Example 1:

A sound wave has a frequency of 350 Hz and has a velocity of 340 m/s in air. The wave passes through a wall in which its speed increases to 1200 m/s.

a.) What is the wavelength of the wave as it propagates through the air?

b.) What is the wavelength of the wave as it propagates through the wall?

Example 1:

$$f = 350 \text{ Hz},\ v_1 = 340\ \frac{\text{m}}{\text{s}},\ v_2 = 1200\ \frac{\text{m}}{\text{s}}$$

a.) $\lambda_1 = \ ?$

$$v_1 = \lambda_1 f$$

$$\lambda_1 = \frac{v_1}{f} = \frac{\left(340\ \frac{\text{m}}{\text{s}}\right)}{(350 \text{ Hz})}$$

$$\boxed{\lambda_1 = 0.971 \text{ m}}$$

b.) $\lambda_2 = \ ?$

$$\lambda_2 = \frac{v_2}{f} = \frac{\left(1200\ \frac{\text{m}}{\text{s}}\right)}{(350 \text{ Hz})}$$

$$\boxed{\lambda_2 = 3.43 \text{ m}}$$

Example 2:

Rat is on a raft in the ocean and notices that the raft bobs up and down and makes 8 oscillations every 20 seconds. She also notices that the distance between the crests of the waves is 2.0 m. Find the frequency, wavelength, period, and speed of the waves.

Example 2:

8 oscillations every 20 seconds, crest to crest distance of 2.00 meters

$f = \ ?$ $\quad f = \dfrac{8 \text{ oscillations}}{20 \text{ s}}$

$$\boxed{f = 0.400 \text{ Hz}}$$

$\lambda = \ ?$ $\quad \boxed{\lambda = 2.00 \text{ m}}$

$T = \ ?$ $\quad T = \dfrac{1}{f} = \dfrac{1}{(0.400 \text{ Hz})}$

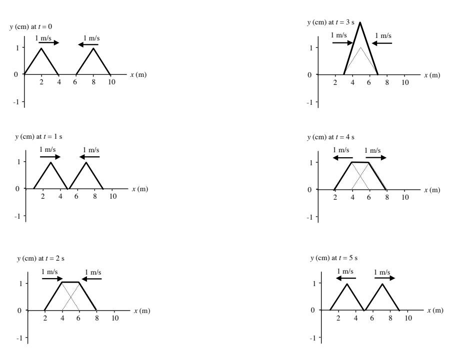
$$\boxed{T = 2.50 \text{ s}}$$

$v = \ ?$ $\quad v = \lambda f = (2.00 \text{ m})(0.400 \text{ Hz})$

$$\boxed{v = 0.800\ \frac{\text{m}}{\text{s}}}$$

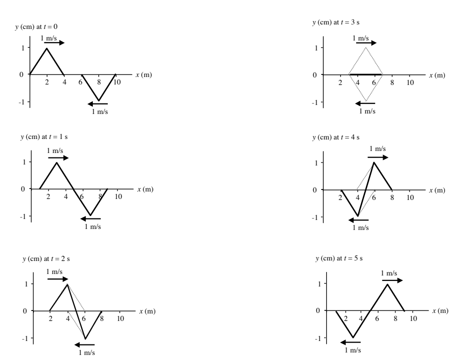
Example 3:

The figure below shows a snapshot of two pulses at time $t = 0$ s approaching each other at 1 m/s. Draw a snapshot of the pulses at $t = 1$ s, 2 s, 3 s, 4 s , and 5 s.



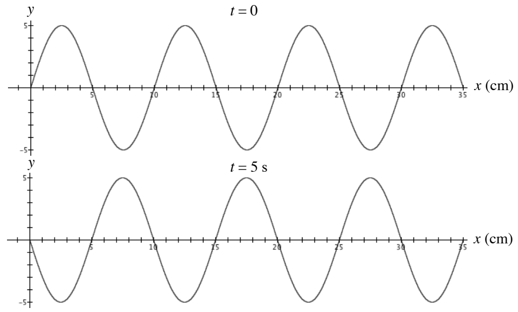
Example 4:

The figure below shows a snapshot of two pulses at time $t = 0$ s approaching each other at 1 m/s. Draw a snapshot of the pulses at $t = 1$ s, 2 s, 3 s, 4 s , and 5 s.



Example 5:

The figures below show a snapshot of a traveling wave at time $t = 0$ s and 5 s.



a.) What is the wavelength and period of this wave?

$\boxed{\lambda = 10 \text{ cm}}$ $\quad t = \dfrac{T}{2}$ so $T = 2t = 2(5 \text{ s})$ $\boxed{T = 10 \text{ s}}$

b.) What is speed of this wave? $v = \dfrac{\lambda}{T} = \dfrac{(10 \text{ cm})}{(10 \text{ s})}$ $\boxed{v = 1.0 \ \dfrac{\text{cm}}{\text{s}}}$

Example 6:

A 220 cm length of string is stretched between two supports. What are four longest possible wavelengths for traveling waves on the string that can produce standing waves?

$$L = 2.20 \text{ m},\ \lambda_1 = ?,\ \lambda_2 = ?,\ \lambda_3 = ?,\ \lambda_4 = ?,$$

$$\lambda_n = \frac{2L}{n}$$

$$\lambda_1 = \frac{2L}{1} = \frac{2(2.20 \text{ m})}{1} \qquad \lambda_3 = \frac{2L}{3} = \frac{2(2.20 \text{ m})}{3}$$

$$\boxed{\lambda_1 = 4.40 \text{ m}} \qquad \boxed{\lambda_3 = 1.47 \text{ m}}$$

$$\lambda_2 = \frac{2L}{2} = \frac{2(2.20 \text{ m})}{2} \qquad \lambda_4 = \frac{2L}{4} = \frac{2(2.20 \text{ m})}{4}$$

$$\boxed{\lambda_2 = 2.20 \text{ m}} \qquad \boxed{\lambda_4 = 1.10 \text{ m}}$$

Example 7:

What is the speed of a transverse wave in a 40.0 g string that is 80.0 cm long under a tension of 300 N?

$$m = 0.0400 \text{ kg},\ L = 0.800 \text{ m},\ T = 300 \text{ N},\ v = ?$$

$$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{T}{\left(\frac{m}{L}\right)}} = \sqrt{\frac{TL}{m}}$$

$$v = \sqrt{\frac{(300 \text{ N})(0.800 \text{ m})}{(0.0400 \text{ kg})}}$$

$$\boxed{v = 77.5 \ \frac{\text{m}}{\text{s}}}$$

Example 8:

A wire has a linear density of 0.35 kg/m and is fixed at both ends such that the tension in the wire is 185 N. When the wire is excited using the vibration from a 350 Hz tuning fork, a standing wave pattern is formed containing 5 loops.

a.) What is the length of the wire?

b.) Sketch the standing wave pattern.

Example 8:

$$\mu = 0.350 \ \frac{\text{kg}}{\text{m}},\ T = 185 \text{ N},\ f = 350 \text{ Hz},\ 5 \text{ loops}$$

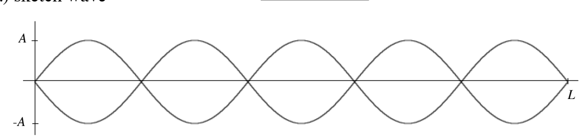
a.) $L = ?$

$$\lambda_n = \frac{2L}{n} \text{ and } \lambda_n = \frac{v}{f_n} \text{ and } v = \sqrt{\frac{T}{\mu}}$$

$$L = \frac{n\lambda_n}{2} = \frac{nv}{2f_n} = \frac{n\sqrt{\frac{T}{\mu}}}{2f_n} \quad (5 \text{ loops} \Rightarrow n = 5) \quad L = \frac{5\sqrt{\frac{(185 \text{ N})}{\left(0.350 \ \frac{\text{kg}}{\text{m}}\right)}}}{2(350 \text{ Hz})}$$

$$\boxed{L = 0.164 \text{ m}}$$

b.) sketch wave



Example 9:

A string fixed at both ends is 0.640 m long and is oscillating such that there are 7 nodes present along the string (including the end points). The tension and linear density are such that the wave velocity is 48.0 m/s.

a.) What is the wavelength of the standing wave pattern?

b.) What is the fundamental frequency of the string assuming the same tension and wave velocity?

Example 9:

$$L = 0.640\text{ m},\ v = 48.0\ \frac{\text{m}}{\text{s}},\ 7\text{ nodes}$$

a.) $\lambda_n = \ ?$ $\quad (7\text{ nodes} \Rightarrow n = 6)$

$$\lambda_n = \frac{2L}{n} \quad \text{so } \lambda_6 = \frac{2L}{6} = \frac{2(0.640\text{ m})}{6}$$

$$\boxed{\lambda_6 = 0.213\text{ m}}$$

b.) $f_1 = \ ?$

$$\lambda_n = \frac{v}{f_n} \quad \text{so } f_n = \frac{v}{\lambda_n} = \frac{nv}{2L} \quad \text{and } f_1 = \frac{(1)v}{2L} = \frac{(1)\left(48.0\ \frac{\text{m}}{\text{s}}\right)}{2(0.640\text{ m})}$$

$$\boxed{f_1 = 37.5\text{ Hz}}$$

$$\text{also } f_6 = \frac{v}{\lambda_6} = \frac{\left(48.0\ \frac{\text{m}}{\text{s}}\right)}{(0.213\text{ m})} \quad \text{and } f_6 = 225\text{ Hz}$$

$$f_n = nf_1 \quad \text{so } f_6 = 6f_1 \text{ and } f_1 = \frac{f_6}{6} = \frac{225\text{ Hz}}{6} \quad \boxed{f_1 = 37.5\text{ Hz}}$$

Example 10:

A 1.40 m string, clamped at both ends, vibrates at a frequency of 280 Hz forming a standing wave pattern with 7 antinodes.

a.) If the string has a mass of 25.0 g, what is the tension in the string?

b.) What frequency will cause the string to vibrate with 4 loops?

Example 10:

$$L = 1.40\text{ m},\ f_n = 280\text{ Hz},\ 7\text{ antinodes}$$

a.) $m = 0.0250\text{kg},\ T = \ ?$ $\quad (7\text{ antinodes} \Rightarrow n = 7)$

$$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{TL}{m}} \quad \text{and } \lambda_n = \frac{2L}{n} \quad \text{and } \lambda_n = \frac{v}{f_n} \quad \text{so } v = \lambda_n f_n \text{ and } v = \frac{2L}{n} f_n$$

$$T = \frac{mv^2}{L} = \frac{m\left(\frac{2L}{n} f_n\right)^2}{L} = \frac{4mLf_n^{\ 2}}{n^2} = \frac{4(0.0250\text{ kg})(1.40\text{ m})(280\text{ Hz})^2}{7^2}$$

$$\boxed{T = 224\text{ N}}$$

b.) $(4\text{ loops} \Rightarrow n = 4)\, f_4 = \ ?$

$$f_n = nf_1 \quad \text{so } f_7 = 7f_1 \text{ and } f_1 = \frac{f_7}{7} = \frac{280\text{ Hz}}{7} = 40\text{ Hz}$$

$$f_4 = 4f_1 = 4(40\text{ Hz})$$

$$\boxed{f_4 = 160\text{ Hz}}$$