1/1

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

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

$\boxed{1/2}$ For a 180-lb person:

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

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

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

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

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

1/3

$\underline{V}_1 = 15\left(\frac{4}{5}\underline{i} + \frac{3}{5}\underline{j}\right) = 12\underline{i} + 9\underline{j}$

$\underline{V}_2 = 12\left(-\cos 60°\underline{i} + \sin 60°\underline{j}\right) = -6\underline{i} + 10.39\underline{j}$

$V_1 + V_2 = 15 + 12 = \underline{27}$

$\underline{V}_1 + \underline{V}_2 = (12-6)\underline{i} + (9+10.39)\underline{j} = \underline{6\underline{i} + 19.39\underline{j}}$

$\underline{V}_1 - \underline{V}_2 = (12-(-6))\underline{i} + (9-10.39)\underline{j} = \underline{18\underline{i} - 1.392\underline{j}}$

$\underline{V}_1 \times \underline{V}_2 = (12\underline{i} + 9\underline{j}) \times (-6\underline{i} + 10.39\underline{j})$

$= (124.7 + 54)\underline{k} = \underline{178.7\,\underline{k}}$

$\underline{V}_2 \times \underline{V}_1 = -(\underline{V}_1 \times \underline{V}_2) = \underline{-178.7\,\underline{k}}$

$\underline{V}_1 \cdot \underline{V}_2 = (12\underline{i} + 9\underline{j}) \cdot (-6\underline{i} + 10.39\underline{j})$

$= 12(-6) + 9(10.39) = \underline{21.5}$

1/4 The weight of an average apple is

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

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

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

$$= \underline{0.1888 \text{ kg}}$$

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!

1/5 Mass of iron sphere $m = \rho V$

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

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

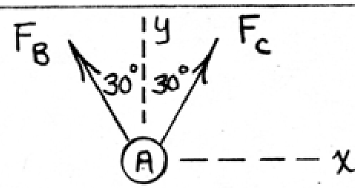
Weight of each sphere : $\dfrac{Gm_e m}{r^2}$

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

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

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

1/6



$r = 0.050$ m for all spheres

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

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

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

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

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

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

$$\underline{R} = \underline{F}_B + \underline{F}_C = 4.38(10^{-10})\left[-\sin 30^\circ \underline{i} + \cos 30^\circ \underline{j}\right] + 1.175(10^{-9})\left[\sin 30^\circ \underline{i} + \cos 30^\circ \underline{j}\right]$$

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

1/7

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

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

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

Absolute weight at $h = 150$ miles :

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

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

1/8

$$mg = 0.1\, mg_0$$

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

Solve for h to obtain $\underline{h = 2.16R}$

1/9

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

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

$$g_{abs} = g_{rel} + 0.03382\cos^2\gamma$$
$$= 9.806198 + 0.03382\cos^2 45°$$
$$= \underline{9.823 \text{ m/s}^2}$$

1/10

$$g_{rel} = 9.780\,327(1 + 0.005279 \sin^2\gamma + 0.000023 \sin^4\gamma + \cdots)$$

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

$$g_{abs} = g_{rel} + 0.03382 \cos^2\gamma$$

$$= 9.801698 + 0.03382 \cos^2 40°$$

$$= 9.821544 \text{ m/s}^2$$

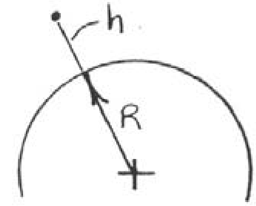
$$W_{abs} = mg_{abs} = 90\,(9.821544) = \underline{883.9 \text{ N}}$$

$$W_{rel} = mg_{rel} = 90\,(9.801698) = \underline{882.2 \text{ N}}$$

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

From Fig. 1/1, $g_0 = 9.818$ m/s^2

@ 28° N latitude & sea level.



At $h = 2440$ m :

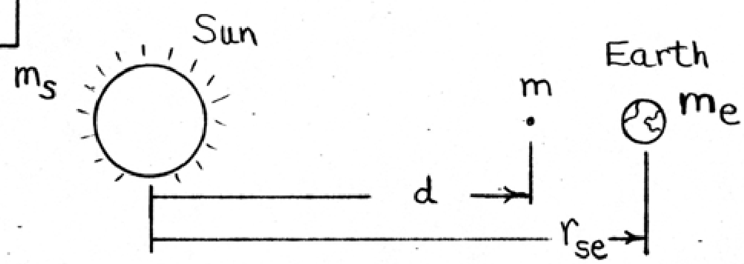
$$g = 9.818\left[\frac{6371(10^3)}{6371(10^3) + 2440}\right]^2 = 9.810 \text{ m/s}^2$$

At $h = 8848$ m :

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

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

1/12



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

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

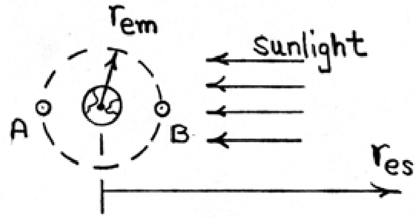
and $r_{se} = 149.6(10^9)$ m,

then solve the quadratic to obtain

$d = 149.3(10^9)$ m

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

1/13



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:

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

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

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

Ratios:

$R_A = 2.19$

$R_B = 2.21$

1/14

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

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

<u>C_D is nondimensional.</u>