

Wentworth Institute of Technology

Engineering Physics I

Problemset 4 - SOLUTIONS

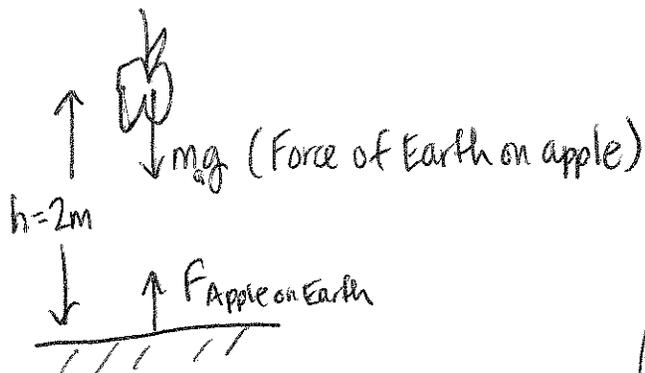
1) weight = mg , $g_E = 9.81 \text{ m/s}^2$

$$g_{\text{mars}} = 3.71 \frac{\text{m}}{\text{s}^2}$$

at mars, scale reports "mass" = $\frac{\text{weight}}{9.81 \text{ m/s}^2} = \frac{mg_M}{g_E}$

Scale will display $\frac{3.71}{9.81} m = \boxed{0.38 m}$

2)



$$F_{E \text{ on } A} = m_a g$$

$$m_a = \text{mass of apple} = 1 \text{ kg}$$

$$F_{A \text{ on } E} = M_E a_E$$

$$|F_{A \text{ on } E}| = |F_{E \text{ on } A}| \quad \text{Newton's 3rd Law}$$

$$\begin{aligned} M_E &= \text{mass of Earth} = 6 \times 10^{24} \text{ kg} \\ a_E &= \text{accel. of Earth} \end{aligned}$$

a) $F_{E \text{ on } A} = (1 \text{ kg})(9.81 \text{ m/s}^2)$

$$= 9.81 \text{ N}$$

Newton's 2nd Law

b) $F_{A \text{ on } E} = 9.81 \text{ N}$ Newton's 3rd Law

Equal in magnitude, opposite in direction to $F_{E \text{ on } A}$

c) time to hit ground

$$y(t) = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$$

$$2\text{ m} = \frac{1}{2}gt^2$$

$$t = \frac{2}{\sqrt{g}} = \boxed{0.63\text{ s} = t}$$

d) in $t = 0.63\text{ s}$ how far does Earth move? $F_{\text{A on E}} = M_E a_E$

$$F_{\text{A on E}} = 9.81\text{ N} = \cancel{2 \times 10^{-24}} (6 \times 10^{24}\text{ kg})(a_E)$$

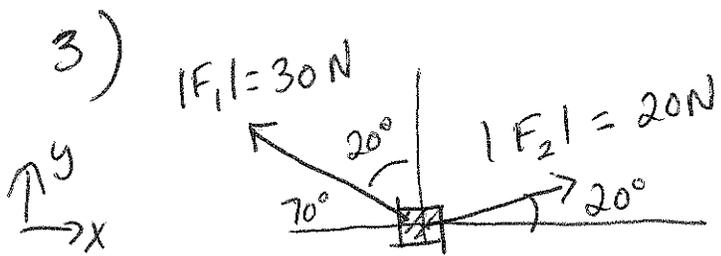
$$a_E = 1.6 \times 10^{-24} \frac{\text{m}}{\text{s}^2}$$

$$y(0.63\text{ s}) = 0 + 0 + \frac{1}{2}a_E t^2 = \frac{1}{2} (1.6 \times 10^{-24} \frac{\text{m}}{\text{s}^2}) (0.63\text{ s})^2$$

$$= \boxed{3.2 \times 10^{-25}\text{ m}}$$

The Earth moves only $3.2 \times 10^{-25}\text{ m}$ but the apple moves $2\text{ m} \rightarrow 10^{25}$ times the distance!

The effect of the apple on the Earth is negligible



a)

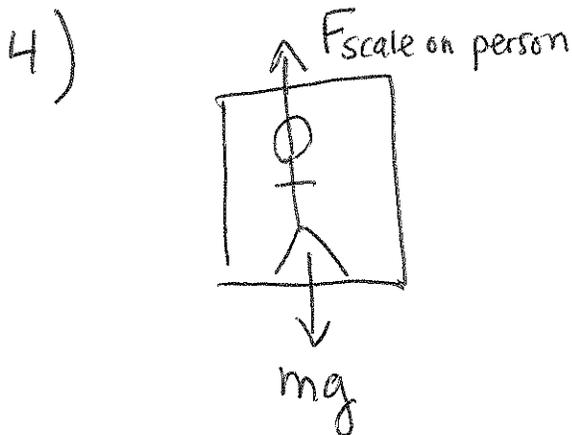
$$\vec{F}_1 = -30 \cos 70^\circ \hat{x} + 30 \sin 70^\circ \hat{y}$$

$$\vec{F}_2 = 20 \cos 20^\circ \hat{x} + 20 \sin 20^\circ \hat{y}$$

b) net force = $\vec{F}_1 + \vec{F}_2 = (20 \cos 20^\circ - 30 \cos 70^\circ) \hat{x} + (20 \sin 20^\circ + 30 \sin 70^\circ) \hat{y}$

$$= 8.5 \hat{x} + 35.0 \hat{y}$$

$$|F_{\text{total}}| = \sqrt{8.5^2 + 35^2} = 36\text{ N}$$



Whole elevator is accelerating $\uparrow a = 2\text{ m/s}^2$

$$\sum F_{\text{on person}} = ma$$

$$= F_{\text{scale}} - mg$$

The scale reads a weight equivalent to F_{scale} .

$$ma = F_{\text{scale}} - mg \rightarrow F_{\text{scale}} = m(a + g)$$

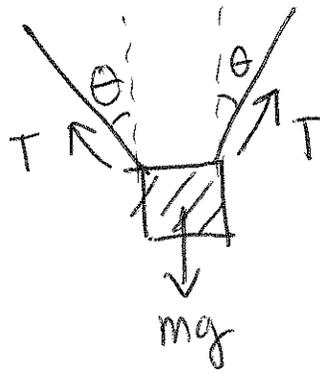
At rest, $F_{\text{scale}} = mg = 70\text{ kg} (9.81 \frac{\text{m}}{\text{s}^2})$

$$= 687\text{ N}$$

$$= 70\text{ kg} (2\text{ m/s}^2 + 9.81\text{ m/s}^2)$$

$$|F_{\text{scale}}| = 826\text{ N}$$

5)



$$m = 10 \text{ kg}$$

 $\uparrow y$

a)

b) net force on the box is zero since the box is hanging on the strings without accelerating.

$$c) \quad \sum F_y = 2T \cos \theta - mg = 0$$

$$\text{if } \theta = 60^\circ \quad \cos \theta = \frac{1}{2} \quad \text{so} \quad 2T \cos \theta = mg$$

$$T = mg$$

$$T = mg$$

$$= 10 \text{ kg} \cdot 9.81 \text{ m/s}^2 = \boxed{98.1 \text{ N}}$$

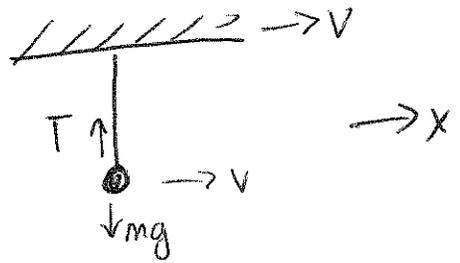
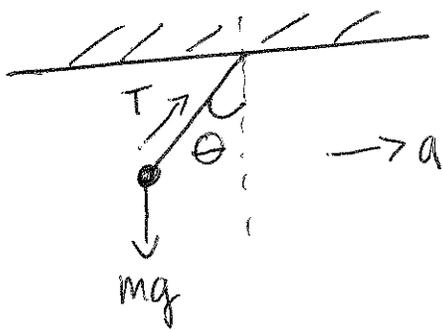
$$d) \quad 2T \cos \theta = mg$$

now $T = 98.1 \text{ N}$ and $m = 20 \text{ kg}$, find θ

$$\cos \theta = \frac{mg}{2T} \quad \rightarrow \quad \theta = 0^\circ$$

$$= \frac{20 \text{ kg} \cdot 9.81 \frac{\text{m}}{\text{s}^2}}{2(98.1 \text{ N})} = 1$$

e)



b) net force on the ball = $\Sigma \vec{F} = m\vec{a}$

$$\Sigma F_x = ma = T \sin \theta$$

$$\Sigma \vec{F}_y = T \cos \theta - mg = 0$$

$$ma = T \sin \theta, \quad ma = \frac{mg}{\cos \theta} \cdot \sin \theta$$

$$mg = T \cos \theta$$

$$ma = mg \tan \theta$$

$$c) \theta = \tan^{-1} \frac{a}{g}$$

a) case w/ uniform velocity
(no acceleration)
 $\Sigma F = 0$