CHAPTER 17

The Speed of Sound

Q1. The volume of a certain solid shrinks by 2 parts in 10^6 when it is subject to an external hydrostatic pressure of 1 atm. The density of the solid is 8.0 g/cm^3. What is the speed of a longitudinal wave through this material? Ans: 2.5×10^3 m/s.

Q2. In a liquid having density 1.30×10^3 kg/m^3, longitudinal waves with frequency of 400 Hz are found to have a wavelength of 8.0 m. Calculate the bulk modulus of the liquid. Ans: 1.33×10^{10} Pa.

Q3. A man strikes a long steel rod at one end. Another man, at the other end with his ear close to the rod, hears the sound of the blow twice (one through air and once through the rod), with a 0.1 seconds interval between. How long is the rod? [For the steel, the bulk modulus = 2.1×10^{11} Pa, and the density = 7.0×10^3 kg/m^3. Speed of sound in air = 340 m/s.] Ans:36 m

Q4. In figure 3, the two observers at A and B are hearing the sound emitted by the point source S. What is the time difference between hearing the sound at the two locations? Use 345 m/s as the speed of sound. Ans:0.315 s

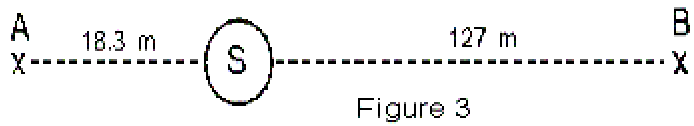


Figure 3

Traveling Sound Waves

Q5. If two sound waves, one in air and the other in water, are of equal intensity. What is the ratio of the pressure amplitude of the wave in water to that of the wave in air? (rho(air)= 1.21 kg/m^3, v(air)= 343 m/s, rho(water)= 1×10^3 kg/m^3, v(water)= 1482 m/s) Ans:59.8

Q6. The maximum pressure amplitude that the human ear can tolerate in loud sounds is 28 Pa. What is the displacement amplitude for such a sound in air of density 1.21 kg/m^3 at a frequency of 5.0×10^3 Hz? [speed of sound in air = 343 m/s]. Ans: 2.15×10^{-6} m.

Q7. A sinusoidal sound wave is described by the displacement

$$S(x,t) = 2\times10^{-8}\cos[1.25x - 1850t],$$

where x is in meters and t is seconds. What is the pressure amplitude of this wave if it is traveling in a material with a bulk modulus of 2.1×10^9 N/m^2? Ans:53 Pa

Interference

Q8. Two identical speakers, facing each other are driven by a common oscillator of frequency 600 Hz. A man, at the midpoint between the speakers, start moving toward one of them. He reaches the first minimum sound when he is 1 m from one of the speakers. Find the distance between the speakers. (Speed of sound = 343 m/s.) Ans:2.3 m

Q9. Two speakers are driven by a common oscillator and face each other at a distance of 1.500 m. A man is standing at 0.700 m from one of the speakers along the line joining the two speakers. What is the highest frequency of the oscillator, within the audible range (20.0 Hz to 20.0 kHz), so that the man hears a minimum sound? (Speed of sound = 343 m/s). Ans:18.9 kHz

Q10. Two sound waves, from two different sources with the same frequency, 660 Hz, travel at a speed of 330 m/s. The sources are in phase. What is the phase difference of the waves at a point that is 5.0 m from one source and 4.0 m from the other? (The waves are traveling in the same direction.) Ans:4π.

Q11. A sound wave of 50.0 cm wavelength enters the tube shown in figure 1 at the source end. What must be the smallest radius(r) (other than zero) such that a maximum sound will be heard at the detector end? Ans:43.8 cm.

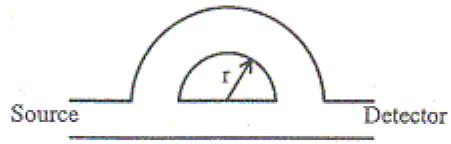
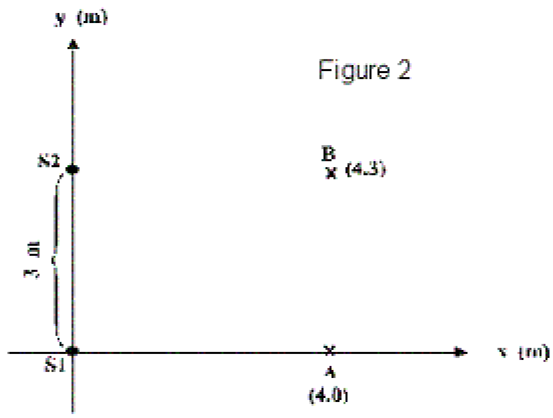
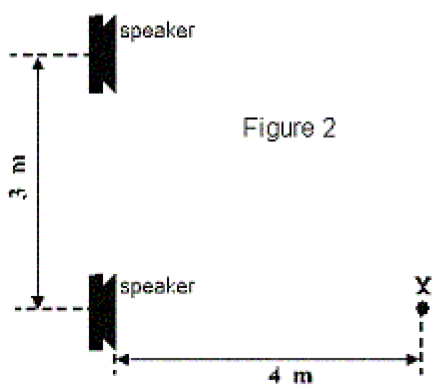


Figure (1)

Q12. Two point sources S1 and S2 are placed on the y-axis as shown in figure 2. The two sources are in phase and emit identical sound waves with frequency 860 Hz. An observer starts at point A and moves to point B along a straight line parallel to the y-axis. How many points of maximum intensity (constructive interference) will he observe? (speed of sound in air = 344 m/s). Ans:5



Q13. Two small identical speakers are in phase (see figure 2). The speakers are 3.0 m apart. An observer stands at point X, 4.0 m in front of one of the speakers. The sound he hears will be a maximum if the wavelength is Ans:1.0 m.



CHAPTER 17

Intensity and Sound Level

Q14. Find the ratio of the intensities of two sound waves if the difference in their intensity levels is 7 dB. Ans:5.

Q15. A tone has a frequency of 1800 Hz and intensity level of 110 dB in air. What is the amplitude of oscillation of air molecules? [Density of air = 1.21 kg/m^3, speed of sound in air = 343 m/s]. Ans:1.94×10^{-6} m.

Q16. The intensity of sound waves at 5 m from a speaker vibrating at 1000 Hz is 0.5 W/m^2. Determine the displacement amplitude of the particles in the wave at that location (5 m away from the speaker). (The density of air = 1.3 kg/m^3 and the speed of sound in air = 340 m/s).
Ans:7.6×10^{-6} m

Q17. A source of sound (1000 Hz) emits uniformly in all directions. An observer 3.0 m from the source measures a sound level of 40 dB. Calculate the average power output of the source. Ans:1.13 micro-W

Sources of Musical Sound

Q18. An air column 2 m in length is open at both ends. The frequency of a certain harmonic is 410 Hz, and the frequency of the next higher harmonic is 492 Hz. Determine the speed of sound in the air column. Ans:328 m/s.

Q19. An air column 2 m in length is open at one end and closed at the other end. The frequency of a certain harmonic is 369 Hz, and the frequency of the next higher harmonic is 451 Hz. Determine the speed of sound in the air column. Ans:328 m/s.

Q20. The second harmonic of a string, fixed at both ends, of length 0.6 m and linear density 1.1×10^{-3} kg/m, has the same frequency as the fifth harmonic (n=5) of a pipe closed at one end of length 1.0 m. Find the tension in the string. (Speed of sound = 343 m/s). Ans:73 N

Q21. If two successive frequencies of a pipe, closed at one end and filled by air, are 500 Hz and 700 Hz, the length of the pipe is: [speed of sound in air = 340 m/s].Ans:0.85 m.

The Doppler Effect

Q22. A driver of a racing car hears a frequency of 1.0×10^4 Hz while moving with a speed of 0.25 v (v is the speed of sound in air) towards a stationary source. Find the frequency of the source.Ans:0.8×10^4 Hz.

Q23. A stationary device generates sound waves of unknown frequency. An observer hears a frequency of 825 Hz as he approaches the device with a speed of 16 m/s. He hears a frequency of 750 Hz as he moves away from the device with the same speed. Find the speed of sound from the above information.Ans:336 m/s

Q24. An ambulance siren emits a sound of frequency 1.60 kHz. A person running with a speed of 2.50 m/s hears a frequency of 1.70 kHz as the ambulance approaches him from the back. How fast is the ambulance moving?(speed of sound is 340 m/s).Ans:22.4 m/s

Q25. A train passes a train station at a constant speed of 40 m/s. The train whisle is sounded at a frequency of 320 Hz. An observer at the station hears a frequency f1 while the train is approaching and a frequency f2 while the train is moving away from the station. What change in frequency (f1-f2) does the observer notice? (v(air)= 343 m/s.)Ans:76 Hz