1/1

(a) $m = \frac{W}{g} = \frac{3500}{32.2} = \underline{108.7 \text{ slugs}}$

(b) $W = 3500 \text{ lb} \left[\frac{4.4482 \text{ N}}{\text{lb}}\right] = \underline{15\,570 \text{ N}}$

(c) $m = \frac{W}{g} = \frac{15\,570}{9.81} = \underline{1587 \text{ kg}}$

1/2 For a 180-lb person:

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

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

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

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

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

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 $m = \rho V$

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

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

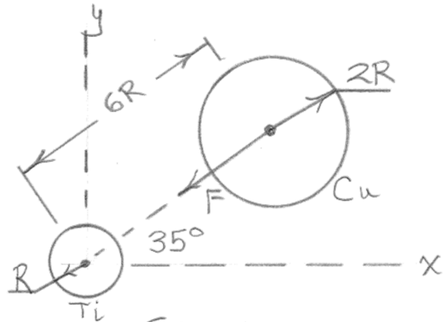
Weight of each sphere : $\frac{Gm_e m}{r^2}$

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

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

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

1/6



$$F = \frac{G m_{Ti} m_{Cu}}{d^2} = \frac{G\left[\frac{4}{3}\pi R^3 \rho_{Ti}\right]\left[\frac{4}{3}\pi (2R)^3 \rho_{Cu}\right]}{(6R)^2}$$

$$= \frac{32}{81}\pi^2 G \rho_{Ti} \rho_{Cu} R^4$$

$$= \frac{32}{81}\pi^2 (6.673\cdot 10^{-11})(4510)(8910)(0.040)^4$$

$$= 2.68(10^{-8}) \text{ N}$$

Force is a vector quantity, so

$$\underline{F} = F\underline{n} = 2.68(10^{-8})\left[-\cos 35^\circ \underline{i} - \sin 35^\circ \underline{j}\right]$$

$$= \underline{(-2.19\underline{i} - 1.535\underline{j})\, 10^{-8} \text{ N}}$$

1/7

$$\cancel{m}g = \frac{1}{3}\cancel{m}g_{h=0}$$

$$\frac{R^2}{(R+h)^2}g_0 = \frac{1}{3}g_0$$

Solve for h: $h = (\sqrt{3}-1)R = \underline{0.732R}$

1/8

$g_{rel} = 9.780\,327\,(1 + 0.005\,279 \sin^2\gamma + 0.000\,023 \sin^4\gamma \cdots)$

At $\gamma = 35°$, $g_{rel} = 9.797\,337$ m/s^2

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

$= 9.797\,337 + 0.03382 \cos^2 35°$

$= 9.820\,031$ m/s^2

$W_{abs} = mg_{abs} = 60\,(9.820\,031) = \underline{589 \text{ N}}$

$W_{rel} = mg_{rel} = 60\,(9.797\,337) = \underline{588 \text{ N}}$

(More precise values : $W_{abs} = 589.2$ N

$W_{rel} = 587.8$ N)

1/9

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

$$= \frac{(3.439 \cdot 10^{-8})(4.095 \cdot 10^{23})}{[(3959+200)(5280)]^2} = \underline{29.2 \text{ ft/sec}^2}$$

Mass of passenger $m = \frac{W}{g} = \frac{180}{32.174}$

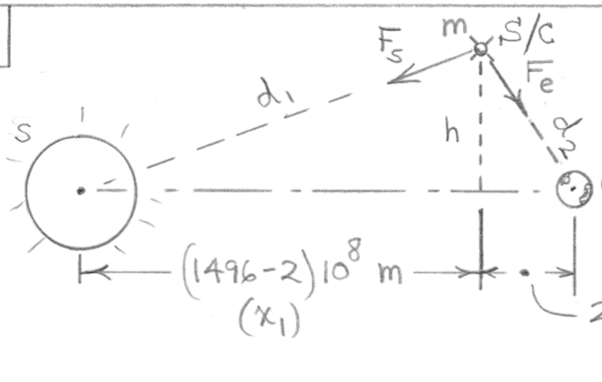
$= 5.59$ slugs

Absolute weight at $h = 200$ mi:

$W_h = mg_h = (5.59)(29.2) = \underline{163.4 \text{ lb}}$

The terms "zero-g" and "weightless" are <u>absolutely</u> (!) misnomers in this case.

1/10



$$\begin{cases} d_1^2 = x_1^2 + h^2 \\ d_2^2 = x_2^2 + h^2 \end{cases}$$

$$F_s = \frac{Gmm_s}{d_1^2}, \quad F_e = \frac{Gmm_e}{d_2^2}$$

For equal force magnitudes, $F_s = F_e$

$$\Rightarrow \frac{m_s}{d_1^2} = \frac{m_e}{d_2^2} \quad \text{or} \quad \frac{m_s}{x_1^2 + h^2} = \frac{m_e}{x_2^2 + h^2}$$

$$h = \left[\frac{m_e x_1^2 - m_s x_2^2}{m_s - m_e}\right]^{1/2}$$

With $m_e = 5.976(10^{24})$ kg, $m_s = 333\,000\, m_e$, and x_1 and x_2 as above:

$h = 1.644(10^8)$ m or $\underline{1.644(10^5) \text{ km}}$