

1. Two timpani (tunable drums) are played at the same time. One is correctly tuned so that when it is struck, sound is produced that has a wavelength of 2.20 m. The second produces sound with a wavelength of 2.10 m. If the speed of sound is 343 m/s, what beat frequency is heard?
  - A) 7 beats/s
  - B) 9 beats/s
  - C) 11 beats/s
  - D) 13 beats/s
  - E) 15 beats/s
  
2. A rope of length  $L$  is clamped at both ends. Which one of the following is not a possible wavelength for standing waves on this rope?
  - A)  $L/2$
  - B)  $2L/3$
  - C)  $L$
  - D)  $2L$
  - E)  $4L$
  
3. A string with a linear density of 0.035 kg/m and a mass of 0.014 kg is clamped at both ends. Under what tension in the string will it have a fundamental frequency of 110 Hz?
  - A) 270 N
  - B) 310 N
  - C) 450 N
  - D) 580 N
  - E) 690 N

Use the following to answer question 4:

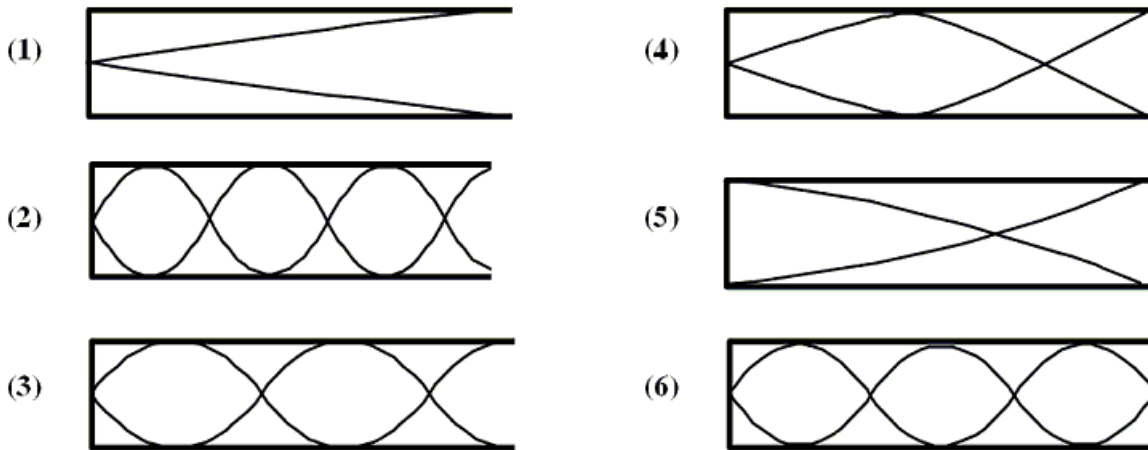
Vibrations with frequency  $6.00 \times 10^2$  Hz are established on a 1.33-m length of string that is clamped at both ends. The speed of waves on the string is  $4.00 \times 10^2$  m/s.

4. How many antinodes are observed for the resulting standing wave pattern?
  - A) 2
  - B) 3
  - C) 4
  - D) 5
  - E) 6

5. When a tuba is played, the player makes a buzzing sound and blows into one end of a tube that has an effective length of 3.50 m. The other end of the tube is open. If the speed of sound in air is 343 m/s, what is the lowest frequency the tuba can produce?
- A) 8.00 Hz
  - B) 12.0 Hz
  - C) 16.0 Hz
  - D) 24.0 Hz
  - E) 49.0 Hz

Use the following to answer question 6:

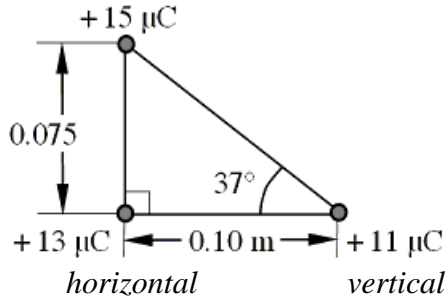
The figures show standing waves of sound in six organ pipes of the same length. Each pipe has one end open and the other end closed. *Note: some of the figures show situations that are not possible.*



6. If the length of the pipes is 0.500 m, what is the frequency of the sound emitted from pipe 3? The speed of sound is 343 m/s.
- A) 172 Hz
  - B) 344 Hz
  - C) 429 Hz
  - D) 515 Hz
  - E) 858 Hz

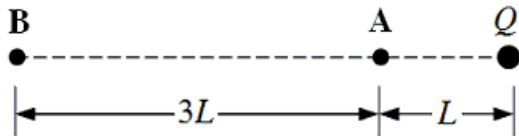
7. Two positive point charges  $Q$  and  $2Q$  are separated by a distance  $R$ . If the charge  $Q$  experiences a force of magnitude  $F$  when the separation is  $R$ , what is the magnitude of the force on the charge  $2Q$  when the separation is  $2R$  ?
- A)  $F/4$
  - B)  $F/2$
  - C)  $F$
  - D)  $2F$
  - E)  $4F$
8. A charge  $Q$  exerts a 1.2 N force on another charge  $q$ . If the distance between the charges is doubled, what is the magnitude of the force exerted on  $Q$  by  $q$ ?
- A) 0.30 N
  - B) 0.60 N
  - C) 2.4 N
  - D) 3.6 N
  - E) 4.8 N
9. 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) 1.4 m

10. Three charges are positioned as indicated in the figure. What are the horizontal and vertical components of the net force exerted on the  $+15 \mu\text{C}$  charge by the  $+11 \mu\text{C}$  and  $+13 \mu\text{C}$  charges?



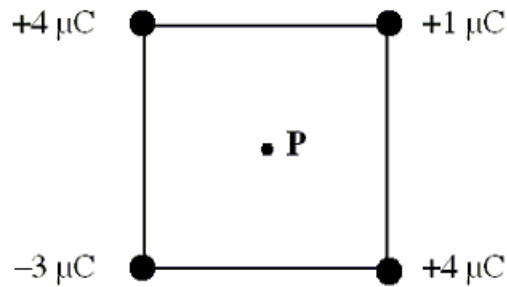
- A) 95 N 310 N  
 B) 76 N 310 N  
 C) 250 N 130 N  
 D) 95 N 130 N  
 E) 76 N 370 N

11. 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**,  $E_B/E_A$ ?



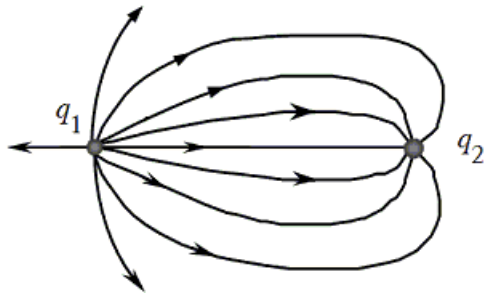
- A)  $1/16$   
 B)  $1/9$   
 C)  $1/4$   
 D)  $1/3$   
 E) This cannot be determined since neither the value of  $Q$  nor the length  $L$  is specified.

12. Four point charges are placed at the corners of a square as shown in the figure. Each side of the square has length 2.0 m. Determine the magnitude of the electric field at the point **P**, the center of the square.



- A)  $2.0 \times 10^{-6} \text{ N/C}$   
 B)  $3.0 \times 10^{-6} \text{ N/C}$   
 C)  $9.0 \times 10^3 \text{ N/C}$   
 D)  $1.8 \times 10^4 \text{ N/C}$   
 E)  $2.7 \times 10^4 \text{ N/C}$

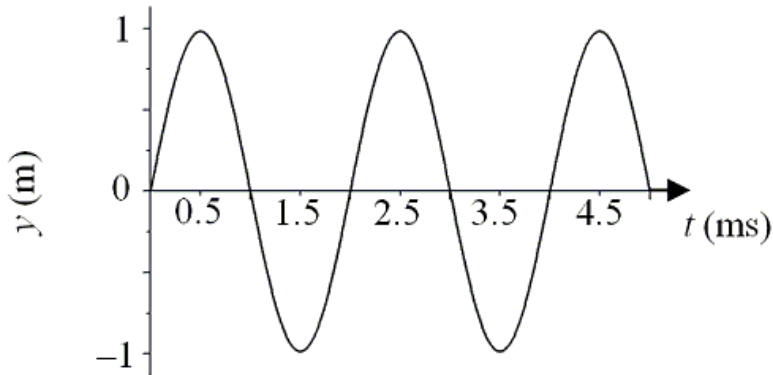
13. The figure shows the electric field lines in the vicinity of two point charges. Which one of the following statements concerning this situation is true?



- A)  $q_1$  is negative and  $q_2$  is positive.  
 B) The magnitude of the ratio ( $q_2/q_1$ ) is less than one.  
 C) Both  $q_1$  and  $q_2$  have the same sign of charge.  
 D) The magnitude of the electric field is the same everywhere.  
 E) The electric field is strongest midway between the charges.

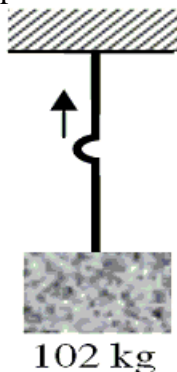
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14. The speed of sound in a certain metal block is  $2.00 \times 10^3$  m/s. The graph shows the amplitude (in meters) of a wave traveling through the block versus time (in milliseconds). What is the wavelength of this wave?



- A) 0.5 m  
 B) 1.5 m  
 C) 3.0 m  
 D) 4.0 m  
 E) 6.0 m
15. Two canoes are 10 m apart on a lake. Each bobs up and down with a period of 8.0 seconds. When one canoe is at its highest point, the other canoe is at its lowest point. Both canoes are always within a single cycle of the waves. Determine the speed of the waves.
- A) 2.5 m/s  
 B) 1.3 m/s  
 C) 5.0 m/s  
 D) 0.65 m/s  
 E) 0.75 m/s
16. A certain string on a piano is tuned to produce middle C ( $f = 261.63$  Hz) by carefully adjusting the tension in the string. For a fixed wavelength, what is the frequency when this tension is tripled?
- A) 87.21 Hz  
 B) 151.05 Hz  
 C) 370.00 Hz  
 D) 453.16 Hz  
 E) 784.89 Hz

17. A steel wire of mass 0.400 kg and length 0.640 m supports a 102-kg block. The wire is struck exactly at its midpoint causing a small displacement. How long does it take the peak of this displacement to reach the top of the wire?



- A)  $2.00 \times 10^{-3}$  s  
 B)  $4.00 \times 10^{-3}$  s  
 C)  $6.00 \times 10^{-3}$  s  
 D)  $8.00 \times 10^{-3}$  s  
 E)  $1.60 \times 10^{-2}$  s
18. A wave has an amplitude of 0.35 m, a frequency of  $1.05 \times 10^6$  Hz, and travels in the positive  $x$  direction at the speed of light,  $3.00 \times 10^8$  m/s. Which one of the following equations correctly represents this wave?
- A)  $y = 0.35 \sin (6.60 \times 10^6 t - 0.022x)$   
 B)  $y = 0.35 \sin (6.60 \times 10^6 t + 0.022x)$   
 C)  $y = 0.35 \sin (286t - 1.05 \times 10^6 x)$   
 D)  $y = 0.35 \sin (286t + 1.05 \times 10^6 x)$   
 E)  $y = 0.35 \sin (1.05 \times 10^6 t + 3.00 \times 10^8 x)$
19. Two fans are watching a baseball game from different positions. One fan is located directly behind home plate, 18.3 m from the batter. The other fan is located in the centerfield bleachers, 127 m from the batter. Both fans observe the batter strike the ball at the same time (because the speed of light is about a million times faster than that of sound), but the fan behind home plate hears the sound first. What is the time difference between hearing the sound at the two locations? Use 345 m/s as the speed of sound.
- A) 0.316 s  
 B) 0.368 s  
 C) 3.17 s  
 D) 1.89 s  
 E) 0.053 s

20. A physics student is asked to determine the length of a long, slender, copper bar by measuring the time required for a sound pulse to travel the length of the bar. The Young's modulus of copper is  $1.1 \times 10^{11} \text{ N/m}^2$ ; and its density is  $8890 \text{ kg/m}^3$ . The student finds that the time for the pulse to travel from one end to the other is  $5.6 \times 10^{-4} \text{ s}$ . How long is the rod?
- A) 11 m
  - B) 7.8 m
  - C) 5.5 m
  - D) 2.0 m
  - E) 0.45 m
21. The intensity of a spherical wave 2.5 m from the source is  $120 \text{ W/m}^2$ . What is the intensity at a point 9.0 m away from the source?
- A)  $9.3 \text{ W/m}^2$
  - B)  $24 \text{ W/m}^2$
  - C)  $53 \text{ W/m}^2$
  - D)  $80 \text{ W/m}^2$
  - E)  $270 \text{ W/m}^2$
22. How far must one stand from a 5-mW point sound source if the intensity at that location is at the hearing threshold? Assume the sound waves travel to the listener without being disturbed.
- A) 500 m
  - B) 1 km
  - C) 2 km
  - D) 4 km
  - E) 20 km
23. The decibel level of a jackhammer is 125 dB relative to the threshold of hearing. Determine the sound intensity produced by the jackhammer.
- A)  $1.0 \text{ W/m}^2$
  - B)  $3.2 \text{ W/m}^2$
  - C)  $4.8 \text{ W/m}^2$
  - D)  $12 \text{ W/m}^2$
  - E)  $88 \text{ W/m}^2$

24. At a distance of 5.0 m from a point sound source, the sound intensity level is 110 dB. At what distance is the intensity level 95 dB?
- A) 5.0 m
  - B) 7.1 m
  - C) 14 m
  - D) 28 m
  - E) 42 m
25. A train moving at a constant speed is passing a stationary observer on a platform. On one of the train cars, a flute player is continually playing the note known as concert A ( $f = 440$  Hz). After the flute has passed, the observer hears the sound with a frequency of 415 Hz. What is the speed of the train? The speed of sound in air is 343 m/s.
- A) 7.3 m/s
  - B) 12 m/s
  - C) 21 m/s
  - D) 37 m/s
  - E) 42 m/s

## Answer Key

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