TEACHER'S GUIDE OBJECTIVES

Students should be able to

- explain the relationship between surface material and sound level.
- explain the relationship between surface structure and sound level.
- explain the relationship between surface texture and sound level.

EQUIPMENT

- 4x8 ft plywood
- screws, bolts, or nails
- tone-generating device (iPod, cell phone, tablet speaker connected to one of these devices with tone generator app)
- sound-measuring device (sound meter or cellphone/iPod with sound meter app)
- 6 in. 1x4 board

STUDENT ORIENTATION

The students must design sound-reducing surface coverings for the inside of an enclosure—your simulated building. The teacher supplies the enclosure that simulates a rectangular building with four walls, a floor, and a roof. The teacher provides both the dimensions of the enclosure and any design parameters—limitations for the thickness of surface treatments for the walls and ceiling. Once students have designed their surface coverings, they will then test them inside the enclosure.

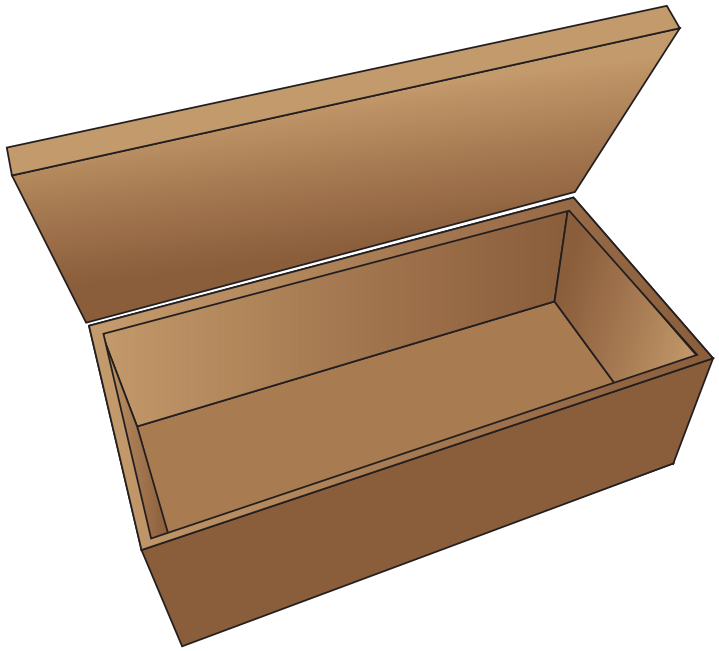
PREPARATION

1. Build the test enclosure.

   A 4x8 ft piece of plywood can be cut according to the following measurements to form the enclosure.

<table>
<tr><td>End Wall
24″ x 16″</td><td>End Wall
24″ x 16″</td><td rowspan="2">Roof
48″ x 24″</td></tr>
<tr><td colspan="2">Side Wall
48″ x 16″</td></tr>
<tr><td colspan="2">Side Wall
48″ x 16″</td><td rowspan="2">Floor
48″ x 24″</td></tr>
</table>

   These dimensions are approximate and will need to be adjusted based on the thickness of the plywood. For instance, if the two end walls are fastened between the two side walls, their width should be reduced by the thickness of the plywood on both sides. The walls should be fastened to the floor with screws or nails. Thinner plywood may require angle brackets and bolts to maintain the integrity of the enclosure. Thicker plywood such as 5/8 in. or 3/4 in. would require less bracketing, though the box would be much heavier and more cumbersome. The roof should be easy to remove while installing the surface covering and inserting both a sound-making device and a sound-measuring device.



2. Prepare the enclosure for the project.

   A tone-generating device should be placed in a central location at one end of the enclosure. It could be a cell phone with a tone generator app or a speaker connected to a cell phone, iPod, or tablet with a tone generator app. If the device is not fastened in place, there should be some type of marking so the location of the device is consistent. There should also be a marked location for the sound-measuring device at the opposite end of the enclosure. Holes may be drilled in the walls and ceiling so screws or bolts can hold the material in place. To prevent sound from traveling directly between the two devices, place the 1x4 board next to the sound-measuring device and between the devices. This will allow the sound-measuring device to capture more of the sound reflected off the walls and ceiling or off the student-constructed surfaces.

3. Divide students into groups of two to four.

PROCEDURE

Note: Students should record all notes, designs, data, calculations, analyses, and conclusions in a project log.

Plan the Design

1. Students should research materials for sound reduction, as well as the effect of loud sounds on hearing.
2. Students should measure the inside dimensions of the enclosure to determine the dimensions for their surface coverings.
3. Based on their research, the students should determine how to line the walls and ceiling of the enclosure. They can line the enclosure with almost any material as long as it is not thicker than stated by the teacher. The wall coverings' thickness may be different from that of the ceiling because more soundproofing material is often installed in ceilings than in walls. A 1–2 in. limit for the walls and 3–4 in. limit for the ceiling is reasonable.
4. Each student should choose a design for their coverings.
5. Each group should come to a consensus regarding the materials and design. The team will then construct their coverings.

Test the Design

1. Before installing the sound-reducing materials, the students should measure the sound level as a benchmark so they can determine the degree of sound reduction.

   The students will place the devices in their specified locations and start the appropriate apps. They will then install the roof and allow the measuring device to record for 15–30 s after the roof is installed. Students will record the baseline data and produce a graph of this data. Students will do this for all three assigned frequencies.

2. Allow teams to take turns installing their surface coverings and measuring the sound (three different tones) inside the enclosure.
3. Based on their results from Step 2, each team should make any necessary modifications to their surface covering and retest.
4. Teams should share their data with the other teams in the class. They should record the type of surface and results of each of the other teams.
5. Each team should discuss among themselves the reasons why the different designs performed the way they did.
6. Each team should reach a consensus as to which materials and design provide the best soundproofing in their notes. They should include any supporting information for their conclusions.

TEXTBOOK CONNECTIONS

- Fundamentals of Math—Ch. 6
- Pre-Algebra—Ch. 7
- Algebra 1—Ch. 3
- Algebra 2—Ch. 8
- Physics—Ch. 12
- Physical Science—Ch. 13
- Life Science—Ch. 22
- Biology—Ch. 23

CELL PHONE APPS

Measuring sound

iOS: Decibel 10th: Professional Noise Meter; dB ($0.99)

Android: Noise Meter; Sound Meter (data exportable); Sound Meter Pro; Physics Toolbox – Sound Meter

Producing sound

iOS: Audio Function Generator PRO; Signal Generator: Audio Test Tone Utility; Signal Gen-erator ($0.99); Tone Generator Ultra ($0.99)

Android: Physical Toolbox –Tone Generator; FuncGen Signal Generator; Signal Generator

ASSESSMENT RUBRIC

	4–Mastery	3–Competent	2–Emerging	1–Poor
Analysis	The relationship between variables is discussed. Trends or patterns are described and analyzed. Predictions are made regarding possible changes to surface coverings.	The relationship between variables is discussed. Trends or patterns are described.	The relationship between variables is discussed. No patterns or trends mentioned or predictions made.	The relationship between variables is not discussed.
Drawings/Diagrams	Choice of materials and designs show good understanding of sound absorption, adhere to all parameters, are easy to understand, and include all dimensions and material list.	Choices of materials and designs show good understanding of sound absorption, are easy to understand, and include most dimensions.	Choices of materials and designs show fair understanding of sound absorption, and dimensions are not included.	No choices of materials or designs present, or design is identical to that of another team member with minor tweaks. No dimensions of the enclosure included.
Calculations	All calculations are shown, and the results are accurate and correctly labeled.	Some calculations are shown, and the results are accurate and correctly labeled.	Some calculations are shown, and the results are labeled correctly.	No calculations shown, or they are inaccurate.
Conclusion	Evidence is cited to support the conclusion drawn from the activity, and possible reasons are given for errors or success.	Evidence is cited that supports the conclusion drawn from the activity.	What was learned from the experiment was stated.	No conclusions recorded; no evidence of reflection.
Organization/Appearance	Almost all entries are organized, neat, and easy to follow. Numbers, bullet points, and spaces are almost always used to separate different items.	Most entries are organized, neat, and easy to follow. Numbers, bullet points, and spaces are usually used to separate different items.	Some entries are organized, neat, and easy to follow. Many are not. Numbers, bullet points, and spaces are sometimes used to separate different items.	Entries are not organized or neat. Order is difficult to follow. Numbers, bullet points, and spaces are rarely used to separate different items.
Collaboration with Peers	Always listened carefully to others and offered detailed, constructive feedback. Participated fully and shared the workload fairly.	Usually listened to others and usually offered constructive feedback. Participated most of the time and usually shared the workload fairly.	Sometimes listened to others, occasionally offered constructive feedback. Participated but sometimes did not share the workload fairly.	Did not listen to others and often interrupted them. Did not offer constructive feedback. Did not participate and relied on others to carry the workload most of the time.