Week 7

Detailed learning goals

By completing this topic, you should be able to:

- Define standing waves.
- Explain the relationship between superposition and standing waves
- Explain the movement of a reflected wave
- Calculate the frequency and wavelength of standing waves
- Explain and calculate the fundamental wave and higher harmonics.
- Describe sound waves.
- Explain pitch and how animals including humans use it
- Explain that sound waves travel at different speeds in different media
- Explain that sound waves travel in spherical waves from a source.
- Calculate the intensity of a sound wave
- Use the intensity to calculate the loudness of a sound wave
- Explain the movement of sound waves in tubes of differing configurations.
- Calculate the wavelength and frequencies of standing sound waves in different tubes
- Explain the Doppler effect from the point of view of the observer and the source of sound waves.
- Explain what happens when the source of sound waves moves faster than the waves
- Calculate Doppler shifts in frequency.

Prescribed readings for SLE123 content

Please read the following sections from Giambattista Physics (5th ed.). New York: McGraw-Hill:

- Section 11.10 Standing Waves.
- Section 12.1 Sound Waves.
- Section 12.3 Amplitude and Intensity of Sound Waves.
- Section 12.4 Standing Sound Waves.
- Section 12.8 The Doppler Effect.

7.1 During an extremely loud sound, the intensity of the sound is 1.2×10^{3} Wm^{-2}. What is the intensity level of the sound (in dB)?

Answer: 151 dB

7.2 After giving an intense performance, a confused and disoriented flautist has wandered onto the motorway! They are playing a constant 300Hz tone on their flute and are essentially stationary. If You are driving along the motorway at 100 kmh^{-1} ($27.8ms^{-1}$), what is the frequency you hear from the flautist's instrument before you pass them, and after you pass them? (c(air) = $343ms^{-1}$.)

Answer: *f*(approaching) = 324Hz, *f*(passed) = 276Hz

7.3 Coincidentally the horn on your car, which you sound as you narrowly miss the flautist in Problem 9.7, also gives a constant 300Hz tone. What frequency does the flautist hear before and after you pass them?

Answer: *f*(approaching) = 326Hz, *f*(passed) = 278Hz

More problems:

1. A dolphin emits ultrasound at 100 kHz and uses the timing of reflections to determine the position of objects in the water. What is the wavelength of this ultrasound? (the speed of sound in water is 1480 m/s)

2. An FM channel transmits the frequency of 91.1 MHz.
   a. Calculate its wavelength? (Hint: radio waves are electromagnetic waves with a speed of $c = 3.0 \times 10^8$ m/s)
   b. What is the frequency of a sound source that produces the similar wavelength in 25°C air (speed of sound in air 343 m/s)?

3. Calculate the sound intensity level of a sound with an intensity of 1.3×10^{-2} kW/m^2?

4. An opera singer in a convertible sings a note at 600 Hz while cruising down the highway at 90 km/h. What is the frequency heard by
   a. A person standing beside the road in front of the car?
   b. A person standing beside the road behind the car?