SN EDUCATOR GUIDE

January 18, 2020

Saving Notre Dame's Sound

Activity Guide for Students: A World of Acoustics

Directions: During this activity, you will be making observations about how the volume of a sound changes as it travels in two different spaces. Use Part 1 of this guide to complete the experiment. Part 2 contains questions that you should answer in groups or at home, depending on your teacher's instructions.

First, you will perform the experiment in an open space. You will need to measure the size of the space, as well as make notes about the materials that cover the space and the number and types of objects, including people, in the space. You will also want to make a map of the space for your reference later — don't forget to include the location of the speaker, as well as a key and scale bar.

Students holding the decibel readers will stand around a speaker as your teacher plays a sound. Create a circle with a radius of 1 meter. When the teacher turns the speaker on, record the decibel meter's reading and your decibel meter's initial distance from the speaker (1 meter).

The value given by your decibel meters will likely fluctuate during use as small changes (such as background noise, the angles the meters are held, the movement of people and so on) affect what intensity of sound reaches the meters. Try to obtain readings that are as stable as possible, or record the value that best approximates a stable reading.

Your team will then slowly and carefully walk the decibel meter directly away from the sound source in a straight line (like outward rays). You will record the decibels for three additional distances: 2 meters, 4 meters and 8 meters. If you have to go around any objects, do your best to approximate the correct distances from the source.

You will record results at least twice at each distance and average the data for that distance.

You will then repeat the procedure (observations, mapping and decibel readings) in the smaller space with more objects.

Part 1: Experiment

1. What is the first location in which your teacher has indicated the experiment will be done? Give a brief description by filling in the following details.

Location:
Length of space:
Width of space:
Height of space (estimated):
Materials in space:
Objects within space:
People within space:
Brief summary of space:

2. Draw a map of the space and its objects (be sure to include the location of the speaker, other objects, a key and a scale bar).

3. Create a table to record your data for the location. Include the distances and decibel readings for four distances: 1 meter, 2 meters, 4 meters and 8 meters. Include rows for two trials and an average at each distance. After you've taken your decibel measurements at those distances, record your data in the table and calculate your averages. Be sure to write down the units you are using on your decibel meter and tape measure.

4. On your drawing of the space, indicate where your four decibel readings were taken.

5. What is the second location in which your teacher has indicated the experiment will be done? Give a brief description by filling in the following details.

Location:
Length of space:
Width of space:
Height of space (estimated):
Materials in space:
Objects within space:
People within space:
Brief summary of space:

6. Draw a map of the space and its objects (be sure to include the location of the speaker, other objects, a key and a scale bar).

7. Create a table to record your data for the location. Include the distances and decibel readings for four distances: 1 meter, 2 meters, 4 meters and 8 meters. Include rows for two trials and an average at each distance. After you've taken your decibel measurements at those distances, record your data in the table and calculate your averages. Be sure to write down the units you are using on your decibel meter and tape measure.

8. On your map of the space, indicate where your four decibel readings were taken.

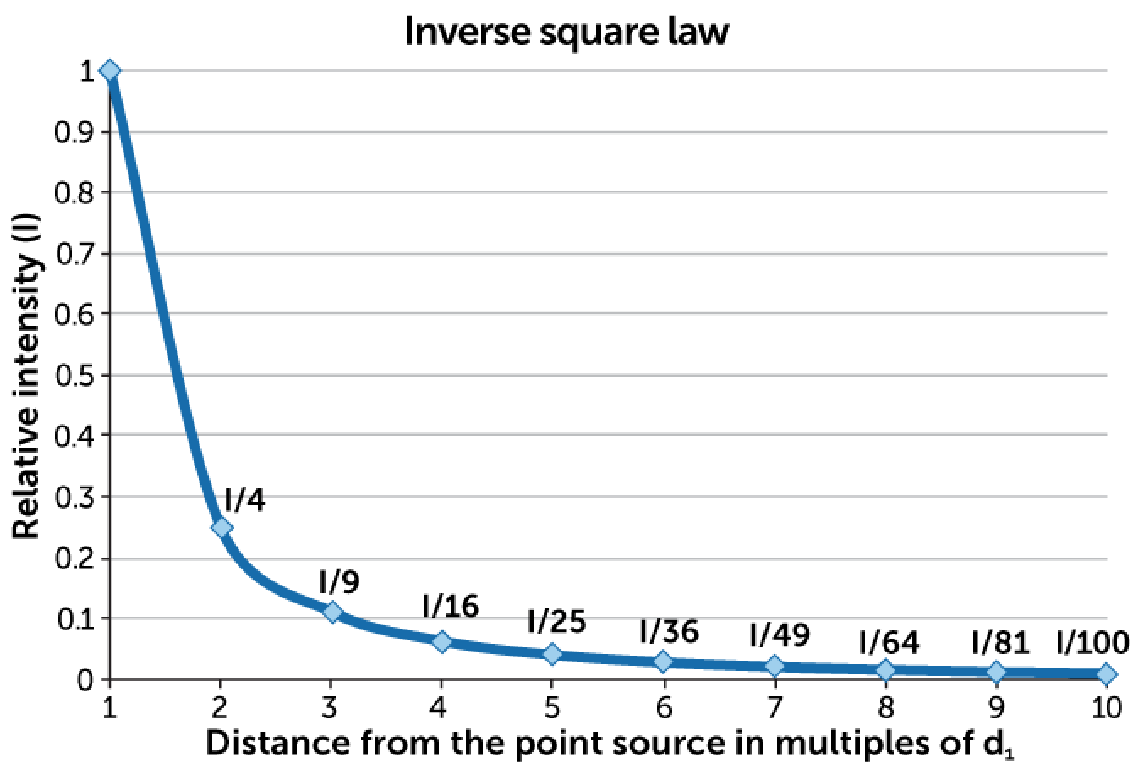
Part 2: Questions

Background questions

1. Sound waves are created by vibrations. The sound travels as particles crash into each other. What types of materials can sound travel through?

2. Why do you think your teacher played the same sound (same pitch and volume) for each trial in each space?

3. As sound travels in an open space, it spreads out in all directions. The energy twice as far from the source is spread over four times the area, therefore the sound wave has one fourth of the original intensity. In an idealized space, sound dissipation follows the inverse square law. A graph of the law is shown below.



From the graph, describe the equation of the inverse square law. How would you express the intensity of the sound (I) at some distance (d_2) relative to an initial distance (d_1)?

4. Based on the graph and your equation for the inverse square law, at what distance would you expect the intensity of the sound to be 25 percent of that at the original distance (d_1), 50 percent and 75 percent? Express your answers in terms of d_1.

5. The intensity level of a sound is expressed in decibels (dB). To estimate the theoretical intensity level in decibels at specific distances according to the inverse square law, you can use the following equation: $I_2/I_1 = [d_1/d_2]^2$, where I_1 is the intensity level in decibels at d_1, or distance 1, and I_2 is the intensity level in decibels at d_2, or distance 2. Using the given equation or a decibel calculator (this Hyperphysics page from Georgia State University has a decibel calculator), find the theoretical intensity levels in decibels for the sound at 2 meters, 4 meters and 8 meters from its source, based on your initial decibel measurement at 1 meter. Complete the calculations for both of your spaces.

6. How did your decibel readings in location 1 compare to the decibel readings predicted by the inverse square law calculations? Be sure to say whether the values were different and by how much.

7. Why do you think your readings at location 1 differed from the theoretical predictions made by the inverse square law?

8. How did your decibel readings in location 2 compare to the decibel readings predicted by the inverse square law calculations? Be sure to say whether the values were different and by how much.

9. Did your readings in location 2 differ from the predictions of the inverse square law more or less than your readings in location 1? Note any patterns you see in the data.

10. At which distance in location 2 did the intensity level most closely match the predictions of the inverse square law? At which distance in location 2 was there the greatest difference between actual and predicted values? Why do you think this is so?

11. Do the overall results match your expectations for the two spaces? Why or why not?

12. If you were tasked with adding a third location to this activity that gave intensity level readings that most closely matched those predicted by the inverse square law, what would be the characteristics of your space? What factors might you consider? What barriers might exist to designing such a space?