Waves: Basics

The Big Idea

A wave is a disturbance in a medium that transfers energy from one point in a medium to another point in that medium. The wave "travels" from one point to another, but the particles in the medium ***do not***. The particles in the medium simply oscillate back and forth transferring the energy. Waves come in two flavors: *transverse waves* (the disturbance or movement of the particles is at a right angle to the direction of the wave's travel) and *longitudinal* or compression *waves* (the particles in the medium move back and forth along the path the wave travels).

More details

Waves have three inherent properties that can be measured: *amplitude*, ***A*** (the magnitude of the wave's disturbance), *wavelength*, ***λ*** (the distance between successive waves), and *speed*, ***v*** (how fast the wave travels). Two other wave properties that are commonly used are *frequency*, ***f*** (how often waves pass a given point) and *period*, ***T*** (how long the time is between waves passing a given point). Speed, frequency, and wavelength are all related by the formula: $v = \lambda f$. Frequency and period are just the reciprocals of each other: $T = 1/f$. Frequency has the special unit "hertz" (Hz) which is equal to 1/s or s^{-1}.

Light waves, actually all EM (electromagnetic) waves, are special in a number of ways: EM waves do not travel through a "medium" (although you can think of them as disturbances in the electromagnetic field) like other waves although they do still transfer energy, and they all always travel at the same speed in a vacuum: 3.00×10^8 m/s (the "speed of light" which is also given the special symbol '***c***'). Memorize this.

The speed of sound in the air depends on the temperature of the air. At 0 °C, sound travels slightly faster than 330 m/s, whereas at 35 °C sound travels at just over 350 m/s. In our class, we will usually use 340 m/s unless specified otherwise.

How to recognize the type of problem

There are a few common basic wave problems. Some problems will ask you to find amplitude and/or wavelength directly from a wave diagram. Other problems ask you to convert frequency to period or vice versa. The most common type of wave problem asks you to find velocity, wavelength, or frequency when given the other two values. Wave problems often contain a combination of these types.

How to tackle this kind of problem

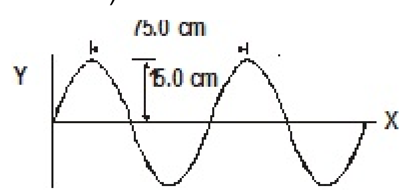
Most wave problems are just going to be plug and chug using $v = \lambda f$. Plug two values in to get the missing value. Occasionally, the wavelength may come from a diagram rather than being given, or the problem may give you or ask you for period rather than frequency.

Common pitfalls to avoid

- If period is given or asked for rather than frequency, be sure to switch it (reciprocal!)
- When finding amplitude on a diagram, it is the distance from the undisturbed position to the max, ***not*** the peak to peak amplitude (unless peak to peak amplitude is specifically asked for)

Example problem

The wave shown on the right travels at 3.0 m/s. (a) What is the frequency of the wave shown? (b) How long after the crest of one wave passes a given point will it be until the next wave crest passes?



Solution:

a. $f = v/\lambda = 3.0\ m/s\ /\ 0.75\ m = \boxed{4.0\ Hz}$ ($\lambda = 0.75$ m from diagram)

b. $T = 1/f = 1\ /\ 4.0\ s^{-1} = \boxed{0.25\ s}$