Chapter 15: OSCILLATIONS

1. In simple harmonic motion, the restoring force must be proportional to the:
   A. amplitude
   B. frequency
   C. velocity
   D. displacement
   E. displacement squared

   ans: D

2. An oscillatory motion must be simple harmonic if:
   A. the amplitude is small
   B. the potential energy is equal to the kinetic energy
   C. the motion is along the arc of a circle
   D. the acceleration varies sinusoidally with time
   E. the derivative, dU/dx, of the potential energy is negative

   ans: D

3. In simple harmonic motion, the magnitude of the acceleration is:
   A. constant
   B. proportional to the displacement
   C. inversely proportional to the displacement
   D. greatest when the velocity is greatest
   E. never greater than g

   ans: B

4. A particle is in simple harmonic motion with period T. At time $t = 0$ it is at the equilibrium point. Of the following times, at which time is it furthest from the equilibrium point?
   A. $0.5T$
   B. $0.7T$
   C. T
   D. $1.4T$
   E. $1.5T$

   ans: B

5. A particle moves back and forth along the x axis from $x = -x_m$ to $x = +x_m$, in simple harmonic motion with period T. At time $t = 0$ it is at $x = +x_m$. When $t = 0.75T$:
   A. it is at $x = 0$ and is traveling toward $x = +x_m$
   B. it is at $x = 0$ and is traveling toward $x = -x_m$
   C. it at $x = +x_m$ and is at rest
   D. it is between $x = 0$ and $x = +x_m$ and is traveling toward $x = -x_m$
   E. it is between $x = 0$ and $x = -x_m$ and is traveling toward $x = -x_m$

   ans: A

6. A particle oscillating in simple harmonic motion is:
   A. never in equilibrium because it is in motion
   B. never in equilibrium because there is always a force
   C. in equilibrium at the ends of its path because its velocity is zero there
   D. in equilibrium at the center of its path because the acceleration is zero there
   E. in equilibrium at the ends of its path because the acceleration is zero there

   ans: D

7. An object is undergoing simple harmonic motion. Throughout a complete cycle it:
   A. has constant speed
   B. has varying amplitude
   C. has varying period
   D. has varying acceleration
   E. has varying mass

   ans: D

8. When a body executes simple harmonic motion, its acceleration at the ends of its path must be:
   A. zero
   B. less than g
   C. more than g
   D. suddenly changing in sign
   E. none of these

   ans: E

9. A particle is in simple harmonic motion with period T. At time $t = 0$ it is halfway between the equilibrium point and an end point of its motion, traveling toward the end point. The next time it is at the same place is:
   A. $t = T$
   B. $t = T/2$
   C. $t = T/4$
   D. $t = T/8$
   E. none of the above

   ans: E

10. An object attached to one end of a spring makes 20 complete oscillations in 10 s. Its period is:
   A. 2 Hz
   B. 10 s
   C. 0.5 Hz
   D. 2 s
   E. 0.50 s

   ans: E

11. An object attached to one end of a spring makes 20 vibrations in 10 s. Its frequency is:
   A. 2 Hz
   B. 10 s
   C. 0.05 Hz
   D. 2 s
   E. 0.50 s
   ans: A

12. An object attached to one end of a spring makes 20 vibrations in 10 s. Its angular frequency is:
   A. 0.79 rad/s
   B. 1.57 rad/s
   C. 2.0 rad/s
   D. 6.3 rad/s
   E. 12.6 rad/s
   ans: E

13. Frequency f and angular frequency ω are related by
   A. $f = \pi\omega$
   B. $f = 2\pi\omega$
   C. $f = \omega/\pi$
   D. $f = \omega/2\pi$
   E. $f = 2\omega/\pi$
   ans: D

14. A block attached to a spring oscillates in simple harmonic motion along the x axis. The limits of its motion are $x = 10$ cm and $x = 50$ cm and it goes from one of these extremes to the other in 0.25 s. Its amplitude and frequency are:
   A. 40 cm, 2 Hz
   B. 20 cm, 4 Hz
   C. 40 cm, 2 Hz
   D. 25 cm, 4 Hz
   E. 20 cm, 2 Hz
   ans: B

15. A weight suspended from an ideal spring oscillates up and down with a period T. If the amplitude of the oscillation is doubled, the period will be:
   A. T
   D. $1.5T$
   B. $2T$
   C. $T/2$
   E. $4T$
   ans: A

16. In simple harmonic motion, the magnitude of the acceleration is greatest when:
    A. the displacement is zero
    B. the displacement is maximum
    C. the speed is maximum
    D. the force is zero
    E. the speed is between zero and its maximum
    ans: B

17. In simple harmonic motion, the displacement is maximum when the:
    A. acceleration is zero
    B. velocity is maximum
    C. velocity is zero
    D. kinetic energy is maximum
    E. momentum is maximum
    ans: C

18. In simple harmonic motion:
    A. the acceleration is greatest at the maximum displacement
    B. the velocity is greatest at the maximum displacement
    C. the period depends on the amplitude
    D. the acceleration is constant
    E. the acceleration is greatest at zero displacement
    ans: A

19. The amplitude and phase constant of an oscillator are determined by:
    A. the frequency
    B. the angular frequency
    C. the initial displacement alone
    D. the initial velocity alone
    E. both the initial displacement and velocity
    ans: E

20. Two identical undamped oscillators have the same amplitude of oscillation only if:
    A. they are started with the same displacement x_0
    B. they are started with the same velocity v_0
    C. they are started with the same phase
    D. they are started so the combination $\omega^2 x_0^2 + v_0^2$ is the same
    E. they are started so the combination $x_0^2 + \omega^2 v_0^2$ is the same
    ans: D

21. The amplitude of any oscillator can be doubled by:
    A. doubling only the initial displacement
    B. doubling only the initial speed
    C. doubling the initial displacement and halving the initial speed
    D. doubling the initial speed and halving the initial displacement
    E. doubling both the initial displacement and the initial speed
    ans: E

22. It is impossible for two particles, each executing simple harmonic motion, to remain in phase with each other if they have different:
    A. masses
    B. periods
    C. amplitudes
    D. spring constants
    E. kinetic energies
    ans: B

23. The acceleration of a body executing simple harmonic motion leads the velocity by what phase?
    A. 0
    B. $\pi/8$ rad
    C. $\pi/4$ rad
    D. $\pi/2$ rad
    E. π rad
    ans: D

24. The displacement of an object oscillating on a spring is given by $x(t) = x_m \cos(\omega t + \phi)$. If the initial displacement is zero and the initial velocity is in the negative x direction, then the phase constant ϕ is:
    A. 0
    B. $\pi/2$ rad
    C. π rad
    D. $3\pi/2$ rad
    E. 2π rad
    ans: B

25. The displacement of an object oscillating on a spring is given by $x(t) = x_m \cos(\omega t + \phi)$. If the object is initially displaced in the negative x direction and given a negative initial velocity, then the phase constant ϕ is between:
    A. 0 and $\pi/2$ rad
    B. $\pi/2$ and π rad
    C. π and $3\pi/2$ rad
    D. $3\pi/2$ and 2π rad
    E. none of the above (ϕ is exactly 0, $\pi/2$, π, or $3\pi/2$ rad)
    ans: B

26. A certain spring elongates 9.0 mm when it is suspended vertically and a block of mass M is hung on it. The natural angular frequency of this block-spring system:
    A. is 0.088 rad/s
    B. is 33 rad/s
    C. is 200 rad/s
    D. is 1140 rad/s
    E. cannot be computed unless the value of M is given
    ans: B

27. An object of mass m, oscillating on the end of a spring with spring constant k, has amplitude A. Its maximum speed is:

A. $A\sqrt{k/m}$
B. $A^2 k/m$
C. $A\sqrt{m/k}$
D. Am/k
E. $A^2 m/k$

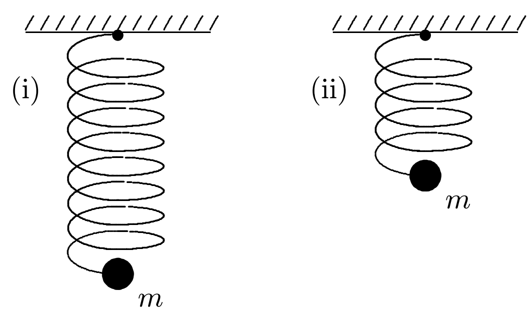
ans: A

28. A 0.20-kg object attached to a spring whose spring constant is $500\,\mathrm{N/m}$ executes simple harmonic motion. If its maximum speed is $5.0\,\mathrm{m/s}$, the amplitude of its oscillation is:

A. $0.0020\,\mathrm{m}$
B. $0.10\,\mathrm{m}$
C. $0.20\,\mathrm{m}$
D. $25\,\mathrm{m}$
E. $250\,\mathrm{m}$

ans: B

29. A simple harmonic oscillator consists of an particle of mass m and an ideal spring with spring constant k. Particle oscillates as shown in (i) with period T. If the spring is cut in half and used with the same particle, as shown in (ii), the period will be:



A. $2T$
B. $\sqrt{2}T$
C. $T/\sqrt{2}$
D. T
E. $T/2$

ans: C

30. A particle moves in simple harmonic motion according to $x = 2\cos(50t)$, where x is in meters and t is in seconds. Its maximum velocity in m/s is:

A. $100\sin(50t)$
B. $100\cos(50t)$
C. 100
D. 200
E. none of these

ans: C

31. A 3-kg block, attached to a spring, executes simple harmonic motion according to $x = 2\cos(50t)$ where x is in meters and t is in seconds. The spring constant of the spring is:
   A. $1\,\mathrm{N/m}$
   B. $100\,\mathrm{N/m}$
   C. $150\,\mathrm{N/m}$
   D. $7500\,\mathrm{N/m}$
   E. none of these
   ans: D

32. Let U be the potential energy (with the zero at zero displacement) and K be the kinetic energy of a simple harmonic oscillator. U_{avg} and K_{avg} are the average values over a cycle. Then:
   A. $K_{\mathrm{avg}} > U_{\mathrm{avg}}$
   B. $K_{\mathrm{avg}} < U_{\mathrm{avg}}$
   C. $K_{\mathrm{avg}} = U_{\mathrm{avg}}$
   D. $K = 0$ when $U = 0$
   E. $K + U = 0$
   ans: C

33. A particle is in simple harmonic motion along the x axis. The amplitude of the motion is x_m. At one point in its motion its kinetic energy is $K = 5\,\mathrm{J}$ and its potential energy (measured with $U = 0$ at $x = 0$) is $U = 3\,\mathrm{J}$. When it is at $x = x_m$, the kinetic and potential energies are:
   A. $K = 5\,\mathrm{J}$ and $U = 3\,\mathrm{J}$
   B. $K = 5\,\mathrm{J}$ and $U = -3\,\mathrm{J}$
   C. $K = 8\,\mathrm{J}$ and $U = 0$
   D. $K = 0$ and $U = 8\,\mathrm{J}$
   E. $K = 0$ and $U = -8\,\mathrm{J}$
   ans: D

34. A particle is in simple harmonic motion along the x axis. The amplitude of the motion is x_m. When it is at $x = x_1$, its kinetic energy is $K = 5\,\mathrm{J}$ and its potential energy (measured with $U = 0$ at $x = 0$) is $U = 3\,\mathrm{J}$. When it is at $x = -\frac{1}{2}x_1$, the kinetic and potential energies are:
   A. $K = 5\,\mathrm{J}$ and $U = 3\,\mathrm{J}$
   B. $K = 5\,\mathrm{J}$ and $U = -3\,\mathrm{J}$
   C. $K = 8\,\mathrm{J}$ and $U = 0$
   D. $K = 0$ and $U = 8\,\mathrm{J}$
   E. $K = 0$ and $U = -8\,\mathrm{J}$
   ans: A

35. A 0.25-kg block oscillates on the end of the spring with a spring constant of $200\,\mathrm{N/m}$. If the system has an energy of $6.0\,\mathrm{J}$, then the amplitude of the oscillation is:
   A. $0.06\,\mathrm{m}$
   B. $0.17\,\mathrm{m}$
   C. $0.24\,\mathrm{m}$
   D. $4.9\,\mathrm{m}$
   E. $6.9\,\mathrm{m}$
   ans: C

36. A 0.25-kg block oscillates on the end of the spring with a spring constant of 200 N/m. If the system has an energy of 6.0 J, then the maximum speed of the block is:

A. 0.06 m/s
B. 0.17 m/s
C. 0.24 m/s
D. 4.9 m/s
E. 6.9 m/s

ans: E

37. A 0.25-kg block oscillates on the end of the spring with a spring constant of 200 N/m. If the oscillation is started by elongating the spring 0.15 m and giving the block a speed of 3.0 m/s, then the maximum speed of the block is:

A. 0.13 m/s
B. 0.18 m/s
C. 3.7 m/s
D. 5.2 m/s
E. 13 m/s

ans: D

38. A 0.25-kg block oscillates on the end of the spring with a spring constant of 200 N/m. If the oscillation is started by elongating the spring 0.15 m and giving the block a speed of 3.0 m/s, then the amplitude of the oscillation is:

A. 0.13 m
B. 0.18 m
C. 3.7 m
D. 5.2 m
E. 13 m

ans: B

39. An object on the end of a spring is set into oscillation by giving it an initial velocity while it is at its equilibrium position. In the first trial the initial velocity is v_0 and in the second it is $4v_0$. In the second trial:

A. the amplitude is half as great and the maximum acceleration is twice as great
B. the amplitude is twice as great and the maximum acceleration is half as great
C. both the amplitude and the maximum acceleration are twice as great
D. both the amplitude and the maximum acceleration are four times as great
E. the amplitude is four times as great and the maximum acceleration is twice as great

ans: C

40. A block attached to a spring undergoes simple harmonic motion on a horizontal frictionless surface. Its total energy is 50 J. When the displacement is half the amplitude, the kinetic energy is:

A. zero
B. 12.5 J
C. 25 J
D. 37.5 J
E. 50 J

ans: D

41. A mass-spring system is oscillating with amplitude A. The kinetic energy will equal the potential energy only when the displacement is:

A. zero
B. $\pm A/4$
C. $\pm A/\sqrt{2}$
D. $\pm A/2$
E. anywhere between $-A$ and $+A$

ans: C

42. If the length of a simple pendulum is doubled, its period will:

A. halve
B. be greater by a factor of $\sqrt{2}$
C. be less by a factor of $\sqrt{2}$
D. double
E. remain the same

ans: B

43. The period of a simple pendulum is 1 s on Earth. When brought to a planet where g is one-tenth that on Earth, its period becomes:

A. 1 s
B. $1/\sqrt{10}$ s
C. $1/10$ s
D. $\sqrt{10}$ s
E. 10 s

ans: D

44. The amplitude of oscillation of a simple pendulum is increased from 1° to 4°. Its maximum acceleration changes by a factor of:

A. $1/4$
B. $1/2$
C. 2
D. 4
E. 16

ans: D

45. A simple pendulum of length L and mass M has frequency f. To increase its frequency to $2f$:

A. increase its length to $4L$
B. increase its length to $2L$
C. decrease its length to $L/2$
D. decrease its length to $L/4$
E. decrease its mass to $< M/4$

ans: D

46. A simple pendulum consists of a small ball tied to a string and set in oscillation. As the pendulum swings the tension force of the string is:

A. constant
B. a sinusoidal function of time
C. the square of a sinusoidal function of time
D. the reciprocal of a sinusoidal function of time
E. none of the above

ans: E

47. A simple pendulum has length L and period T. As it passes through its equilibrium position, the string is suddenly clamped at its midpoint. The period then becomes:

A. $2T$
B. T
C. $T/2$
D. $T/4$
E. none of these

ans: E

48. A simple pendulum is suspended from the ceiling of an elevator. The elevator is accelerating upwards with acceleration a. The period of this pendulum, in terms of its length L, g, and a is:

A. $2\pi\sqrt{L/g}$
B. $2\pi\sqrt{L/(g+a)}$
C. $2\pi\sqrt{L/(g-a)}$
D. $2\pi\sqrt{L/a}$
E. $(1/2\pi)\sqrt{g/L}$

ans: B

49. Three physical pendulums, with masses m_1, $m_2 = 2m_1$, and $m_3 = 3m_1$, have the same shape and size and are suspended at the same point. Rank them according to their periods, from shortest to longest.

A. 1, 2, 3
B. 3, 2, 1
C. 2, 3, 1
D. 2, 1, 3
E. All the same

ans: E

50. Five hoops are each pivoted at a point on the rim and allowed to swing as physical pendulums. The masses and radii are

hoop 1: $M = 150\,\text{g}$ and $R = 50\,\text{cm}$
hoop 2: $M = 200\,\text{g}$ and $R = 40\,\text{cm}$
hoop 3: $M = 250\,\text{g}$ and $R = 30\,\text{cm}$
hoop 4: $M = 300\,\text{g}$ and $R = 20\,\text{cm}$
hoop 5: $M = 350\,\text{g}$ and $R = 10\,\text{cm}$

Order the hoops according to the periods of their motions, smallest to largest.

A. 1, 2, 3, 4, 5
B. 5, 4, 3, 2, 1
C. 1, 2, 3, 5, 4
D. 1, 2, 5, 4, 3
E. 5, 4, 1, 2, 3

ans: B

51. A meter stick is pivoted at a point a distance a from its center and swings as a physical pendulum. Of the following values for a, which results in the shortest period of oscillation?

A. $a = 0.1\,\text{m}$
B. $a = 0.2\,\text{m}$
C. $a = 0.3\,\text{m}$
D. $a = 0.4\,\text{m}$
E. $a = 0.5\,\text{m}$

ans: C

52. The rotational inertia of a uniform thin rod about its end is $ML^2/3$, where M is the mass and L is the length. Such a rod is hung vertically from one end and set into small amplitude oscillation. If $L = 1.0\,\text{m}$ this rod will have the same period as a simple pendulum of length:

A. 33 cm
B. 50 cm
C. 67 cm
D. 100 cm
E. 150 cm

ans: C

53. Two uniform spheres are pivoted on horizontal axes that are tangent to their surfaces. The one with the longer period of oscillation is the one with:

A. the larger mass
B. the smaller mass
C. the larger rotational inertia
D. the smaller rotational inertia
E. the larger radius

ans: E

54. The x and y coordinates of a point each execute simple harmonic motion. The result might be a circular orbit if:

A. the amplitudes are the same but the frequencies are different
B. the amplitudes and frequencies are both the same
C. the amplitudes and frequencies are both different
D. the phase constants are the same but the amplitudes are different
E. the amplitudes and the phase constants are both different

ans: B

55. The x and y coordinates of a point each execute simple harmonic motion. The frequencies are the same but the amplitudes are different. The resulting orbit might be:

A. an ellipse
B. a circle
C. a parabola
D. a hyperbola
E. a square

ans: A

56. For an oscillator subjected to a damping force proportional to its velocity:

A. the displacement is a sinusoidal function of time.
B. the velocity is a sinusoidal function of time.
C. the frequency is a decreasing function of time.
D. the mechanical energy is constant.
E. none of the above is true.

ans: E

57. Five particles undergo damped harmonic motion. Values for the spring constant k, the damping constant b, and the mass m are given below. Which leads to the smallest rate of loss of mechanical energy?

A. $k = 100\,\mathrm{N/m}$, $m = 50\,\mathrm{g}$, $b = 8\,\mathrm{g/s}$
B. $k = 150\,\mathrm{N/m}$, $m = 50\,\mathrm{g}$, $b = 5\,\mathrm{g/s}$
C. $k = 150\,\mathrm{N/m}$, $m = 10\,\mathrm{g}$, $b = 8\,\mathrm{g/s}$
D. $k = 200\,\mathrm{N/m}$, $m = 8\,\mathrm{g}$, $b = 6\,\mathrm{g/s}$
E. $k = 100\,\mathrm{N/m}$, $m = 2\,\mathrm{g}$, $b = 4\,\mathrm{g/s}$

ans: B

58. A sinusoidal force with a given amplitude is applied to an oscillator. To maintain the largest amplitude oscillation the frequency of the applied force should be:

A. half the natural frequency of the oscillator
B. the same as the natural frequency of the oscillator
C. twice the natural frequency of the oscillator
D. unrelated to the natural frequency of the oscillator
E. determined from the maximum speed desired

ans: B

59. A sinusoidal force with a given amplitude is applied to an oscillator. At resonance the amplitude of the oscillation is limited by:

A. the damping force
B. the initial amplitude
C. the initial velocity
D. the force of gravity
E. none of the above

ans: A

60. An oscillator is subjected to a damping force that is proportional to its velocity. A sinusoidal force is applied to it. After a long time:

A. its amplitude is an increasing function of time
B. its amplitude is a decreasing function of time
C. its amplitude is constant
D. its amplitude is a decreasing function of time only if the damping constant is large
E. its amplitude increases over some portions of a cycle and decreases over other portions

ans: C

61. A block on a spring is subjected to a damping force that is proportional to its velocity and to an applied sinusoidal force. The energy dissipated by damping is supplied by:

A. the potential energy of the spring
B. the kinetic energy of the mass
C. gravity
D. friction
E. the applied force

ans: E

62. The table below gives the values of the spring constant k, damping constant b, and mass m for a particle in damped harmonic motion. Which of these takes the longest time for its mechanical energy to decrease to one-fourth of its initial value?

	k	b	m
A	k_0	b_0	m_0
B	$3k_0$	$2b_0$	m_0
C	$k_0/2$	$6b_0$	$2m_0$
D	$4k_0$	b_0	$2m_0$
E	k_0	b_0	$10m_0$

ans: E

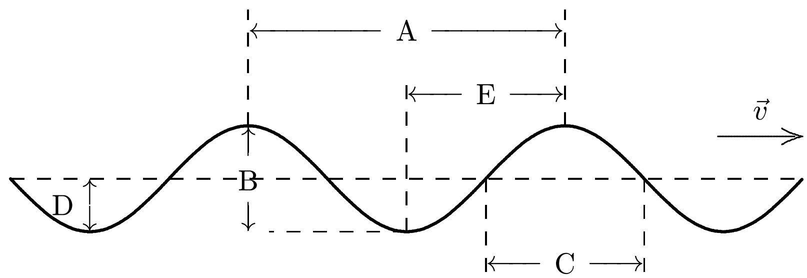
Chapter 16: WAVES — I

1. For a transverse wave on a string the string displacement is described by $y(x, t) = f(x - at)$, where f is a given function and a is a positive constant. Which of the following does NOT necessarily follow from this statement?

   A. The shape of the string at time $t = 0$ is given by $f(x)$.
   B. The shape of the waveform does not change as it moves along the string.
   C. The waveform moves in the positive x direction.
   D. The speed of the waveform is a.
   E. The speed of the waveform is x/t.

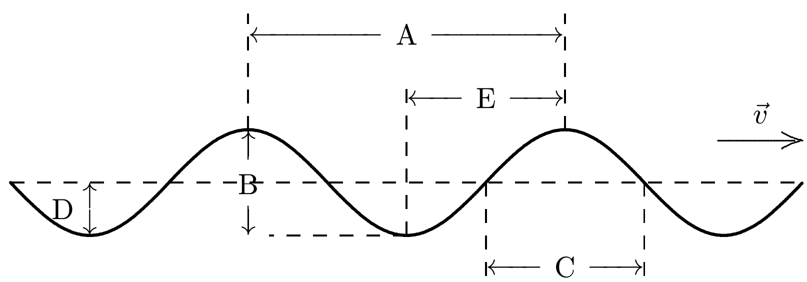
   ans: E

2. A sinusoidal wave is traveling toward the right as shown. Which letter correctly labels the amplitude of the wave?



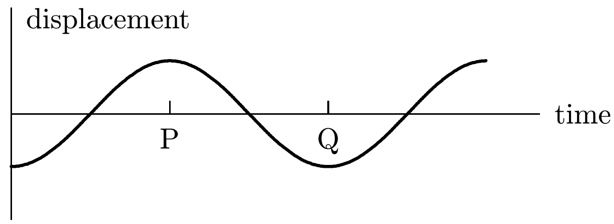
   ans: D

3. A sinusoidal wave is traveling toward the right as shown. Which letter correctly labels the wavelength of the wave?



   ans: A

4. In the diagram below, the interval PQ represents:



A. wavelength/2
B. wavelength
C. $2 \times$ amplitude
D. period/2
E. period

ans: D

5. Let f be the frequency, v the speed, and T the period of a sinusoidal traveling wave. The correct relationship is:

A. $f = 1/T$
B. $f = v + T$
C. $f = vT$
D. $f = v/T$
E. $f = T/v$

ans: A

6. Let f be the frequency, v the speed, and T the period of a sinusoidal traveling wave. The angular frequency is given by:

A. $1/T$
B. $2\pi/T$
C. vT
D. f/T
E. T/f

ans: B

7. The displacement of a string is given by

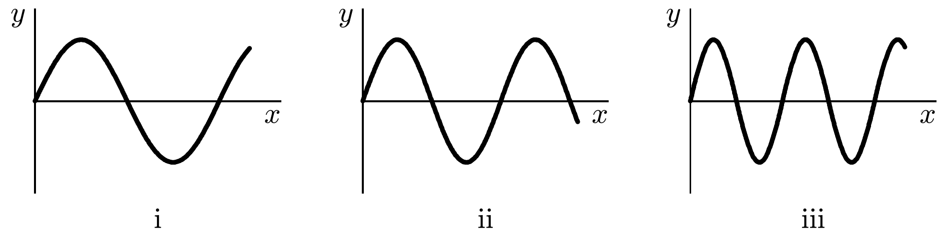
$$y(x,t) = y_m \sin(kx + \omega t)\,.$$

The wavelength of the wave is:

A. $2\pi k/\omega$
B. k/ω
C. ωk
D. $2\pi/k$
E. $k/2\pi$

ans: D

8. Three traveling sinusoidal waves are on identical strings, with the same tension. The mathematical forms of the waves are $y_1(x,t) = y_m \sin(3x - 6t)$, $y_2(x,t) = y_m \sin(4x - 8t)$, and $y_3(x,t) = y_m \sin(6x - 12t)$, where x is in meters and t is in seconds. Match each mathematical form to the appropriate graph below.



A. y_1: i, y_2: ii, y_3: iii
B. y_1: iii, y_2: ii, y_3: i
C. y_1: i, y_2: iii, y_3: ii
D. y_1: ii, y_2: i, y_3: iii
E. y_1: iii, y_2: i, y_3: ii

ans: A

9. The displacement of a string is given by

$$y(x,t) = y_m \sin(kx + \omega t)\,.$$

The speed of the wave is:

A. $2\pi k/\omega$
B. ω/k
C. ωk
D. $2\pi/k$
E. $k/2\pi$

ans: B

10. A wave is described by $y(x,t) = 0.1 \sin(3x + 10t)$, where x is in meters, y is in centimeters, and t is in seconds. The angular wave number is:

A. $0.10\,\mathrm{rad/m}$
B. $3\pi\,\mathrm{rad/m}$
C. $10)\,\mathrm{rad/m}$
D. $10\pi)\,\mathrm{rad/m}$
E. $3.0\,\mathrm{rad/cm}$

ans: E

11. A wave is described by $y(x,t) = 0.1 \sin(3x - 10t)$, where x is in meters, y is in centimeters, and t is in seconds. The angular frequency is:

A. $0.10\,\mathrm{rad/s}$
B. $3.0\pi\,\mathrm{rad/s}$
C. $10\pi\,\mathrm{rad/s}$
D. $20\pi\,\mathrm{rad/s}$
E. $(10\,\mathrm{rad/s}$

ans: E

12. Water waves in the sea are observed to have a wavelength of 300 m and a frequency of 0.07 Hz. The speed of these waves is:

A. 0.00021 m/s
B. 2.1 m/s
C. 21 m/s
D. 210 m/s
E. none of these

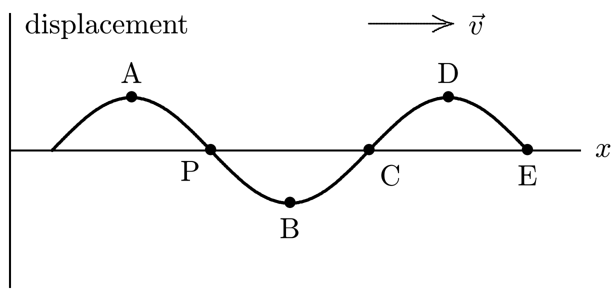
ans: C

13. Sinusoidal water waves are generated in a large ripple tank. The waves travel at 20 cm/s and their adjacent crests are 5.0 cm apart. The time required for each new whole cycle to be generated is:

A. 100 s
B. 4.0 s
C. 2.0 s
D. 0.5 s
E. 0.25 s

ans: E

14. A traveling sinusoidal wave is shown below. At which point is the motion 180° out of phase with the motion at point P?



ans: C

15. The displacement of a string carrying a traveling sinusoidal wave is given by

$$y(x,t) = y_m \sin(kx - \omega t - \phi)\,.$$

At time $t = 0$ the point at $x = 0$ has a displacement of 0 and is moving in the positive y direction. The phase constant ϕ is:

A. 45°
B. 90°
C. 135°
D. 180°
E. 270°

ans: D

16. The displacement of a string carrying a traveling sinusoidal wave is given by

$$y(x,t) = y_m \sin(kx - \omega t - \phi)\,.$$

At time $t = 0$ the point at $x = 0$ has a velocity of 0 and a positive displacement. The phase constant ϕ is:

A. 45°
B. 90°
C. 135°
D. 180°
E. 270°

ans: E

17. The displacement of a string carrying a traveling sinusoidal wave is given by

$$y(x,t) = y_m \sin(kx - \omega t - \phi)\,.$$

At time $t = 0$ the point at $x = 0$ has velocity v_0 and displacement y_0. The phase constant ϕ is given by $\tan\phi =$:

A. $v_0/\omega y_0$
B. $\omega y_0/v_0$
C. $\omega v_0/y_0$
D. $y_0/\omega v_0$
E. $\omega v_0 y_0$

ans: B

18. A sinusoidal transverse wave is traveling on a string. Any point on the string:

A. moves in the same direction as the wave
B. moves in simple harmonic motion with a different frequency than that of the wave
C. moves in simple harmonic motion with the same angular frequency as the wave
D. moves in uniform circular motion with a different angular speed than the wave
E. moves in uniform circular motion with the same angular speed as the wave

ans: C

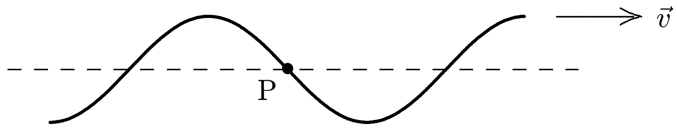
19. Here are the equations for three waves traveling on separate strings. Rank them according to the maximum transverse speed, least to greatest.

wave 1: $y(x,t) = (2.0\,\mathrm{mm})\sin[(4.0\,\mathrm{m}^{-1})x - (3.0\,\mathrm{s}^{-1})t]$
wave 2: $y(x,t) = (1.0\,\mathrm{mm})\sin[(8.0\,\mathrm{m}^{-1})x - (4.0\,\mathrm{s}^{-1})t]$
wave 3: $y(x,t) = (1.0\,\mathrm{mm})\sin[(4.0\,\mathrm{m}^{-1})x - (8.0\,\mathrm{s}^{-1})t]$

A. 1, 2, 3
B. 1, 3, 2
C. 2, 1, 3
D. 2, 3, 1
E. 3, 1, 2

ans: C

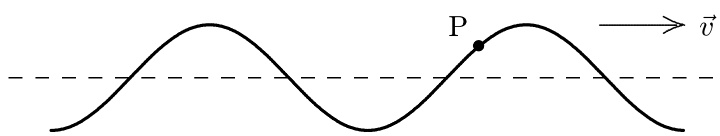
20. The transverse wave shown is traveling from left to right in a medium. The direction of the instantaneous velocity of the medium at point P is:



A. $\uparrow$
B. $\downarrow$
C. $\rightarrow$
D. $\nearrow$
E. no direction since $v = 0$

ans: A

21. A wave traveling to the right on a stretched string is shown below. The direction of the instantaneous velocity of the point P on the string is:



A. $\uparrow$
B. $\downarrow$
C. $\rightarrow$
D. $\nearrow$
E. no direction since $v = 0$

ans: B

22. Sinusoidal waves travel on five different strings, all with the same tension. Four of the strings have the same linear mass density, but the fifth has a different linear mass density. Use the mathematical forms of the waves, given below, to identify the string with the different linear mass density. In the expressions x and y are in centimeters and t is in seconds.

A. $y(x, t) = (2\,\mathrm{cm})\sin(2x - 4t)$
B. $y(x, t) = (2\,\mathrm{cm})\sin(4x - 10t)$
C. $y(x, t) = (2\,\mathrm{cm})\sin(6x - 12t)$
D. $y(x, t) = (2\,\mathrm{cm})\sin(8x - 16t)$
E. $y(x, t) = (2\,\mathrm{cm})\sin(10x - 20t)$

ans: B

23. Any point on a string carrying a sinusoidal wave is moving with its maximum speed when:

A. the magnitude of its acceleration is a maximum
B. the magnitude of its displacement is a maximum
C. the magnitude of its displacement is a minimum
D. the magnitude of its displacement is half the amplitude
E. the magnitude of its displacement is one-fourth the amplitude

ans: C

24. The mathematical forms for three sinusoidal traveling waves are given by

wave 1: $y(x,t) = (2\,\text{cm})\sin(3x - 6t)$
wave 2: $y(x,t) = (3\,\text{cm})\sin(4x - 12t)$
wave 3: $y(x,t) = (4\,\text{cm})\sin(5x - 11t)$

where x is in meters and t is in seconds. Of these waves:

A. wave 1 has the greatest wave speed and the greatest maximum transverse string speed
B. wave 2 has the greatest wave speed and wave 1 has the greatest maximum transverse string speed
C. wave 3 has the greatest wave speed and the greatest maximum transverse string speed
D. wave 2 has the greatest wave speed and wave 3 has the greatest maximum transverse string speed
E. wave 3 has the greatest wave speed and wave 2 has the greatest maximum transverse string speed

ans: D

25. Suppose the maximum speed of a string carrying a sinusoidal wave is v_s. When the displacement of a point on the string is half its maximum, the speed of the point is:

A. $v_s/2$
B. $2v_s$
C. $v_s/4$
D. $3v_s/4$
E. $\sqrt{3}v_s/2$

ans: E

26. A string carries a sinusoidal wave with an amplitude of 2.0 cm and a frequency of 100 Hz. The maximum speed of any point on the string is:

A. 2.0 m/s
B. 4.0 m/s
C. 6.3 m/s
D. 13 m/s
E. unknown (not enough information is given)

ans: D

27. A transverse traveling sinusoidal wave on a string has a frequency of 100 Hz, a wavelength of 0.040 m, and an amplitude of 2.0 mm. The maximum velocity in m/s of any point on the string is:

A. 0.2
B. 1.3
C. 4
D. 15
E. 25

ans: B

28. A transverse traveling sinusoidal wave on a string has a frequency of 100 Hz, a wavelength of 0.040 m, and an amplitude of 2.0 mm. The maximum acceleration in m/s^2 of any point on the string is:

A. 0
B. 130
C. 395
D. 790
E. 1600

ans: D

29. The speed of a sinusoidal wave on a string depends on:

A. the frequency of the wave
B. the wavelength of the wave
C. the length of the string
D. the tension in the string
E. the amplitude of the wave

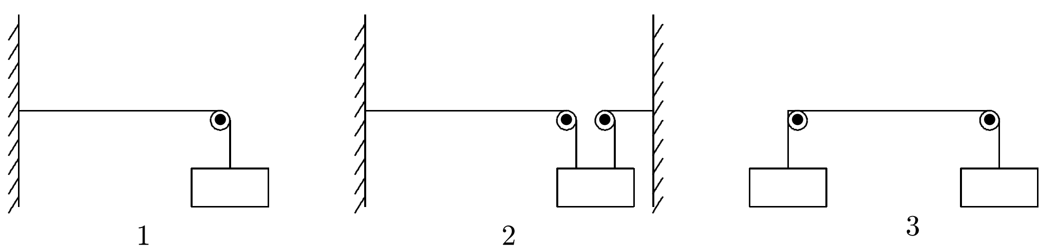
ans: D

30. The time required for a small pulse to travel from A to B on a stretched cord shown is NOT altered by changing:

A. the linear mass density of the cord
B. the length between A and B
C. the shape of the pulse
D. the tension in the cord
E. none of the above (changes in all alter the time)

ans: C

31. The diagrams show three identical strings that have been put under tension by suspending blocks of 5 kg each. For which is the wave speed the greatest?



A. 1
B. 2
C. 3
D. 1 and 3 tie
E. 2 and 3 tie

ans: D

32. For a given medium, the frequency of a wave is:

A. independent of wavelength
B. proportional to wavelength
C. inversely proportional to wavelength
D. proportional to the amplitude
E. inversely proportional to the amplitude

ans: C

33. The tension in a string with a linear mass density of 0.0010 kg/m is 0.40 N. A sinusoidal wave with a wavelength of 20 cm on this string has a frequency of:

A. 0.0125 Hz
B. 0.25 Hz
C. 100 Hz
D. 630 Hz
E. 2000 Hz

ans: C

34. When a 100-Hz oscillator is used to generate a sinusoidal wave on a certain string the wavelength is 10 cm. When the tension in the string is doubled the generator produces a wave with a frequency and wavelength of:

A. 200 Hz and 20 cm
B. 141 Hz and 10 cm
C. 100 Hz and 20 cm
D. 100 Hz and 14 cm
E. 50 Hz and 14 cm

ans: D

35. A source of frequency f sends waves of wavelength λ traveling with speed v in some medium. If the frequency is changed from f to $2f$, then the new wavelength and new speed are (respectively):

A. 2λ, v
B. $\lambda/2$, v
C. λ, $2v$
D. λ, $v/2$
E. $\lambda/2$, $2v$

ans: B

36. A long string is constructed by joining the ends of two shorter strings. The tension in the strings is the same but string I has 4 times the linear mass density of string II. When a sinusoidal wave passes from string I to string II:

A. the frequency decreases by a factor of 4
B. the frequency decreases by a factor of 2
C. the wavelength decreases by a factor of 4
D. the wavelength decreases by a factor of 2
E. the wavelength increases by a factor of 2

ans: D

37. Three separate strings are made of the same material. String 1 has length L and tension τ, string 2 has length $2L$ and tension 2τ, and string 3 has length $3L$ and tension 3τ. A pulse is started at one end of each string. If the pulses start at the same time, the order in which they reach the other end is:

A. 1, 2, 3
B. 3, 2, 1
C. 2, 3, 1
D. 3, 1, 2
E. they all take the same time

ans: A

38. A long string is constructed by joining the ends of two shorter strings. The tension in the strings is the same but string I has 4 times the linear mass density of string II. When a sinusoidal wave passes from string I to string II:

A. the frequency decreases by a factor of 4
B. the frequency decreases by a factor of 2
C. the wave speed decreases by a factor of 4
D. the wave speed decreases by a factor of 2
E. the wave speed increases by a factor of 2

ans: E

39. Two identical but separate strings, with the same tension, carry sinusoidal waves with the same frequency. Wave A has a amplitude that is twice that of wave B and transmits energy at a rate that is ______ that of wave B.

A. half
B. twice
C. one-fourth
D. four times
E. eight times

ans: D

40. Two identical but separate strings, with the same tension, carry sinusoidal waves with the same frequency. Wave A has an amplitude that is twice that of wave B and transmits energy at a rate that is ______ that of wave B.

A. half
B. twice
C. one-fourth
D. four times
E. eight times

ans: D

41. A sinusoidal wave is generated by moving the end of a string up and down periodically. The generator must supply the greatest power when the end of the string

A. has its greatest acceleration
B. has its greatest displacement
C. has half its greatest displacement
D. has one-fourth its greatest displacement
E. has its least displacement

ans: E

42. A sinusoidal wave is generated by moving the end of a string up and down periodically. The generator does not supply any power when the end of the string

A. has its least acceleration
B. has its greatest displacement
C. has half its greatest displacement
D. has one-fourth its greatest displacement
E. has its least displacement

ans: B

43. The sum of two sinusoidal traveling waves is a sinusoidal traveling wave only if:

A. their amplitudes are the same and they travel in the same direction.
B. their amplitudes are the same and they travel in opposite directions.
C. their frequencies are the same and they travel in the same direction.
D. their frequencies are the same and they travel in opposite directions.
E. their frequencies are the same and their amplitudes are the same.

ans: C

44. Two traveling sinusoidal waves interfere to produce a wave with the mathematical form

$$y(x,t) = y_m \sin(kx + \omega t + \alpha)\,.$$

If the value of ϕ is appropriately chosen, the two waves might be:

A. $y_1(x,t) = (y_m/3)\sin(kx + \omega t)$ and $y_2(x,t) = (y_m/3)\sin(kx + \omega t + \phi)$
B. $y_1(x,t) = 0.7y_m \sin(kx - \omega t)$ and $y_2(x,t) = 0.7y_m \sin(kx - \omega t + \phi)$
C. $y_1(x,t) = 0.7y_m \sin(kx - \omega t)$ and $y_2(x,t) = 0.7y_m \sin(kx + \omega t + \phi)$
D. $y_1(x,t) = 0.7y_m \sin[(kx/2) - (\omega t/2)]$ and $y_2(x,t) = 0.7y_m \sin[(kx/2) - (\omega t/2) + \phi]$
E. $y_1(x,t) = 0.7y_m \sin(kx + \omega t)$ and $y_2(x,t) = 0.7y_m \sin(kx + \omega t + \phi)$

ans: E

45. Fully constructive interference between two sinusoidal waves of the same frequency occurs only if they:

A. travel in opposite directions and are in phase
B. travel in opposite directions and are 180° out of phase
C. travel in the same direction and are in phase
D. travel in the same direction and are 180° out of phase
E. travel in the same direction and are 90° out of phase

ans: C

46. Fully destructive interference between two sinusoidal waves of the same frequency and amplitude occurs only if they:
   A. travel in opposite directions and are in phase
   B. travel in opposite directions and are 180° out of phase
   C. travel in the same direction and are in phase
   D. travel in the same direction and are 180° out of phase
   E. travel in the same direction and are 90° out of phase

   ans: D

47. Two sinusoidal waves travel in the same direction and have the same frequency. Their amplitudes are y_{1m} and y_{2m}. The smallest possible amplitude of the resultant wave is:
   A. $y_{1m} + y_{2m}$ and occurs if they are 180° out of phase
   B. $|y_{1m} - y_{2m}|$ and occurs if they are 180° out of phase
   C. $y_{1m} + y_{2m}$ and occurs if they are in phase
   D. $|y_{1m} - y_{2m}|$ and occurs if they are in phase
   E. $|y_{1m} - y_{2m}|$ and occurs if they are 90° out of phase

   ans: B

48. Two sinusoidal waves have the same angular frequency, the same amplitude y_m, and travel in the same direction in the same medium. If they differ in phase by 50°, the amplitude of the resultant wave is given by:
   A. $0.64y_m$
   B. $1.3y_m$
   C. $0.91y_m$
   D. $1.8y_m$
   E. $0.35y_m$

   ans: D

49. Two separated sources emit sinusoidal traveling waves that have the same wavelength λ and are in phase at their respective sources. One travels a distance ℓ_1 to get to the observation point while the other travels a distance ℓ_2. The amplitude is a minimum at the observation point if $\ell_1 - \ell_2$ is:
   A. an odd multiple of $\lambda/2$
   B. an odd multiple of $\lambda/4$
   C. a multiple of λ
   D. an odd multiple of $\pi/2$
   E. a multiple of π

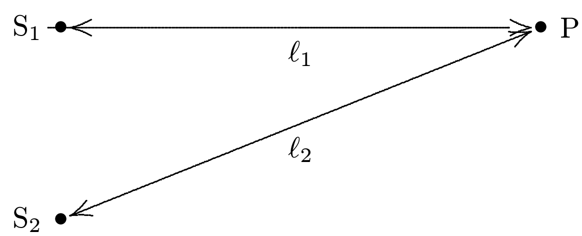
   ans: A

50. Two separated sources emit sinusoidal traveling waves that have the same wavelength λ and are in phase at their respective sources. One travels a distance ℓ_1 to get to the observation point while the other travels a distance ℓ_2. The amplitude is a maximum at the observation point if $\ell_1 - \ell_2$ is:

A. an odd multiple of $\lambda/2$
B. an odd multiple of $\lambda/4$
C. a multiple of λ
D. an odd multiple of $\pi/2$
E. a multiple of π

ans: C

51. Two sources, S_1 and S_2, each emit waves of wavelength λ in the same medium. The phase difference between the two waves, at the point P shown, is $(2\pi/\lambda)(\ell_2 - \ell_1) + \epsilon$. The quantity ϵ is:



A. the distance S_1S_2
B. the angle S_1PS_2
C. $\pi/2$
D. the phase difference between the two sources
E. zero for transverse waves, π for longitudinal waves

ans: D

52. A wave on a stretched string is reflected from a fixed end P of the string. The phase difference, at P, between the incident and reflected waves is:

A. zero
B. π rad
C. $\pi/2$ rad
D. depends on the velocity of the wave
E. depends on the frequency of the wave

ans: B

53. The sinusoidal wave

$$y(x, t) = y_m \sin(kx - \omega t)$$

is incident on the fixed end of a string at $x = L$. The reflected wave is given by:

A. $y_m \sin(kx + \omega t)$
B. $-y_m \sin(kx + \omega t)$
C. $y_m \sin(kx + \omega t - kL)$
D. $y_m \sin(kx + \omega t - 2kL)$
E. $-y_m \sin(kx + \omega t + 2kL)$

ans: D

54. A wave on a string is reflected from a fixed end. The reflected wave:

A. is in phase with the original wave at the end
B. is 180° out of phase with the original wave at the end
C. has a larger amplitude than the original wave
D. has a larger speed than the original wave
E. cannot be transverse

ans: B

55. A standing wave:

A. can be constructed from two similar waves traveling in opposite directions
B. must be transverse
C. must be longitudinal
D. has motionless points that are closer than half a wavelength
E. has a wave velocity that differs by a factor of two from what it would be for a traveling wave

ans: A

56. Which of the following represents a standing wave?

A. $y = (6.0\,\text{mm})\sin[(3.0\,\text{m}^{-1})x + (2.0\,\text{s}^{-1})t] - (6.0\,\text{mm})\cos[(3.0\,\text{m}^{-1})x + 2.0]$
B. $y = (6.0\,\text{mm})\cos[(3.0\,\text{m}^{-1})x - (2.0\,\text{s}^{-1})t] + (6.0\,\text{mm})\cos[(2.0\,\text{s}^{-1})t + 3.0\,\text{m}^{-1})x]$
C. $y = (6.0\,\text{mm})\cos[(3.0\,\text{m}^{-1})x - (2.0\,\text{s}^{-1})t] - (6.0\,\text{mm})\sin[(2.0\,\text{s}^{-1})t - 3.0]$
D. $y = (6.0\,\text{mm})\sin[(3.0\,\text{m}^{-1})x - (2.0\,\text{s}^{-1})t] - (6.0\,\text{mm})\cos[(2.0\,\text{s}^{-1})t + 3.0\,\text{m}^{-1})x]$
E. $y = (6.0\,\text{mm})\sin[(3.0\,\text{m}^{-1})x] + (6.0\,\text{mm})\cos[(2.0\,\text{s}^{-1})t]$

ans: B

57. When a certain string is clamped at both ends, the lowest four resonant frequencies are 50, 100, 150, and 200 Hz. When the string is also clamped at its midpoint, the lowest four resonant frequencies are:

A. 50, 100, 150, and 200 Hz
B. 50, 150, 250, and 300 Hz
C. 100, 200, 300, and 400 Hz
D. 25, 50, 75, and 100 Hz
E. 75, 150, 225, and 300 Hz

ans: C

58. When a certain string is clamped at both ends, the lowest four resonant frequencies are measured to be 100, 150, 200, and 250 Hz. One of the resonant frequencies (below 200 Hz) is missing. What is it?

A. 25 Hz
B. 50 Hz
C. 75 Hz
D. 125 Hz
E. 225 Hz

ans: B

59. Two traveling waves $y_1 = A\sin[k(x - vt)]$ and $y_2 = A\sin[k(x + vt)]$ are superposed on the same string. The distance between the adjacent nodes is:

A. vt/π
B. $vt/2\pi$
C. $\pi/2k$
D. π/k
E. $2\pi/k$

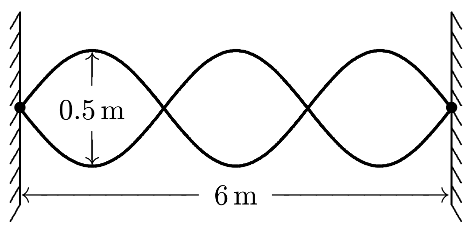
ans: D

60. If λ is the wavelength of each of the component sinusoidal traveling waves that form a standing wave, the distance between adjacent nodes in the standing wave is:

A. $\lambda/4$
B. $\lambda/2$
C. $3\lambda/4$
D. λ
E. 2λ

ans: B

61. A standing wave pattern is established in a string as shown. The wavelength of one of the component traveling waves is:



A. 0.25 m
B. 0.5 m
C. 1 m
D. 2 m
E. 4 m

ans: E

62. Standing waves are produced by the interference of two traveling sinusoidal waves, each of frequency 100 Hz. The distance from the second node to the fifth node is 60 cm. The wavelength of each of the two original waves is:

A. 50 cm
B. 40 cm
C. 30 cm
D. 20 cm
E. 15 cm

ans: B

63. A string of length 100 cm is held fixed at both ends and vibrates in a standing wave pattern. The wavelengths of the constituent traveling waves CANNOT be:

A. 400 cm
B. 200 cm
C. 100 cm
D. 66.7 cm
E. 50 cm

ans: A

64. A string of length L is clamped at each end and vibrates in a standing wave pattern. The wavelengths of the constituent traveling waves CANNOT be:

A. L
B. $2L$
C. $L/2$
D. $2L/3$
E. $4L$

ans: E

65. Two sinusoidal waves, each of wavelength 5 m and amplitude 10 cm, travel in opposite directions on a 20-m long stretched string that is clamped at each end. Excluding the nodes at the ends of the string, how many nodes appear in the resulting standing wave?

A. 3
B. 4
C. 5
D. 7
E. 8

ans: D

66. A string, clamped at its ends, vibrates in three segments. The string is 100 cm long. The wavelength is:

A. 33.3 cm
B. 66.7 cm
C. 150 cm
D. 300 cm
E. need to know the frequency

ans: B

67. A stretched string, clamped at its ends, vibrates in its fundamental frequency. To double the fundamental frequency, one can change the string tension by a factor of:

A. 2
B. 4
C. $\sqrt{2}$
D. $1/2$
E. $1/\sqrt{2}$

ans: B

68. When a string is vibrating in a standing wave pattern the power transmitted across an antinode, compared to the power transmitted across a node, is:

A. more
B. less
C. the same (zero)
D. the same (non-zero)
E. sometimes more, sometimes less, and sometimes the same

ans: C

69. A 40-cm long string, with one end clamped and the other free to move transversely, is vibrating in its fundamental standing wave mode. The wavelength of the constituent traveling waves is:

A. 10 cm
B. 20 cm
C. 40 cm
D. 80 cm
E. 160 cm

ans: E

70. A 30-cm long string, with one end clamped and the other free to move transversely, is vibrating in its second harmonic. The wavelength of the constituent traveling waves is:

A. 10 cm
B. 30 cm
C. 40 cm
D. 60 cm
E. 120 cm

ans: C

71. A 40-cm long string, with one end clamped and the other free to move transversely, is vibrating in its fundamental standing wave mode. If the wave speed is 320 cm/s the frequency is:

A. 32 Hz
B. 16 Hz
C. 8 Hz
D. 4 Hz
E. 2 Hz

ans: E

Chapter 17: WAVES — II

1. The speed of a sound wave is determined by:
   A. its amplitude
   B. its intensity
   C. its pitch
   D. number of harmonics present
   E. the transmitting medium

   ans: E

2. Take the speed of sound to be 340 m/s. A thunder clap is heard about 3 s after the lightning is seen. The source of both light and sound is:
   A. moving overhead faster than the speed of sound
   B. emitting a much higher frequency than is heard
   C. emitting a much lower frequency than is heard
   D. about 1000 m away
   E. much more than 1000 m away

   ans: D

3. A sound wave has a wavelength of 3.0 m. The distance from a compression center to the adjacent rarefaction center is:
   A. 0.75 m
   B. 1.5 m
   C. 3.0 m
   D. need to know wave speed
   E. need to know frequency

   ans: B

4. A fire whistle emits a tone of 170 Hz. Take the speed of sound in air to be 340 m/s. The wavelength of this sound is about:
   A. 0.5 m
   B. 1.0 m
   C. 2.0 m
   D. 3.0 m
   E. 340 m

   ans: C

5. During a time interval of exactly one period of vibration of a tuning fork, the emitted sound travels a distance:
   A. equal to the length of the tuning fork
   B. equal to twice the length of the tuning fork
   C. of about 330 m
   D. which decreases with time
   E. of one wavelength in air

   ans: E

6. At points in a sound wave where the gas is maximally compressed, the pressure
   A. is a maximum
   B. is a minimum
   C. is equal to the ambient value
   D. is greater than the ambient value but less than the maximum
   E. is less than the ambient value but greater than the minimum

   ans: A

7. You are listening to an "A" note played on a violin string. Let the subscript "s" refer to the violin string and "a" refer to the air. Then:
   A. $f_s = f_a$ but $\lambda_s \neq \lambda_a$
   B. $f_s = f_a$ and $\lambda_s = \lambda_a$
   C. $\lambda_s = \lambda_a$ but $f_s \neq f_a$
   D. $\lambda_s \neq \lambda_a$ and $f_s \neq f_a$
   E. linear density of string = volume density of air

   ans: A

8. "Beats" in sound refer to:
   A. interference of two waves of the same frequency
   B. combination of two waves of slightly different frequency
   C. reversal of phase of reflected wave relative to incident wave
   D. two media having slightly different sound velocities
   E. effect of relative motion of source and observer

   ans: B

9. To produce beats it is necessary to use two waves:
   A. traveling in opposite directions
   B. of slightly different frequencies
   C. of equal wavelengths
   D. of equal amplitudes
   E. whose ratio of frequencies is an integer

   ans: B

10. In order for two sound waves to produce audible beats, it is essential that the two waves have:
   A. the same amplitude
   B. the same frequency
   C. the same number of harmonics
   D. slightly different amplitudes
   E. slightly different frequencies

   ans: E

11. The largest number of beats per second will be heard from which pair of tuning forks?
    A. 200 and 201 Hz
    B. 256 and 260 Hz
    C. 534 and 540 Hz
    D. 763 and 774 Hz
    E. 8420 and 8422 Hz

    ans: D

12. Two stationary tuning forks (350 and 352 Hz) are struck simultaneously. The resulting sound is observed to:
    A. beat with a frequency of 2 beats/s
    B. beat with a frequency of 351 beats/s
    C. be loud but not beat
    D. be Doppler shifted by 2 Hz
    E. have a frequency of 702 Hz

    ans: A

13. When listening to tuning forks of frequency 256 Hz and 260 Hz, one hears the following number of beats per second:
    A. zero
    B. 2
    C. 4
    D. 8
    E. 258

    ans: C

14. Two identical tuning forks vibrate at 256 Hz. One of them is then loaded with a drop of wax, after which 6 beats/s are heard. The period of the loaded tuning fork is:
    A. 0.006 s
    B. 0.005 s
    C. 0.004 s
    D. 0.003 s
    E. none of these

    ans: C

15. Which of the following properties of a sound wave determine its "pitch"?
    A. Amplitude
    B. Distance from source to detector
    C. Frequency
    D. Phase
    E. Speed

    ans: C

16. Two notes are an "octave" apart. The ratio of their frequencies is:
    A. 8
    B. 10
    C. $\sqrt{8}$
    D. 2
    E. $\sqrt{2}$
    ans: D

17. Consider two imaginary spherical surfaces with different radii, each centered on a point sound source emitting spherical waves. The power transmitted across the larger sphere is ______ the power transmitted across the smaller and the intensity at a point on the larger sphere is ______ the intensity at a point on the smaller.
    A. greater than, the same as
    B. greater than, greater than
    C. greater than, less than
    D. the same as, less than
    E. the same as, the same as
    ans: D

18. The sound intensity 5.0 m from a point source is $0.50\,\mathrm{W/m^2}$. The power output of the source is:
    A. 39 W
    B. 160 W
    C. 266 W
    D. 320 W
    E. 390 W
    ans: B

19. The standard reference sound level is about:
    A. the threshold of human hearing at 1000 Hz
    B. the threshold of pain for human hearing at 1000 Hz
    C. the level of sound produced when the 1 kg standard mass is dropped 1 m onto a concrete floor
    D. the level of normal conversation
    E. the level of sound emitted by a standard 60 Hz tuning fork
    ans: A

20. The intensity of sound wave A is 100 times that of sound wave B. Relative to wave B the sound level of wave A is:
    A. -2 db
    B. $+2$ db
    C. $+10$ db
    D. $+20$ db
    E. $+100$ db
    ans: D

21. The intensity of a certain sound wave is $6\,\mu\text{W/cm}^2$. If its intensity is raised by 10 db, the new intensity (in $\mu\text{W/cm}^2$) is:

A. 60
B. 6.6
C. 6.06
D. 600
E. 12

ans: A

22. If the sound level is increased by 10 db the intensity increases by a factor of:

A. 2
B. 5
C. 10
D. 20
E. 100

ans: C

23. The sound level at a point P is 14 db below the sound level at a point 1.0 m from a point source. The distance from the source to point P is:

A. 4.0 cm
B. 20 2m
C. 2.0 m
D. 5.0 m
E. 25 m

ans: D

24. To raise the pitch of a certain piano string, the piano tuner:

A. loosens the string
B. tightens the string
C. shortens the string
D. lengthens the string
E. removes some mass

ans: B

25. A piano wire has length L and mass M. If its fundamental frequency is f, its tension is:

A. $2Lf/m$
B. $4MLf$
C. $2Mf^2/L$
D. $4f^2L^3/M$
E. $4LMf^2$

ans: E

26. If the length of a piano wire (of given density) is increased by 5%, what approximate change in tension is necessary to keep its fundamental frequency unchanged?

A. Decrease of 10%
B. Decrease of 5%
C. Increase of 5%
D. Increase of 10%
E. Increase of 20%

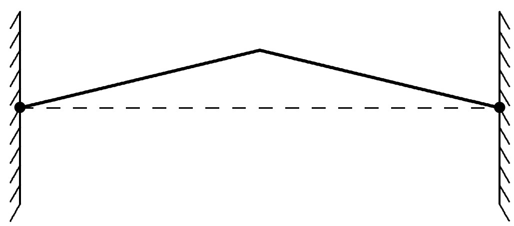
ans: C

27. A piano wire has a length of 81 cm and a mass of 2.0 g. If its fundamental frequency is to be 394 Hz, its tension must be:

A. 0.32 N
B. 63 N
C. 130 N
D. 250 N
E. none of these

ans: B

28. A stretched wire of length 1.0 m is clamped at both ends. It is plucked at its center as shown. The three longest wavelengths in the wire are (in meters):



A. 4, 2, 1
B. 2, 1, 0.5
C. 2, 0.67, 0.4
D. 1, 0.5, 0.33
E. 1, 0.67, 0.5

ans: C

29. Two identical strings, A and B, have nearly the same tension. When they both vibrate in their fundamental resonant modes, there is a beat frequency of 3 Hz. When string B is tightened slightly, to increase the tension, the beat frequency becomes 6 Hz. This means:

A. that before tightening A had a higher frequency than B, but after tightening, B has a higher frequency than A
B. that before tightening B had a higher frequency than A, but after tightening, A has a higher frequency than B
C. that before and after tightening A has a higher frequency than B
D. that before and after tightening B has a higher frequency than A
E. none of the above

ans: D

30. Two pipes are each open at one end and closed at the other. Pipe A has length L and pipe B has length $2L$. Which harmonic of pipe B matches in frequency the fundamental of pipe A?
    A. The fundamental
    B. The second
    C. The third
    D. The fourth
    E. There are none
    ans: E

31. A column of argon is open at one end and closed at the other. The shortest length of such a column that will resonate with a 200 Hz tuning fork is 42.5 cm. The speed of sound in argon must be:
    A. 85.0 m/s
    B. 170 m/s
    C. 340 m/s
    D. 470 m/s
    E. 940 m/s
    ans: C

32. A tuning fork produces sound waves of wavelength λ in air. This sound is used to cause resonance in an air column, closed at one end and open at the other. The length of this column CANNOT be:
    A. $\lambda/4$
    B. $2\lambda/4$
    C. $3\lambda/4$
    D. $5\lambda/4$
    E. $7\lambda/4$
    ans: B

33. A 1024 Hz tuning fork is used to obtain a series of resonance levels in a gas column of variable length, with one end closed and the other open. The length of the column changes by 20 cm from resonance to resonance. From this data, the speed of sound in this gas is:
    A. 20 cm/s
    B. 51 cm/s
    C. 102 cm/s
    D. 205 m/s
    E. 410 m/s
    ans: E

34. A vibrating tuning fork is held over a water column with one end closed and the other open. As the water level is allowed to fall, a loud sound is heard for water levels separated by 17 cm. If the speed of sound in air is 340 m/s, the frequency of the tuning fork is:
    A. 500 Hz
    B. 1000 Hz
    C. 2000 Hz
    D. 5780 Hz
    E. 578,000 Hz
    ans: B

35. An organ pipe with one end open and the other closed is operating at one of its resonant frequencies. The open and closed ends are respectively:

A. pressure node, pressure node
B. pressure node, displacement node
C. displacement antinode, pressure node
D. displacement node, displacement node
E. pressure antinode, pressure node

ans: B

36. An organ pipe with one end closed and the other open has length L. Its fundamental frequency is proportional to:

A. L
B. $1/L$
C. $1/L^2$
D. L^2
E. $\sqrt{L}$

ans: B

37. Five organ pipes are described below. Which one has the highest frequency fundamental?

A. A 2.3-m pipe with one end open and the other closed
B. A 3.3-m pipe with one end open and the other closed
C. A 1.6-m pipe with both ends open
D. A 3.0-m pipe with both ends open
E. A pipe in which the displacement nodes are 5 m apart

ans: C

38. If the speed of sound is 340 m/s, the length of the shortest closed pipe that resonates at 218 Hz is:

A. 23 cm
B. 17 cm
C. 39 cm
D. 78 cm
E. 1.56 cm

ans: C

39. The lowest tone produced by a certain organ comes from a 3.0-m pipe with both ends open. If the speed of sound is 340 m/s, the frequency of this tone is approximately:

A. 7 Hz
B. 14 Hz
C. 28 Hz
D. 57 Hz
E. 70 Hz

ans: D

40. The speed of sound in air is 340 m/s. The length of the shortest pipe, closed at one end, that will respond to a 512 Hz tuning fork is approximately:

A. 4.2 cm
B. 9.4 cm
C. 17 cm
D. 33 cm
E. 66 cm

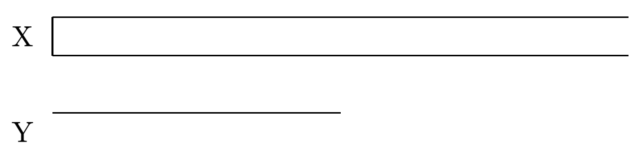
ans: C

41. If the speed of sound is 340 m/s, the two lowest frequencies of an 0.5-m organ pipe, closed at one end, are approximately:

A. 170 and 340 Hz
B. 170 and 510 Hz
C. 340 and 680 Hz
D. 340 and 1020 Hz
E. 57 and 170 Hz

ans: B

42. Organ pipe Y (open at both ends) is half as long as organ pipe X (open at one end) as shown. The ratio of their fundamental frequencies f_X:f_Y is:



A. 1:1
B. 1:2
C. 2:1
D. 1:4
E. 4:1

ans: A

43. A 200-cm organ pipe with one end open is in resonance with a sound wave of wavelength 270 cm. The pipe is operating in its:

A. fundamental frequency
B. second harmonic
C. third harmonic
D. fourth harmonic
E. fifth harmonic

ans: B

44. An organ pipe with both ends open is 0.85 m long. Assuming that the speed of sound is 340 m/s, the frequency of the third harmonic of this pipe is:

A. 200 Hz
B. 300 Hz
C. 400 Hz
D. 600 Hz
E. none of these

ans: D

45. The "A" on a trumpet and a clarinet have the same pitch, but the two are clearly distinguishable. Which property is most important in enabling one to distinguish between these two instruments?

A. Intensity
B. Fundamental frequency
C. Displacement amplitude
D. Pressure amplitude
E. Harmonic content

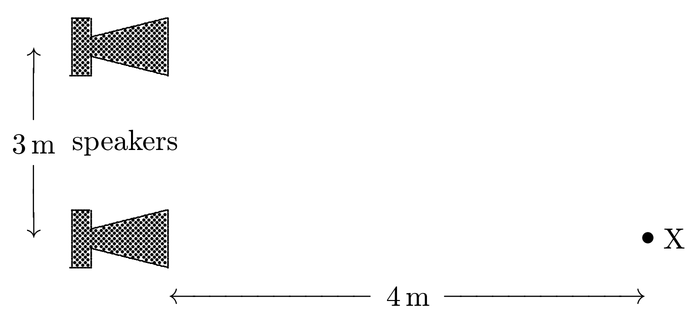
ans: E

46. The valves of a trumpet and the slide of a trombone are for the purpose of:

A. playing short (staccato) notes
B. tuning the instruments
C. changing the harmonic content
D. changing the length of the air column
E. producing gradations in loudness

ans: D

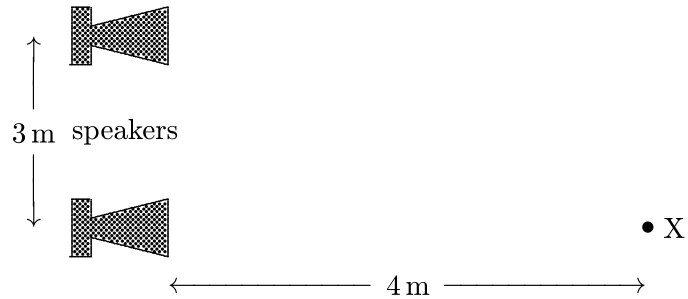
47. Two small identical speakers are connected (in phase) to the same source. The speakers are 3 m apart and at ear level. An observer stands at X, 4 m in front of one speaker as shown. If the amplitudes are not changed, the sound he hears will be most intense if the wavelength is:



A. 1 m
B. 2 m
C. 3 m
D. 4 m
E. 5 m

ans: A

48. Two small identical speakers are connected (in phase) to the same source. The speakers are 3 m apart and at ear level. An observer stands at X, 4 m in front of one speaker as shown. The sound she hears will be most intense if the wavelength is:



A. 5 m
B. 4 m
C. 3 m
D. 2 m
E. 1 m

ans: E

49. The rise in pitch of an approaching siren is an apparent increase in its:

A. speed
B. amplitude
C. frequency
D. wavelength
E. number of harmonics

ans: C

50. The diagram shows four situations in which a source of sound S with variable frequency and a detector D are either moving or stationary. The arrows indicate the directions of motion. The speeds are all the same. Detector 3 is stationary. The frequency detected is the same. Rank the situations according to the frequency of the source, lowest to highest.

A. 1, 2, 3, 4
B. 4, 3, 2, 1
C. 1, 3, 4, 2
D. 2, 1, 2, 3
E. None of the above

ans: B

51. A stationary source generates 5.0 Hz water waves whose speed is 2.0 m/s. A boat is approaching the source at 10 m/s. The frequency of these waves, as observed by a person in the boat, is:

A. 5.0 Hz
B. 15 Hz
C. 20 Hz
D. 25 Hz
E. 30 Hz

ans: E

52. A stationary source S generates circular outgoing waves on a lake. The wave speed is 5.0 m/s and the crest-to-crest distance is 2.0 m. A person in a motor boat heads directly toward S at 3.0 m/s. To this person, the frequency of these waves is:

A. 1.0 Hz
B. 1.5 Hz
C. 2.0 Hz
D. 4.0 Hz
E. 8.0 Hz

ans: D

53. A stationary source emits a sound wave of frequency f. If it were possible for a man to travel toward the source at the speed of sound, he would observe the emitted sound to have a frequency of:

A. zero
B. $f/2$
C. $2f/3$
D. $2f$
E. infinity

ans: D

54. A source emits sound with a frequency of 1000 Hz. It and an observer are moving in the same direction with the same speed, 100 m/s. If the speed of sound is 340 m/s, the observer hears sound with a frequency of:

A. 294 Hz
B. 545 Hz
C. 1000 Hz
D. 1830 Hz
E. 3400 Hz

ans: C

55. A source emits sound with a frequency of 1000 Hz. It and an observer are moving toward each other, each with a speed of 100 m/s. If the speed of sound is 340 m/s, the observer hears sound with a frequency of:

A. 294 Hz
B. 545 Hz
C. 1000 Hz
D. 1830 Hz
E. 3400 Hz

ans: D

56. A source emits sound with a frequency of 1000 Hz. It is moving at 20 m/s toward a stationary reflecting wall. If the speed of sound is 340 m/s an observer at rest directly behind the source hears a beat frequency of:

A. 11 Hz
B. 86 Hz
C. 97 Hz
D. 118 Hz
E. 183 Hz

ans: D

57. In each of the following two situations a source emits sound with a frequency of 1000 Hz. In situation I the source is moving at 100 m/s toward an observer at rest. In situation II the observer is moving at 100 m/s toward the source, which is stationary. The speed of sound is 340 m/s. The frequencies heard by the observers in the two situations are:

A. I: 1417 Hz; II: 1294 Hz
B. I: 1417 Hz; II: 1417 Hz
C. I: 1294 Hz; II: 1294 Hz
D. I: 773 Hz; II: 706 Hz
E. I: 773 Hz; II: 773 Hz

ans: A

58. The Doppler shift formula for the frequency detected is

$$f = f'\frac{v \pm v_D}{v \mp v_S}\,,$$

where f' is the frequency emitted, v is the speed of sound, v_D is the speed of the detector, and v_S is the speed of the source. Suppose the source is traveling at 5 m/s away from the detector, the detector is traveling at 7 m/s toward the source, and there is a 3-m/s wind blowing from the source toward the detector. The values that should be substituted into the Doppler shift equation are:

A. $v_D = 7\,\mathrm{m/s}$ and $v_S = 5\,\mathrm{m/s}$
B. $v_D = 10\,\mathrm{m/s}$ and $v_S = 8\,\mathrm{m/s}$
C. $v_D = 4\,\mathrm{m/s}$ and $v_S = 2\,\mathrm{m/s}$
D. $v_D = 10\,\mathrm{m/s}$ and $v_S = 2\,\mathrm{m/s}$
E. $v_D = 4\,\mathrm{m/s}$ and $v_S = 8\,\mathrm{m/s}$

ans: B

59. A plane produces a sonic boom only when:

A. it emits sound waves of very long wavelength
B. it emits sound waves of high frequency
C. it flys at high altitudes
D. it flys on a curved path
E. it flys faster than the speed of sound

ans: E

60. If the speed of sound is 340 m/s a plane flying at 400 m/s creates a conical shock wave with an apex half angle of:

A. 0 (no shock wave)
B. 32°
C. 40°
D. 50°
E. 58°

ans: E

61. The speed of sound is 340 m/s. A plane flys horizontally at an altitude of 10,000 m and a speed of 400 m/s. When an observer on the ground hears the sonic boom the horizontal distance from the point on its path directly above the observer to the plane is:

A. 5800 m
B. 6200 m
C. 8400 m
D. 12,000 m
E. 16,000 m

ans: B