

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.

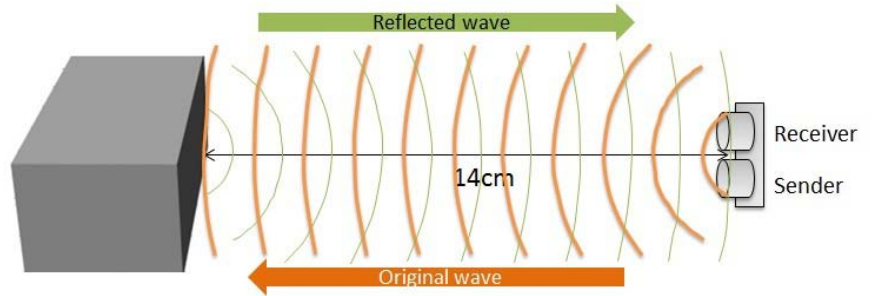


Table 1			
Distance to object Take 1 (in cm)	Distance to object Take 2 (in cm)	Distance to object Take 3 (in cm)	Distance to object Average (in cm)
<b>68</b>	<b>69</b>	<b>68</b>	<b>68.3</b>

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  $1 \text{ second} = 1\,000\,000 \text{ microseconds}$  or  $1 \text{ microsecond} = 10^{-6} \text{ seconds}$ .

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)
<b>0.683</b>	<b>343.6</b>	<b>0.002</b>	<b>0.004</b>	<b>4000</b>

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**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) =**

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

## 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  $\frac{10(\text{cycles})}{1(s)} = \frac{1(\text{cycle})}{x(s)}$ , 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.**

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

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

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,**

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