INSTRUCTOR'S MANUAL

To Accompany

ENGINEERING MECHANICS - DYNAMICS

Volume 2

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USE OF THE INSTRUCTOR'S MANUAL

The problem solution portion of this manual has been prepared for the instructor who wishes to occasionally refer to the authors' method of solution or who wishes to check the answer of his (her) solution with the result obtained by the authors. In the interest of space and the associated cost of educational materials, the solutions are very concise. Because the problem solution material is not intended for posting of solutions or classroom presentation, the authors request that it not be used for these purposes.

In the transparency master section there are approximately 65 solved problems selected to illustrate typical applications. These problems are different from and in addition to those in the textbook. Instructors who have adopted the textbook are granted permission to reproduce these masters for classroom use.

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

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

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

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

1/2 For a 180-lb person:

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

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

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

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

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

1/3 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!

1/4

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

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

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

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

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

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

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

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

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

1/6

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

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

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.

1/7

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

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

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

or $\underline{h = 0.414R}$

1/8

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

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

$$g_{abs} = g_{rel} + 0.03382 \cos^2\gamma$$
$$= 9.801698 + 0.03382 \cos^2 40°$$
$$= 9.821544 \text{ m/s}^2$$

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

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

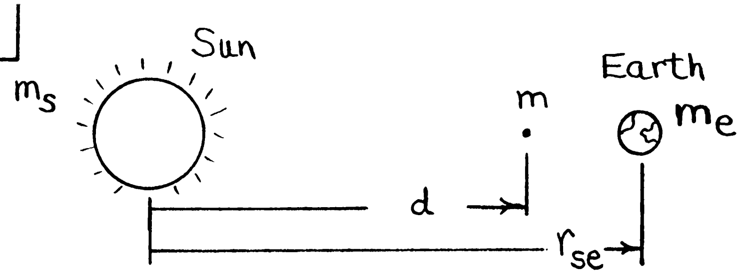
1/9 Use $r_{ms} = 149.6(10^6)$ km as the moon-sun distance.

$$F_s = \frac{G m_s m}{r_{ms}^2} = \frac{[6.673(10^{-11})][5.976(10^{24})(333{,}000)]90}{[149.6(10^9)]^2}$$

$$= \underline{0.534 \text{ N}}$$

$$F_m = m g_m = 90(1.62) = \underline{146 \text{ N}}$$

1/10



Newton's Universal Gravitational Law:

$$\frac{Gmm_s}{d^2} = \frac{Gmm_e}{(r_{se}-d)^2}$$

$$d^2[m_s - m_e] - d[2m_s r_{se}] + m_s r_{se}^2 = 0$$

Substitute $m_e = 5.976\,(10^{24})$ kg,

$m_s = 333\,000\,[5.976\,(10^{24})]$ kg,

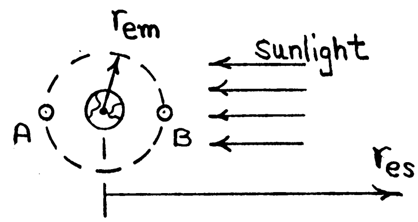
and $r_{se} = 149.6\,(10^9)$ m,

then solve the quadratic to obtain

$d = 149.3\,(10^9)$ m

or $d = 149.9\,(10^9)$ m

1/11



Force exerted by earth on moon:

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

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

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:

$R_A = 2.19$

$R_B = 2.21$

1/12

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

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

$$[MLT^{-1}] = [MLT^{-1}] \quad ✓$$