Interference and Standing Waves

Basic Problems

1. Two speakers, one directly behind the other, are each generating a 245-Hz sound wave. What is the smallest separation distance between the speakers that will produce destructive interference at a listener standing in front of them?
2. Sketch the interference pattern along the line connecting two loudspeakers separated by 55 cm and emitting sound waves at a frequency of 440 Hz.
3. Two loudspeakers generate sound waves with slightly different frequencies. What can you tell about the interference pattern? What does a listener standing between the loudspeakers hear?
4. Sketch the first four harmonics for a steel rod with length 1.2 m. Calculate the corresponding frequencies.
5. The G string on a guitar has a fundamental frequency of 196 Hz and a length of 62 cm. Calculate the wave speed on the string.
6. The A string on a string bass is tuned to vibrate at a fundamental frequency of 55 Hz. If the tension in the string were increased by a factor of four, what would be the new frequencies of the first three harmonics?
7. A tube is open at only one end and has a length of 1.5 m. This tube sustains a standing wave at its third harmonic. What is the distance between one node and the adjacent antinode?
8. What interval can you hear between the second and third overtone generated with a tube open at both ends? Is it the same interval between the same overtones of a tube with only one open end?
9. Sound enters the ear, travels through the auditory canal, and reaches the eardrum. The auditory canal is approximately a tube open at only one end. The other end is closed by the eardrum. A typical length for the auditory canal in an adult is about 2.9 cm. What is the fundamental frequency of the canal?

Additional Problems

10. Two loudspeakers 2.9 m apart produce sound waves with a frequency of 350 Hz.
    a) Find the points of maximum intensity along the perpendicular to the line connecting the loudspeakers at 1.2 m from the left loudspeaker.
    b) What is the general shape of a curve with constant intensity (in two dimensions)?
11. A person hums into the top of a well and finds that standing waves are established at frequencies of 42 Hz, 70 Hz and 98 Hz. How deep is the well?
12. The e' (329.6 Hz) string of a guitar is 66 cm long and has a diameter of 0.23 mm.
    a) Calculate the force acting on the string attachment.
    b) The string is touched with a finger at half its length and plucked. Calculate the fundamental frequency of the resulting sound. Is there a qualitative difference in the frequency spectrum to the normal sound?
13. An alphorn 3.5 m long has no holes or valves to adjust the effective tube length while playing it. Therefore, it is only possible to use the notes of the *natural scale* consisting of the harmonics.
    a) Calculate the frequencies of the first six harmonics that can be played on the alphorn. What are the intervals between subsequent tones?
    b) For some reason the alphorn is filled with helium. Calculate its new fundamental frequency.

Solutions to Basic Problems: 1. 69 cm; 4. 2.1 kHz, 4.2 kHz, 6.3 kHz, 8.4 kHz; 5. 243 m/s; 6. 110 Hz, 220 Hz, 330 Hz; 7. 30 cm; 8. fourth; no; 9. 2.9 kHz