CHAPTER THIRTEEN SOLUTIONS

13.7 Using conservation of energy, we have: $\frac{1}{2}kx^2 = mgh$

From which, $k = \frac{2mgh}{x^2} = \frac{2(0.100\text{ kg})(9.80\text{ m/s}^2)(0.600\text{ m})}{(0.02\text{ m})^2} = 2940$ N/m.

13.9 In the presence of non-conservative forces, we use:

$W_{nc} = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 + mgy_f - mgy_i + \frac{1}{2}kx_f^2 - \frac{1}{2}kx_i^2$, or

$(20\text{ N})(0.30\text{ m}) = \frac{1}{2}(1.5\text{ kg})\,v_f^2 - 0 + 0 - 0 + \frac{1}{2}(19.6\text{ N/m})(0.30\text{ m})^2 - 0$.

This gives: $v_f = 2.6$ m/s.

13.13 We use $v = \sqrt{\frac{k}{m}(A^2 - x^2)}$. Squaring gives: $v^2 = \frac{k}{m}(A^2 - x^2)$, yielding

$v^2 = \frac{19.6\text{ N/m}}{0.40\text{ kg}}[(4.0 \times 10^{-2}\text{ m})^2 - x^2] = 49\text{ s}^{-2}[1.6 \times 10^{-3}\text{ m}^2 - x^2]$.

(1)

(a) If $x = 0$, (1) gives: $v = 0.28$ m/s $= 28$ cm/s (as the maximum velocity)

(b) If $x = -1.5 \times 10^{-2}$ m, (1) gives $v = 0.26$ m/s $= 26$ cm/s.

(c) if $x = 1.5 \times 10^{-2}$ m, (1) gives $v = 0.26$ m/s $= 26$ cm/s.

(d) One-half the maximum velocity is 0.14 m/s. (See part (a).) We use this for v in (1) and solve for x to find: $x = 3.5$ cm.

13.23 (a) We have: $x = (0.30\text{ m})\cos \pi t/3$. (1)

At $t = 0$, $x = (0.30\text{ m})\cos 0 = 0.30$ m.

At $t = 0.60$ s: $x = (0.30\text{ m})\cos\left(\frac{\pi}{3}\frac{\text{rad}}{\text{s}}\,0.60\text{ s}\right) = (0.30\text{ m})\cos(0.628\text{ rad})$,

or $x = 0.24$ m.

(b) The general form for oscillatory motion is: $x = A\cos 2\pi ft$. (2)

Thus, by comparing (1) to (2), we see that $A = 0.30$ m.

(c) Using comparison as in (b), we see that: $2\pi f = \pi/3$, and $f = 1/6$ Hz.

(d) $T = \frac{1}{f} = 6.0$ s

13.31 (a) The period of a pendulum is given by $T = 2\pi\sqrt{\frac{L}{g}}$, so $L = \frac{gT^2}{4\pi^2}$.

On Earth, a 1-s pendulum has length $L = \frac{(9.80)(1.0)^2}{4\pi^2} = 0.248$ m $= 25$ cm.

On Mars, a 1-s pendulum has length $L = \frac{(3.7)(1.0)^2}{4\pi^2} = 0.0937$ m $= 9.4$ cm.

(b) The period of a mass on a spring is given by $T = 2\pi\sqrt{\frac{m}{k}}$.

The mass for a 1-s oscillator is

$$m = \frac{kT^2}{4\pi^2} = \frac{(10\ \mathrm{N/m})(1.0\ \mathrm{s})^2}{4\pi^2} = 0.253\ \mathrm{kg} = 0.25\ \mathrm{kg}$$

This same mass works for both the Earth and Mars.

13.33 From $\lambda = \frac{v}{f}$, we get: $\lambda = \frac{340\ \mathrm{m/s}}{60000\ \mathrm{s}^{-1}} = 5.67$ mm.

13.39 The speed of the wave is: $v = d/t = 20.0$ m/0.800 s = 25.0 m/s.

We now use, $v = \sqrt{\frac{F}{\mu}}$. We have $\mu = \frac{0.35\ \mathrm{kg}}{1.00\ \mathrm{m}} = 0.35$ kg/m.

Thus, $F = v^2\mu = (25.0\ \mathrm{m/s})^2(0.35\ \mathrm{kg/m}) = 219$ N.

13.42 (a) The tension in the string is $F = (3.00\ \mathrm{kg})(9.80\ \mathrm{m/s^2}) = 29.4$ N.

$$\mu = \frac{F}{v^2} = \frac{29.4\ \mathrm{N}}{(24.0\ \mathrm{m/s})^2} = 5.10 \times 10^{-2}\ \mathrm{kg/m}.$$

(b) If $m = 2.0$ kg, then $F = 19.6$ N, and

$$v = \sqrt{\frac{F}{\mu}} = \sqrt{\frac{19.6\ \mathrm{N}}{5.10 \times 10^{-2}\ \mathrm{kg/m}}} = 19.6\ \mathrm{m/s}. \quad (20\ \mathrm{m/s})$$

ANSWERS TO EVEN ASSIGNED CONCEPTUAL QUESTIONS

14. If the tension remains the same, the speed of a wave on the string does not change. This means, from $v = f\lambda$, that if the frequency is doubled, the wavelength must decrease by a factor of two.

16. The speed of a wave on a string is given by $v = \sqrt{\frac{F}{\mu}}$. This says the speed is independent of the frequency of the wave. Thus, doubling the frequency leaves the speed unaffected.