13.1 Simple Harmonic Motion

1. **MC** A particle in SHM has (a) variable amplitude, (b) a restoring force in the form of Hooke's law, (c) a frequency directly proportional to its period, (d) a position that is represented graphically by $x(t) = at + b$. (b)

2. **MC** The maximum kinetic energy of a mass–spring system in SHM is equal to (a) *A*, (b) A^2, (c) *kA*, (d) $kA^2/2$. (d)

3. **MC** If the period of a system in SHM is doubled, the frequency of the system is (a) doubled, (b) halved, (c) four times as large, (d) one-quarter as large. (b)

4. **MC** When a particle in a horizontal SHM is at the equilibrium position, the potential energy of the system is (a) zero, (b) maximum, (c) negative, (d) none of the preceding. (a)

5. **CQ** If the amplitude of a mass in SHM is doubled, how are (a) the energy and (b) the maximum speed affected? (a) four times as large (b) twice as large

6. **CQ** How does the speed of a mass in SHM change as the mass approaches its equilibrium position? Explain. increases

7. **CQ** A mass–spring system in SHM has an amplitude *A* and period *T*. How long does the mass take to travel a distance *A*? How about $2A$? $T/4$, $T/2$

8. **CQ** A tennis player uses a racket to bounce a ball up and down with a constant period. Is this a simple harmonic motion? Explain. no, restoring force does not obey Hooke's law

9. ● A particle oscillates in SHM with an amplitude *A*. What is the total *distance* the particle travels in one period? $4A$

10. ● A 0.75-kg toy oscillating on a spring completes a cycle every 0.60 s. What is the frequency of this oscillation? 1.7 Hz

12. ● The frequency of a simple harmonic oscillator is doubled from 0.25 Hz to 0.50 Hz. What is the change in its period? decrease of 2.0 s

13. ● What is the spring constant of a spring scale that stretches 6.0 cm when a basket of vegetables of mass 0.25 kg is suspended from it? 41 N/m

14. ● An object of mass 0.50 kg is attached to a spring with spring constant 10 N/m. If the object is pulled down 0.050 m from the equilibrium position and released, what is its maximum speed? 0.22 m/s

20. ●● A horizontal spring on a frictionless level air track has a 150-g object attached to it and it is stretched 6.50 cm. Then the object is given an outward initial velocity of 2.20 m/s. If the spring constant is 35.2 N/m, determine how much farther the spring stretches. 9.26 cm

21. ●● A 350-g block moving vertically upward collides with a light vertical spring and compresses it 4.50 cm before coming to rest. If the spring constant is 50.0 N/m, what was the initial speed of the block? (Ignore energy losses to sound and other factors during the collision.) 1.08 m/s

26. ●●● A 0.250-kg ball is dropped from a height of 10.0 cm onto a spring, as illustrated in >Fig. 13.23. If the spring has a spring constant of 60.0 N/m, (a) what distance will the spring be compressed? (Neglect energy loss during collision.) (b) On recoiling upward, how high will the ball go? (a) 0.140 m (b) 10.0 cm (original position)

13.2 Equations of Motion

27. **MC** The equation of motion for a particle in SHM (a) is always a cosine function, (b) reflects damping action, (c) is independent of the initial conditions, or (d) gives the position of the particle as a function of time. (d)

28. **MC** For the SHM equation $y = A \sin \omega t$, the initial position y_o is (a) $+A$, (b) $-A$, (c) 0, or (d) any of the preceding. (c)

29. **MC** For the SHM equation $y = A\sin(2\pi t/T)$, the *y*-position of the object in three quarters of the period is (a) $+A$, (b) $-A$, (c) $A/2$, (d) 0. (b)

37. ● The simple pendulum in a tall clock is 0.75 m long. What are (a) the period and (b) the frequency of this pendulum? (a) 1.7 s (b) 0.57 Hz

38. ● A breeze sets a suspended lamp into oscillation. If the period is 1.0 s, what is the distance from the ceiling to the lamp at the lowest point? Assume that the lamp acts as a simple pendulum. 0.25 m

53. ●● For a few seconds during an earthquake, the floor of an apartment building is measured to oscillate in approximately simple harmonic motion with a period of 1.95 seconds and an amplitude of 8.65 cm. Determine the maximum speed and acceleration of the floor during this motion. Express the acceleration as a fraction of *g*. $0.279\ \text{m/s},\ 0.897\ \text{m/s}^2 = (0.00915)g$

54. ●● Two equal masses oscillate on light springs, the second with a spring constant twice that of the first. Which system will have the greater frequency and how much greater? the second system, $f_2 = \sqrt{2} f_1$

60. ●●● A clock uses a pendulum that is 75 cm long. The clock is accidentally broken, and when it is repaired, the length of the pendulum is shortened by 2.0 mm. Consider the pendulum to be a simple pendulum. (a) Will the repaired clock gain or lose time? (b) By how much will the time indicated by the repaired clock differ from the correct time (taken to be the time determined by the original pendulum in 24 h)? (c) If the pendulum string were metal, would the surrounding temperature make a difference in the timekeeping of the clock? Explain. (a) gain time (b) 1.9 min (c) yes, because of linear expansion

13.3 Wave Motion

61. **MC** Wave motion in a material medium involves (a) the propagation of a disturbance, (b) interparticle interactions, (c) the transfer of energy, (d) all of the preceding. (d)

62. **MC** For a periodic wave propagating at a speed *v*, the following relationship holds: (a) $\lambda = v/f$, (b) $v = \lambda/f$, (c) $v = \lambda f^2$, or (d) $f = \lambda/v$. (a)

63. **MC** A water wave is (a) transverse, (b) longitudinal, (c) a combination of transverse and longitudinal, (d) none of the preceding. (c)

64. **CQ** What type(s) of wave(s), transverse or longitudinal, will propagate through (a) solids, (b) liquids, and (c) gases? (a) transverse and longitudinal (b) longitudinal (c) longitudinal

66. Standing on a hill and looking at a tall wheat field, you see a beautiful wave traveling across the field when there is a breeze. What type of wave is this? Explain. longitudinal

69. ● A student reading his physics book on a lake dock notices that the distance between two incoming wave crests is about 0.75 m, and he then measures the time of arrival between the crests to be 1.6 s. What is the approximate speed of the waves? $0.47\ \text{m/s}$

70. ● Light waves travel in a vacuum at a speed of $300\,000\ \text{km/s}$. The frequency of visible light is about 5×10^{14} Hz. What is the approximate wavelength of the light? $6\times10^{-7}\ \text{m}$

77. ● Assume that P and S (primary and secondary) waves from an earthquake with a focus near the Earth's surface travel through the Earth at nearly constant average speeds of $8.0\ \text{km/s}$ and $6.0\ \text{km/s}$, respectively. Assume that there is no deflection or refraction of the waves. (a) How long is the delay between the arrivals of successive waves at a seismic monitoring station located 90° in latitude from the epicenter (the spot on the surface directly above the focus) of the quake? (b) Do the waves cross the boundary of the mantle? (c) How long do the waves take to arrive at a monitoring station on the opposite side of the Earth? (a) $3.8\times10^2\ \text{s}$ (b) yes, see Solutions (c) $1.6\times10^3\ \text{s}$

13.4 Wave Properties

81. **MC** When two waves meet each other and interfere, the resultant waveform is determined by (a) reflection, (b) refraction, (c) diffraction, (d) superposition. (d)

82. **MC** Refraction (a) involves constructive interference, (b) refers to a change in direction at media interfaces, (c) is identical to diffraction, (d) occurs only for media or mechanical waves. (b)

83. **MC** You can often hear people talking from around a corner of a building. This is due primarily to (a) reflection, (b) refraction, (c) interference, (d) diffraction. (d)

84. **CQ** What is destroyed when destructive interference occurs? What happens to energy? Explain. only waveform; energy is not destroyed, but redistributed

85. **CQ** Dolphins and bats determine the location of their prey by emitting ultrasonic sound waves. Which wave phenomenon is involved? reflection (this is called echolocation)

86. **CQ** If sound waves were dispersive (that is, if the speed of sound depended on its frequency), what consequences would you experience if you were listening to an orchestra in a concert hall? sounds from different instruments would arrive at different times

13.5 Standing Waves and Resonance

87. **MC** For two traveling waves to form standing waves, the waves must have the same (a) frequency, (b) amplitude, (c) speed, (d) all of the preceding. (d)

88. **MC** The points of maximum amplitude on a rope with a standing wave waveform are called (a) nodes, (b) antinodes, (c) fundamentals, (d) resonance points. (b)

89. **MC** When a stretched violin string oscillates in its third harmonic mode, the standing wave in the string will exhibit (a) 3 wavelengths, (b) $1/3$ wavelength, (c) $3/2$ wavelengths, (d) 2 wavelengths. (c)

94. ● The fundamental frequency of a stretched string is 150 Hz. What are the frequencies of (a) the second harmonic and (b) the third harmonic? (a) 300 Hz (b) 450 Hz

95. ● If the frequency of the third harmonic of a vibrating string is 450 Hz, what is the frequency of the first harmonic? 150 Hz

99. ●● Two waves of equal amplitude and wavelength of 0.80 m travel in opposite directions at a speed of $250\ \text{m/s}$ in a string. If the string is 2.0 m long, for which harmonic mode is the standing wave set up in the string? $n = 5$

100. ●●On a violin, a correctly tuned A string has a frequency of 440 Hz. If an A string produces sound at 450 Hz under a tension of 500 N, what should the tension be to produce the correct frequency? 478 N

106. ●●● In a common laboratory experiment on standing waves, the waves are produced in a stretched string by an electrical vibrator that oscillates at 60 Hz (>Fig. 13.28). The string runs over a pulley, and a hanger is suspended from the end. The tension in the string is varied by adding weights to the hanger. If the active length of the string (the part that vibrates) is 1.5 m and this length of the string has a mass of 0.10 g, what masses must be suspended to produce the first four harmonics in that length? 0.22 kg; 0.055 kg; 0.024 kg; 0.014 kg