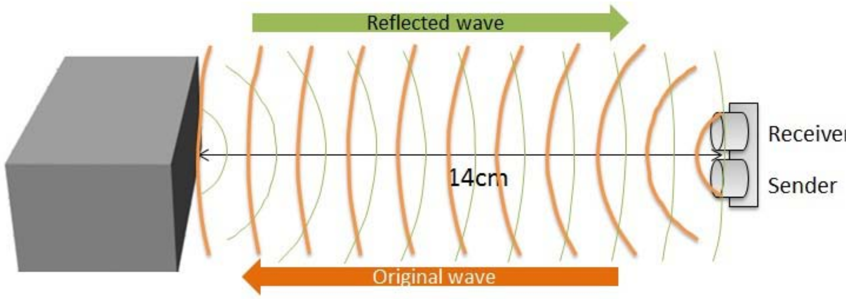
Name: ______________________________ **Date:** ____________________

Measuring Distance with Sound Waves Activity – Distance and Time Worksheet – Answers

Part I: Distance and Time



1. Look around and choose a stationary object.
2. Turn on the LEGO® Ultrasonic sensor and obtain ultrasonic measurements in centimeters. Log that distance in Table 1.
3. Take two more distance measurements and log them in Table 1, for a total of three measurements (Take 1, Take 2 and Take 3).
4. Obtain the average of these three measurements and log it in the last column of Table 1.

Table 1			
Distance to object **Take 1 (in cm)**	Distance to object **Take 2 (in cm)**	Distance to object **Take 3 (in cm)**	Distance to object **Average (in cm)**
68	69	68	68.3

5. Convert the average measured distance to the object from Table 1 into meters, and log the conversion in Table 2.
6. Ask your instructor for a value of the speed of sound at current classroom temperature and log it in Table 2.
7. Calculate the time it takes for a sound wave to get from the sensor to the object (one way trip) using the distance formula. Log the calculation in Table 2.
8. Calculate the time it takes for a sound wave to travel from the sensor to the object and back (round-trip). Log the calculation in Table 2.
9. Convert the round-trip time of a sound wave from seconds into microseconds. Log the calculation in Table 2. Remember that $1\ second = 1\ 000\ 000\ microseconds$ or $1\ microsecond = 10^{-6}\ seconds$.

Table 2				
Distance to object **Average (meters)**	Speed of sound **(m/s)**	Time to the object **(s)**	Round-trip time **(s)**	Round-trip time **(microseconds)**
0.683	343.6	0.002	0.004	4000

Name: ______________________________ **Date:** ____________________

Time to the object = Distance between ÷Speed of sound = 0.683(m)÷343.6 (m/s) = 0.002s

Time round-trip (s) = 2 * Time between = 2 * 0.002 (s) = 0.004 (s)

Time round-trip (microseconds) =

$$0.004\ (s) * \frac{10^6 (microseconds)}{1(s)} = 4000\ (microseconds)$$

Part II: Frequency

Recall that the frequency of a wave is defined as a number of cycles a wave completes in a second. For example, if the frequency of the wave is 10 Hz, then we can say that this wave completes 10 full cycles in 1 second. We also know that the wave completes 1 cycle in 0.1 seconds or 100,000 microseconds. We can figure this out by phrasing the problem as follows:

A wave competes 10 cycles in 1 second, hence 1 cycle is completed after x number of seconds.

Set up a proportion $\frac{10(cycles)}{1\ (s)} = \frac{1\ (cycle)}{x\ (s)}$, solve for x, and convert into microseconds to get the above result. Since it takes 100,000 microseconds for a wave to complete 1 cycle, then after 4,000,000 microseconds, the wave completes 40 cycles.

Questions

1. How many cycles does the LEGO® Ultrasonic sensor wave make in 1 second? Note that the frequency of a LEGO Ultrasonic sensor wave is 40 000 Hz.
   40,000 (cycles) The answer to this question is based on the definition of Hertz.

2. Calculate the time it takes for LEGO Ultrasonic sensor wave to travel one cycle?
   25 (microseconds) Note: methods of solving this question may vary. A wave competes 40000 cycles in 1 second, hence 1 cycle is completed after *x* number of seconds. Set up a proportion and solve for *x*.

$$\frac{40000\ (cycles)}{1\ (s)} = \frac{1\ (cycle)}{x\ (s)}$$

$$x = \frac{1(s) * 1(cycle)}{40000\ (cycles)}$$

3. How many cycles does the LEGO® Ultrasonic sensor wave go through, traveling from a sensor to the object and back? To answer this question, use the calculated round-trip time in Table 2.

   160 (cycles) Note: methods of solving this question may vary. It takes 4000 microseconds for a wave to travel from LEGO Ultrasonic sensor to an object and back. In question 5 we discovered that it takes 25 microseconds for LEGO Ultrasonic wave to make 1 cycle. Hence,

$$4000\ (microseconds) * \frac{1\ (cycle)}{25\ (microseconds)} = 160\ (cycles)$$