4.1.2 In Class or Homework Exercise

1. A sound wave produced by a clock chime 515 m away is heard 1.50 s later. The frequency of the sound is 436 Hz.
   a. What is the speed of sound in air?

   $\Delta d = 515m$

   $t = 1.50s$

   $f = 436Hz$

   $v = ?$

   $$v = \frac{\Delta d}{t} = \frac{515}{1.50} = \boxed{343m/s}$$

   b. What is the period of the sound wave?

   $$T = \frac{1}{f} = \frac{1}{436} = \boxed{2.29\times10^{-3}s}$$

   c. What is its wavelength?

   $$v = \lambda f$$
   $$343 = \lambda(436)$$
   $$\lambda = \boxed{0.787m}$$

2. AM radio signals are broadcast at frequencies between 550 kHz and 1600 kHz and travel 3.0×10^{8} m/s. FM frequencies range between 88 MHz and 108 MHz and travel at the same speed. What is the range of wavelengths for each type of signal?

   <u>AM Waves</u>

   $v = 3.0\times10^{8} m/s$

   $f_1 = 550kHz = 5.5\times10^{5} Hz$

   $f_2 = 1600kHz = 1.6\times10^{6} Hz$

   $\lambda_1 = ?$

   $\lambda_2 = ?$

$$v = \lambda_1 f_1$$
$$3.0\times10^8 = \lambda_1(5.5\times10^5)$$
$$\lambda_1 = \boxed{550m}$$

$$v = \lambda_2 f_2$$
$$3.0\times10^8 = \lambda_2(1.6\times10^6)$$
$$\lambda_2 = \boxed{190m}$$

So AM radio waves range from 190 m to 550 m long.

<u>FM Waves</u>

$v = 3.0\times10^8 m/s$

$f_1 = 88MHz = 8.8\times10^7 Hz$

$f_2 = 108MHz = 1.08\times10^8 Hz$

$\lambda_1 = ?$

$\lambda_2 = ?$

$$v = \lambda_1 f_1$$
$$3.0\times10^8 = \lambda_1(8.8\times10^7)$$
$$\lambda_1 = \boxed{3.4m}$$

$$v = \lambda_2 f_2$$
$$3.0\times10^8 = \lambda_2(1.08\times10^8)$$
$$\lambda_2 = \boxed{2.8m}$$

So FM radio waves range from 2.8 m to 3.4 m long. FM waves are much smaller than AM waves.

3. A group of swimmers is resting in the sun on an off-shore raft, watching the hungry sharks circling them. They estimate that a horizontal distance of 3.0 m separates a trough and an adjacent crest of surface waves on the lake. They count 14 crests that pass by the raft in 20.0 s. How fast are the waves moving?

   The horizontal distance between a crest and trough represents half of a wave; the wavelength will therefore be twice that distance.

   $\lambda = 6.0m$

   $N = 14$

   $t = 20.0s$

   $v = ?$

   $$f = \frac{N}{t} = \frac{14}{20.0} = 0.70Hz$$

   $$v = \lambda f = (6.0)(0.70) = \boxed{4.2m/s}$$

4. Rubber Ducky bobs up and down 14.0 times in 18.0 s in the bathtub. The tub measures 87.0 cm from side to side. It takes 4.77 s for a wave to go straight across the tub. Find the distance between a wave crest and the next adjacent trough in the tub.

We are looking for half of the wavelength.

$N = 14.0$

$t = 18.0s$

$\Delta d = 87.0cm = 0.870m$

$t = 4.77s$

$\frac{1}{2}\lambda = ?$

$$f = \frac{N}{t} = \frac{14.0}{18.0} = 0.778Hz$$

$$v = \frac{\Delta d}{t} = \frac{0.870}{4.77} = 0.182m/s$$

$$v = \lambda f$$
$$0.182 = \lambda(0.778)$$
$$\lambda = 0.234m$$

$$\frac{1}{2}\lambda = \frac{1}{2}(0.234) = \boxed{0.117m}$$

5. Water drops are being dropped into a body of water at a rate of 43.0 drops every 60.0 s. The distance between a crest and the seventh crest ahead of it is 2.40 m. Find the speed at which the waves are travelling.

$N = 43.0$

$t = 60.0s$

$7\lambda = 2.40m$

$v = ?$

$$\lambda = \frac{2.40}{7} = 0.343m$$

$$f = \frac{N}{t} = \frac{43.0}{60.0} = 0.717Hz$$

$$v = \lambda f = (0.343)(0.717) = \boxed{0.246m/s}$$

6. As we examine waves on a water surface we notice that 34.0 waves pass in 54.4 s. We also notice that the distance between the third wave crest and the ninth wave crest is 22.3 cm. How far will these waves travel in 1.50 min?

$N = 34.0$

$t = 54.4s$

$6\lambda = 22.3cm = 0.223m$

$t = 1.50\min = 90.0s$

$\Delta d = ?$

$$f=\frac{N}{t}=\frac{34.0}{54.4}=0.625Hz$$

$$\lambda=\frac{0.223}{6}=0.0372m$$

$$v=\lambda f=(0.0372)(0.625)=0.0233m/s$$

$$v=\frac{\Delta d}{t}$$

$$0.0233=\frac{\Delta d}{90.0}$$

$$\Delta d=\boxed{2.10m}$$

7. A spring carries a standing wave with 1.50 waves on the spring at one time. This standing wave is produced by creating vibrations at a rate of 80.0 times in 1.00 min. The length of the spring is 6.30 m. Find the speed of these waves.

$1.5\lambda=6.30m$

$N=80.0$

$t=1.00\min=60.0s$

$v=?$

$$\lambda=\frac{6.30}{1.50}=4.20m$$

$$f=\frac{N}{t}=\frac{80.0}{60.0}=1.33Hz$$

$$v=\lambda f=(4.20)(1.33)=\boxed{5.59m/s}$$

8. Waves on a lake are travelling at 0.440 m/s. We are in a boat travelling at 2.33 m/s in a direction opposite to the direction of wave travel. The distance between wave crests is 1.20 m. At what frequency do we feel the boat hitting the waves?

$v_w=0.440m/s$

$v_b=2.33m/s$

$\lambda=1.20m$

$f=?$

$$v_{rel}=v_w+v_b=0.440+2.33=2.77m/s$$

$$v = \lambda f$$
$$2.77 = (1.20) f$$
$$f = \boxed{2.31 Hz}$$

9. The wind is blowing our boat along with a speed of 1.50 m/s. We notice that the waves are passing the boat (going in the same direction) and we measure the speed of the waves at 2.00 m/s from inside the boat; that is, the waves pass the boat 2.00 m/s faster than the boat is travelling. The distance between wave crests is 0.670 m.
   a. Find the rate at which the boat bobs up and down.

$$v_b = 1.50 m/s$$
$$v_w = 3.50 m/s$$
$$\lambda = 0.670 m$$
$$f = ?$$

$$v_{rel} = 2.00 m/s$$

$$v = \lambda f$$
$$2.00 = (0.670) f$$
$$f = \boxed{2.99 Hz}$$

   b. Find the rate at which the waves bounce off a stationary dock.

$$v_w = 3.50 m/s$$
$$\lambda = 0.670 m$$
$$f = ?$$

$$v = \lambda f$$
$$3.50 = (0.670) f$$
$$f = \boxed{5.22 Hz}$$

10. The ripples in a certain groove 12 cm from the centre of a 33-rpm phonograph record have a wavelength of 2.4 mm. What will be the frequency of the sound emitted?

$$\lambda = 2.4 mm = 0.0024 m$$
$$r = 12 cm = 0.12 m$$
$$f_s = ?$$

Since the phonograph makes 33 rpm, we can calculate the speed of the ripple:

$$
\begin{aligned}
v &= \frac{\Delta d}{t} \\
&= \frac{33(2\pi(0.12))}{60.0} \\
&= 0.41 m/s
\end{aligned}
$$

Since the phonograph needle vibrates along the groove to produce the sound,

$$
\begin{aligned}
v &= \lambda f \\
0.41 &= (0.0024) f \\
f &= \boxed{170 Hz}
\end{aligned}
$$