TEACHER'S GUIDE OBJECTIVES

Students should be able to

- explain sound conduction, reflection and amplification.
- design a sound amplifying device for a cell phone within the given parameters.
- conduct a controlled experiment to test the effectiveness of their device.
- explain the performance of their device within the context of other project parameters.

EQUIPMENT

- Tone-generating device
- Sound-measuring device
- Hot glue gun
- Scissors
- Tape (clear, masking, duct)
- Utility knife
- Paper & plastic cups (various sizes)
- Cardboard rolls, bath tissue and paper towels
- Potato chip can
- Posterboard
- Paper
- Pushpins
- Paper clips
- Paper clamps
- Squares of cardboard
- Plastic bottles, 16 oz, 20 oz, and 2 L
- Shoebox
- Facial tissue box

STUDENT ORIENTATION

The volume (amplitude) of sound is related to the energy of the sound wave. Electric amplifiers add additional energy to the wave produced. As the wave travels, its amplitude decreases in accordance with an inverse square law. In other words, when the wave travel distance doubles, its amplitude reduces to 1/4 of its previous value. Alternatively, if you move closer to the source by cutting your original distance to 1/3, then the volume will be 9 times greater. Students have to design a non-electrical device that will increase the sound at a specified distance. Above are some suggested materials. You can add or subtract from this list. Students will test their devices and analyze the effectiveness of their devices.

PREPARATION

1. Gather enough of the listed materials so each team will have the same supplies. Decide if you will allow other materials. If students want to use other materials, you need to approve them.
2. Mark locations for tone-generating device (regular tone generator or cell phone with tone generator app) and the sound-measuring device (sound meter or cell phone with sound measuring app) so that the same distance between the two will be consistent for each team. Constructed devices are limited to 12 in. cubed, so factor that into device placement.
3. Determine the frequencies that they will test. Have the students test at three different frequencies (low, medium, and high).
4. Determine the volume level for the sound producing device by setting the two devices at the marked locations and adjust the volume to get the desired reading at the sound measuring device. For example, you may selected the criteria of the tone registering 40 decibels at 3 m.
5. Divide students into teams of 2–4.

PROCEDURE

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

Planning the Device

1. Have the students research sound conduction, reflection, and amplification. Allow the students to familiarize themselves with the available materials and conduct tests with the different materials.
2. Each student should draw up a design for his or her device. Teams should discuss and record their ideas before coming up with a consensus on a design.
3. Let the teams construct their amplification devices.

Testing the Device

1. The students will confirm baseline data by setting up and adjusting the tone-generating device and sound-measuring device.
2. Have students install their amplification device and test their device. Make sure they test all three frequencies.
3. After testing their devices, the teams will individually calculate the effectiveness of their device. Let them decide how to calculate the effectiveness. You may need to offer some suggestions, such as change in sound level or percent change in sound level, but they may come up with other measures of effectiveness.
4. Have the teams discuss their device's performance and make modifications as needed.
5. Have teams retest their device.
6 Have the teams share their average effectiveness data with the other teams and analyze their device's effectiveness.

   If this is conducted by physics students, you may want to have them relate decibels to loudness and intensity of sound.

TEXTBOOK CONNECTIONS

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

CELL PHONE APPS

Measuring sound

iOS: Decibel 10th: Professional Noise Meter; dB ($.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 Generator ($1.99); Tone Generator Ultra ($1.99)

Android: Physics 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 performance and changes to design.	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	Designs show good knowledge of sound properties, are easy to understand, and are labeled properly (including materials).	Designs show good understanding of sound properties, are easy to understand, and are partially labeled.	Designs show fair understanding of sound properties, but they are somewhat confusing.	No designs present or design is identical to that of another team member with minor tweaks.
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.