



# Science and Innovation

A Boeing/Teaching Channel Partnership

## DESIGN A QUIETER CABIN Teacher Handbook



TeachingChannel®

## Design a Quieter Cabin

### Day 6: Sounds Passengers Are Most Sensitive To

Grade Level	Early Middle School (Grade 6)
Lesson Length	One 50-minute session (if possible, consider adding another day)



#### Lesson Overview

Students participate in a variety of activities focusing on how humans receive sound input. Students design and conduct an investigation to answer the question, *Do we hear all pitches at the same volume?* Students figure out that humans hear certain pitches better than other pitches. Students revise their design criteria to include the idea that the airplane cabin only needs to block certain pitches.



#### Connecting to the Next Generation Science Standards

On Day 6, students make progress toward developing understanding across the following three dimensions:

- **Science and Engineering Practices:** Planning and Carrying Out Investigations
- **Disciplinary Core Ideas:** ETS1.A Defining and Delimiting Engineering Problems, LS1.D Information Processing
- **Crosscutting Concepts:** Structure and Function

In the following table, the specific components addressed in this lesson are underlined and italicized. The specific connections to classroom activity are stated.

Performance Expectations
<p>This lesson contributes toward building understanding of the following <i>engineering</i> performance expectations:</p> <p><u><a href="#">MS-ETS1-1</a>. Define criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.</u></p> <p>This lesson contributes toward building understanding of the following <i>life science</i> performance expectations:</p> <p><u><a href="#">MS-LS1-8</a>. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.</u></p>
<p><b>Specific Connections to Classroom Activity</b></p> <p>On Day 6, students explore the science of hearing. Students figure out that sensory receptors in the ear respond to sound waves by sending messages to the brain. In addition, students design an investigation to determine if humans hear all pitches at the same volume. Students realize that humans hear certain pitches as “louder” than others, even when they are played at the same volume. Students add the idea that only certain pitches need to be blocked by the airplane cabin wall to their criteria list.</p>

Dimension	NGSS Element	Connections to Classroom Activity
Science and Engineering Practices	<b>Planning and Carrying Out Investigations</b> <ul style="list-style-type: none"> <li><u>Conduct an investigation to produce data to serve as the basis for evidence that meets the goals of an investigation.</u></li> </ul>	Students plan and carry out an investigation to answer the question, <i>Do we hear all pitches at the same volume?</i>
Disciplinary Core Ideas	<b>ETS1.A: Defining and Delimiting Engineering Problems</b> <ul style="list-style-type: none"> <li><u>The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge likely to limit possible solutions.</u></li> </ul> <b>LS1.D: Information Processing</b> <ul style="list-style-type: none"> <li><u>Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.</u></li> </ul>	<p>After figuring out that humans hear some pitches better than others, students are able to further refine their design problem. Students add that only certain pitches, not all pitches, need to be blocked from the airplane cabin.</p> <p>Students figure out how the human ear “feels” sound waves and how the message from sound waves is transmitted to the brain.</p>
Crosscutting Concepts	<b>Structure and Function</b> <ul style="list-style-type: none"> <li><u>Structures can be designed to serve particular functions by taking into account properties of different materials and how materials can be shaped and used.</u></li> </ul>	Students relate the structures in the inner ear to their hearing functions.



## Basic Teacher Preparation

This lesson presents the fundamental science of hearing. Review the videos listed in the **Suggested Teacher Resources** prior to the lesson.

Review the [Talk Science Primer](#) to prepare for leading class discussions.

Refer to the **Design a Quieter Cabin Student Handbook** ahead of time so you can address any questions students might have. The Day 6 document can be found on page 9 in the **Design a Quieter Cabin Student Handbook**. The document used in this lesson is:

- Do We Hear All Pitches at the Same Volume? (page 9)

Required Preparation	Links/Additional Information
<input type="checkbox"/> Gather or purchase the required materials for the lesson	Refer to the <b>Materials List</b> below
<input type="checkbox"/> Review suggested teacher preparation resources	Refer to the <b>Suggested Teacher Resources</b> at the end of this lesson



## Materials List

Item	Description/Additional Information	Quantity	Where to Locate/Buy
Computer	To use the Online Tone Generator ( <a href="http://onlinetonegenerator.com">onlinetonegenerator.com</a> )	1 per team, if possible	Available in most schools

## Day 6: Sounds Passengers Are Most Sensitive To



### Introduction (5 minutes)

Reference the Driving Question Board, and add the question, *What sounds are passengers most sensitive to?* At this point in the module, students should have a good sense of how airplane engines produce sound and how sound travels through cabin walls into airplanes. Tell students that their goal now is to figure out how humans hear sound and what sounds passengers are most sensitive to.



### Mini-Lesson: Do We All Hear the Same Sounds? (15 minutes)

Ask students if they think that all humans hear the same sounds. Students might suggest that younger people can hear more than older people.

Show the [How Old Are Your Ears? \(Hearing Loss\)](#) video about frequency and hearing loss to the class. Have students raise their hand when they can hear the tone played in the video. Engage the class in a discussion about the video. Ask students to consider the question:

- *Why are higher pitches more difficult to hear than lower pitches?*

To answer the question about pitches, show the [Auditory Transduction \(Ear Physiology\)](#) video about the composition of the ear, and then discuss the video as a class. Focus on the first 2 minutes of the video, but show all of the video if time permits. Focus specifically on the following prompts:

- *How are sound waves converted into messages that our brain understands?*
- *Why are high pitches more difficult to hear than low pitches?*



#### Video Links

- ▶ How Old Are Your Ears? (Hearing Loss) [YouTube Link](#)
- ▶ Auditory Transduction (Ear Physiology) [YouTube Link](#)



#### NGSS Key Moment

This investigation marks a key moment in the development of MS-LS1-8. Students learn that sound waves cause structures in the ear to move, which sends a signal to the brain.



## Investigation: Do We Hear Pitches at the Same Volume? (15 minutes)

Ask students if they think that we hear all pitches at the same volume. Accept all ideas. Tell students that they are going to design an investigation to test their hypotheses.

Demonstrate the [online tone generator](#) by changing the pitch and the volume.



### Web Resource

▶ Online Tone Generator [\[Web Link\]](#)

Instruct students to meet with their design teams to design an investigation to answer the question, *Do we hear all pitches at the same volume?*

Give students enough time to design an investigation and test their hypotheses. Students should record their investigation and results on page 9 in the **Design a Quieter Cabin Student Handbook**.



## Whole Group Discussion: Do We Hear Pitches at the Same Volume? (10 minutes)

After students conduct their investigation, gather students into circle for a whole group discussion. Have students share their investigations and findings. In general, students should have noticed that some pitches sound louder than others, even when they are played at the same volume. Ask students why they think our brains hear some pitches louder than others. Guide students to the idea that humans have a range of pitches that they hear better than others. Have students consider why this is an advantage or a disadvantage.

Relate the discussion back to the design challenge. Ask students what their findings tell them about their design challenge. Students should recognize that they don't need to block out all sounds from the airplane engine. Rather, they need to block out sounds that humans are most sensitive to. Add this idea as an additional criteria for the design problem.



## Lesson Close (5 minutes)

Reference the lesson question on the DQB, *What sounds are passengers most sensitive to?* Ask students if they think they made progress in answering the question. Tell students to record their progress on sticky notes. They should answer the question with as much evidence as they can. When students are finished, have them read their sticky notes out loud to the class and post them to the DQB.

Listen to students read their sticky notes, and/or read the sticky notes that students post to assess their progress in answering the questions on the DQB.



### Extension

As an optional extension, consider having students read about human perceptions of sound in airplane cabins in an article called “Sound of Silence” published by Boeing. [\[Web Link\]](#)



### Assessment

Several opportunities for formative assessment exist in this lesson:

- **Design a Quieter Cabin Student Handbook** entries can be used to monitor student progress during the module. Focus specifically on student-developed investigations and results on page 9.
- Consider gathering evidence of student progress through small group and whole group discussions.
- Student contributions to the Driving Question Board can also be monitored.

Use the identified assessment opportunities to monitor student progress on disciplinary core ideas, science and engineering practices, and crosscutting concepts. Provide appropriate supports or extensions when necessary. Reference **Appendix B** for suggestions for meeting the needs of all learners.



### Community Connections

If any students have family members who work as musicians, engineers, or doctors, invite the family members into the classroom to assist as volunteers or to share their work experiences related to sound and the biology of hearing.



### Suggested Teacher Resources

Meeting the Needs of All Learners	Design a Quieter Cabin Teacher Handbook, Appendix B
Design a Quieter Cabin Student Handbook	<a href="#">[Resource Link]</a>
Talk Science Primer	<a href="#">[Web Link]</a>
Online Tone Generator	<a href="#">[Web Link]</a>
How Old Are Your Ears? (Hearing Loss)	<a href="#">[YouTube Link]</a>
Auditory Transduction (Ear Physiology)	<a href="#">[YouTube Link]</a>
Boeing: Sound of Silence	<a href="#">[Web Link]</a>