STANDING WAVES

Standing Waves

1. 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

2. 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

3. 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

4. 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

5. 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

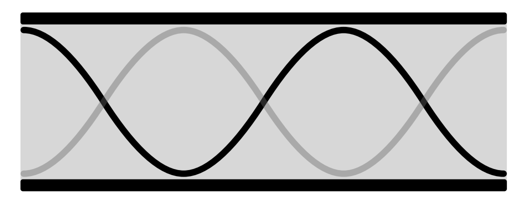
6. A tube of air is open at both ends. Which of the following number of wavelengths could fit inside the tube? (Select all that apply)
   - A 1/2
   - B 3/4
   - C 1
   - D 1 1/2

7. 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

8. 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

9. 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

10. 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

11. 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?

12. 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. D
2. B
3. A
4. B
5. A
6. A, C, D
7. A, C, D
8. B
9. C
10. C
11. 0.4 m
12. 285.8 Hz

Answers - Standing Waves

1. **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.

2. **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.

3. **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.

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

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

6. **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.

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

7. **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.

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

8. **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.

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

9. **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).

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

10. **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.

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

11. **Answer: 0.4 m**

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

12. **Answer: 285.8 Hz**

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