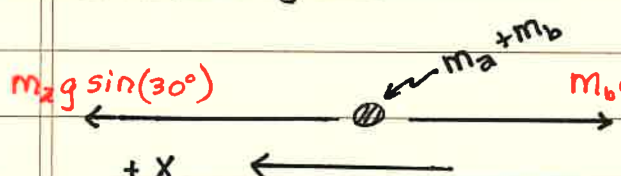
$W_{counterweight} = m_c g = 28\text{ kg}\,(9.8\,m/s^2) = 274\text{ N}$

Prob. 90 Two blocks connected by a massless cord passing over a small ....

a.) Which way will the system move?



Free-Body Diagram



⇐ assume accel. in this direction, and see if it is correct.

$\sum F_x = m a_x$ (m: mass of the system) $\qquad +m_a g\,\frac{1}{2} - m_b g\,\frac{4}{5} = (m_a + m_b)\,a_x$

$+50g - 40g = 150\,a_x \qquad a_x = \frac{10\text{ kg}}{150\text{kg}}\,(9.8\,m/s^2) = 0.653\,\frac{m}{s^2}$

$\boxed{a_x = 0.563\ m/s^2}$

a.) Yes! The system accelerates from "right to left."

b.) $a_x = 0.653\ m/s^2$

c.) T = ? Draw a free-body diagram for one of the blocks.

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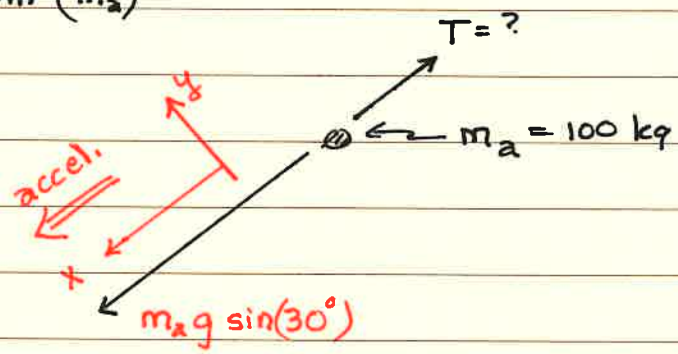
Prob. 90 cont'd

Free-Body Diagram (m_a)



$$\sum F_x = m_a a_x$$

$$m_a g \sin(30°) - T = m_a a_x \qquad T = m_a (g \sin(30°) - a_x)$$

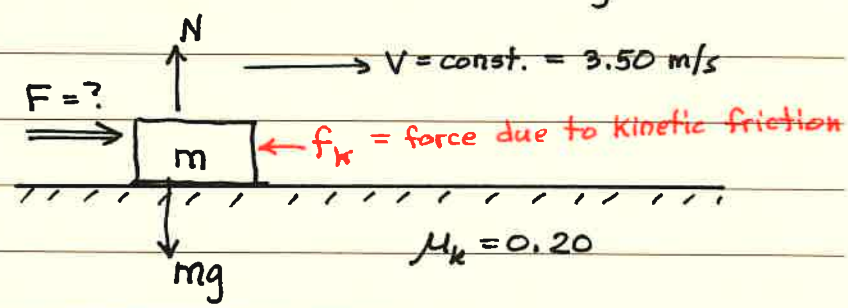
$$T = 100\,\text{kg}\left(9.8\,\text{m/s}^2 \left(\tfrac{1}{2}\right) - 0.653\,\text{m/s}^2\right) = \boxed{424.7\ \text{N}}$$

Ex. 25

A stockroom worker pushes a box with mass 16.8 kg . . . .

$m = 16.8$ kg

a.) $F = ?$



$$\sum F_y = 0$$

$$N - mg = 0 \qquad \boxed{N = mg}$$

$\sum F_x = 0$ ← No acceleration

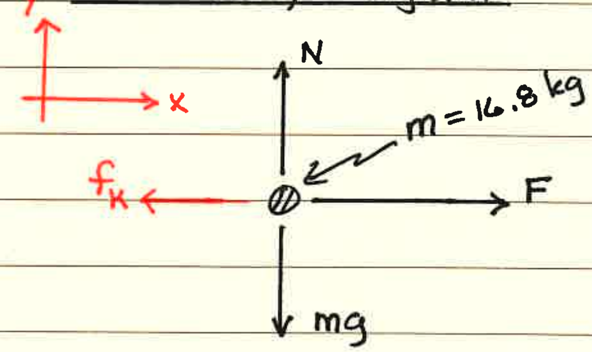
$$F - f_k = 0 \qquad F - \mu_k N = 0$$

$$F - \mu_k (mg) = 0$$

$$F = \mu_k mg = 0.20(16.8\,\text{kg})\,9.8\,\text{m/s}^2$$

$$\boxed{F = 32.9\ \text{N}}$$

Free-Body Diagram



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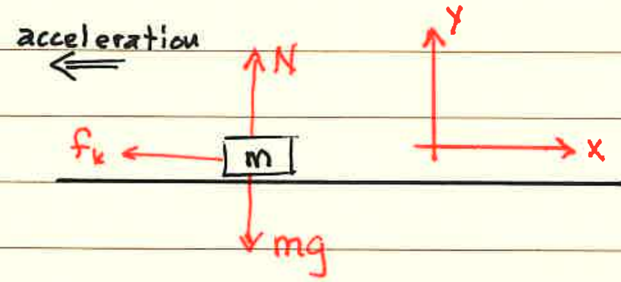
Ex. 25 cont'd.

b.) How far does the block slide if the force is removed?

Free-Body Diagram



$\Sigma F_x = ma_x$

$-f_k = ma_x$

$a_x = \frac{-f_k}{m} = \frac{-\mu_k mg}{m}$

$a_x = -\mu_k g = -0.20(9.8\ m/s^2)$

$\boxed{a_x = -1.96\ m/s^2}$

$V_o = 3.50\ m/s$

$V = 0.00\ m/s$

$X = ?$

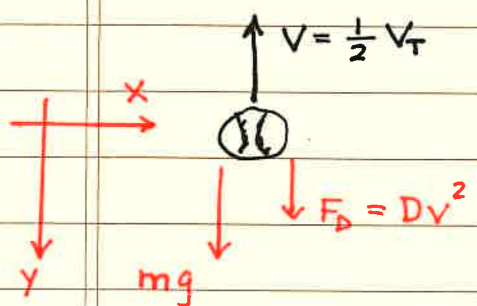
Eq. 4 $\quad V^2 = V_o^2 + 2a_xX$

$X = \frac{V^2 - V_o^2}{2a_x}$

$X = \frac{(0.00^2 - (3.50)^2)\ m^2/s^2}{2(-1.96\ m/s^2)}$ $\quad \boxed{X = 3.125 \text{ meters}}$

Ex. 40 You throw a baseball straight up. $F_D \sim V^2 \quad F_D = DV^2$

a.) Moving upward $\quad V_T = \sqrt{mg/D}$ (terminal velocity) $\quad$ If $V = \frac{1}{2}V_T \quad a_y = ?$



$\Sigma F_y = ma_y \qquad mg + DV^2 = ma_y$

$mg + D\left(\frac{1}{2}V_T\right)^2 = ma_y$

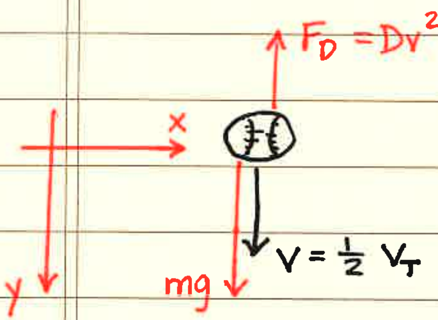
$\cancel{m}g + D\left(\frac{1}{4}\frac{\cancel{m}g}{\cancel{D}}\right) = \cancel{m}a_y$

$a_y = g + \frac{1}{4}g$

downward $\quad \boxed{a_y = \frac{5}{4}g}$

Ex. 40 cont'd

b.) Moving downward recall: $V_T = \sqrt{mg/D}$ $a_y = ?$



$$\sum F_y = ma_y$$

$$mg - Dv^2 = ma_y$$

$$mg - D\left(\tfrac{1}{2} V_T\right)^2 = ma_y$$

$$\cancel{m}g - D\left(\tfrac{1}{4}\,\tfrac{\cancel{m}g}{D}\right) = \cancel{m}a_y$$

$$a_y = g - \tfrac{1}{4} g \qquad \boxed{a_y = \tfrac{3}{4} g} \quad \text{downward}$$

Ex. 53 Rotating Space Stations. One problem for humans living . . . .

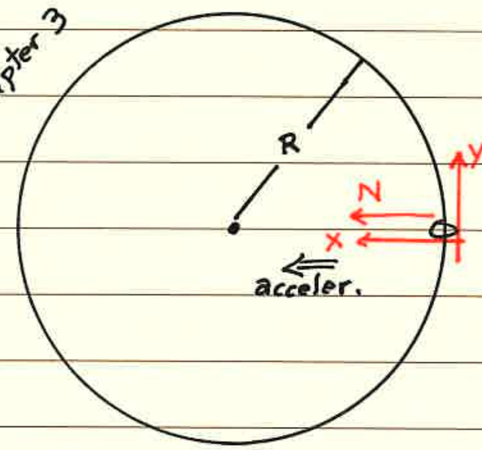
R = 400 m

a.) $N = mg$ ← to produce your earthly weight

$$\sum F_x = ma_x \Rightarrow N = m\left(\frac{v^2}{R}\right)$$

$\frac{v^2}{R} = \frac{4\pi^2 R}{T^2}$ (see chapter 3)

$$\cancel{m}g = \cancel{m}\left(\frac{4\pi^2 R}{T^2}\right)$$



$$\text{rpm} = \frac{\text{rev}}{\text{min}} = \frac{1}{T\,(\text{minutes})} = ?$$

$$\frac{1}{T^2} = \frac{g}{4\pi^2 R} \qquad \frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{g}{R}} = \frac{1}{2\pi}\sqrt{\frac{9.8\ m/s^2}{400\ m}} = \frac{0.0249}{\text{sec}}$$

$$\frac{1}{T} = 0.0249\ \frac{\text{rev}}{\text{sec}}\left(\frac{60\ s}{\text{min}}\right) = 1.49\ \frac{\text{rev}}{\text{min}} \qquad \boxed{\frac{1}{T} = 1.49\ \text{rpm}}$$

b.) $N = mg_{mars}$ ($g_{mars} = 3.70\ m/s^2$)

$$\frac{1}{T} = \frac{1}{2\pi}\sqrt{\frac{3.70\ m/s^2}{400\ m}}\left(\frac{60\ s}{\text{min}}\right) \Rightarrow \boxed{\frac{1}{T} = 0.918\ \frac{\text{rev}}{\text{min}}}$$

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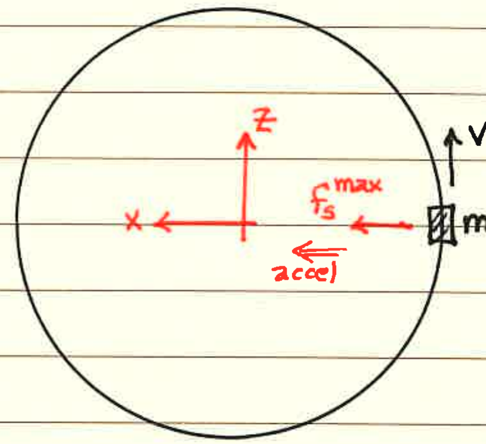
Example: A car is traveling at 20 m/s on ground level and begins ....

$R = 70\ m$

$\mu_s = ?$

$f_s^{max} = \mu_s^{min} N$ ← normal force

Top View



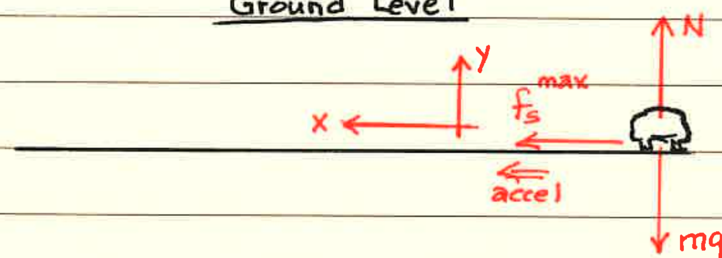
$\sum F_y = 0 \Rightarrow N - mg = 0$

$$\boxed{N = mg}$$

$$\sum F_x = ma_x = m\left(\frac{v^2}{R}\right) \quad (a_{rad} = \frac{v^2}{R})$$

$$f_s^{max} = \frac{mv^2}{R}$$

Ground Level



$$\mu_s N = \mu_s (mg) = \frac{mv^2}{R}$$

$$\mu_s^{min} = \frac{v^2}{gR} = \frac{(20\ m/s)^2}{9.8\frac{m}{s^2}(70m)}$$

$$\boxed{\mu_s^{min} = 0.583}$$