19 Waves and Vibrations

Solutions to Chapter 19 Exercises

1. The period of a pendulum does not depend on the mass of the bob, but does depend on the length of the string.

4. A shorter pendulum swings to and fro with a higher frequency and shorter period.

10. The wavelength is lengthened to twice. Speed and frequency are directly proportional.

16. To produce a transverse wave with a Slinky, shake it to and fro in a direction that is perpendicular to the length of the Slinky itself (as with the garden hose in the previous exercise). To produce a longitudinal wave, shake it to-and-fro along the direction of its length, so that a series of compressions and rarefactions is produced.

28. Not including endpoints, there are 3 nodes in a wave two wavelengths long, and 5 nodes in a wave three wavelengths long. (Make a drawing and count them!)

31. The speed of light is 300,000 km/s, about a million times faster than sound. Because of this difference in speeds, lightning is seen a million times sooner than it is heard.

35. The Doppler effect is a change in frequency as a result of the motion of source, receiver, or both. So if you move toward a stationary sound source, yes, you encounter wave crests more frequently and the frequency of the received sound is higher. Or if you move away from the source, the wave crests encounter you less frequently, and you hear sound of a lower frequency.

Chapter 19 Problem Solutions

3. The skipper notes that 15 meters of wave pass each 5 seconds, or equivalently, that 3 meters pass each 1 second, so the speed of the wave must be

   $$\text{Speed} = \frac{\text{distance}}{\text{time}} = \frac{15\text{ m}}{5\text{ s}} = \mathbf{3\ m/s}.$$

   Or in wave terminology:
   Speed = frequency × wavelength = (1/5 Hz)(15 m) = **3 m/s**.

5. To say that the frequency of radio waves is 100 MHz and that they travel at 300,000 km/s, is to say that there are 100 million wavelengths packed into 300,000 kilometers of space. Or expressed in meters, 300 million m of space. Now 300 million m divided by 100 million waves gives a wavelength of 3 meters per wave. Or

   $$\text{Wavelength} = \frac{\text{speed}}{\text{frequency}} = \frac{(300\ \text{megameters/s})}{(100\ \text{megahertz})} = \mathbf{3\ m}.$$