**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).

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| **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** |

1. Obtain the average of these three measurements and log it in the last column of Table 1.
2. Convert the average measured distance to the object from Table 1 into meters, and log the conversion in Table 2.
3. Ask your instructor for a value of the speed of sound at current classroom temperature and log it in Table 2.
4. 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.
5. 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.
6. 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 $1 microsecond=10^{-6} seconds$.

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| **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** |

**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) =**

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

**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*.**

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

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

1. 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,**

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