CHAPTER THIRTEEN SOLUTIONS

13.7 Using conservation of energy, we have: \[ \frac{1}{2} kx^2 = mgh \]
From which, \[ k = \frac{2mgh}{x^2} = \frac{2(0.100 \text{ kg})(9.80 \text{ m/s}^2)(0.600 \text{ m})}{(0.02 \text{ m})^2} = 2940 \text{ N/m}. \]

13.9 In the presence of non-conservative forces, we use:
\[ W_{nc} = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 + mgy_f - mgy_i + \frac{1}{2} kx_f^2 - \frac{1}{2} kx_i^2, \]
\[ (20 \text{ N})(0.30 \text{ m}) = \frac{1}{2} (1.5 \text{ kg}) v_f^2 - 0 + 0 - 0 + \frac{1}{2} (19.6 \text{ N/m})(0.30 \text{ m})^2 - 0. \]
This gives: \[ v_f = 2.6 \text{ m/s}. \]

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

(a) If \( x = 0 \), (1) gives: \( v = 0.28 \text{ m/s} = 28 \text{ cm/s} \) (as the maximum velocity)
(b) If \( x = -1.5 \times 10^{-2} \text{ m} \), (1) gives \( v = 0.26 \text{ m/s} = 26 \text{ cm/s} \).
(c) If \( x = 1.5 \times 10^{-2} \text{ m} \), (1) gives \( v = 0.26 \text{ m/s} = 26 \text{ cm/s} \).
(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: \( x = 3.5 \text{ cm} \).

13.23 (a) We have: \( x = (0.30 \text{ m}) \cos \pi t/3. \) (1)
At \( t = 0 \), \( x = (0.30 \text{ m}) \cos 0 = 0.30 \text{ m} \).
At \( t = 0.60 \text{ s} \): \( x = (0.30 \text{ m}) \cos \left( \frac{\pi \text{ rad}}{3} \times 0.60 \text{ s} \right) = (0.30 \text{ m}) \cos(0.628 \text{ rad}), \)
or \( x = 0.24 \text{ m} \).
(b) The general form for oscillatory motion is: \( x = A \cos 2\pi ft. \) (2)
Thus, by comparing (1) to (2), we see that \( A = 0.30 \text{ m} \).
(c) Using comparison as in (b), we see that: \( 2\pi f = \pi/3 \), and \( f = 1/6 \text{ Hz} \).
(d) \( T = \frac{1}{f} = 6.0 \text{ s} \)

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 \( L = \frac{(9.80)(1.0)^2}{4\pi^2} = 0.248 \text{ m} = 25 \text{ cm} \).
On Mars, a 1-s pendulum has length \( L = \frac{(3.7)(1.0)^2}{4\pi^2} = 0.0937 \text{ m} = 9.4 \text{ cm} \).
(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
CHAPTER THIRTEEN SOLUTIONS

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

This same mass works for both the Earth and Mars.

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

13.39 The speed of the wave is: \( v = \frac{d}{t} = 20.0 \text{ m}/0.800 \text{ s} = 25.0 \text{ m/s} \).

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

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

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

\[ \mu = \frac{F}{v^2} = \frac{29.4 \text{ N}}{(24.0 \text{ m/s})^2} = 5.10 \times 10^{-2} \text{ kg/m} \]

(b) If \( m = 2.0 \text{ kg} \), then \( F = 19.6 \text{ N} \), and

\[ v = \sqrt{\frac{F}{\mu}} = \sqrt{\frac{19.6 \text{ N}}{5.10 \times 10^{-2} \text{ kg/m}}} = 19.6 \text{ m/s} \] (20 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.