
1/1 For a 180-lb person :

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

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

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

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

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

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

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

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

$$\underline{1/3} \quad \underline{V}_1 = 12 (\cos 30^\circ \underline{i} + \sin 30^\circ \underline{j})$$
$$= 10.39 \underline{i} + 6 \underline{j}$$

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

$$\underline{V}_1 + \underline{V}_2 = 12 + 15 = \underline{27}$$

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

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

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

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

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

1/4 | The weight of an average apple is

$$W = \frac{5 \text{ lb}}{12 \text{ apples}} = 0.417 \text{ lb}$$

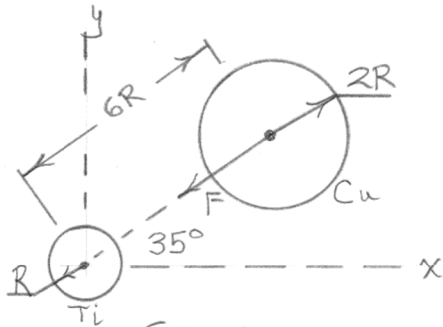
$$\text{Mass in slugs is } m = \frac{W}{g} = \frac{0.417}{32.2} = \underline{0.01294 \text{ slugs}}$$

$$\text{Mass in kg is } m = 0.01294 \text{ slugs} \left(\frac{14.594 \text{ kg}}{1 \text{ slug}} \right) \\ = \underline{0.1888 \text{ kg}}$$

$$\text{Weight in N is } W = mg = 0.1888 (9.81) = \underline{1.853 \text{ N}}$$

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

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

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

1/6

$$r/g = \frac{1}{2} r/g_{h=0}$$

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

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

or $h = 0.414R$

1/7

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

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

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

$$= 9.797\,337 + 0.03382 \cos^2 35^\circ$$

$$= 9.820\,031 \text{ m/s}^2$$

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

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

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

$W_{\text{rel}} = 587.8 \text{ N}$)

$$\frac{1}{8} \quad g_h = \frac{Gm_e}{(R+h)^2}$$
$$= \frac{(3.439 \times 10^{-8})(4.095 \times 10^{23})}{[(3959)(5280) + (150)(5280)]^2} = \underline{29.9 \text{ ft/sec}^2}$$

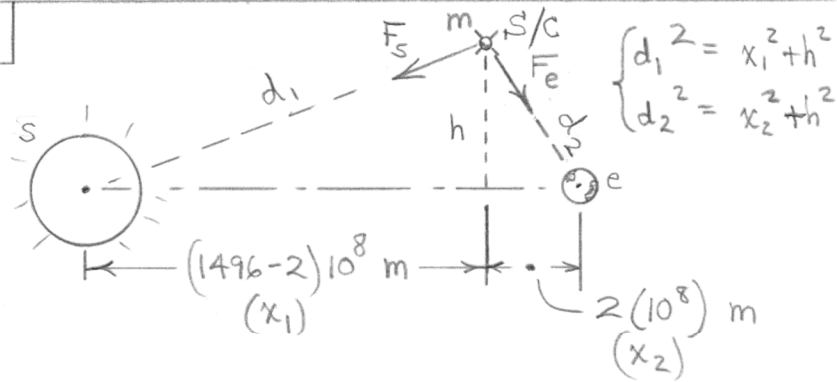
$$\text{Mass of man: } m = \frac{W}{g} = \frac{200}{32.174} = 6.22 \text{ slugs}$$

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



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

For equal force magnitudes, $F_s = F_e$

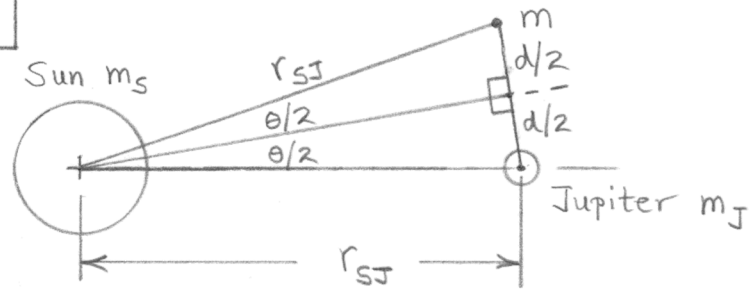
$$\Rightarrow \frac{m_s}{d_1^2} = \frac{m_e}{d_2^2} \quad \text{or} \quad \frac{m_s}{x_1^2 + h^2} = \frac{m_e}{x_2^2 + h^2}$$

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

With $m_e = 5.976(10^{24}) \text{ kg}$, $m_s = 333000 m_e$,
and x_1 and x_2 as above:

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

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Newton's Law of Universal Gravitation:

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

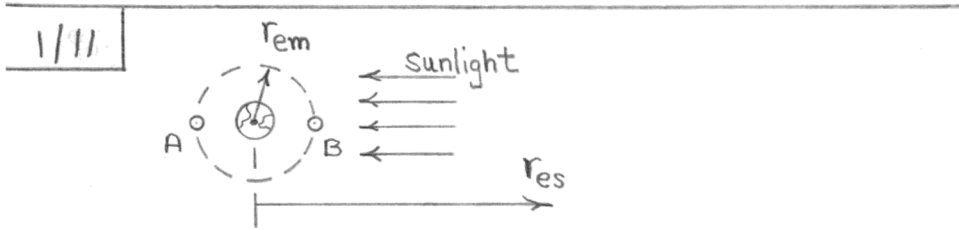
$$d = r_{SJ} \sqrt{\frac{m_J}{m_s}} = 778 (10^6) \sqrt{\frac{317.8}{333000}}$$

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

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

$$\theta = 1.770^\circ$$

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



Force exerted by earth on moon :

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

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

Forces exerted by sun on moon :

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

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

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

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

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$$1/12 \quad E = \int_{t_1}^{t_2} mgr \, dt$$

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

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

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

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

WILEY

$$\frac{1}{13} \quad Q = \frac{1}{2} \rho v^2$$
$$[Q] = \frac{M}{L^3} \left(\frac{L}{T}\right)^2 = \underline{ML^{-1}T^{-2}}$$