1/1 For a 180-lb person:

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

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

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

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

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

1/2

$$W = mg = (1500\ \text{kg})\left(9.81\ \frac{\text{m}}{\text{s}^2}\right) = \underline{14\ 720\ \text{N}}$$

$$m = (1500\ \text{kg})\left(\frac{1\ \text{slug}}{14.594\ \text{kg}}\right) = \underline{102.8\ \text{slugs}}$$

$$W = mg = (102.8\ \text{slugs})\left(32.2\ \frac{\text{ft}}{\text{sec}^2}\right)$$

$$= \underline{3310\ \text{lb}}$$

1/3

$$\underline{V}_1 = 12(\cos 30^\circ \underline{i} + \sin 30^\circ \underline{j})$$
$$= 10.39\underline{i} + 6\underline{j}$$

$$\underline{V}_2 = 15\left(-\frac{3}{5}\underline{i} + \frac{4}{5}\underline{j}\right) = -9\underline{i} + 12\underline{j}$$

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

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

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

$$\underline{V}_1 \times \underline{V}_2 = (10.39\underline{i} + 6\underline{j}) \times (-9\underline{i} + 12\underline{j})$$
$$= [10.39(12) - 6(-9)]\underline{k} = \underline{178.7\underline{k}}$$

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

$$\underline{V}_1 \cdot \underline{V}_2 = 10.39(-9) + 6(12) = \underline{-21.5}$$

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

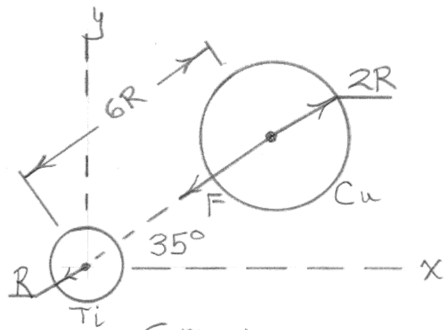
Mass in kg is $m = 0.01294\ \text{slugs}\left(\frac{14.594\ \text{kg}}{1\ \text{slug}}\right)$

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

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



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

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

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

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

Force is a vector quantity, so

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

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

1/6

$$\cancel{m}g = \frac{1}{2}\cancel{m}g_{h=0}$$

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

Solve for h to obtain $\underline{h = (\sqrt{2} - 1)R}$

or $\underline{h = 0.414R}$

1/7

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

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)

1/8

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

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

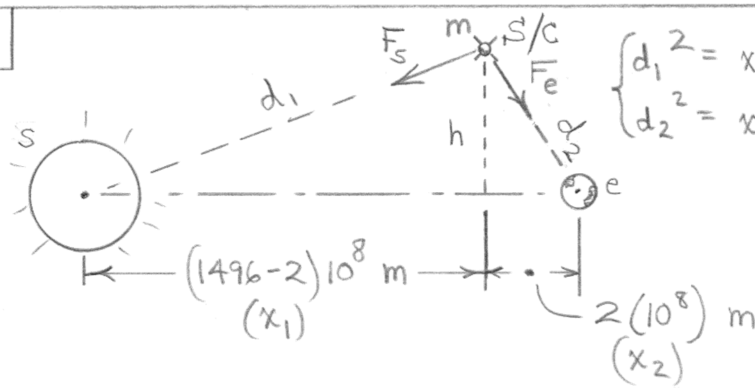
Mass of man : $m = \frac{W}{g} = \frac{200}{32.174} = 6.22$ slugs

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.

1/9



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

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

For equal force magnitudes, $F_s = F_e$

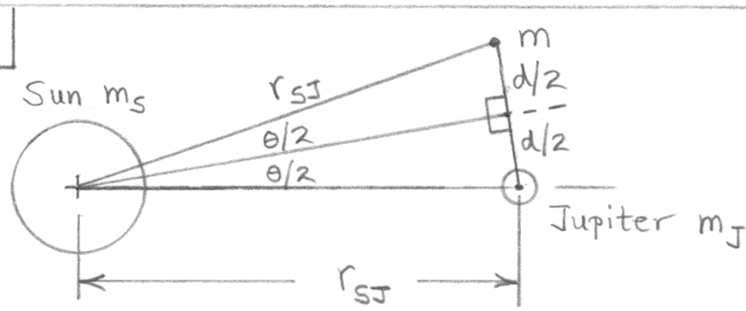
$$\Rightarrow \frac{m_s}{d_1^2} = \frac{m_e}{d_2^2} \quad \text{or} \quad \frac{m_s}{x_1^2 + h^2} = \frac{m_e}{x_2^2 + h^2}$$

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

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

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

1/10



Newton's Law of Universal Gravitation:

$$\frac{Gmm_S}{r_{SJ}^2} = \frac{Gmm_J}{d^2}$$

$$d = r_{SJ}\sqrt{\frac{m_J}{m_S}} = 778(10^6)\sqrt{\frac{317.8}{333000}}$$

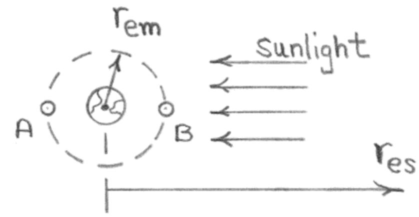
$$= 24.0(10^6) \text{ km}$$

Then $\sin\frac{\theta}{2} = \frac{d/2}{r_{SJ}} = \frac{24.0(10^6)/2}{778(10^6)}$

$$\underline{\theta = 1.770°}$$

(We could have used the small-angle approach $d = r_{SJ}\theta$!)

1/11



Force exerted by earth on moon:

$$F_e = \frac{Gm_e m_m}{r_{em}^2} = \frac{(6.673\times10^{-11})(5.976\times10^{24})^2(1)(0.0123)}{(3.84398\times10^{8})^2}$$

$$= 1.984\times10^{20}\ \text{N}$$

Forces exerted by sun on moon:

$$F_{S_A} = \frac{Gm_s m_m}{(r_{es}+r_{em})^2} = \frac{(6.673\times10^{-11})(5.976\times10^{24})^2(333{,}000)(0.0123)}{(1.496\times10^{11}+3.84398\times10^{8})^2}$$

$$= 4.34\times10^{20}\ \text{N}$$

$$F_{S_B} = \frac{Gm_s m_m}{(r_{es}-r_{em})^2} = 4.38\times10^{20}\ \text{N}$$

Ratios:

$R_A = 2.19$

$R_B = 2.21$

1/12

$$E = \int_{t_1}^{t_2} mgr\, dt$$

$$[E] = (M)(L/T^2)(L)(T) = ML^2/T$$

SI: $\underline{[E] = kg \cdot m^2/s}$ (base ✓)

U.S.: $[E] = slugs \cdot ft^2/sec$ (not base)

$$= \frac{lb\text{-}sec^2}{ft} \cdot ft^2/sec = \underline{lb\text{-}ft\text{-}sec}$$

1/13

$$Q = \frac{1}{2}\rho v^2$$

$$[Q] = \frac{M}{L^3}\left(\frac{L}{T}\right)^2 = \underline{ML^{-1}T^{-2}}$$