

111 For a 180-lb person :

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

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

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

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

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

$$\frac{1}{2} \quad W = mg = (1500 \text{ kg}) \left(9.81 \frac{\text{m}}{\text{s}^2} \right) = \underline{14\,720 \text{ N}}$$

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

$$W = mg = (102.8 \text{ slugs}) \left(32.2 \frac{\text{ft}}{\text{sec}^2} \right) \\ = \underline{3310 \text{ lb}}$$

$\frac{1}{3}$	The mass of an average apple is
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$$m = \frac{2 \text{ kg}}{12} = 0.1667 \text{ kg}$$

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!

$$\begin{aligned} \underline{1/4} \quad \underline{V_1} &= 12 (\cos 30^\circ \underline{i} + \sin 30^\circ \underline{j}) \\ &= 10.39 \underline{i} + 6 \underline{j} \\ \underline{V_2} &= 15 \left(-\frac{3}{5} \underline{i} + \frac{4}{5} \underline{j} \right) = -9 \underline{i} + 12 \underline{j} \\ \underline{V_1} + \underline{V_2} &= 12 + 15 = \underline{27} \\ \underline{V_1} + \underline{V_2} &= (10.39 - 9) \underline{i} + (6 + 12) \underline{j} = \underline{1.392 \underline{i} + 18 \underline{j}} \\ \underline{V_1} - \underline{V_2} &= (10.39 - (-9)) \underline{i} + (6 - 12) \underline{j} = \underline{19.39 \underline{i} - 6 \underline{j}} \\ \underline{V_1} \times \underline{V_2} &= (10.39 \underline{i} + 6 \underline{j}) \times (-9 \underline{i} + 12 \underline{j}) \\ &= [10.39(12) - 6(-9)] \underline{k} = \underline{178.7 \underline{k}} \\ \underline{V_1} \cdot \underline{V_2} &= 10.39(-9) + 6(12) = \underline{-21.5} \end{aligned}$$

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$r = 0.050 \text{ m for both spheres}$

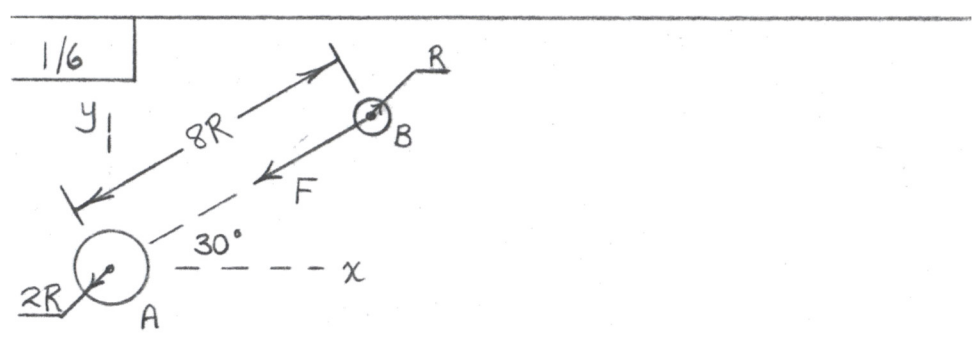
$$F = \frac{G m_c m_t}{d^2} = \frac{G (\rho_c \frac{4}{3} \pi r^3) (\rho_t \frac{4}{3} \pi r^3)}{d^2}$$
$$= \frac{G \rho_c \rho_t (\frac{4}{3} \pi r^3)^2}{d^2}$$

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

We obtain , as vectors :

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

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



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

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

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

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

Force is a vector quantity, so

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

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

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$$mg = \frac{1}{2} mg_{h=0}$$

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

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

or $h = 0.414R$

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

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

$$\begin{aligned} g_{abs} &= g_{rel} + 0.03382 \cos^2 \gamma \\ &= 9.801698 + 0.03382 \cos^2 40^\circ \\ &= 9.821544 \text{ m/s}^2 \end{aligned}$$

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

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

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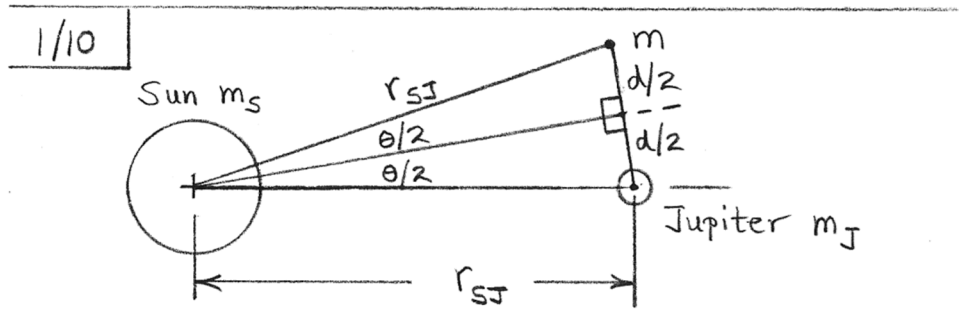
$$g_h = \frac{G m_e}{(R+h)^2}$$
$$= \frac{(6.673 \times 10^{-11})(5.976 \times 10^{24})}{[(6371+250)(1000)]^2} = \underline{9.10 \text{ m/s}^2}$$

Mass of person : $m = \frac{W}{g} = \frac{880}{9.80665} = 89.74 \text{ kg}$

Absolute weight at $h = 250 \text{ km}$:

$$W_h = m g_h = 89.74 (9.10) = \underline{816 \text{ N}}$$

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

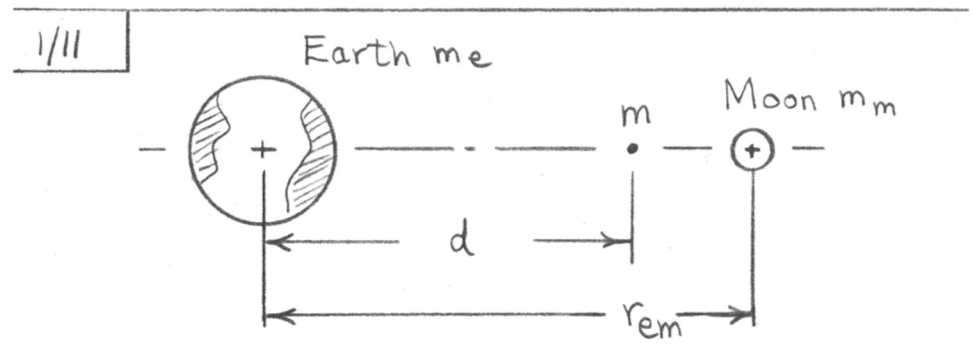


Newton's Law of Universal Gravitation :

$$\frac{G m m_s}{r_{SJ}^2} = \frac{G m m_J}{d^2}$$

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

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

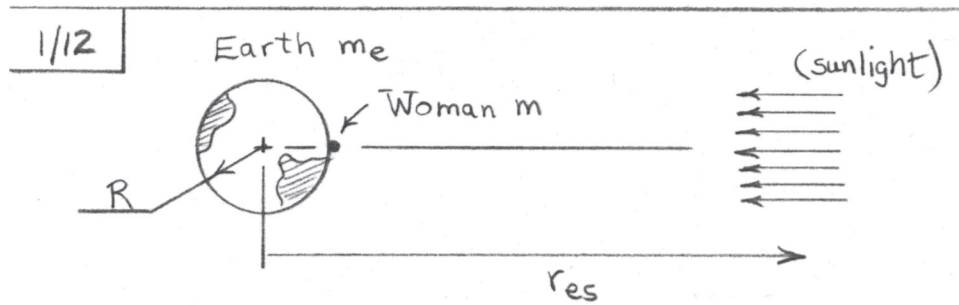


Newton's Law of Universal Gravitation:

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

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

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



$$F_e = \frac{G m_e m}{R^2}$$

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

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

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

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Earth m_e

Woman m

R

On Earth

Moon m_m

R_m

r_{em}

$$F_e = \frac{G m_e m}{R^2}$$

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

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

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

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

On moon

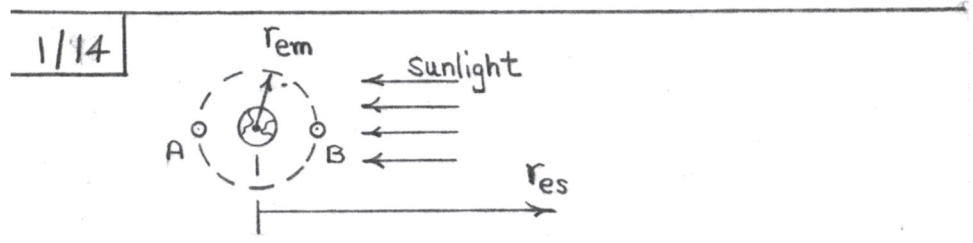
$$F_e = \frac{G m_e m}{(r_{em} - R_m)^2}$$

$$F_m = \frac{G m_m m}{R_m^2}$$

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

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

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



Force exerted by earth on moon :

$$F_e = \frac{Gm_em_m}{r_{em}^2} = \frac{(6.673 \times 10^{-11})(5.976 \times 10^{24})^2(1)(0.0123)}{(3.84398 \times 10^8)^2}$$

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

Forces exerted by sun on moon :

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

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

$$F_{sB} = \frac{Gm_sm_m}{(r_{es} + r_{em})^2} = 4.38 \times 10^{20} \text{ N}$$

Ratios :	
$R_A = 2.19$	
$R_B = 2.21$	

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

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

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