Exercises

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question.

1. The source of all wave motion is a
   a. region of variable high and low pressure.
   b. vibration.
   c. movement of matter.
   d. harmonic object.

2. The time needed for a wave to make one complete cycle is its
   a. frequency.
   b. velocity.
   c. amplitude.
   d. period.
   e. wavelength.

3. The distance between successive identical parts of a wave is called its
   a. frequency.
   b. period.
   c. velocity.
   d. amplitude.
   e. wavelength.

4. The Hertz is a
   a. special radio wave.
   b. type of car.
   c. unit of period.
   d. unit of wavelength.
   e. unit of frequency.

5. A wave created by shaking a rope up and down is called a
   a. Doppler wave.
   b. standing wave.
   c. longitudinal wave.
   d. constructive wave.
   e. transverse wave.

6. Which of the following is NOT a transverse wave?
   a. light.
   b. radio wave.
   c. sound.
   d. all of the above.
   e. none of the above

7. Sound is an example of a
   a. longitudinal wave.
   b. constructive wave.
   c. Doppler wave.
   d. transverse wave.
   e. standing wave.

8. A longitudinal wave lacks which of the following properties?
   a. speed.
   b. frequency.
c. wavelength.
d. amplitude.
e. A longitudinal wave has all of the above.

9. When two or more waves are at the same place at the same time, the resulting effect is called
   a. a standing wave.
   b. a Doppler wave.
   c. a shock wave.
   d. interference.
   e. a period.

10. Where can you touch a standing wave on a rope without disturbing the wave?
   a. At a node
   b. At any place along the wave
   c. At an antinode

11. Standing waves can be set up
   a. in organ pipes.
   b. by blowing across the top of a soda bottle.
   c. on strings of musical instruments.
   d. all of the above
   e. none of the above

12. Suppose a bug is jiggling up and down and swimming towards you at the same time. Compared to the
    frequency at which the bug is emitting waves, the frequency of the waves reaching you is
    a. lower.
    b. higher.
    c. just the same.

13. As the sound of a car's horn passes and recedes from you, the pitch of the horn seems to
    a. increase.
    b. stay the same.
    c. decrease.

14. The Doppler effect is the change in observed frequency due to
    a. the original frequency of the source.
    b. the type of medium the wave is in.
    c. the motion of the source or observer.
    d. the type of wave.
    e. all of the above

15. When a sound source moves towards you, what happens to the wave speed?
    a. It decreases.
    b. It increases.
    c. It stays the same.

16. Some of a wave's energy is always being dissipated as heat. In time, this will reduce the wave's
    a. frequency.
    b. wavelength.
    c. speed.
    d. period.
    e. amplitude.

17. The amplitude of a particular wave is 4.0 m. The top-to-bottom distance of the disturbance is
    a. 2.0 m.
    b. 4.0 m.
    c. 8.0 m.
    d. none of the above
18. When a pendulum clock is taken from sea level to the top of a high mountain, it will
   a. neither lose nor gain time.
   b. gain time.
   c. lose time.

19. If you double the frequency of a vibrating object, its period
   a. halves.
   b. is quartered.
   c. doubles.

20. You dip your finger repeatedly into water and make waves. If you dip your finger more frequently, the
    wavelength of the waves
   a. lengthens.
   b. stays the same.
   c. shortens.

21. During a single period, the distance traveled by a wave is
   a. two wavelengths.
   b. one wavelength.
   c. one half wavelength.

22. A child swings back and forth on a playground swing. If the child stands rather than sits, the time for a
    to-and-fro swing is
   a. unchanged.
   b. lengthened.
   c. shortened.

23. Suppose a simple pendulum is suspended in an elevator. When the elevator is accelerating upward, the period
    of the pendulum
   a. doesn't change.
   b. increases.
   c. decreases.

24. A horse would be able to run faster if most of the mass in its legs were concentrated
   a. in the upper part, nearer the horse's body.
   b. halfway up its legs.
   c. toward its feet.
   d. uniformly all along its legs.
   e. none of the above

25. What happens when an airplane is flying faster than the speed of sound?
   a. There is no sonic boom.
   b. It becomes very quiet inside the plane.
   c. Nobody can hear the plane fly overhead.
   d. A shock wave is produced.
   e. none of the above

26. A sonic boom
   a. is swept continuously behind a plane flying faster than the speed of sound.
   b. is produced as a plane breaks through the sound barrier.
   c. is produced by subsonic projectiles as well as subsonic aircraft.
   d. all of the above
   e. none of the above

27. An observer on the ground hears a sonic boom that is created by an airplane flying at a speed
   a. equal to the speed of sound.
   b. greater than the speed of sound.
   c. just below the speed of sound.
28. An aircraft that flies faster than the speed of sound is said to be
   a. subsonic.
   b. supersonic.
   c. neither of the above

29. The Doppler effect occurs when a source of sound moves
   a. away from you.
   b. toward you.
   c. both A and B
   d. none of the above

30. A sound wave that has a higher frequency has a wavelength that is
   a. shorter.
   b. longer.

31. The frequency of the second hand on a clock is
   a. \( \frac{1}{60} \) hertz.
   b. 1 hertz.
   c. 60 hertz.

32. Two waves arrive at the same place at the same time exactly in step with each other. Each wave has an amplitude of 2.5 m. The resulting wave has an amplitude of
   a. 0.6 m.
   b. 1.3 m.
   c. 2.5 m.
   d. 5.0 m.
   e. 10.0 m.

33. The period of an ocean wave is 10 seconds. What is the wave’s frequency?
   a. 0.10 Hz
   b. 5.0 Hz
   c. 10.0 Hz
   d. 20.0 Hz
   e. 30.0 Hz

34. A certain ocean wave has a frequency of 0.07 hertz and a wavelength of 10 meters. What is the wave’s speed?
   a. 0.07 m/s
   b. 0.70 m/s
   c. 1.0 m/s
   d. 10 m/s
   e. 143 m/s

35. A weight on the end of a spring bobs up and down one complete cycle every 4.0 seconds. Its frequency is
   a. 0.25 hertz.
   b. 4.0 hertz.
   c. none of the above.

36. A weight on the end of a spring bobs up and down one complete cycle every 5.00 seconds. Its period is
   a. 0.20 sec.
   b. 5.00 sec.
   c. none of the above

37. A weight suspended from a spring bobs up and back down again over a distance of 3.00 meters in 10.00 seconds. Its frequency is
   a. 0.10 hertz.
   b. 3.0 hertz.
c. 10.0 hertz.
d. none of the above

38. A leaf on a pond oscillates up and down two complete cycles each second as a water wave passes. What is the wave's frequency?
a. 0.5 hertz
b. 1 hertz
c. 2 hertz
d. 3 hertz
e. 6 hertz

39. A cork floating in a pool oscillates up and down three complete cycles in 1 second as a wave passes by. The wave's wavelength is 2 meters. What is the wave's speed?
a. 1 m/s
b. 2 m/s
c. 6 m/s
d. 12 m/s
e. More than 12 m/s

40. A wave travels an average distance of 6 meters in 3 seconds. What is the wave's velocity?
a. Less than 0.5 m/s
b. 3 m/s
c. 1 m/s
d. 2 m/s
e. More than 2 m/s

41. A wave has two crests and two troughs each second. If the wave travels an average distance of 8 meters in 4 seconds, its wavelength is
a. 20 m.
b. 15 m.
c. 10 m.
d. 1 m.
e. 0 m.

42. Radio waves travel at the speed of light, 300,000 km/s. The wavelength of a radio wave received at 200 megahertz is
a. 0.7 m.
b. 1.5 m.
c. 6.7 m.
d. 15 m.

43. A skipper on a boat notices wave crests passing the anchor chain every 6.0 seconds. The skipper estimates the distance between crests at 30.0 m. What is the speed of the water waves?
a. 5.0 m/s
b. 6.0 m/s
c. 30.0 m/s
d. not enough information given

44. Compared to the speed of light, sound travels
a. faster.
b. at about the same speed.
c. slower.

45. Sound waves are produced by
a. radio stations.
b. vibrating objects.
c. soft objects.
46. Sound waves in air are a series of
   a. periodic disturbances.
   b. periodic condensations and rarefactions.
   c. high- and low-pressure regions.
   d. all of the above
   e. none of the above

47. Which of the following would be most likely to transmit sound with the highest speed?
   a. Steel in a bridge
   b. Wood in a cabinet
   c. Water in the ocean
   d. Water in a swimming pool
   e. Air in your classroom

48. A sound wave is a
   a. standing wave.
   b. longitudinal wave.
   c. transverse wave.
   d. shock wave.
   e. none of the above

49. Sound waves cannot travel in
   a. steel.
   b. air.
   c. a vacuum.
   d. water.
   e. Sound can travel in all of the above.

50. The speed of a sound wave depends on
   a. the air temperature.
   b. its frequency.
   c. its wavelength.
   d. all of the above
   e. none of the above

51. Sound travels faster in air if the air is
   a. neither warm nor cold.
   b. cold.
   c. warm.

52. If the sounding board were left out of a music box, the music box would
   a. not sound at all.
   b. make little "plinks" that you could hardly hear.
   c. sound the same as usual.

53. Resonance occurs when
   a. sound changes speed in going from one medium to another.
   b. sound makes multiple reflections.
   c. the amplitude of a wave is amplified.
   d. an object is forced to vibrate at its natural frequency.
   e. all of the above

54. A tuning fork of frequency 300 Hz will resonate if a sound wave incident on it has a frequency of
   a. 150 Hz.
   b. 600 Hz.
55. A singer shattering crystal glass with her voice is a demonstration of
   a. beats.
   b. sound refraction.
   c. an echo.
   d. interference.
   e. resonance.

56. Noise-canceling earphones are an example of
   a. constructive interference.
   b. destructive interference.
   c. beats.
   d. resonance.

57. When the handle of a tuning fork is held solidly against a table, the sound becomes louder and the length of
time the fork vibrates
   a. becomes shorter.
   b. becomes longer.
   c. remains the same.

58. In which one of the following does sound travel the fastest?
   a. Water
   b. Ice
   c. Steam
   d. Sound travels at the same speed in all of the above.

59. The phenomenon of beats results from sound
   a. interference.
   b. reflection.
   c. refraction.
   d. all of the above
   e. none of the above

60. Beats can be heard when two tuning forks
   a. are sounded together.
   b. have almost the same frequency and are sounded together.
   c. have the same frequency and are sounded together.
   d. all of the above
   e. none of the above

61. A 1134-Hz tuning fork is sounded at the same time a piano note is struck. You hear three beats per second.
    What is the frequency of the piano string?
   a. 1131 Hz
   b. 1134 Hz
   c. 1137 Hz
   d. 2268 Hz
   e. Not enough information given to determine

62. An explosion occurs 340 km away. Given that sound travels at 340 m/s, the time the sound takes to reach you is
   a. 1 s.
   b. 10 s.
   c. 100 s.
   d. 200 s.
   e. more than 200 s.

63. The Tacoma Narrows Bridge collapsed due to
   a. resonance.
   b. frequency modulation.
   c. beats.
   d. destructive interference.

64. A general rule for estimating the distance in kilometers between an observer and a lightning bolt is to count
   the number of seconds between seeing and hearing the bolt, and divide by
   a. 2.
   b. 3.
   c. 4.
   d. 5.
   e. none of the above

65. Compared to a sound of 10 decibels, a sound of 50 decibels has
   a. 40 times the intensity.
   b. 400 times the intensity.
   c. 10,000 times the intensity.

66. Compared to the threshold of hearing, a sound level of 10 decibels is
   a. 1 times more intense.
   b. 20 times more intense.
   c. 200 times more intense.
   d. 10 times more intense.

67. The speed of sound in dry air at 20 degrees Celsius is 340 m/s. How far away is a jet plane when you notice a
   2-second delay between seeing the plane and hearing it?
   a. 20 m
   b. 40 m
   c. 340 m
   d. 680 m
   e. 6,800 m

68. A 680-Hz sound wave travels at 340 m/s in air, with a wavelength of
   a. 0.5 m.
   b. 5 m.
   c. 50 m.
   d. 500 m.
   e. none of the above

69. Beats are produced when two tuning forks, one of frequency 240 Hz and the other of frequency 248 Hz, are
   sounded together. The frequency of the beats is
   a. 8 Hz.
   b. 16 Hz.
   c. 240 Hz.
   d. 247 Hz.
   e. none of the above

70. How many times a minute will you be in step with a friend when you walk at 77 steps per minute and your
   friend walks at 65 steps per minute?
   a. 0
   b. 12
   c. 65
   d. 77
   e. 142

71. Two whistles produce sounds of wavelengths 3.4 m and 3.2 m. What is the beat frequency produced?
72. Suppose you sound a tuning fork at the same time you hit a 1053-Hz note on the piano and hear 3 beats/sec. You tighten the piano string very slightly and now hear 4 beats/sec. What is the frequency of the tuning fork?
   a. 1049 Hz
   b. 1050 Hz
   c. 1053 Hz
   d. 1056 Hz
   e. 1057 Hz

73. A sound wave that has a wavelength of 2 m in room-temperature air has a frequency of about
   a. 170 Hz.
   b. 1360 Hz.
   c. 2040 Hz.
   d. none of the above

74. An oceanic depth-sounding vessel surveys the ocean bottom with ultrasonic sound that travels 1530 m/s in seawater, and finds a 10-second time delay of the echo to the ocean floor and back. The ocean depth there is
   a. 1700 m.
   b. 3400 m.
   c. 7650 m.
   d. 15,300 m.
   e. none of the above

75. The time for a complete to and fro swing of a pendulum is its frequency.

76. The amplitude of a wave is the vertical distance from the midpoint to either the crest or the trough of the wave.

77. The distance between successive identical parts of a wave is its displacement.

78. The number of times a wave vibrates each second is its period.

79. A wave on a rope whose motion is at right angles to the direction of wave propagation is a longitudinal wave.

80. Sound waves are examples of longitudinal waves.

81. The unit of the period of a wave is the hertz.

82. When the high part of one wave fills in the low part of another wave, constructive interference occurs.

83. Nodes in a standing wave normally remain stationary.

84. Galaxies show a red shift in their spectrums.

85. We hear a sonic boom just at the moment a supersonic plane flies directly overhead.

86. If you tie a rope to a wall and shake the free end up and down just right, the reflected wave will be in and out of phase with the incident wave at fixed places along the rope and can form a standing wave.

87. As a train sounding a horn goes away from you, both the sound speed and the pitch of the horn fall.
88. As a light source is coming towards you, you see light of a frequency higher than the source it emits.
89. A pulse of compressed air that is part of a sound wave is a rarefaction.
90. When an object is forced to vibrate at its natural frequency, resonance occurs.
91. Sound can travel through solids, liquids, gases, and even a vacuum.
92. In order for sound from a speaker to reach a listener, air near the speaker must travel to the listener.
93. Almost everything that exists has a natural frequency.
94. Even a steel bridge can collapse because of resonance.
95. The word "pitch" refers to the period of a sound wave.
96. If you strike a tuning fork and hold it on a table, the sound becomes relatively loud.
97. When an object is disturbed slightly and then left alone, it vibrates at its natural frequency.
98. When an object is forced to vibrate at its natural frequency, its vibration amplitude increases.

Essay

99. What is a transverse wave? For a transverse wave, define wavelength, amplitude, period, frequency, and wave speed. What are the units of each? Explain how these characteristics are related.
100. What is the period of a sound wave whose wavelength is 17.0 m?
101. What is the difference between a transverse wave and a longitudinal wave? Give examples of each.
102. What is an interference pattern? What are the two types of interference and what are the conditions for producing them?
103. What is a standing wave? A node? An antinode?
104. What is the Doppler effect? How does it work? If a star looks bluer to us than it should, is the star moving away from us or toward us? Explain.
105. What is a sonic boom? Explain in as much detail as you can.
106. What is sound, and how does it propagate through the air?
107. What is resonance and what conditions cause it? Give examples.
108. Write a short paragraph on beats and how they are produced. Give examples.

Problem

109. Waves in a lake are 1.5 m in length and pass an anchored boat 0.5 s apart. What is the speed of the waves?
110. A boat at anchor is rocked by waves whose crests are 28 m apart and whose speed is 7 m/s. How often do these waves reach the boat?
111. Radio amateurs are permitted to communicate on the “10-meter band”. What frequency of radio waves corresponds to a wavelength of 10 m? (The speed of radio waves is $3.0 \times 10^8$ m/s.)
112. A radio station broadcasts at a frequency of 600 kHz. Knowing that radio waves have a speed of $3.00 \times 10^8$ m/s, what is the wavelength of these waves?
113. A supersonic aircraft produces a shock wave that describes a 30° cone. What happens to the angle of the cone as the aircraft travels faster?

114. If you wished to produce a sound with a wavelength in air equal to the length of a 5-m room, what would its frequency be?

115. You note a 2.0-second delay for an echo in a canyon. What is the distance to the wall of the canyon?

116. How many times more intense is a 110-dB sound than a 70-dB sound?

117. Ten violins produce a sound intensity level of 50 dB in a concert hall. How many violins are needed in the hall to produce a level of 60 dB?

118. What beat frequency is produced by two tuning forks that vibrate simultaneously with frequencies 300 Hz and 311 Hz?

119. Two notes are sounding, one of which is 369 Hz. If a beat frequency of 4 Hz is heard, what is the other note's frequency?
MULTIPLE CHOICE

1. ANS: B  DIF: 2  REF: p. 374  OBJ: 25.2
   STO: Ph.4.f
2. ANS: D  DIF: 1  REF: p. 372  OBJ: 25.1
   STO: Ph.4.f
3. ANS: E  DIF: 1  REF: p. 374  OBJ: 25.2
   STO: Ph.4.f
4. ANS: E  DIF: 1  REF: p. 374  OBJ: 25.2
   STO: Ph.4.f
5. ANS: E  DIF: 1  REF: p. 378  OBJ: 25.5
   STO: Ph.4.b
6. ANS: C  DIF: 2  REF: p. 378, p. 379
   OBJ: 25.6
   STO: Ph.4.b
7. ANS: A  DIF: 1  REF: p. 379  OBJ: 25.6
   STO: Ph.4.b
8. ANS: E  DIF: 2  REF: p. 378, p. 379
   OBJ: 25.6
   STO: Ph.4.b
   STO: Ph.4.f
10. ANS: A  DIF: 1  REF: p. 380  OBJ: 25.8
    STO: Ph.4.f
11. ANS: D  DIF: 2  REF: p. 382  OBJ: 25.8
    STO: Ph.4.f
12. ANS: B  DIF: 2  REF: p. 382  OBJ: 25.9
    STO: Ph.4.f
13. ANS: C  DIF: 2  REF: p. 383  OBJ: 25.9
    STO: Ph.4.f
14. ANS: C  DIF: 1  REF: p. 383  OBJ: 25.9
    STO: Ph.4.f
15. ANS: C  DIF: 3  REF: p. 383  OBJ: 25.9
    STO: Ph.4.f
16. ANS: E  DIF: 3  REF: p. 375, p. 376
    OBJ: 25.3
    STO: Ph.4.a
17. ANS: C  DIF: 2  REF: p. 374  OBJ: 25.2
    STO: Ph.4.f
18. ANS: C  DIF: 3  REF: p. 372, p. 373
    OBJ: 25.1
    STO: Ph.4.f
19. ANS: A  DIF: 3  REF: p. 375  OBJ: 25.2
    STO: Ph.4.f
20. ANS: C  DIF: 2  REF: p. 376  OBJ: 25.3
    STO: Ph.4.a
21. ANS: B  DIF: 3  REF: p. 374  OBJ: 25.2
    STO: Ph.4.f
22. ANS: C  DIF: 3  REF: p. 372, p. 373
| OBJ: 25.1 | STO: Ph.4.f | ANS: C | DIF: 3 | REF: p. 372 | OBJ: 25.1 |
| OBJ: 25.1 | STO: Ph.4.f | ANS: A | DIF: 3 | REF: p. 372, p. 373 |
| OBJ: 25.1 | STO: Ph.4.f | ANS: D | DIF: 2 | REF: p. 385 | OBJ: 25.11 |
| OBJ: 25.1 | STO: Ph.4.f | ANS: A | DIF: 2 | REF: p. 386 | OBJ: 25.11 |
| OBJ: 25.1 | STO: Ph.4.f | ANS: B | DIF: 1 | REF: p. 385 | OBJ: 25.11 |
| OBJ: 25.1 | STO: Ph.4.f | ANS: B | DIF: 1 | REF: p. 384 | OBJ: 25.1 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: C | DIF: 2 | REF: p. 382, p. 383 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: A | DIF: 2 | REF: p. 376 | OBJ: 25.4 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: A | DIF: 3 | REF: p. 375 | OBJ: 25.2 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: D | DIF: 2 | REF: p. 379 | OBJ: 25.7 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: A | DIF: 2 | REF: p. 375 | OBJ: 25.2 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: B | DIF: 2 | REF: p. 377 | OBJ: 25.4 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: A | DIF: 2 | REF: p. 374 | OBJ: 25.2 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: B | DIF: 2 | REF: p. 375 | OBJ: 25.2 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: A | DIF: 2 | REF: p. 374 | OBJ: 25.2 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: C | DIF: 2 | REF: p. 374 | OBJ: 25.2 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: C | DIF: 3 | REF: p. 377 | OBJ: 25.4 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: D | DIF: 2 | REF: p. 377 | OBJ: 25.4 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: D | DIF: 3 | REF: p. 377 | OBJ: 25.4 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: B | DIF: 3 | REF: p. 377 | OBJ: 25.4 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: A | DIF: 2 | REF: p. 377 | OBJ: 25.4 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: C | DIF: 2 | REF: p. 393 | OBJ: 26.4 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: B | DIF: 1 | REF: p. 390, p. 391 |
| OBJ: 25.9 | STO: Ph.4.f | ANS: D | DIF: 2 | REF: p. 391, p. 392 |
STO: Ph.4.d

71. ANS: D
    OBJ: 26.10
    STO: Ph.4.f
    DIF: 3
    REF: p. 398, p. 399

72. ANS: B
    OBJ: 26.10
    STO: Ph.4.f
    DIF: 3
    REF: p. 398, p. 399

73. ANS: A
    STO: Ph.4.d
    DIF: 2
    REF: p. 393
    OBJ: 26.4

74. ANS: C
    STO: Ph.4.d
    DIF: 3
    REF: p. 393
    OBJ: 26.4

TRUE/FALSE

75. ANS: F
    STO: Ph.4.f
    DIF: 1
    REF: p. 372
    OBJ: 25.1

76. ANS: T
    STO: Ph.4.f
    DIF: 1
    REF: p. 374
    OBJ: 25.2

77. ANS: F
    STO: Ph.4.f
    DIF: 1
    REF: p. 374
    OBJ: 25.2

78. ANS: F
    STO: Ph.4.f
    DIF: 1
    REF: p. 374
    OBJ: 25.2

79. ANS: F
    STO: Ph.4.b
    DIF: 1
    REF: p. 378
    OBJ: 25.5

80. ANS: T
    STO: Ph.4.b
    DIF: 2
    REF: p. 379
    OBJ: 25.6

81. ANS: F
    STO: Ph.4.f
    DIF: 1
    REF: p. 372
    OBJ: 25.1

82. ANS: F
    STO: Ph.4.f
    DIF: 1
    REF: p. 379
    OBJ: 25.7

83. ANS: T
    STO: Ph.4.f
    DIF: 2
    REF: p. 380
    OBJ: 25.8

84. ANS: T
    STO: Ph.4.f
    DIF: 2
    REF: p. 383
    OBJ: 25.9

85. ANS: F
    STO: Ph.4.f
    DIF: 2
    REF: p. 386
    OBJ: 25.11

86. ANS: T
    OBJ: 25.8
    STO: Ph.4.f
    DIF: 2
    REF: p. 380, p. 381

87. ANS: F
    STO: Ph.4.f
    DIF: 3
    REF: p. 383
    OBJ: 25.9

88. ANS: T
    STO: Ph.4.f
    DIF: 2
    REF: p. 383
    OBJ: 25.9

89. ANS: F
    STO: Ph.4.a, Ph.4.d
    DIF: 1
    REF: p. 392
    OBJ: 26.2

90. ANS: T
    OBJ: 26.8
    STO: Ph.4.f
    DIF: 1
    REF: p. 395, p. 396

91. ANS: F
    STO: Ph.4.d
    DIF: 1
    REF: p. 392
    OBJ: 26.3

92. ANS: F
    OBJ: 26.2
    STO: Ph.4.a, Ph.4.d
    DIF: 2
    REF: p. 391, p. 392
99. **ESSAY**

An oscillation that propagates in space and time is a wave. When the oscillation vibrates at right angles to the direction of wave travel, the wave is a transverse wave. The distance between successive crests or other corresponding of the wave is the wavelength. Wavelength is measured in centimeters, meters, or any unit of distance. The depth of a transverse wave, at right angles to the wavelength, is the amplitude. This is the distance from the equilibrium point to the crest of the wave (or to a trough). Wavelength is measured in any appropriate unit of distance. The time for equal parts of a wave to pass a given point is called its period, usually measured in seconds. How frequently the wave vibrates is called its frequency, usually measured in hertz. One hertz is one vibration per second. The wave speed is the speed at which the wave travels, measured in meters per second or any other appropriate unit of distance. The period and frequency of a wave are reciprocals. For example, a 2-hertz wave has a period of \( \frac{1}{2} \) second a 3-hertz wave has a period of \( \frac{1}{3} \) second and so on. Wave speed is equal to wavelength multiplied by frequency.

\[ \text{Period} = \frac{\text{wavelength}}{\text{speed}} = \frac{17.0 \text{ m}}{340 \frac{\text{m}}{\text{s}}} = 0.050 \text{ s} \]

101. **ANS:**

In a transverse wave, oscillations are perpendicular to the wave velocity. Oscillations in a longitudinal wave are forward and backward in the direction of the wave’s velocity. Waves on a string, waves on the surface of water, and electromagnetic waves are transverse waves; sound waves and waves along the axis of a coil spring are longitudinal waves.

\[ \text{Period} = \frac{\text{wavelength}}{\text{speed}} = \frac{17.0 \text{ m}}{340 \frac{\text{m}}{\text{s}}} = 0.050 \text{ s} \]

\[ \text{Period} = \frac{17.0 \text{ m}}{340 \frac{\text{m}}{\text{s}}} = 0.050 \text{ s} \]

DIF: 3  
REF: p. 376, p. 377  
OBJ: 25.4

102. **ANS:**
An interference pattern is the result of two or more waves being in the same place at the same time. The amplitude of the resulting wave is the vector sum of the individual amplitudes. When two waves are completely in phase with each other, constructive interference occurs. When the waves are completely out of phase with each other, destructive interference occurs. In general, most interference will be somewhere between constructive and destructive.

DIF: 3       REF: p. 379, p. 380       OBJ: 25.7
STO: Ph.4.f

103. ANS:
A standing wave occurs when a wave is reflected back on itself in such a way that the reflected wave is always out of phase with the incident wave at fixed places called nodes. Nodes are parts of the wave pattern that do not move. At other places, called antinodes, the waves are always in phase with each other. These are places that vibrate at full amplitude.

DIF: 3       REF: p. 380, p. 381, p. 382       OBJ: 25.8
STO: Ph.4.f

104. ANS:
The Doppler effect is an increase or decrease in frequency due to relative motion of the source of a wave with respect to the receiver. If a wave source approaches a receiver, its frequency increases. If the source is going away from a receiver, its frequency decreases. If a star looks blue to us, the star is coming toward us. The reason for this is that the frequency of light from the star has increased.

DIF: 3       REF: p. 382, p. 383, p. 384       OBJ: 25.9
STO: Ph.4.f

105. ANS:
A sonic boom is a shock wave produced when an object moves faster than the speed of sound in the medium. For example, when an airplane flies faster than the speed of sound in air, a shock wave is produced that makes an audible "boom."

DIF: 3       REF: p. 385, p. 386       OBJ: 25.11
STO: Ph.4.f

106. ANS:
Sound is a longitudinal wave created by compressions and rarefactions in the air or other medium. A vibrating source produces a crowding of air molecules, a compression that emanates outward and crowds other air molecules together. This moving region of compressed air is followed by a low-density region, a rarefaction, which in turn is followed by a compression, and so on.

STO: Ph.4.a, Ph.4.d

107. ANS:
Resonance is an unusually large increase in amplitude when a system is driven at its natural frequency by an outside force. A good example of resonance is someone pushing another person on a swing. The pushing person pushes with small pushes in rhythm with the natural swing motion. Soon the swing is very high in the air but with little effort on the part of the pushing person. Another example is the sounding of a tuning fork by the vibrations of another fork of matched frequency. An unfortunate example is the destruction of a bridge when small pushes are applied in rhythm with the natural frequency of the bridge.

DIF: 3       REF: p. 395, p. 396       OBJ: 26.8
STO: Ph.4.f

108. ANS:
Beats occur when two waves with almost the same frequency interfere. Beats have a frequency of their own equal to the difference between the two wave frequencies. Sounding two tuning forks slightly out of tune with each other produces beats. Beats are produced by a pair of whining diesel engines running side by side.

**PROBLEM**

109. **ANS:**
3.0 m/s

DIF: 2  REF:  p. 377  OBJ:  25.4  STO:  Ph.4.c, Ph.4.d

110. **ANS:**
every 4 s

DIF: 3  REF:  p. 377  OBJ:  25.4  STO:  Ph.4.c, Ph.4.d

111. **ANS:**
3.0 \( \times 10^7 \) Hz

DIF: 2  REF:  p. 376  OBJ:  25.4  STO:  Ph.4.c, Ph.4.d

112. **ANS:**
500 m

DIF: 3  REF:  p. 377  OBJ:  25.4  STO:  Ph.4.c, Ph.4.d

113. **ANS:**
the angle decreases

DIF: 2  REF:  p. 385  OBJ:  25.1  STO:  Ph.4.f

114. **ANS:**
68 Hz

DIF: 3  REF:  p. 393  OBJ:  26.4  STO:  Ph.4.d

115. **ANS:**
340 m

DIF: 3  REF:  p. 393  OBJ:  26.4  STO:  Ph.4.d

116. **ANS:**
10,000

DIF: 3  REF:  p. 393, p. 394  OBJ:  26.5  STO:  Ph.4.c, Ph.4.d

117. **ANS:**
100

DIF: 3  REF:  p. 394  OBJ:  26.5  STO:  Ph.4.c, Ph.4.d

118. **ANS:**
11 Hz
DIF: 2  REF: p. 394  OBJ: 26.5  STO: Ph.4.c, Ph.4.d

119. ANS:
373 Hz or 365 Hz

DIF: 2  REF: p. 399  OBJ: 26.10  STO: Ph.4.f