1/1 For a 180-lb person:

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

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

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

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

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

1/2

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

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

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

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

1/3 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!

1/4

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

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

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

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

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

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

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

1/5 $r = 0.050$ m for both spheres

$$F = \frac{G m_c m_t}{d^2} = \frac{G\left(\rho_c \frac{4}{3}\pi r^3\right)\left(\rho_t \frac{4}{3}\pi r^3\right)}{d^2}$$

$$= \frac{G \rho_c \rho_t \left(\frac{4}{3}\pi r^3\right)^2}{d^2}$$

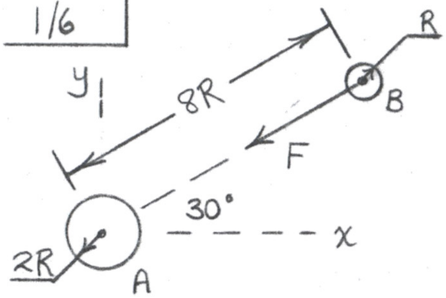
With $\begin{cases} G = 6.673(10^{-11}) \frac{m^3}{kg \cdot s^2} \\ \rho_c = 8910 \text{ kg/m}^3 \\ \rho_t = 3080 \text{ kg/m}^3, \end{cases}$

we obtain, as vectors:

(a) $\underline{\underline{F} = -1.255(10^{-10})\,\underline{i} \text{ N}}$ (for $d = 2$m)

(b) $\underline{\underline{F} = -3.14(10^{-11})\,\underline{i} \text{ N}}$ (for $d = 4$m)

1/6



$$F = \frac{G m_A m_B}{d^2} = \frac{G\left[\frac{4}{3}\pi (2R)^3 \rho\right]\left[\frac{4}{3}\pi R^3 \rho\right]}{(8R)^2}$$

$$= \frac{2}{9}\pi^2 G \rho^2 R^4$$

$$= \frac{2}{9}\pi^2 (6.673 \cdot 10^{-11})(2690)^2(0.050)^4$$

$$= 6.62(10^{-9}) \text{ N}$$

Force is a vector quantity, so

$$\underline{F} = F\underline{n} = 6.62(10^{-9})\left[-\frac{\sqrt{3}}{2}\underline{i} - \frac{1}{2}\underline{j}\right]$$

$$= -(5.73\,\underline{i} + 3.31\,\underline{j})10^{-9} \text{ N}$$

1/7

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

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

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

or $\underline{h = 0.414R}$

1/8

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

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

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

$= 9.801698 + 0.03382 \cos^2 40°$

$= 9.821544$ m/s^2

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

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

1/9

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

$$= \frac{(6.673 \times 10^{-11})(5.976 \times 10^{24})}{[(6371+250)(1000)]^2} = \underline{9.10 \text{ m/s}^2}$$

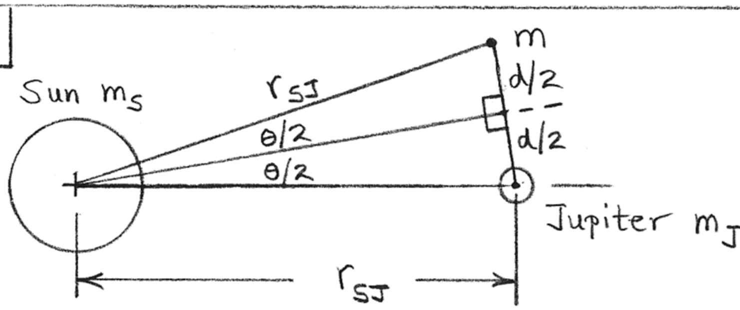
Mass of person : $m = \frac{W}{g} = \frac{880}{9.806\,65} = 89.74$ kg

Absolute weight at $h = 250$ km:

$W_h = mg_h = 89.74\,(9.10) = \underline{816 \text{ N}}$

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

1/10



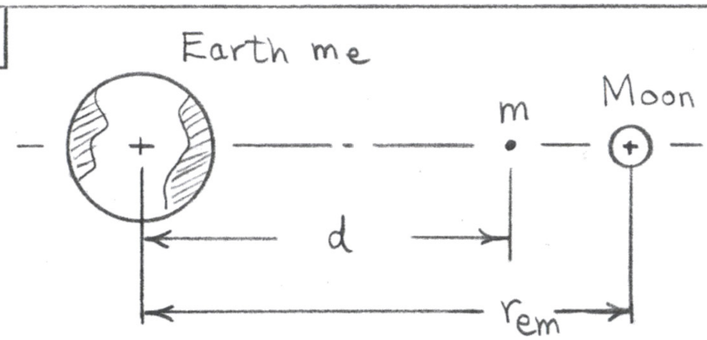
Newton's Law of Universal Gravitation:

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

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

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

1/11



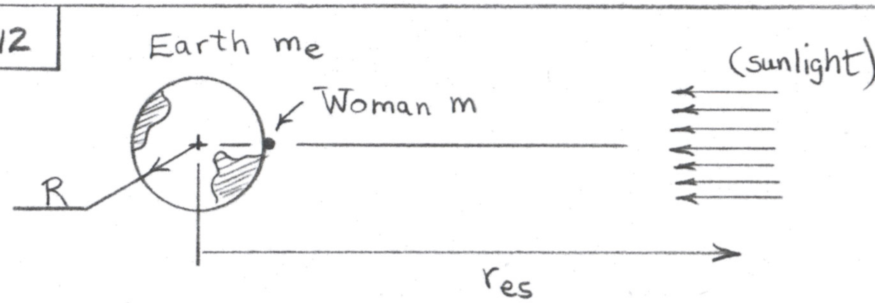
Newton's Law of Universal Gravitation:

$$\frac{G m_e m}{d^2} = \frac{G m_m m}{(r_{em}-d)^2} \Rightarrow m_m d^2 = m_e (r_{em}-d)^2$$

With $m_m = 0.0123\, m_e$ and $r_{em} = 384\,398$ km,

$$\begin{cases} d = 346\,022 \text{ km} & \text{(between earth \& moon)} \\ d = 432\,348 \text{ km} & \text{(to right of moon)} \end{cases}$$

1/12

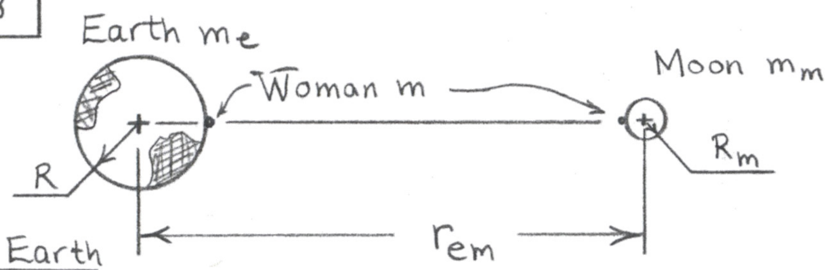


$$F_e = \frac{G m_e m}{R^2} \qquad F_s = \frac{G m_s m}{(r_{es} - R)^2}$$

$$\text{Ratio } R_{es} = \frac{F_e}{F_s} = \frac{m_e (r_{es} - R)^2}{m_s R^2}$$

$$= \frac{1}{333\,000} \frac{[149.6(10^6) - 6371]^2}{[6371]^2} = \underline{1656}$$

1/13



On Earth

$$F_e = \frac{G m_e m}{R^2} \qquad F_m = \frac{G m_m m}{(r_{em} - R)^2}$$

$$\text{Ratio} \quad R_{em} = \frac{F_e}{F_m} = \frac{m_e (r_{em} - R)^2}{m_m R^2}$$

$$\text{or } R_{em} = \frac{1}{0.0123} \frac{[384\,398 - 6371]^2}{[6371]^2}$$

$$= \underline{286\,000}$$

On moon

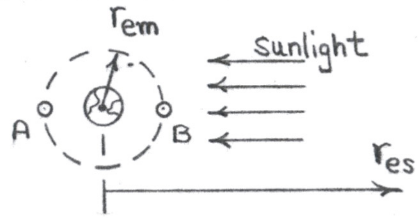
$$F_e = \frac{G m_e m}{(r_{em} - R_m)^2} \qquad F_m = \frac{G m_m m}{R_m^2}$$

$$R_{em} = \frac{F_e}{F_m} = \frac{m_e R_m^2}{m_m (r_{em} - R)^2}$$

$$= \frac{1}{0.0123} \frac{[3476/2]^2}{[384\,398 - 3476/2]^2} = \underline{0.001677}$$

(Note: $R_{me} = F_m / F_e = 1/R_{em} = 596$)

1/14



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:

$R_A = 2.19$

$R_B = 2.21$

1/15

$$mv = \int_{t_1}^{t_2} (F \cos\theta)\, dt$$

$$[M][LT^{-1}] = [MLT^{-2}][T]$$

$$[MLT^{-1}] = [MLT^{-1}] \checkmark$$