The Echo Exterminator:
Sound Absorption by Materials

Challenge

A group of friends from the sixth grade decided to form a band – Sam is the drummer, Violet is the singer, and Jack plays bass guitar.

They wrote the songs, composed the music and spent hours practicing in Sam's large, empty basement. When it came time to record, everything was set up perfectly except for one thing – the echo, echo, echo….

Since they didn't have money to rent a studio, they decided to investigate everything they could about sound to try to solve the problem.

To prepare for your investigation:

1. Describe the phenomenon of an echo in your own words.
2. Propose a solution to the band's problem.
3. Propose a way to test your solution to see if it works.

What will we investigate?

We will use a Sound sensor to investigate the phenomenon of sound absorption, specifically how different types of materials absorb sound within an empty box.

Equipment and Materials

- einstein™Tablet+ or einstein™Labmate+™ paired with a tablet
- Sound sensor
- A sound source (must make a continuous tone which does not change in pitch or volume)

  440Hz.wav
- Roll of Velcro (both hook and loop sides) with adhesive backing
- Shoebox (with a cover)
- Adhesive tape
- 3 of the following materials
  - Toilet paper
  - Sponge
  - Felt
  - Styrofoam
  - Cotton Wool
  - Cardboard

Note: You must have enough of each material to cover the four inner walls of the shoebox.

Experimental Setup einstein™

Group Work

1. Turn on the einstein™Tablet+ or einstein™Labmate+™ paired with a tablet.
2. Tap the MiLAB ( ) icon to open the application.

Sensor Setup

Tap the **Setup** cog ( ) and use the table below to set up the measurement parameters:

Sensor:	Sound
Range:	65-110 dB
Rate:	25/Sec
Duration:	60 Sec

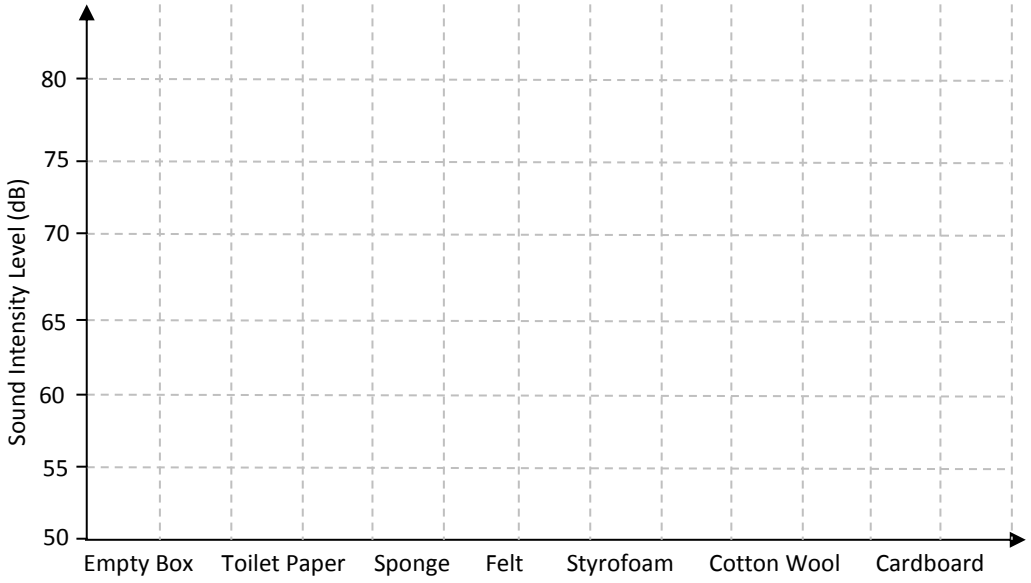
Before You Begin

1. Prepare a data table like the one below:

Sample Data Table

	Sound Intensity Level (dB) Empty box	Sound Intensity Level (dB) (Name of material)	Sound Intensity Level (dB) (Name of material)	Sound Intensity Level (dB) (Name of material)
First Measurement				
Second Measurement				
Third Measurement				
Average				

2. Prepare a bar graph like the one below which you will use to chart your measurements :



Experimental Procedure

Note: You must remain quiet while conducting this experiment

Empty Box

1. Place the sound source at one end of the shoebox - use the adhesive tape to fix it in place (see illustration below).
2. Place the Sound sensor at the opposite end of the shoebox - use the adhesive tape to fix it in place (see illustration below).

3. Connect the Sound sensor to the einstein™ device.
4. Activate the sound source and close the shoebox.
5. Tap the **Run** button ( ) to start recording the sound intensity level inside the box.
6. Save ( ) the results of the run.
7. Repeat this procedure 3 times.
8. Calculate the average sound intensity level of your sound source in the empty box. Record this value in the table you prepared and plot it on your bar graph.

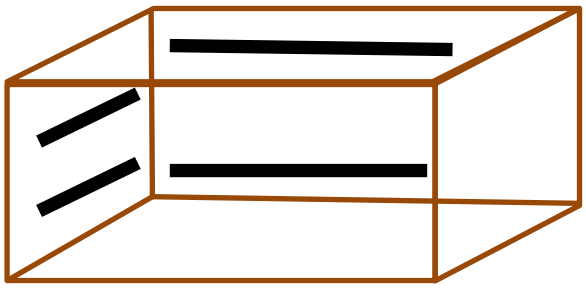
Make a Prediction

1. Choose three materials from the list above.
2. What do you think will happen to the intensity level of the sound source when the walls of the shoebox are lined with various materials?
3. Will the sound be more intense or less for each material you have chosen?
4. Choose one color for predictions and second color for your results and chart your predictions on the bar graph.

Test Your Materials

1. Measure the dimensions of the walls of the shoebox.
2. Cut sections of the materials you have chosen to measure so that you can completely line the inner walls of the shoe box.
3. Cut two strips of Velcro (both hook and loop) for each side of the box, according to your measurements.
4. Peel off the paper from the adhesive backing and stick the hook side of the Velcro to the four inside walls of the box, two strips per wall, one near the top and one near the bottom of the box, as in the illustration below.
5. Stick 8 strips of the loop side of the Velcro to the hook strips you have mounted in the shoe box (if they aren't already stuck on).
6. Peel off the paper from the adhesive backing of the Velcro and stick your first material to the loop side of the Velcro.
7. The walls of the shoe box should now be fully lined with the first material you plan to test.
8. Return the sound source and the Sound sensor to the shoe box if they are not there already.
9. Connect the Sound sensor to the einstein™-enabled device.
10. Activate the sound source and close the shoebox.
11. Tap the **Run** button ( ) to start recording the sound intensity level inside the box.
12. Save ( ) the results of the run.
13. Repeat this procedure 3 times.
14. Calculate the average sound intensity level of your sound source in the lined box. Record this value in the table you prepared and plot it on your bar graph.
15. Remove the first material from the walls of the shoe box.
16. Cut 8 more strips of the loop side of the Velcro and stick them to the hook side of the Velcro on the walls of the box.

17. Line the box with your next material and repeat the procedure as above.
18. Repeat again for the third material to be tested.



Understanding the Measurements

Compare the predictions you made about how the materials would affect the intensity level of the sound in the box with the measurements you made.
Discuss the following questions:

In Depth Learning

1. With which lining material was the sound most intense?
2. With which lining material was the sound least intense?
3. Of the materials your group tested, the best sound insulator was:
4. Compare your results to those of the other groups in the class. Rank each of the materials that was tested and make a list in which you put the materials in order from the most effective sound insulator to the least effective.
5. According to the class results, the best sound insulator was:
6. Complete the following sentence:

   A good sound insulator will **absorb/reflect** sound waves?

Using What You Learned

Let's return to the problem of the sixth grade band.
Now that you've studied which materials absorb sound, what can you recommend for the band to improve their basement recording studio?

Understanding the Science

People and animals use sounds as one of their means of communication with each other. Sounds travel through the air in waves. A sound begins with a vibrating object. The vibrating object causes the medium around it to vibrate, whether it is a gas, a liquid or a solid. In the example of the sixth grade band, the vibrating string of the guitar or the vibrating drum or the vibrating vocal chords cause the air molecules around them to vibrate. These vibrations travel through the air to your ears. The stronger the vibrations are, the louder the sound will be.

The sound waves travel away from the source until they reach an object. When the sound waves reach an object, like a wall, two of the possibilities are that the sound will be reflected off the object or be absorbed by the object. Materials which are smooth and hard are good at reflecting sound waves. Materials which are soft and textured are good at absorbing sound waves.
An empty room like the basement the sixth grade band was using will allow the sounds to bounce off the walls. The band will hear an echo when the sound bounces back to the band members. Concert halls are designed using materials which reflect sound and those that absorb sound in different parts of the room to make sure that everyone can hear clearly. The acoustics of a concert hall also depend on the furniture and the audience. The fabric of the audience's clothes absorbs some of the sound and prevents an echo.