Name ____________________ Class ________________ Date ____________

Measuring the Speed of Sound

Background Information

An echo is reflected sound that can be heard separately from the original sound that produced it. The original sound is heard for about 0.10 second. You will hear an echo clearly if you are far enough away so that it takes more than 0.10 second for the sound to travel to the reflecting surface and back to you. To calculate the speed of sound, you must find your distance from the reflecting surface when you are just far enough away so that you do not hear an echo. It will take 0.10 second for the sound to travel this distance and back.

Sound travels at different speeds through different materials. Temperature also affects how rapidly sound is transmitted. Sound will travel faster in warm air than in cold air. However, the speed of sound in air does not depend upon the frequency of the sound. If it did, you would not be able to listen to music because the high-pitched sounds would arrive at your ear at a different time than the low-pitched sounds would.

The speed of light is much greater than the speed of sound. You will use this principle to calculate the speed of sound. You will perform an experiment similar to one performed by French scientists in 1738. They set up a cannon on a hill and timed the interval between the flash and the sound. Since they knew the distance and the time, they could calculate the speed of sound.

In Part A of this investigation, you will create echoes and measure the distance between you and a reflecting surface in order to determine the speed of sound. Then, in Part B, you will calculate the speed of sound in air by measuring the time between seeing an event and hearing the event.

Problem

What is the speed of sound in air?

Pre-Lab Discussion

Read the entire investigation. Then, work with a partner to answer the following questions.

1. **Comparing and Contrasting** Which method for measuring the speed of sound in air do you think will produce more accurate results—the method used in Part A or the method in Part B? Explain your answer.

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2. **Controlling Variables** Identify the manipulated and responding variables for both Parts A and B.

3. **Evaluating** The speed of sound in dry air at a temperature of 20°C is 342 m/s. What sources of error might account for obtaining a different value than this?

4. **Controlling Variables** How can the variables that introduce error in the results be controlled?

5. **Designing Experiments** How might you vary the design of the investigation in Part B to test if the speed of sound in air is independent of frequency?

Materials *(per group)*

2 wooden blocks, each about 20 cm long
metric tape measure or meter stick
drum
stopwatch (that can measure hundredths of a second)
measuring rope, marked off in meters, or a bicycle with a metric odometer

Safety

Be careful when handling sharp instruments such as a tape measure. Note all safety alert symbols next to the steps in the Procedure and review the meaning of each symbol by referring to the Safety Symbols on page xiii.

Procedure

Part A: Estimating the Speed of Sound from Echoes

1. In an auditorium or outdoors near a high wall, use a metric tape measure or meter stick to measure a distance of 25 meters from the wall.
2. Stand facing the wall and clap the two wooden blocks together. Listen for an echo. If you can hear one, move closer to the wall by about 1 meter, and repeat. Keep moving closer, 1 meter at a time, until you can no longer hear a separate echo.
3. Measure and record the distance between you and the wall.

Part B: Determining the Speed of Sound From the Delay Between Seeing and Hearing an Event

4. This experiment must be conducted outdoors. Select an area such as an open field or a long, lightly traveled road. Record your observations of the weather conditions.
5. With the measuring rope (or a bicycle equipped with a metric odometer), measure a distance of 100 meters in a straight line.
6. One student should stand at each end of this measured distance, as shown in Figure 1.
7. One student should create a loud, short noise by striking the drum.

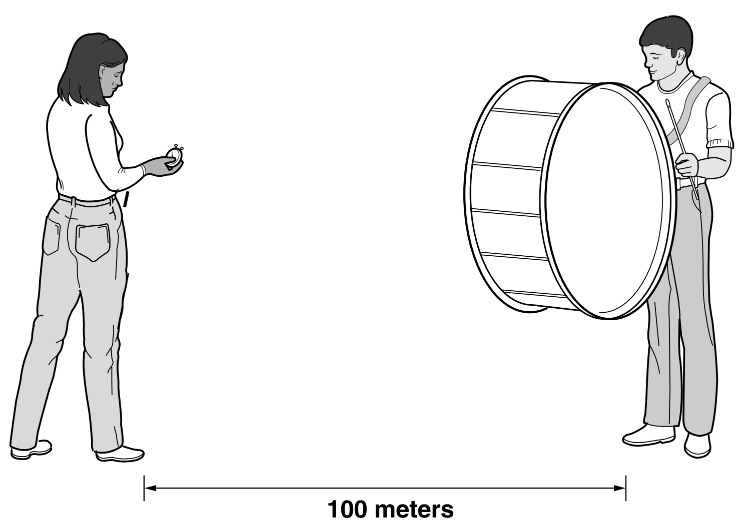

Figure 1

8. The other student should start the stopwatch precisely when he or she sees the drum being struck. The student should stop the watch precisely when he or she hears the noise.
9. Repeat Steps 8 and 9 three more times. Record the times to a hundredth of a second in the data table.
10. The two students should change places with each other and repeat the experiment. This will help to eliminate any effect the wind might have on the speed at which the sound waves travel. Record your results in the data table.

Observations

Part A

1. What did you observe when you made the sound at a distance of 25 meters from the reflecting surface?

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2. At what distance were you no longer able to hear an echo?

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Part B

DATA TABLE

Trial	Time (first student with stopwatch) (s)	Time (second student with stopwatch) (s)
1		
2		
3		
4		

Analysis and Conclusions

1. **Calculating** For Part A, calculate the total distance the sound traveled from you to the reflecting surface and back again.

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2. **Calculating** Divide the total round-trip distance by the time, 0.10 s, needed for you to hear the echo and the original clapping sound as just one sound. Express your answer in the correct units.

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3. **Inferring** What type of surface would not have reflected sound back to you? Why?

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4. **Controlling Variables** For Part B, what were the weather conditions in which you measured the speed of sound? Do you think the speed would have been different under different conditions?

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5. **Calculating** Average the eight time values in the data table. Calculate the speed of sound by dividing the distance by the average time.

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6. **Analyzing Data** What factors might have caused variations in the results of your eight trials?

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7. **Comparing and Contrasting** Compare the values for the speed of sound in air calculated in Part A and in Part B. Account for both the differences and similarities in the results.

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8. **Applying Concepts** Explain how you can determine the distance from you that lightning strikes if you know the speed of sound and have a stopwatch.

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9. **Applying Concepts** When fireworks burst in the sky, will you hear the explosion or see the color first? Explain your answer.

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10. **Applying Concepts** Sound usually travels faster in liquids than in gases, and faster in some solids than in liquids. Explain why a worker who puts one ear against a long steel pipe would hear two sounds if another worker struck the pipe only once at some distance away.

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Go Further

Suspend an alarm clock inside a bell jar from which air can be evacuated by a vacuum pump. Observe what happens to the sound of the bell or alarm as the air is sucked out. Observe the speed of sound through other materials such as water or iron. Before conducting any experiments, submit your procedure to your teacher for approval.