WAVES

Waves

1. Which of the following are examples of longitudinal waves? (Select all that apply)
   - A A wave traveling through a long spring
   - B A wave traveling through water
   - C A sound wave traveling through the air
   - D A wave traveling along a string

2. Which of the following is transported with all types of waves? (Select all that apply)
   - A Physical matter
   - B Energy
   - C Sound
   - D None of the above

3. Which of the following are examples of transverse waves? (Select all that apply)
   - A An ocean wave
   - B A wave traveling along a string
   - C A wave traveling through a long spring
   - D A sound wave traveling through the air

4. Wave A and wave B have the same frequenc, but wave A has three times the wavelength of wave B. How do the speeds of wave A and wave B compare?
   - A $v_A = v_B$
   - B $v_A = v_B/3$
   - C $v_A = 3v_B$
   - D $v_A = 9v_B$

5. A person is sitting on the beach near the ocean. They observe that there is 4 seconds between each wave that crashes on the beach. What is the frequency of the ocean waves traveling towards the beach?
   - A 0.25 Hz
   - B 1 Hz
   - C 2 Hz
   - D 4 Hz

6. Two guitar strings with the same length are tuned so they have the same tension. String A has more mass than string B. A wave will travel faster through which string?
   - A String A
   - B String B
   - C A wave will travel the same speed through each string
   - D Cannot be determined

7. How many crests are in the wave shown in Figure 1?

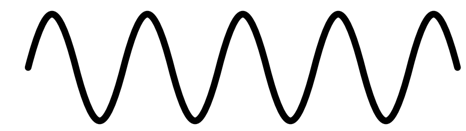


Figure 1

8. How many troughs are in the wave shown in Figure 1?

9. How many wavelengths are in the wave shown in Figure 1?

10. A wave is shown in Figure 2. What is the amplitude of the wave?

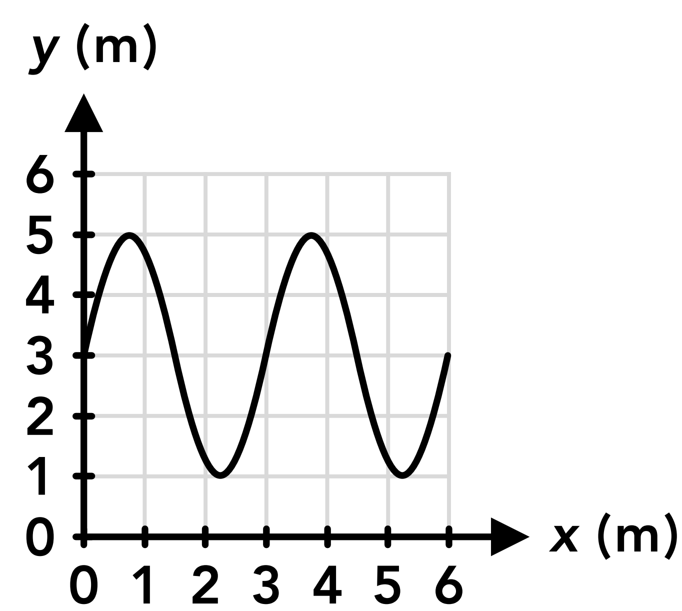


Figure 2

11. A wave is shown in Figure 2. What is the wavelength?

12. If the wave shown in Figure 2 takes 5 seconds to travel the distance of one wavelength, what is the wave speed?

13. A 80 cm long string has a mass of 600 g. If one end of the string is plucked and a wave travels across the string at 10 m/s, what is the tension in the string?

Standing Waves

14. Which of the following results in standing waves?
    - A The superposition of two waves with different wavelengths and different amplitudes
    - B The superposition of two waves with the same wavelength and different amplitudes
    - C The superposition of two waves with different wavelengths and the same amplitude
    - D The superposition of two waves with the same wavelength and the same amplitude

15. At which of the following points in a standing wave does the maximum constructive interference always occur?
    - A Nodes
    - B Antinodes
    - C At the ends of the medium
    - D At the center of the medium

16. At which of the following points in a standing wave does the maximum destructive interference always occur?
    - A Nodes
    - B Antinodes
    - C At the ends of the medium
    - D At the center of the medium

17. A standing wave is produced in a string by oscillating one end up and down while the other end is fixed. The oscillating end is which of the following?
    - A A node
    - B An antinode
    - C Neither a node or an antinode

18. A standing wave is produced in a tube of air with one closed end and one open end. The closed end of the tube is which of the following (for the displacement wave)?
    - A A node
    - B An antinode
    - C Neither a node or an antinode

19. A tube of air is open at both ends. Which of the following number of wavelengths could fit inside the tube? (Select all that apply)
    - A 1/2
    - B 3/4
    - C 1
    - D 1 1/2

20. A string is fixed at both ends and a standing wave is produced in the string. Which of the following number of wavelengths could fit in the length of string? (Select all that apply)
    - A 1/2
    - B 1
    - C 1 1/4
    - D 2

21. A tube of air is closed at one end and open at the other end. Which of the following number of wavelengths could fit inside the tube? (Select all that apply)

A 1/2

B 3/4

C 1

D 1 1/2

22. An instrument is made of a tube which can change length and which is open at both ends. The tube is made to resonate at the first mode (the fundamental frequency). If the length of the tube is extended, what will happen to the frequency of the pitch being produced (still at the first mode)?

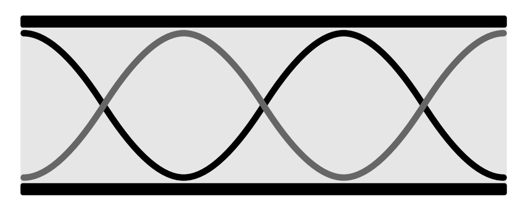
A It will stay the same

B It will increase

C It will decrease

D Cannot be determined

23. A standing wave in a tube is shown on the right. What is the mode of the wave?



A 1

B 2

C 3

D 4

24. A string is fixed at one end and is forced to oscillate at the other end so that a standing wave is produced with a wavelength of 0.8 m. If the mode of vibration is 2, what is the length of the string?

25. An instrument is made from a 60 cm long tube which is closed at one end and open at the other end. What is the frequency of the lowest pitch that can be played on the instrument? Use 343 m/s for the speed of sound in air.

Answers

1. A, C	6. B	11. 3 m	16. A	21. B
2. B	7. 5	12. 0.6 m/s	17. B	22. C
3. A, B	8. 4	13. 75 N	18. A	23. C
4. C	9. 4.5	14. D	19. A, C, D	24. 0.4 m
5. A	10. 2 m	15. B	20. A, C, D	25. 285.8 Hz

Answers - Waves

1. **Answer: A, C**
   In a longitudinal wave the physical material moves back and forth parallel to the direction of the wave. This is the case for a wave traveling through a spring and a sound wave traveling through the air, where the physical material stretches and compresses in the direction of the wave motion. In a water wave and a wave traveling through a string, the material moves up and down, perpendicular to the wave direction.

2. **Answer: B**
   All waves transport energy in some form: kinetic energy, potential energy, electromagnetic energy, etc.

3. **Answer: A, B**
   In a transverse wave the physical material moves perpendicular to the direction of the wave. This is the case for water waves (ocean waves) and waves traveling along a string. A wave traveling through a long spring and a sound wave traveling through the air are longitudinal waves, where the physical material moves back and forth parallel to the direction of the wave.

4. **Answer: C**
   The equation for wave speed is given below. If the frequency is the same and the wavelength is multiplied by 3 then the wave speed must be multiplied by 3.
   $v = \lambda f$

5. **Answer: A**
   4 seconds is the period of the waves. Frequency is the inverse of the period.
   $$f = \frac{1}{T} = \frac{1}{4\text{ s}} = 0.25\text{ Hz}$$

6. **Answer: B**
   The equations for the wave speed in a string and the linear density of a string are given below. The wave speed is inversely proportional to the square root of the linear density, which is directly proportional to the mass of the string. If the lengths and tensions are the same for both strings, a greater mass will result in a slower wave speed.
   $$\mu \quad \frac{m}{L} \qquad v_{\text{string}} = \sqrt{\frac{T_s}{\mu}} = \sqrt{\frac{T_s L}{m}}$$

7. **Answer: 5**
   A crest is the upper amplitude or the top of a wave.

8. **Answer: 4**
   A trough is the lower amplitude of the bottom of a wave.

9. **Answer: 4.5**
   A wavelength is the length of a repeating section of the wave.

10. **Answer: 2 m**
The amplitude of a wave is the distance between the middle of the wave and a crest or trough, or half of the distance between the crests (at 5 m) and the troughs (at 1 m) which is 4 m.

11. **Answer: 3 m**
The wavelength is the length of a repeating section of the wave. That is the distance between two crests, the distance between two troughs, or the distance of three nodes across. There are also 2 wave lengths that fit in the 6 m, so the wavelength is 3 m.

12. **Answer: 0.6 m/s**
The wavelength is 3 m, and the wave speed is the wavelength divided by the period (5 seconds).

$$v = \frac{\Delta x}{t} = \frac{\lambda}{T} = \frac{3\text{ m}}{5\text{ s}} = 0.6\text{ m/s}$$

13. **Answer: 75 N**

$$\mu = \frac{0.6\text{ kg}}{0.8\text{ m}} = 0.75\text{ kg/m}$$

$$v_{\text{string}} = \sqrt{\frac{T_s}{\mu}} \qquad (10\text{ m/s}) = \sqrt{\frac{T_s}{0.75\text{ kg/m}}} \qquad T_s = 75\text{ N}$$

Answers - Standing Waves

14. **Answer: D**
Standing waves form due to the superposition of two waves with the same wavelength and amplitude traveling in opposite directions along the same medium (like a string), which results in constructive and destructive interference at different points.

15. **Answer: B**
The antinodes in a standing wave are the points of maximum constructive interference and maximum amplitude. The open end of a tube of air is also an antinode of a displacement standing wave.

16. **Answer: A**
The nodes in a standing wave are the points of maximum destructive interference and zero amplitude. A fixed end of a string and the closed ends of a tube are the nodes of displacement standing waves.

17. **Answer: B**
The oscillating end of the string is a point of maximum displacement which is an antinode.

18. **Answer: A**
The closed end of a tube is a point of zero displacement for air molecules which is a node.

19. **Answer: A, C, D**
A tube which is open at both ends must always have an antinode at each end (for a displacement wave). The relationship between the length of the tube and the number of possible wavelenths is given below. The minimum number of wavelengths is 1/2, and any multiple of 1/2 wavelengths is possible.

$$\lambda_m = \frac{2L}{m} \quad m = 1, 2, 3, \ldots$$

20. **Answer: A, C, D**
A string which is fixed at both ends must always have a node at each end. The relationship between the length of the tube and the number of possible wavelenths is given below. The minimum number of wavelengths is 1/2, and any multiple of 1/2 wavelengths is possible.

$$\lambda_m = \frac{2L}{m} \quad m = 1, 2, 3, \ldots$$

21. **Answer: B**
A tube which is open at one end and closed at the other end must always have a node at the closed end and an antinode at the open end (for a displacement wave). The relationship between the length of the tube and the number of possible wavelenths is given below. The minimum number of wavelengths is 1/4, and any odd number multiple of 1/4 wavelengths is poissible.

$$\lambda_m = \frac{4L}{m} \quad m = 1, 3, 5, \ldots$$

22. **Answer: C**
The equation for the frequencies of a tube open at both ends is given below. If the length of the tube increases the frequency (at the same mode) will decrease).

$$f_m = \frac{v}{\lambda_m} = m\left(\frac{v}{2L}\right) \quad m = 1, 2, 3, \ldots$$

23. **Answer: C**
The tube is open at both ends and 1 1/2 wavelengths or 3/2 wavelengths are in the tube which corresponds with a mode of 3.

$$\lambda_m = \frac{2L}{m} \quad m = 1, 2, 3, \ldots$$

24. **Answer: 0.4 m**

$$\lambda = \frac{4L}{m} \qquad (0.8\text{ m}) = \frac{4L}{(2)} \qquad L = 0.4\text{ m}$$

25. **Answer: 285.8 Hz**

$$f = m\left(\frac{v}{2L}\right) = (1)\left(\frac{343\text{ m/s}}{2(0.6\text{ m})}\right) = 285.8\text{ Hz}$$