Sounds in Solids

Background Information

Sound is a **longitudinal wave.** As sound travels through a substance, the particles vibrate back and forth parallel to the movement of the sound wave. When the particles vibrate, regions form where they are close together (**compression**) and where they are far apart (**rarefaction**). The sound wave consists of compressions and rarefactions spreading through a substance.

Sound must travel through a **medium.** Sound cannot travel through a vacuum because there are no particles to transmit the pattern of compressions and rarefactions. To transmit sound, the medium must vibrate. The term *vibrate* implies back-and-forth movement. If the particles move forth without moving back again, there is no vibration. Once particles begin forward motion, their inertia would continue to carry them forward unless some force brought them back again. A medium that has strong forces of attraction between the particles tends to be **elastic** because the particles spring back to their original positions after a sound wave passes.

A medium in which the particles are close together so that the vibration in one particle could easily pass to its neighboring particles tends to have greater elasticity than a medium in which the particles are far apart. The particles in metals are arranged very close together in an orderly pattern. This makes the metal rigid. It is very difficult to force the particles closer together. Therefore, a metal is not easily compressed or deformed. A piece of plastic, such as a plastic straw, bends easily. A material is elastic if it is rigid and hard to deform. Metal tends to be more elastic than plastic.

In this investigation, you will compare wood, cardboard, and metal for elasticity to discover how well each transmits sound.

Problem

How well do various materials transmit sound?

Pre-Lab Discussion

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

1. Comparing and Contrasting A spring is placed on a tabletop, and one end is held in a fixed position. Two strings are tied to the spring on coils about 1 cm apart, as shown in Figure 1. Then, the spring is given a shove at the left end, causing a wave to travel through it toward the right.

a. Describe the movement of either string as the wave passes by.

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b. What happens to the distance between the two strings as the wave travels along the spring? Explain your answer.

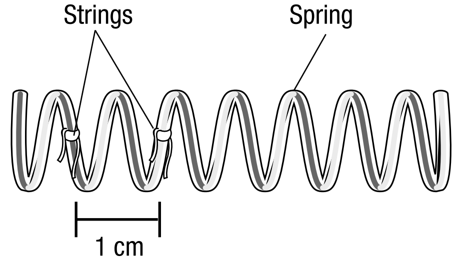

Figure 1

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2. **Using Models** How is the behavior of the spring in Question 1 similar to that of a sound wave?

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3. **Using Models** Suppose that you made a coil out of cotton and tried to send a wave down the cotton coil in the same way as described in Question 1 with a spring. What would happen? Explain your answer. Use the word *elastic* or *elasticity* in your explanation.

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4. **Inferring** Which substance is probably the most elastic—wood, cardboard, or metal? Which is probably the least elastic? How would you test your prediction?

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5. **Predicting** Rank wood, cardboard, and metal from highest to lowest for their ability to conduct sound. Explain your answer.

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Materials *(per group)*

clock or watch with second hand (either should produce a ticking sound)
wooden meter stick
metal rod, 1 m long, (iron, steel, or aluminum)
cardboard sheet, 1 m long

Name ______________________ Class __________________ Date ____________

Safety

Put on safety goggles. Be careful when handling sharp instruments. 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

1. Work with a partner. Check the elasticity of a meter stick by laying it flat on your lab table with about a third of its length hanging over the edge. One student holds the meter stick down on the lab table, and the other flicks the free end to see how easily it bends and how much it vibrates.
2. Repeat Step 1 with a metal rod and a piece of cardboard. Based on your observations, rank the three objects from the most elastic to the least elastic. The harder an object is to bend and the more vigorously it snaps back to its original shape, the more elastic the material is. In the data table, use the numbers 1 to 3 to rank elasticity, with 1 being the most elastic.
3. Hold a ticking watch or clock to your ear. Note the ticking.
4. Hold a wooden meter stick so that one end is pressed gently against your ear. Have your partner hold the watch against the far end of the meter stick. Note whether you can hear any ticking. **CAUTION:** *Use great care when placing the meter sticks and rods near the ear. Pushing these objects against the ear could result in injury.*
5. Repeat Step 5, substituting the metal rod for the meter stick. Note any observations.

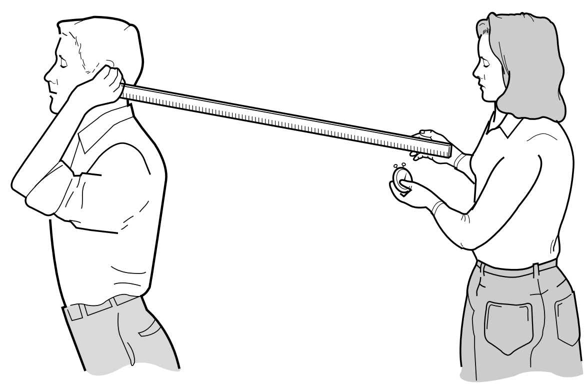

Figure 2

6. Repeat Step 5, substituting a piece of cardboard for the meter stick. Note any observations.
7. Change roles with your partner and repeat Steps 3 through 7. Discuss your observations with your partner and record them, again using the numbers 1 (best) to 3 (poorest) to rank how well each medium conducts sound.

Observations

DATA TABLE

Medium	Elasticity (1 = most elastic)	Sound Conduction (1 = best conductor)
Meter stick		
Metal rod		
Cardboard		

Analysis and Conclusions

1. **Forming Operational Definitions** What property of sound did you observe to determine if the medium was a good conductor?

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2. **Comparing and Contrasting** Compare wood, metal, and cardboard as sound transmitters, based on your observations. How do these compare with your prediction?

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3. **Making Generalizations** Based on your observations, what is the relationship between elasticity and the ability to conduct sound?

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4. **Applying Concepts** Suppose that you are floating outside a spacecraft with another astronaut. You wish to say something to your fellow astronaut, but your two-way radio is not working. How could you transmit a Morse code message by using sound waves?

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Go Further

Does elasticity affect the speed of a wave as well as the loudness (intensity) of the sound? Design an experiment to answer this question. Be sure to describe the responding and manipulated variables. Show your plan to your teacher. When your teacher approves your plan, carry out your experiment and report your results and conclusions.