

1. The siren in an ambulance moving away from an observer at 30 m/s is emitting sound at a frequency of 800 Hz. What is the approximate frequency heard by the observer, in hertz?
  - A) 1098
  - B) 735
  - C) 783
  - D) 814
  - E) None of these
  
2. The sound intensity at the ear of a listener is  $10.5 \times 10^{-10}$  watts per square meter. What is the approximate decibel level, in dB?
  - A) 26
  - B) 21
  - C) 30
  - D) 45
  - E) None of these
  
3. What is the maximum power (in watts) a point sound source could have if the decibel level 10 meters away is to be no greater than 105 dB?
  - A) 124
  - B) 18
  - C) 40
  - D) 225
  - E) None of these
  
4. What is the wavelength of a wave with a speed of 12 m/s and a period of 0.25 s?
  - A) 0.25 m
  - B) 1.5 m
  - C) 3.0 m
  - D) 24 m
  - E) 48 m

5. A transverse periodic wave is established on a string. It is described by the expression

$$y = 0.005 \sin(20.0x - 2\pi ft)$$

where  $y$  is in meters when  $x$  and  $t$  are in meters and seconds, respectively. If the wave travels with a speed of 20.0 m/s, what is its frequency,  $f$ ?

- A) 0.16 Hz
  - B) 0.64 Hz
  - C) 31.9 Hz
  - D) 63.7 Hz
  - E) 400 Hz
6. A 4.00-m long string, clamped at both ends, vibrates at  $2.00 \times 10^2$  Hz. If the string resonates in six segments, what is the speed of transverse waves on the string?
- A) 100 m/s
  - B) 133 m/s
  - C) 267 m/s
  - D) 328 m/s
  - E) 400 m/s

Use the following to answer question 7:

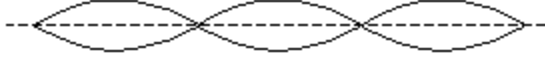
Vibrations with frequency  $6.00 \times 10^2$  Hz are established on a 1.33-m length of string that is clamped at both ends. The speed of waves on the string is  $4.00 \times 10^2$  m/s.

7. How many antinodes are contained in the resulting standing wave pattern?
- A) 2
  - B) 3
  - C) 4
  - D) 5
  - E) 6
8. Determine the shortest length (in cm) of pipe, open at one end, closed at the other end, which will resonate at 256 Hz. The speed of sound is 343 m/s.
- A) 33.5
  - B) 44.6
  - C) 18.9
  - D) 112.0
  - E) None of these

9. For a diffraction horn loudspeaker, the sound emerges through a rectangular opening. The width of a diffraction horn is 0.12 m. If the speed of sound in air is 343 m/s, at what approximate frequency (in hertz) is the diffraction angle  $\theta$  equal to  $35^\circ$ ?
- 3300 Hz
  - 4900 Hz
  - 6300 Hz
  - 7700 Hz
  - 9200 Hz
10. A guitar string produces 6 beats/s when sounded with a 280 Hz tuning fork and 16 beats per second when sounded with a 270 Hz tuning fork. What is the vibrational frequency (in hertz) of the string?
- 240 Hz
  - 246 Hz
  - 254 Hz
  - 286 Hz
  - None of these
11. The intensity of a spherical wave 4.0 m from the source is  $120 \text{ W/m}^2$ . What is the intensity at a point 9.0 m away from the source?
- $11 \text{ W/m}^2$
  - $24 \text{ W/m}^2$
  - $53 \text{ W/m}^2$
  - $80 \text{ W/m}^2$
  - $270 \text{ W/m}^2$
12. A certain string on a piano is tuned to produce a frequency of 261.63 hertz by adjusting the tension in the string. What is the frequency (in hertz) when this tension is halved?
- 130.08
  - 185.00
  - 370.00
  - 446.63
  - None of these
13. A wave is traveling at 5.5 m/s on a string with a linear density of 0.082 kg/m. What is the tension in the string?
- 0.20 N
  - 0.45 N
  - 2.5 N
  - 4.4 N
  - 6.3 N

Use the following to answer question 14:

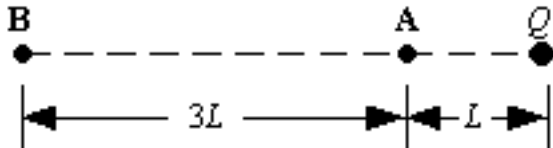
A 3.00-m long string sustains a three-loop standing wave pattern as shown. The wave speed is  $1.00 \times 10^2$  m/s.



14. What is the frequency of vibration?

- A) 25.0 Hz
- B) 33.0 Hz
- C) 50.0 Hz
- D) 75.0 Hz
- E)  $1.00 \times 10^2$  Hz

15. In the figure, point **A** is a distance  $L$  away from a point charge  $Q$ . Point **B** is a distance  $4L$  away from  $Q$ . What is the ratio of the electric field at **B** to that at **A**,  $E_B/E_A$ ?



- A) 1/16
- B) 1/9
- C) 1/4
- D) 1/3
- E) This cannot be determined since neither the value of  $Q$  nor the length  $L$  is specified.

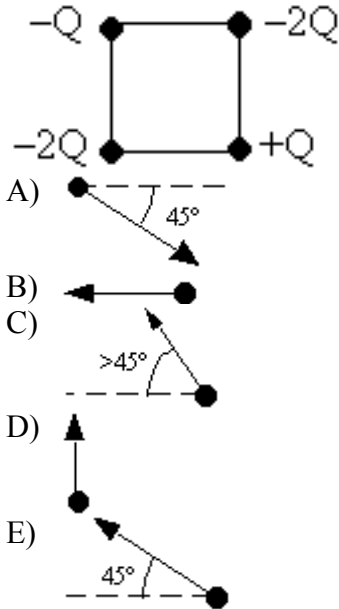
16. The magnitude of the electric field at a distance of 10 meters from a negative point charge is  $E$ . What is the magnitude of the electric field at the same location if the magnitude of the charge is doubled?

- A)  $E/4$
- B)  $E/2$
- C)  $E$
- D)  $2E$
- E)  $4E$

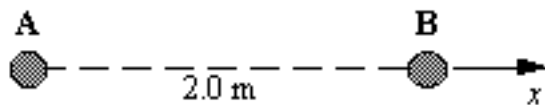
17. One mole of a substance contains  $6.02 \times 10^{23}$  protons and an equal number of electrons. If the protons could somehow be separated from the electrons and placed in very small, individual containers separated by  $1.00 \times 10^3$  m, what would be the magnitude of the electrostatic force exerted by one box on the other?

- A)  $8.7 \times 10^8$  N
- B)  $9.5 \times 10^9$  N
- C)  $2.2 \times 10^{10}$  N
- D)  $8.3 \times 10^{13}$  N
- E)  $1.6 \times 10^{19}$  N

18. Four point charges are held fixed at the corners of a square as shown in the figure. Which of the five arrows shown below most accurately shows the direction of the net force on the charge  $-Q$  due to the presence of the three other charges?



19. Two loudspeakers, **A** and **B**, are separated by a distance of 2.0 m. The speakers emit sound waves at a frequency of 680 Hz that are exactly out of phase. The speed of sound is 343 m/s. How far from speaker **A** along the  $+x$  axis will a point of constructive interference occur?



- A) 0.25 m
- B) 0.30 m
- C) 0.46 m
- D) 0.88 m
- E) 0.98 m

Use the following to answer question 20:

Two loudspeakers are located 3 m apart on the stage of an auditorium. A listener at point **P** is seated 29.0 m from one speaker and 25.0 m from the other. A signal generator drives the speakers in phase with the same amplitude and frequency. The wave amplitude at **P** due to each speaker alone is  $A$ . The frequency is then varied between 20 Hz and 300 Hz. The speed of sound is 343 m/s.

20. What is lowest frequency in this range at which the listener will hear minimum intensity?
- A) 170
  - B) 113
  - C) 86
  - D) 57
  - E) None of these

## Answer Key

1. B
2. C
3. C
4. C
5. D
6. C
7. C
8. A
9. B
10. D
11. B
12. B
13. C
14. C
15. A
16. D
17. D
18. E
19. D
20. C