ANSWERS TO MULTIPLE CHOICE QUESTIONS

1. The wavelength of a wave is the distance from crest to the following crest. Thus, the distance between a crest and the following trough is a half wavelength, giving $\lambda = 2\;\;2\text{ m} \;\; = 4\text{ m}$. The speed of the wave is then $v = \lambda f$ = (4 m)(2 Hz) = 8 m/s, and (c) is the correct choice.

2. When an object undergoes simple harmonic motion, the position as a function of time may be written as $x = A\cos\omega t = A\cos\;\;2\pi f t$. Comparing this to the given relation, we see that the frequency of vibration is f = 3 Hz, and the period is $T = 1/f$ = 1/3, so the correct answer is (c).

3. In this spring-mass system, the total energy equals the elastic potential energy at the moment the mass is temporarily at rest at $x = A$ = 6 cm (i.e., at the extreme ends of the simple harmonic motion). Thus, $E = kA^2/2$ and we see that as long as the spring constant k and the amplitude A remain unchanged, the total energy is unchanged. Hence, the energy is still 12 J and (a) is the correct choice.

4. The energy given the vibratory system equals the elastic potential energy at the extremes of the motion, $x = \pm A$. Thus, $E = kA^2/2$ and this energy will all be in the form of kinetic energy as the body passes through the equilibrium position, giving $mv_{\text{max}}^2/2 = kA^2/2$, or

$$v_{\text{max}} = A\sqrt{\frac{k}{m}} = \;\;0.10\text{ m}\;\;\sqrt{\frac{80.0\text{ N/m}}{0.40\text{ kg}}} = 1.4\text{ m/s}$$

and (b) is the correct choice.

5. The frequency of vibration is

$$f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

Thus, increasing the mass by a factor of 9 will decrease the frequency to $1/3$ of its original value, and the correct answer is (b).

6. When the object is at its maximum displacement, the magnitude of the force exerted on it by the spring is $F_s = k|x_{\max}| = (8.0 \text{ N/m})(0.10 \text{ m}) = 0.80 \text{ N}$. This force will give the mass an acceleration of $a = F_s/m = 0.80 \text{ N}/0.40 \text{ kg} = 2.0 \text{ m/s}^2$, making (d) the correct choice.

7. The car will continue to compress the spring until all of the car's original kinetic energy has been converted into elastic potential energy within the spring, i.e., until $kx^2/2 = mv_i^2/2$, or

$$x = v_i\sqrt{\frac{m}{k}} = (2.0 \text{ m/s})\sqrt{\frac{3.0 \times 10^5 \text{ kg}}{2.0 \times 10^6 \text{ N/m}}} = 0.77 \text{ m}$$

The correct choice is seen to be (a).

8. The period of a simple pendulum is $T = 2\pi\sqrt{\ell/g}$, and its frequency is $f = 1/T = (1/2\pi)\sqrt{g/\ell}$. Thus, if the length is doubled so $\ell' = 2\ell$, the new frequency is

$$f' = \frac{1}{2\pi}\sqrt{\frac{g}{\ell'}} = \frac{1}{2\pi}\sqrt{\frac{g}{2\ell}} = \frac{1}{\sqrt{2}}\left(\frac{1}{2\pi}\sqrt{\frac{g}{\ell}}\right) = \frac{f}{\sqrt{2}}$$

and we see that (d) is the correct response.

9. The period of a simple pendulum is $T = 2\pi\sqrt{\ell/g}$. If the length is changed to $\ell' = 4\ell$, the new period will be

$$T' = 2\pi\sqrt{\frac{\ell'}{g}} = 2\pi\sqrt{\frac{4\ell}{g}} = 2\left(2\pi\sqrt{\frac{\ell}{g}}\right) = 2T$$

or the period will be doubled. The correct choice is (e).

10. For a particle executing simple harmonic motion about an equilibrium point x_0, its position as a function of time is given by $x - x_0 = A\cos(\omega t)$, and the turning points (i.e., the extremes of the position) are at $x = x_0 \pm A$. That is, the equilibrium position is midway between the turning points, so the correct response is choice (c).

11. The only false statement among the listed choices is choice (d). At the equilibrium position, $x = 0$, the elastic potential energy $PE_s = kx^2/2$ is a minimum and the kinetic energy is a maximum.

12. In a vertical mass-spring system, the equilibrium position is the point at which the mass will hang at rest on the lower end of the spring. If the mass is raised distance A above this position and released from rest, it will undergo simple harmonic motion, with amplitude A, about the equilibrium position. The upper turning point of the motion is at the point of release, and the lower turning point is distance A below the equilibrium position or distance $2A$ below the release point. Thus, if the release point is 15 cm above the equilibrium position, the mass drops 30 cm before stopping momentarily and reversing direction. The correct answer is choice (c).