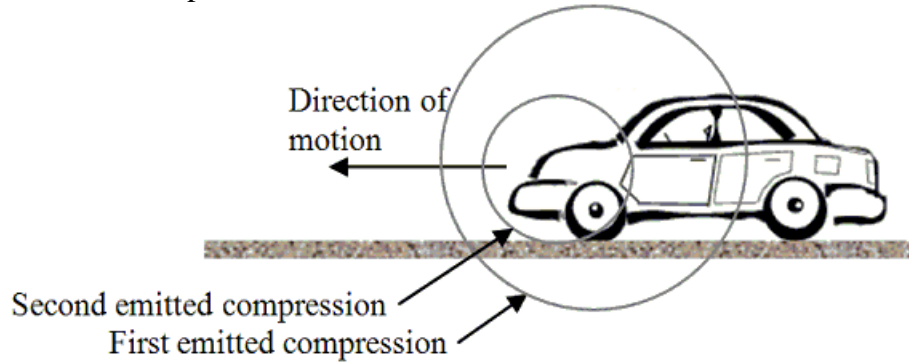


Use the following to answer question 1:

The car in the drawing is moving to the left at 35 m/s. The car's horn continuously emits a 220 Hz sound. The figure also shows the first two regions of compression of the emitted sound waves. The speed of sound is 343 m/s.

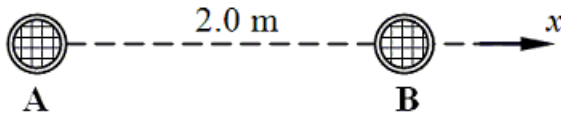


1. What is the approximate frequency heard by a stationary observer standing behind the car?
 - A) 10 Hz
 - B) 176 Hz
 - C) 200 Hz
 - D) 245 Hz
 - E) None of these

2. At a distance of 5.0 m from a point sound source, the sound intensity level is 110 dB. At approximately what distance is the intensity level 92 dB?
 - A) 5 m
 - B) 12 m
 - C) 28 m
 - D) 40 m
 - E) None of these

3. The decibel level of a machine is 135 dB relative to the threshold of hearing. Determine the sound intensity produced by the machine.
 - A) 1.0 W/m^2
 - B) 3.2 W/m^2
 - C) 4.8 W/m^2
 - D) 31.7 W/m^2
 - E) None of these

4. The speed of sound in a metal rod is 2900 m/s. The density of the metal is 3000 kg/m³. What is the Young's modulus of this metal, in N/m²?
- A) 2.5×10^{10}
 B) 2.1×10^9
 C) 5.1×10^{11}
 D) 6.3×10^9
 E) None of these
5. A wave has a frequency of 158 Hz and a speed of 231 m/s. What is distance (in meters) between a maximum ("peak") and a minimum ("valley") ?
- A) 1.98 m
 B) 1.46 m
 C) 0.29 m
 D) 0.73 m
 E) None of these
6. Two loudspeakers, A and B, are separated by a distance of 2.0 m. The speakers emit sound waves at the same frequency, exactly in phase. The speed of sound is 343 m/s. What is the lowest frequency (in Hz) of the speakers for which no sound would be heard at any point on the +x-axis to the right of Speaker B?

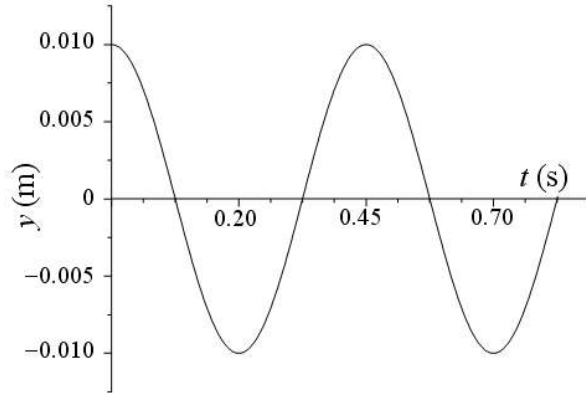
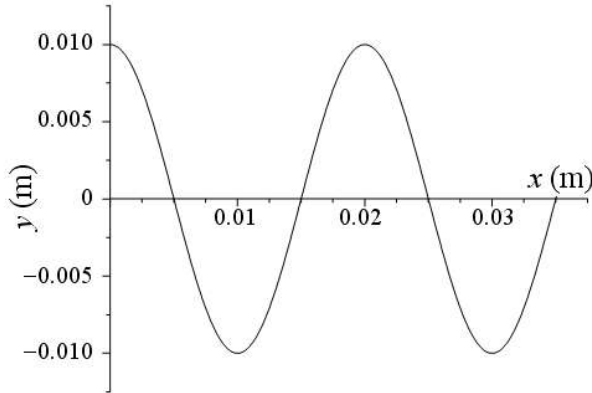


- A) 85.75
 B) 415.6
 C) 85.75
 D) 171.5
 E) None of these
7. What is the distance (in m) between consecutive anti-nodes on a 0.28 m guitar string vibrating in its fourth-lowest frequency?
- A) 0.07
 B) 0.21
 C) 0.18
 D) 0.14
 E) None of these

8. Four standing wave segments, or loops, are observed on a string fixed at both ends as it vibrates at a resonance frequency of 240 Hz. What is the next-highest resonance frequency (in Hz) that is possible for this string?
- A) 300 Hz
 - B) 280 Hz
 - C) 480 Hz
 - D) 360 Hz
 - E) None of these
9. Determine the shortest length of organ pipe, closed at one end, which will resonate at 256 Hz. The speed of sound is 343 m/s.
- A) 0.335 m
 - B) 0.675 m
 - C) 0.995 m
 - D) 1.315 m
 - E) None of these
10. A guitar string produces 4 beats/s when sounded with a 250 Hz tuning fork and 9 beats per second when sounded with a 255 Hz tuning fork. What is the vibrational frequency of the string?
- A) 240 Hz
 - B) 266 Hz
 - C) 254 Hz
 - D) 259 Hz
 - E) None of these

Use the following to answer question 11:

A periodic traveling wave is generated on a string. The figure at the left, below, shows the displacements of the particles in the string as a function of the position x along the string at $t = 0$ s. The figure below, on the right, shows the displacement of the particle at $x = 0$ m as a function of time. The particle positions are measured from the left end of the string ($x = 0$ m) and the wave pulses move to the right.



11. Determine the speed of the wave.

- A) 0.018 m/s
- B) 0.024 m/s
- C) 0.037 m/s
- D) 0.044 m/s
- E) None of these

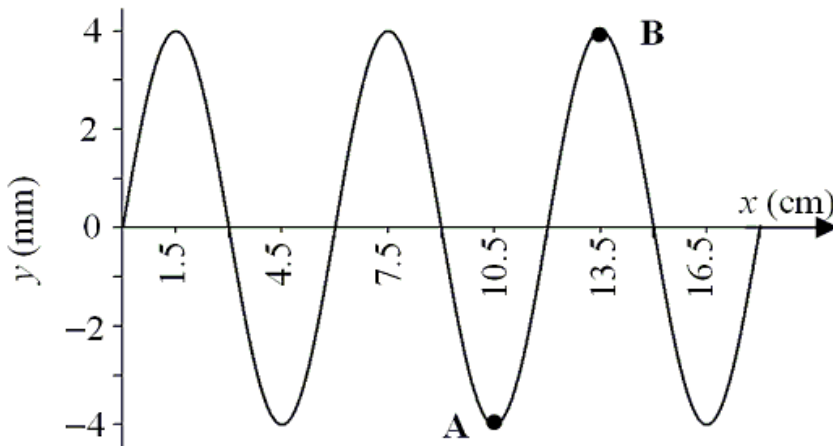
12. Some of the lowest pitches attainable on a musical instrument are achieved on the world's largest pipe organs. What is the length of an organ pipe that is open on both ends and has a fundamental frequency (lowest frequency) of 8.75 Hz when the speed of sound in air is 341 m/s?

- A) 9.8 m
- B) 19.5 m
- C) 21.2 m
- D) 29.3 m
- E) None of these

13. A string with a linear density of 0.035 kg/m and a mass of 0.014 kg is clamped at both ends. Under approximately what tension will it have a fundamental frequency (lowest frequency) of 170 Hz ? Hint: you will need to find the string's length.
- A) 270 N
 - B) 650 N
 - C) 450 N
 - D) 580 N
 - E) None of these

Use the following to answer question 14:

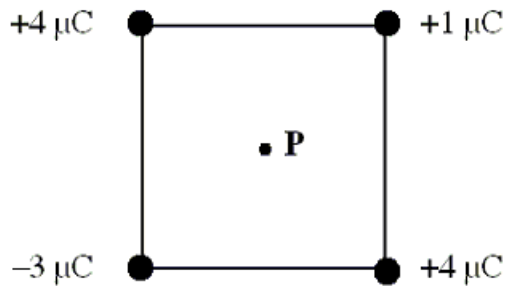
The displacement of a vibrating string versus position along the string is shown in the figure. The periodic waves have a speed of 10.0 cm/s .



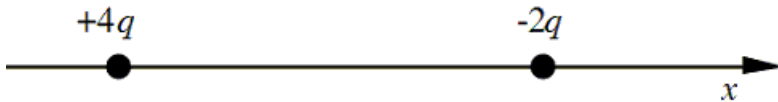
14. What is the approximate frequency of the wave?
- A) 0.6 Hz
 - B) 1.7 Hz
 - C) 1.1 Hz
 - D) 1.3 Hz
 - E) None of these
15. An aluminum nail has an excess charge of $+3.2 \mu\text{C}$. How many electrons must be added to the nail to make it electrically neutral? (Note: the charge of an electron is $-1.6 \times 10^{-19} \text{ C}$.)
- A) 2.0×10^7
 - B) 2.0×10^{19}
 - C) 3.2×10^{16}
 - D) 3.2×10^6
 - E) None of these

16. What is the magnitude and direction of the electric force on a -3.0 C charge at a point where the electric field is 2700 N/C and is directed along the $+y$ axis.
- A) 900 N , $-y$ direction
 - B) 900 N , $+y$ direction
 - C) 8100 N , $-y$ direction
 - D) 8100 N , $+y$ direction
 - E) None of these

17. Four point charges are placed at the corners of a square as shown in the figure. Each side of the square has length 1.41 m . Determine the magnitude of the electric field at the point **P**, the center of the square. ($k = 9 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$)



- A) $2.0 \times 10^{-6} \text{ N/C}$
 - B) $3.6 \times 10^4 \text{ N/C}$
 - C) $9.0 \times 10^3 \text{ N/C}$
 - D) $1.8 \times 10^4 \text{ N/C}$
 - E) None of these
18. The two charges in the figure below have electric charges equal to $4q$, and $-2q$, where q is some arbitrary amount of charge; the charges are 1.0 m apart. How far (in m) from the charge on the right is the electric field zero? Hint: the solution of a quadratic equation will be required.



- A) 1.23
- B) 1.45
- C) 2.41
- D) 3.03
- E) None of these

19. Which one of the following statements is true concerning the *spacing* of the electric field lines in the vicinity of two point charges of equal magnitude and opposite sign?
- A) The spacing indicates the direction of the electric field.
 - B) The spacing does not depend on the magnitude of the charges.
 - C) The spacing is large when the magnitude of the charges is large.
 - D) The spacing indicates the relative magnitude of the electric field.
 - E) The spacing is small when the magnitude of the charges is small.
20. At what separation will two charges, each of magnitude $6.0 \mu\text{C}$, exert a force of 0.70 N on each other?
- A) $1.1 \times 10^{-5} \text{ m}$
 - B) 0.23 m
 - C) 0.48 m
 - D) 0.68 m
 - E) None of these

Answer Key

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