PRACTICE PROBLEMS

SOUND

Sound

1. When you hear sound coming from a speaker across a room, which of the following is true? (Select all that apply)
   - A Air molecules travel from the speaker to your ear
   - B Regions of high and low air pressure travel from the speaker to your ear
   - C Air molecules move back and forth within a small region but they don't travel with the wave
   - D All of the air molecules between the speaker and your ear instantly begin moving

2. You're standing far away from someone. They clap their hands together once and you hear the clap a short time after you see them clap. If the air temperature were warmer, would you hear the clap in less time or more time after you see the clap?
   - A Less time
   - B More time
   - C The same amount of time
   - D Cannot be determined

3. There is a sound source some distance away from you emitting a constant sound, and the sound intensity where you're standing is I_1. If you move twice as far away from the sound source, what sound intensity will you experience in terms of I_1?
   - A $4I_4$
   - B $I_1/2$
   - C $2I_1$
   - D $I_1/4$

4. Which of the following affects the sound intensity level? (Select all that apply)
   - A The power of the sound source
   - B The threshold of human hearing
   - C The speed of sound
   - D The distance from the sound source

5. When a fast car, a siren or another loud vehicle passes by you, you will likely hear a different pitch (frequency) when the sound source is moving towards you compared to when it's moving away from you. Which of the following explains why this happens?
   - A The speed of the sound waves changes
   - B The frequency of the sound source changes
   - C The spacing between the wave fronts changes
   - D The frequency you hear does not actually change

6. Person A is holding a speaker which is emitting a sound with a single frequency. If person A is moving towards person B, will person B hear a higher or lower frequency than the source frequency?
   - A Higher frequency
   - B Lower frequency
   - C They will hear the source frequency
   - D Cannot be determined

7. The alarm of a car near you begins to sound. What happens to the sound of the alarm as you drive away?
   - A You will hear the alarm increase in frequency
   - B You will hear the alarm decrease in frequency
   - C The observed frequency of the alarm will not change
   - D Cannot be determined

8. Which of the following can happen when two sound waves interfere?
   - A The resulting sound wave can have a greater amplitude than either individual wave
   - B The resulting sound wave can have zero amplitude
   - C The resulting sound wave can have a smaller amplitude than either individual wave, but not zero amplitude
   - D The amplitude of the resulting sound wave can oscillate between zero amplitude and a greater amplitude

9. Two sound sources emit identical sound waves which are in phase (both sources emit a maximum amplitude at the same time). If the sources are a distance apart which is equal to 4 wavelengths, what will an observer hear if they are in line with both sound sources?
   - A They hear two different frequencies, which oscillates in amplitude at a beat frequency
   - B They don't hear anything
   - C They hear the same frequency as the sources and the sound is louder than a single source
   - D They hear two different frequencies and the sound is louder than a single source

10. Two sound sources emit identical sound waves which are in phase (both sources emit a maximum amplitude at the same time). If the sources are a distance apart which is equal to 2.5 wavelengths, what will an observer hear if they are in line with both sound sources?
    - A They hear two different frequencies, which oscillates in amplitude at a beat frequency
    - B They don't hear anything
    - C They hear the same frequency as the sources and the sound is louder than a single source
    - D They hear two different frequencies and the sound is louder than a single source

11. An ambulance with a siren that emits a single frequency of 800 Hz is driving towards you at 20 m/s. What is the frequency that you hear? Use 343 m/s for the speed of sound.

12. Two speakers are placed next to each other. One speaker emits a frequency of 450 Hz and the other speaker emits a frequency of 465 Hz. What is the beat frequency observed by someone listening to both speakers?

Answers

1. B, C
2. A
3. D
4. A, B, D
5. C
6. A
7. B
8. A, B, D
9. C
10. B
11. 850 Hz
12. 15 Hz

Answers - Sound

1. **Answer: B, C**
   When a sound wave travels across a room, a region of high and low air pressure is what travels from the speaker to your ear. As the pressure wave passes through the air, air molecules move back and forth within a small region which is what creates the high and low pressure. The air molecules do not travel across the room with the wave. A sound wave travels at the speed of sound, it does not cross the room instantly.

2. **Answer: A**
   The equation for the speed of sound in a gas is given below. The speed is directly proportional to the square root of the temperature. If the temperature increases then the speed of sound will increase and you will hear the clap in less time.

   $$v_{\text{sound}} = \sqrt{\frac{\gamma R T}{M}}$$

3. **Answer: D**
   The equation for sound intensity is given below. Sound intensity is inversely proportional to the square of the distance between the source and the observer. If the distance is multiplied by 2 the sound intensity is divided by 4.

   $$I = \frac{P_{\text{source}}}{4\pi r^2}$$

4. **Answer: A, B, D**
   The equations for sound intensity and sound intensity level are given below. Sound intensity level depends on the threshold of human hearing I_0 and the sound intensity, which depends on the source power and the distance from the sound source.

   $$\beta = (10\text{ dB})\log_{10}\left(\frac{I}{I_0}\right) \qquad I = \frac{P_{\text{source}}}{4\pi r^2}$$

5. **Answer: C**
   This is the doppler effect. The frequency of the sound source does not change. When the sound source is moving towards the observer the wave fronts are closer together and the observed frequency increases, and when the sound source is moving away from the observer the wave fronts are farther apart.

6. **Answer: A**
   When the sound source is moving towards the observer, the observed frequency is higher than the source frequency.

7. **Answer: B**
   When the observer is moving away from the sound source, the observed frequency is lower than the source frequency.

8. **Answer: A, B, D**
   When two sound waves interfere, their amplitudes at every point in space are added together at any given moment in time. If the amplitudes at one point are both positive or both negative, the result is constructive interference and the resulting sound wave has a greater amplitude. If one amplitude is positive and the other is negative, the result is destructive interference and the resulting sound wave has a smaller amplitude. It's possible for the resulting wave to have zero amplitude. If the waves have different frequencies, the resulting wave will oscillate between zero amplitude and a greater amplitude at the beat frequency.

9. **Answer: C**
   The two source sound waves are identical so the observed frequency is the same as the sources. The distance between the sources is a whole number multiple of the wavelength which results in in-line constructive interference, so the observed sound wave is louder (has a higher amplitude).

10. **Answer: B**
    The two source sound waves are identical so the observed frequency would be the same as the sources. The distance between the sources is whole number plus a half multiple of the wavelength which results in in-line destructive interference, so the two sound waves "cancel out" and the observed wave has zero amplitude and the observer does not hear anything.

11. **Answer: 850 Hz**
    The equation for a stationary observer and a source moving towards the observer (doppler effect) is:
    $$f_o = \frac{f_s}{1 - (v_s/v)} = \frac{800\ \text{Hz}}{1 - ((20\ \text{m/s})/(343\ \text{m/s}))} = 850\ \text{Hz}$$

12. **Answer: 15 Hz**
    $f_{beat} = |f_1 - f_2| = |(465\ \text{Hz}) - (450\ \text{Hz})| = 15\ \text{Hz}$