CHAPTER SEVEN SOLUTIONS

Review (a) Newton's Universal Gravitation Law may be written as

$$F = \frac{Gm_1m_2}{r^2} = m_1\frac{Gm_2}{r^2} .$$

If F is the gravitational force (weight) a mass m_1 located on the surface of a planet experiences, then m_2 is the mass of the planet and r, the distance separating m_1 and m_2 is the radius of the planet R. Comparing the above expression to weight = m_1g, we see that the acceleration due to gravity at the surface of the planet is given by

$$g = \frac{Gm_2}{R^2}$$

For Mars, m_2 = 6.42 x 10^{23} kg, and R = 3.37 x 10^6 m.

Therefore, $g_{\text{Mars}} = (6.673 \times 10^{-11}) \frac{6.42 \times 10^{23}}{(3.37 \times 10^6)^2} = 3.77 \text{ m/s}^2$.

(b) Using $y = v_ot + \frac{1}{2}at^2$ with v_{oy} = 0, and $a_y = g_{\text{Mars}}$, we find

$$t = \sqrt{\frac{2y}{g_{\text{Mars}}}} = \sqrt{\frac{2(20.0 \text{ m})}{3.77 \text{ m/s}^2}} = 3.26 \text{ s}.$$

7.3 (a) ω = (33 rev/min)(2π rad/rev)(1 min/60 s) = 3.5 rad/s.
(b) $\theta = \omega t$ = (3.5 rad/s)(1.5 s) = 5.2 rad.

7.8 ω_f = 2.51 x 10^4 rev/min = 2.63 x 10^3 rad/s

(a) $\alpha = \frac{\omega_f - \omega_o}{t} = \frac{2.63 \times 10^3 \text{ rad/s} - 0}{3.20 \text{ s}} = 8.22 \times 10^2 \text{ rad/s}^2$.

(b) $\theta = \omega_o t + \frac{1}{2}\alpha t^2 = 0 + \frac{1}{2}(8.22 \times 10^2 \text{ rad/s}^2)(3.20 \text{ s})^2 = 4.21 \times 10^3 \text{ rad}$

7.13 $\theta = \frac{\omega^2 - \omega_o{}^2}{2\alpha} = \frac{0 - (18.0 \text{ rad/s})^2}{2(-1.90 \text{ rad/s}^2)} = 85.3 \text{ rad}.$

$s = r\theta$ and $r = \frac{1}{2}$ diameter = 1.20 cm,

so s = (1.20 cm)(85.3 rad) = 102 cm = 1.02 m.

7.14 $s = v_ot + \frac{1}{2}at^2 = (17.0 \text{ m/s})(5.00 \text{ s}) + \frac{1}{2}(2.00 \text{ m/s}^2)(5.00 \text{ s})^2 = 110 \text{ m}.$

$s = r\theta$, and r = 48 cm = 0.480 m

Thus, $\theta = \frac{s}{r} = \frac{110 \text{ m}}{0.480 \text{ m}} = 229.2 \text{ rad} = 36.5 \text{ rev}.$

7.21 Let m be the mass of a red corpuscle and let r be the radius of the centrifuge. We are given

$$F_c = 4.0 \times 10^{-11} \text{ N} = \frac{mv^2}{r} = mr\omega^2 \text{, so}$$

$$\omega = \sqrt{\frac{F_c}{m\,r}} = \sqrt{\frac{4.00 \times 10^{-11}}{(3.00 \times 10^{-16})(0.15)}} = 942.8 \text{ rad/s} = 150 \text{ rev/s}.$$

CHAPTER SEVEN SOLUTIONS

7.29 (a) At A the forces on the car are the normal force, N, and its weight. We have $F_c = \frac{mv^2}{r} = N - mg$, or $N = mg + \frac{mv^2}{r}$, which gives

$$N = (500\text{ kg})(9.80\text{ m/s}^2) + \frac{(500\text{ kg})(20.0\text{ m/s})^2}{10.0\text{ m}} = 2.49 \times 10^4\text{ N}.$$

(b) At B we have, $F_c = \frac{mv^2}{r} = mg - N$, or $N = m(g - \frac{v^2}{r})$.

For the vehicle to remain on the track, it is necessary to have

N ε 0 which means g ε $\frac{v^2}{r}$ or $v = \sqrt{rg}$.

Thus, $v_{max} = v = \sqrt{rg} = \sqrt{(15.0\text{ m})(9.80\text{ m/s}^2)} = 12.1\text{ m/s}$

7.39 (a) $PE = -\frac{GM_Em}{r} = \frac{(6.67 \times 10^{-11}\text{ Nm}^2/\text{kg}^2)(5.98 \times 10^{24}\text{ kg})(100\text{ kg})}{(8.38 \times 10^6\text{ m})}$

$= -4.76 \times 10^9$ J

(b) $F = \frac{GM_Em}{r^2} = \frac{(6.67 \times 10^{-11}\text{ Nm}^2/\text{kg}^2)(5.98 \times 10^{24}\text{ kg})(100\text{ kg})}{(8.38 \times 10^6\text{ m})^2}$

$= 5.68 \times 10^2$ N

7.50 (a) At the bottom of the swing, $T - mg = \frac{mv^2}{L}$, or

$$T = mg + \frac{mv^2_b}{L} = (0.400)(9.80) + \frac{(0.400)(3.00)^2}{0.800} = 8.42\text{ N}.$$

(b) From conservation of energy, we may write

$(PE_g)_{\text{at top of swing}} = KE)_{\text{at bottom}}$, or

$mgL(1 - \cos\theta_{max}) = \frac{1}{2} mv^2_{\text{bottom}}$, giving

$$\cos\theta_{max} = 1 - \frac{v^2_{\text{bottom}}}{2gL} = 1 - \frac{(3.00\text{ m/s})^2}{2(9.80\text{ m/s}^2)(0.800\text{ m})} = 0.426.$$

Thus, $\theta_{max} = 64.8°$.

(c) At $\theta = \theta_{max}$, the pendulum is at rest, so the radial force

$$F_c = \frac{mv^2}{L} = T - Mg\cos\theta_{max} = 0.$$

Thus, $T = Mg\cos\theta_{max} = (0.400\text{ kg})(9.80\text{ m/s}^2)\cos 64.8° = 1.67$ N.

7.57 Using Kepler's Third law $T^2 = ka^3$, we have

$$(75.6)^2 = \left(\frac{0.57 + x}{2}\right)^3$$

The farthest distance $x = 2(75.6)^{2/3} - 0.57 = 35.2$ A.U. (near the orbit of Pluto)

ANSWERS TO EVEN ASSIGNED CONCEPTUAL QUESTIONS

4. The speedometer will be inaccurate. The speedometer measures the number of revolutions per second of the tires.