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

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

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

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

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

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

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

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

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

1/4 The mass of an average apple is

$$m = \frac{2\ \text{kg}}{12} = 0.1667\ \text{kg}$$

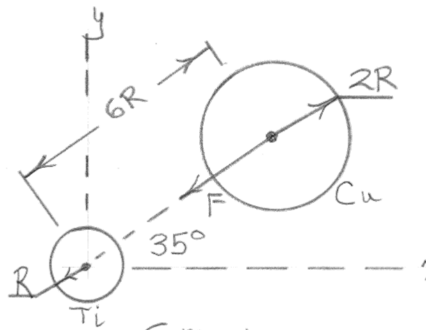
Weight in newtons is $W = mg = 0.1667(9.81) = \underline{1.635\ \text{N}}$

Weight in pounds is $W = 1.635\ \text{N}\left(\frac{1}{4.4482}\ \frac{\text{lb}}{\text{N}}\right)$

$$= \underline{0.368\ \text{lb}}$$

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

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

$$g_h = \frac{(6.673 \times 10^{-11})(5.976 \times 10^{24})}{[(6371+300)(1000)]^2} = \underline{8.96 \text{ m/s}^2}$$

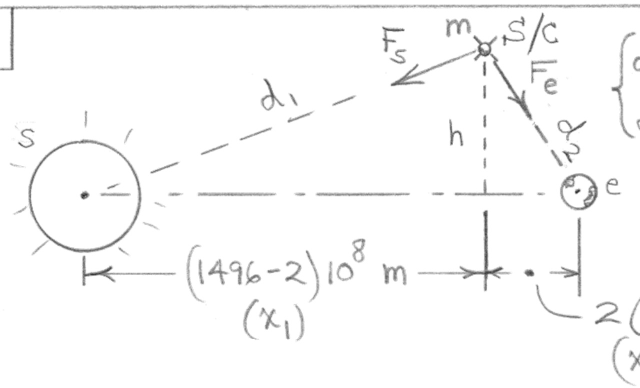
Mass of person: $m = \frac{W}{g} = \frac{880}{9.80665} = 89.7$ kg

Absolute weight at $h = 300$ km:

$W_h = mg_h = 89.7(8.96) = \underline{804 \text{ N}}$

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

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, $F_s = F_e$

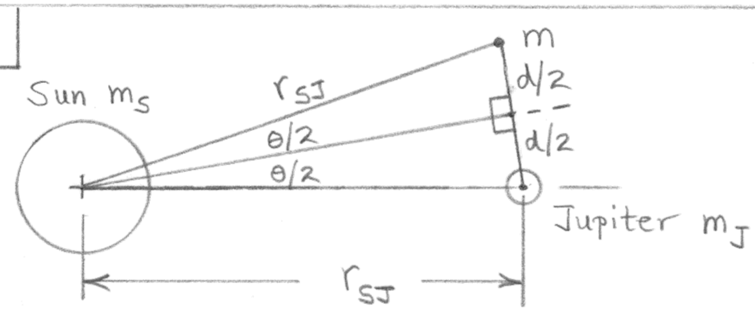
$$\Rightarrow \frac{m_s}{d_1^2} = \frac{m_e}{d_2^2} \quad \text{or} \quad \frac{m_s}{x_1^2+h^2} = \frac{m_e}{x_2^2+h^2}$$

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

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

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

1/10



Newton's Law of Universal Gravitation:

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

$$d = r_{SJ}\sqrt{\frac{m_J}{m_S}} = 778(10^6)\sqrt{\frac{317.8}{333\,000}}$$

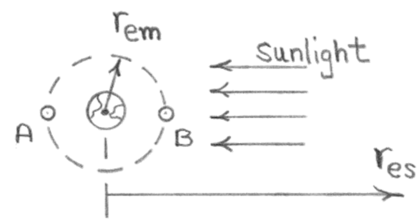
$$= 24.0\,(10^6)\text{ km}$$

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

$$\underline{\theta = 1.770^\circ}$$

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

1/11



Force exerted by earth on moon:

$$F_e = \frac{G m_e m_m}{r_{em}^2} = \frac{(6.673 \times 10^{-11})(5.976 \times 10^{24})^2 (1)(0.0123)}{(3.84\,398 \times 10^8)^2}$$

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

Forces exerted by sun on moon:

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

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

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

Ratios:

$R_A = 2.19$

$R_B = 2.21$

1/12

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

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

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

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

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

1/13

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

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