Chapter 14 Problems

1, 2 = straightforward, intermediate

Section 14.6 The Doppler Effect

23. A commuter train passes a passenger platform at a constant speed of 40.0 m/s. The train horn is sounded at its characteristic frequency of 320 Hz. (a) What overall change in frequency is detected by a person on the platform as the train moves from approaching to receding? (b) What wavelength is detected by a person on the platform as the train approaches? (c) How would the frequency detected by the person change if the train was travelling half the speed?

24. An airplane traveling at half the speed of sound (v = 172 m/s) emits a sound of frequency 5.00 kHz. At what frequency does a stationary listener hear the sound (a) as the plane approaches? (b) after it passes?

25. Two trains on separate tracks move towards one another. Train 1 has a speed of 130 km/h, train 2 a speed of 90.0 km/h. Train 2 blows its horn, emitting a frequency of 500 Hz. What is the frequency heard by the engineer on train 1?

26. At rest, a car's horn sounds the note A (440 Hz). The horn is sounded while the car is moving down the street. A bicyclist moving in the same direction with one-third the car's speed hears a frequency of 415 Hz. What is the speed of the car? Is the cyclist ahead of or behind the car?

28. A bat flying at 5.0 m/s is chasing an insect flying in the same direction. If the bat emits a 40 kHz chirp and receives back an echo at 40.4 kHz, what is the speed of the insect? Take the speed of sound in air to be 340 m/s.

Section 14.10 Standing Waves in Air Columns

49. The windpipe of a typical whooping crane is about 5.0 feet long. What is the lowest resonant frequency of this pipe, assuming that it is closed at one end? Assume a temperature of 37°C.

50. The overall length of a piccolo is 32.0 cm. The resonating air column vibrates as in a pipe that is open at both ends. (a) Find the frequency of the lowest note a piccolo can play, assuming the speed of sound in air is 340 m/s. (b) Opening holes in the side effectively shortens the length of the resonant column. If the highest note a piccolo can sound is 4,000 Hz, find the distance between adjacent antinodes for this mode of vibration.

51. The human ear canal is about 2.8 cm long. If it is regarded as a tube that is open at one end and closed at the eardrum, what is the fundamental frequency around which we would expect hearing to be most sensitive? Take the speed of sound to be 340 m/s.

52. A tunnel under a river is 2.0 km long. (a) At what frequencies can the air in the tunnel resonate? (b) Explain whether it would be good to make a rule against blowing your car horn when you are in the tunnel.

53. A pipe open at both ends has a fundamental frequency of 300 Hz when the temperature is 0°C. (a) What is the length of the pipe? (b) What is the fundamental frequency at a temperature of 30°C?

54. Two adjacent frequencies of an organ pip are found to be 550 Hz and 650 Hz. Calculate the fundamental frequency and length of this pipe (use v = 340 m/s). Determine whether the

pipe is open at both ends or open at only one end.

Multiple Choice Questions

1. _____ Which of the following actions will increase the speed of sound in air? (a) decreasing the air temperature (b) increasing the frequency of the sound (c) increasing the air temperature (d) increasing the amplitude of the sound wave (e) reducing the pressure of the air.

2._____ Suppose you're on a hot air balloon ride, carrying a buzzer that emits a sound of frequency *f*. If you accidentally drop the buzzer over the side while the balloon is rising at constant speed, what can you conclude about the sound you hear as the buzzer falls toward the ground? (a) the frequency and intensity increase, (b) the frequency decreases and the intensity increases, (c) the frequency decreases and the intensity decreases, or (d) the frequency remains the same, but the intensity decreases.

3._____ Which of the following frequencies are higher harmonics of a string with fundamental frequency of 150 Hz? (a) 200 Hz (b) 300 Hz (c) 400 Hz (d) 500 Hz (e) 600 Hz.

4._____ A pipe open at both ends resonates at a fundamental frequency f_{open}. When one end is covered and the pipe is again made to resonate, the fundamental frequency is f_{closed}. Which of the following expressions describes how these two resonant frequencies compare? (a) $f_{closed} = f_{open}$, (b) $f_{closed} = 3/2\ f_{open}$, (c) $f_{closed} = 2\ f_{open}$, (d) $f_{closed} = 1/2\ f_{open}$, (e) none of these.

5._____ Balboa Park in San Diego has an outdoor organ. When the air temperature increases, the fundamental frequency of one of the organ pipes (a) increases (b) decreases (c) stays the same (d) impossible to determine. (The thermal expansion of the pipe is negligible.)

6._____ A sound wave traveling in air has a frequency of *f* and wavelength of λ. A second sound wave traveling in air has a wavelength λ/2. What is the frequency of the second sound wave? (a) 4*f* (b) 2*f* (c) *f* (d) ½ *f* (e) ¼ *f*

7._____ If a 1.0 kHz sound source moves at a speed of 50.0 m/s toward a listener who moves at a speed of 30.0 m/s in a direction away from the source, what is the apparent frequency heard by the listener? (The velocity of sound in 340 m/s.) (a) 937 Hz (b) 947 Hz (c) 1,060 Hz (d) 1,070 Hz (e) 1,230 Hz

8._____ A flute has a length of 58.0 cm. If the speed of sound in air is 343 m/s, what is the fundamental frequency of the flute, assuming it is a tube closed at one end and open at the other? (a) 148 Hz (b) 296 Hz (c) 444 Hz (d) 591 Hz (e) 340 Hz

9._____ The fundamental frequency of a resonating pipe is 150 Hz, and the next higher resonant frequencies are 300 Hz and 450 Hz. From this information, what can you conclude? (a) The pipe is open at one end and closed at the other. (b) The pipe could be open at each end or closed at each end. (c) The pipe must be open at each end. (d) The pipe must be closed at each end.

10._____ As you travel down the highway in your car, and ambulance approaches you from the rear at a high speed, sounding its siren at a frequency of 500 Hz. Which statement is correct? (a) You hear a frequency less than 500 Hz. (b) You hear a frequency equal to 500 Hz. (c) You hear a frequency greater than 500 Hz.

11._____, _____ You are driving down the highway in your car when a police car sounding its siren overtakes you and passes you. If its frequency at rest is f_o, is the frequency you hear while the car is catching up to you (a) higher or (b) lower than f_o? What is the frequency you hear after the car has passed you? (a) higher or (b) lower

12._____ A crude model of the human throat is that of a pipe open at both ends with a vibrating source to introduce the sound into the pipe at one end. Assuming the vibrating source produces a range of frequencies, what happens to the range of frequencies if the pipe length was decreased? (a) overall lower frequencies (b) overall no change in frequencies (c) overall higher frequencies

13._____, _____ You are driving toward a cliff and you honk your horn. You notice a Doppler shift, is it like (a) a moving source or (b) a moving observer (c) a moving source and moving observer? What if the reflection occurs not from a cliff, but from the forward edge of a HUGE alien spacecraft moving toward you as you drive? It is like (a) a moving source or (b) a moving observer (c) a moving source and moving observer?

14._____ A soft drink bottle resonates as air is blown across its top. What happens to the resonant frequency as the level of fluid in the bottle decreases? (a) resonant frequency increases (b) resonant frequency decreases (c) resonant frequency varies (d) resonant frequency stays the same.

Homework 1: 23 – 28
Homework 2: 49 – 54
Homework 3: All Multiple Choice Questions