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$$(a) \ m = \frac{W}{g} = \frac{3600}{32.2} = \underline{111.8 \text{ slugs}}$$

$$(b) \ W = 3600 \text{ lb} \left[\frac{4.4482 \text{ N}}{\text{lb}} \right] = \underline{16\ 010 \text{ N}}$$

$$(c) \ m = \frac{W}{g} = \frac{16\ 010}{9.81} = \underline{1632 \text{ kg}}$$

$$\left(\text{or } m = 111.8 \text{ slugs} \left[\frac{14.594 \text{ kg}}{\text{slug}} \right] = 1632 \text{ kg} \right)$$

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For a 180-lb person :

$$W = mg : 180 \text{ lb} = m (32.2 \text{ ft/sec}^2)$$

$$m = \underline{5.59 \text{ slugs}}$$

$$180 \text{ lb} \left(\frac{4.4482 \text{ N}}{\text{lb}} \right) = \underline{801 \text{ N}}$$

$$W = mg : 801 \text{ N} = m (9.81 \text{ m/s}^2)$$

$$m = \underline{81.6 \text{ kg}}$$

$$\begin{aligned}
 \frac{1}{3} \quad \underline{V}_1 &= 15 \left(\frac{4}{5} \underline{i} + \frac{3}{5} \underline{j} \right) = 12 \underline{i} + 9 \underline{j} \\
 \underline{V}_2 &= 12 (-\cos 60^\circ \underline{i} + \sin 60^\circ \underline{j}) = -6 \underline{i} + 10.39 \underline{j} \\
 \underline{V}_1 + \underline{V}_2 &= 15 + 12 = \underline{27} \\
 \underline{V}_1 + \underline{V}_2 &= (12-6) \underline{i} + (9+10.39) \underline{j} = \underline{6 \underline{i} + 19.39 \underline{j}} \\
 \underline{V}_1 - \underline{V}_2 &= (12-(-6)) \underline{i} + (9-10.39) \underline{j} = \underline{18 \underline{i} - 1.392 \underline{j}} \\
 \underline{V}_1 \times \underline{V}_2 &= (12 \underline{i} + 9 \underline{j}) \times (-6 \underline{i} + 10.39 \underline{j}) \\
 &= (124.7 + 54) \underline{k} = \underline{178.7 \underline{k}} \\
 \underline{V}_2 \times \underline{V}_1 &= -(\underline{V}_1 \times \underline{V}_2) = \underline{-178.7 \underline{k}} \\
 \underline{V}_1 \cdot \underline{V}_2 &= (12 \underline{i} + 9 \underline{j}) \cdot (-6 \underline{i} + 10.39 \underline{j}) \\
 &= 12(-6) + 9(10.39) = \underline{21.5}
 \end{aligned}$$

1/4 The weight of an average apple is

$$W = \frac{5 \text{ lb}}{12 \text{ apples}} = 0.417 \text{ lb}$$

$$\text{Mass in slugs is } m = \frac{W}{g} = \frac{0.417}{32.2} = \underline{0.01294 \text{ slugs}}$$

$$\text{Mass in kg is } m = 0.01294 \text{ slugs} \left(\frac{14.594 \text{ kg}}{1 \text{ slug}} \right) \\ = \underline{0.1888 \text{ kg}}$$

$$\text{Weight in N is } W = mg = 0.1888 (9.81) = \underline{1.853 \text{ N}}$$

These apples weigh closer to 2 N each than
to the rule of 1 N each!

$$\frac{1}{5} \quad \text{Mass of iron sphere } m = \rho V$$

$$= (7210 \frac{\text{kg}}{\text{m}^3}) \left(\frac{4}{3} \pi (0.050)^3 \right) = 3.78 \text{ kg}$$

Force of mutual attraction : $\frac{Gm^2}{d^2}$

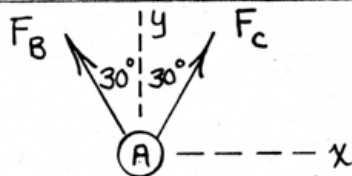
Weight of each sphere : $\frac{Gm_e m}{r^2}$

$$\frac{Gm^2}{d^2} = \frac{Gm_e m}{r^2}, \quad r = d \sqrt{\frac{m_e}{m}}$$

$$= 0.1 \sqrt{\frac{5.976 \times 10^{24}}{3.78}} \frac{1}{10^3}$$

$$= \underline{1.258 (10^8) \text{ km}}$$

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$r = 0.050 \text{ m}$ for
all spheres

$$F_B = \frac{G m_A m_B}{d_{AB}^2} = \frac{G \left(\rho_A \frac{4}{3} \pi r^3 \right) \left(\rho_B \frac{4}{3} \pi r^3 \right)}{d_{AB}^2}$$

$$= \frac{6.673(10^{-11}) \left[\frac{4}{3} \pi (0.050)^3 \right]^2 (8910)(2690)}{1^2}$$

$$= 4.38(10^{-10}) \text{ N}$$

$$F_C = \frac{G m_A m_C}{d_{AC}^2} = \frac{G \left[\frac{4}{3} \pi r^3 \right]^2 \rho_A \rho_C}{d_{AC}^2}$$

$$= \frac{6.673(10^{-11}) \left[\frac{4}{3} \pi (0.050)^3 \right]^2 (8910)(7210)}{1^2}$$

$$= 1.175(10^{-9}) \text{ N}$$

$$\underline{R} = \underline{F}_B + \underline{F}_C = 4.38(10^{-10}) [-\sin 30^\circ \underline{i} + \cos 30^\circ \underline{j}]$$

$$+ 1.175(10^{-9}) [\sin 30^\circ \underline{i} + \cos 30^\circ \underline{j}]$$

$$\underline{R} = (3.68\underline{i} + 13.98\underline{j}) 10^{-10} \text{ N}$$

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$$g_h = \frac{G m_e}{(R+h)^2}$$

$$= \frac{(3.439 \times 10^{-8})(4.095 \times 10^{23})}{[(3959)(5280) + (150)(5280)]^2} = \underline{29.9 \text{ ft/sec}^2}$$

Mass of man : $m = \frac{W}{g} = \frac{200}{32.174} = 6.22 \text{ slugs}$

Absolute weight at $h = 150$ miles :

$$W_h = m g_h = (6.22)(29.9) = \underline{186.0 \text{ lb}}$$

The terms "zero-g" and "weightless" are definitely misnomers in this instance.

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$$mg = 0.1 mg_0$$

$$\frac{R^2}{(R+h)^2} g_0 = 0.1 g_0$$

Solve for h to obtain $h = 2.16R$

$$\frac{1}{9} \quad g_{\text{rel}} = 9.780327 (1 + 0.005279 \sin^2 \gamma + 0.000023 \sin^4 \gamma)$$

$$\text{At } \gamma = 45^\circ, \quad \underline{g_{\text{rel}} = 9.806 \text{ m/s}^2}$$

$$\begin{aligned} g_{\text{abs}} &= g_{\text{rel}} + 0.03382 \cos^2 \gamma \\ &= 9.806198 + 0.03382 \cos^2 45^\circ \\ &= \underline{9.823 \text{ m/s}^2} \end{aligned}$$

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$$g_{\text{rel}} = 9.780327(1 + 0.005279 \sin^2 \gamma + 0.000023 \sin^4 \gamma + \dots)$$

$$\text{At } \gamma = 40^\circ, \quad g_{\text{rel}} = 9.801698 \text{ m/s}^2$$

$$\begin{aligned} g_{\text{abs}} &= g_{\text{rel}} + 0.03382 \cos^2 \gamma \\ &= 9.801698 + 0.03382 \cos^2 40^\circ \\ &= 9.821544 \text{ m/s}^2 \end{aligned}$$

$$W_{\text{abs}} = m g_{\text{abs}} = 90 (9.821544) = \underline{883.9 \text{ N}}$$

$$W_{\text{rel}} = m g_{\text{rel}} = 90 (9.801698) = \underline{882.2 \text{ N}}$$

$$\boxed{1/11} \quad \bar{W} = mg, \quad g = g_0 \left(\frac{R}{R+h} \right)^2$$

From Fig. 1/1, $g_0 = 9.818 \text{ m/s}^2$

@ 28°N latitude & sea level.

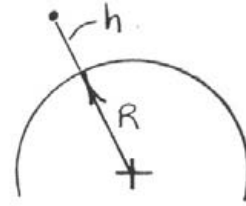
At $h = 2440 \text{ m}$:

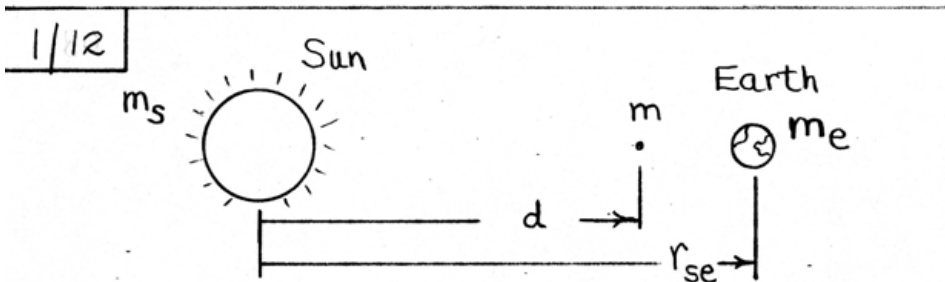
$$g = 9.818 \left[\frac{6371(10^3)}{6371(10^3) + 2440} \right]^2 = 9.810 \text{ m/s}^2$$

At $h = 8848 \text{ m}$:

$$g = 9.818 \left[\frac{6371(10^3)}{6371(10^3) + 8848} \right]^2 = 9.791 \text{ m/s}^2$$

$$\Delta \bar{W} = m \Delta g = 80(9.810 - 9.791) = \underline{1.576 \text{ N}}$$





Newton's Universal Gravitational Law:

$$\frac{Gmm_s}{d^2} = \frac{Gmm_e}{(r_{se}-d)^2}$$

$$d^2[m_s - m_e] - d[2m_s r_{se}] + m_s r_{se}^2 = 0$$

Substitute $m_e = 5.976 (10^{24}) \text{ kg}$,

$$m_s = 333\,000 [5.976 (10^{24})] \text{ kg},$$

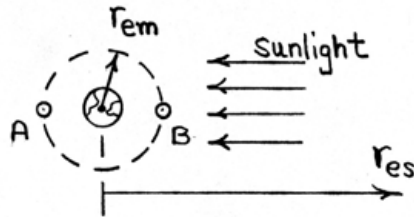
$$\text{and } r_{se} = 149.6 (10^9) \text{ m},$$

Then solve the quadratic to obtain

$$d = 149.3 (10^9) \text{ m}$$

$$\text{or } d = \underline{\underline{149.9 (10^9) \text{ m}}}$$

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Force exerted by earth on moon :

$$F_e = \frac{G m_e m_m}{r_{em}^2} = \frac{(6.673 \times 10^{-11}) (5.976 \times 10^{24})^2 (1) (0.0123)}{(3.84398 \times 10^8)^2}$$

$$= 1.984 \times 10^{20} \text{ N}$$

Forces exerted by sun on moon :

$$F_{sA} = \frac{G m_s m_m}{(r_{es} + r_{em})^2} = \frac{(6.673 \times 10^{-11}) (5.976 \times 10^{24})^2 (333,000) (0.0123)}{(1.496 \times 10^{11} + 3.84398 \times 10^8)^2}$$

$$= 4.34 \times 10^{20} \text{ N}$$

$$F_{sB} = \frac{G m_s m_m}{(r_{es} + r_{em})^2} = 4.38 \times 10^{20} \text{ N}$$

Ratios :	
R_A	$= 2.19$
R_B	$= 2.21$

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$$C_D = \frac{D}{\frac{1}{2} \rho v^2 S}$$

$$[C_D] = \frac{MLT^{-2}}{(M/L^3)(L/T)^2 L^2} = 1$$

C_D is nondimensional.