Wave Motion -- Conceptual Questions

1.) What, exactly, is a wave?

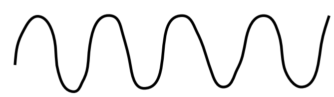
Solution: A wave is a disturbance that moves through a medium You can't have water waves without water! Water is the medium; a disturbance in the water constitutes the wave.

2.) In Star Wars, a giant galactic battle cruiser is attacked in space by a host of little single engine fighters. Cannons from the battle cruiser blaze as the tiny fighters swarm around it. You see a fighter hit, blowing up spectacularly with a ferocious outpouring of light and fire and a cacophonous kaboom. What's wrong with this picture?

Solution: When you clap your hands together while on earth (sounds like the beginning of a song), the clap disturbs the air pressure between your slamming hands. That pressure disturbance propagates out away from you through the surrounding air. A friend in "earshot" will register that disturbance because as the pressure wave passes her by, little hairs in her ears will produce the electrical impulses that our brains associate with sound. The problem with our space scenario is there is essentially no gas of any sort in abundance out in space (in fact, space has only about one molecule per cubic centimeter). Put a little differently, there is no medium in space through which the "cacophonous kaboom" suggested in the scenario might propagate. Put even differently, THERE IS NO SOUND IN SPACE. (This doesn't mean we can't communicate out in space by projecting *radio waves*--these are electromagnetic waves--between radio receivers. That is a *whole other thing*, though.)

3.) How many wavelengths are there between a crest and its adjacent trough? Between every third crests? Between every two successive troughs?

Solution: Hand draw a wave train (I've done so in a very inartistic way to the right). One wavelength measures from one crest to the next crest, or one trough to the next trough, or one point to where that point appears to repeat itself on the wave. As such, the distance between a crest and its nearest trough must be *one-half* a wavelength. Count out three crests and you find *two* wavelengths in between. Count out two successive troughs and you fine *one* wavelength in between.



4.) You are on a pier watching ocean waves pass by. Six crests pass you be in 25 seconds. If there is approximately 20 meters between crests:

a.) Will the wavelength of the train be a whole number?

Solution: This is an odd question in the sense that it has some misdirection to it. Simply, if the distance between crests is approximately 20 meters, then the wavelength is approximately 20 meters and the number is approximately a whole number.

b.) If the number of wave passing by every 25 seconds was halved, what would the period do?

Solution: There are 5 waves (cycles) between 6 crests. Initially, it took 25 seconds for those 5 cycles to pass. That means the period (in *seconds per cycle*) must be *(25 seconds)/(5 cycles) = 5 seconds/cycle*. If it suddenly, mysteriously takes twice as long for the 5 cycles to pass by, then the period must have double to 10 seconds/cycle. Put a little differently, if only 2.5 cycles passes every 25 seconds, then the new period must be *(25 seconds)/(2.5 cycles) = 10 seconds/cycle*. Looking at it either way is OK.

c.) How is the wave velocity related to the time it takes for a full wave to pass by?

Solution: The time it takes for a full wave (crest to crest or trough to trough) to pass by is defined as the wave's *period*. For a given wavelength, wave velocity is directly related to wave frequency. As frequency is inversely related to period, evidently the wave velocity is inversely related to wave period. If you think about it, this make sense intuitively. Assuming the distance between crests doesn't change, an increase in the wave's speed will mark a decrease in the amount of time it takes two crests to pass by (i.e., wave velocity inversely related to period.)

d.) What is the wave frequency?

Solution: Wave frequency is inversely related to period. According to *Part b*, the original wave period was 5 seconds per cycle. That means the frequency must be 1/5 cycle per second.

e.) How is the wave velocity related to the frequency of the wave train?

Solution: Frequency times wavelength equals the wave velocity. For a given wavelength, the frequency and wave velocity will be directly related. Double one and you must double the other (again, assuming the wavelength is held constant.)

f.) A student is given the following scenario: *A closed, empty plastic water bottle is thrown off the end of the pier (bad form!) and into the waves. That day, the wave velocity is 1.5 meters/second and the surf's wavelength is 10 meters. Ignoring currents, and assuming the pier is 100 meters long, how long will it take the bottle to hit the beach?* The student complains that this is a trick question. Explain why he or she might think so.

Solution: As long as you aren't looking at shore-break where the bottom comes into effect, a water wave is simply a disturbance moving through water. As the disturbance passes a particular point, the water and anything floating in the water will respond to the disturbance by raising up only to come right back down again after the disturbance has passes by. In other words, the plastic bottom will never get to the beach as it will simply bob up and down out at the end of the pier forever.