ch 17 sound

sound

Chapter 17: Sound

Conceptual problems

17.C.1 (5.00) An old trick to find out if a train is coming is to put your ear on the rails of the track. Why is this more effective than just listening for the sounds the train makes in air?

17.C.2 (5.00) Why does the sound of a jet plane flying overhead seem to come from a direction trailing the plane itself?

17.C.3 (5.00) Why do people at public events use cone-shaped bullhorns to address the crowd? (We are referring to the non-battery-powered type!)

17.C.4 (10.00) If you have ever watched a World War II movie, you may have heard the frightening sound made by a German Stuka dive bomber as it dove straight down toward its target on the ground during a bombing run. This falling sound, which may be approximated in writing as "eeeeaaaaoooowwww", was produced by a single-note siren attached to each bomber as an instrument of psychological terror by the Luftwaffe. However, a GI who was knowledgeable about physics would actually have been much more frightened to hear an unvarying high-pitched "eeeeeeeeeeeeeeeee" during the plane's vertical dive. Why is this? (Note: acceleration due to gravity will not be a factor in your explanation. The plane is diving at its propeller-driven terminal velocity.)

17.C.5 **(7.00)** It is a lovely day, sunny, with a nice steady breeze blowing. As you stand, dreaming, you hear the tinkle of wind chimes carried to you from directly upwind. Is the frequency of the tinkles you hear higher, the same as, or lower than the frequency emitted by the chimes?

Section 0: Introduction

17.0.1 **(5.00)** Use the simulation in the interactive problem in Section 17.0 to answer the following questions. (a) Does the pitch get higher, lower or does it stay the same as the frequency increases? (b) Does the pitch get higher, lower or does it stay the same as the amplitude increases?

(a)
(b)

Section 3: Interactive problem: sound frequency

17.3.1 **(5.00)** Use the simulation in the interactive in Section 17.3 to determine whether higher pitched notes have higher or lower frequencies than lower pitched notes.

Section 4: Speed of sound in various media

17.4.1 **(5.00)** Any longitudinal wave in water (such as the shock wave from an explosion) moves at the same speed as sound in water. Calculate the speed of longitudinal waves in water. The bulk modulus B of water is 2.18×10^{9} N/m^2 and its density is 1.00 g/cm^3 at 4°C.

m/s

17.4.2 **(5.00)** The highest natural atmospheric temperature ever recorded on Earth was 58°C (136°F), at El Azizia, Libya on September 13, 1922. The record low temperature was −89°C (−129°F), which occurred at the Soviet Vostok Station in Antarctica on July 21, 1983. What is the difference in the speed of sound in air for these two extreme temperatures?

m/s

17.4.3 **(5.00)** You are viewing a New Year's Day fireworks display at a distance of *d* m. It is 4.0°C. How long does it take the sound of the fireworks exploding to reach you?

s

Section 7: Mathematical description of a sound wave

17.7.1 **(5.00)** The threshold of pain for the human ear corresponds to an overpressure amplitude of 29.0 Pa. What is the displacement amplitude for air at this overpressure amplitude? Use a frequency of 1000 Hz, an air density of 1.21 kg/m^3 and the speed of sound in air at room temperature.

m

Section 8: Sound intensity

17.8.1 **(5.00)** You are standing 7.0 meters from a sound source that radiates equally in all directions, but it is too loud for you. How far away from the source should you stand to experience one third the intensity that you did at 7.0 meters?

m

17.8.2 **(5.00)** 15.0 meters from a sound source that radiates freely in all directions, the intensity is *I* W/m^2. What is the rate at which the source is emitting sound energy?

W

17.8.3 **(5.00)** A longitudinal wave spreads radially from a source with power 345 W. What is the intensity 40.0 meters away?

W/m^2

Section 9: Sound level in decibels

17.9.1 **(5.00)** The sound of heavy automobile traffic, heard at a certain distance, has a sound level of about 75 dB. What is the intensity of the noise there?

W/m^2

17.9.2 **(5.00)** Jane and Sam alternately pound a railroad spike into a tie with their hammers. The crew chief has a migraine, and notes that Jane's hammer blows cause a

sound with intensity 5.0 times greater than the sound that Sam makes when he swings his hammer. What is the difference in sound level between the two sounds?

dB

17.9.3 **(5.00)** A grade-school teacher insists that the the overall sound level in his classroom not exceed 64 dB at his location. There are 25 students in his class. If each student talks at the same intensity level, and they all talk at once, what is the highest sound level at which each one can talk without exceeding the limit?

dB

17.9.6 **(7.00)** Pete's family is watching a movie at home, with the TV emitting sound at a level of 71 dB as heard by the family. His dad turns on the popcorn popper, which emits sound that has a level of 68 dB as heard by the family. (a) What is the total sound intensity perceived by Pete's family? (b) What is the total sound level?

(a) W/m2

(b) dB

Section 12: Doppler effect: moving sound source

17.12.1 **(5.00)** Passengers on a train hear its whistle at a frequency of 735 Hz. What frequency does someone standing by the train tracks hear as it moves directly toward her at a speed of 22.5 m/s?

Hz

17.12.3 **(5.00)** A small plane is taxiing directly away from you down a runway. The noise of the engine, as the pilot hears it, has a frequency 1.13 times the frequency that you hear. What is the speed of the plane?

m/s

17.12.4 **(5.00)** A train moves away from you at 29.0 m/s, sounding its horn. You perceive the frequency of the horn's sound as being 415 Hz. What is the frequency heard by the train's passengers?

Hz

Section 14: Doppler effect: moving listener or source

17.14.1 **(5.00)** A team of tornado-chasing meteorology graduate students is out in search of tornados. They drive directly toward a tornado warning siren at *v* m/s. The siren emits sound at 685 Hz. What frequency of sound do the students hear?

Hz

17.14.3 **(5.00)** Takashi is riding a Japanese bullet train, or Shinkansen, that is heading away from Tokyo at 0.250 times the speed of sound. A Tokyo-bound Tohoku Shinkansen is coming toward it on an adjacent track, carrying Yuki at 0.113 times the speed of sound. Acting upon a very unwise impulse, Takashi and Yuki stick their heads out their respective windows and emit primal screams at 3.50 kHz. (a) At what frequency does Takashi hear Yuki's scream? (b) At what frequency does Yuki hear Takashi's scream?

(a) kHz

(b) kHz

Section 18: Supersonic speed and shock waves

17.18.1 **(5.00)** The Mach angle of a jet traveling at supersonic speed is 19.4°. What is the Mach number?

17.18.3 **(7.00)** A jet travels at a speed of *v* m/s through air at 0°C. What is the Mach number?

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