



Sound Effects

Principles of Sound

Suggested Grades: 6-8

Activity Overview

In this activity, students will learn about the principles of sound, specifically, how to amplify and reduce sound volume. Students will construct a speaker to amplify the sound and then will be challenged to find a solution to reduce the perceived sound volume.

Steps*

1. Students should be familiar with the basics of sound. Introduce the topics of noise pollution and ways NASA quiets aircraft noise, including chevrons.
2. Divide students into teams of 2-3 and assign job duties. Suggestions include:
3. Project Manager – Oversees the design, ensures design parameters are followed, keeps track of time, coordinates decision-making.
4. Lead engineer – Leads activity device construction.
5. Lead scientist – Takes measurements, assesses devices for any defects, and tests devices
6. Find the center of the paper towel roll and trace the end of your phone with a pencil. Use scissors to cut out the shape and make sure your phone fits snug into the cutout.
7. Trace the end of the paper towel tube on the sides, near the bottom, of the two plastic cups.
8. Cut out the holes you traced and insert ends of paper towel roll into each cup (See Figure A).
9. Play a consistent sound on the phone (i.e. white noise), listen carefully to the volume of the noise. Then insert the phone into the paper towel roll and note the difference in the sound volume.
10. If a sound meter and/or an oscilloscope are available, give students several minutes to practice using them. Discuss the “Common Sound Levels” chart on the next page.
11. Now challenge students to design a muffling device that can quiet the noise coming from the two cups, which represent the engines of an aircraft.
12. Have the teams brainstorm ideas and construct their devices. Remind students to leave an opening in their device to allow for engine exhaust.
13. Have students test their muffling devices utilizing a sound meter. Give students a chance to discuss how well their muffling devices worked and allow them to make improvements.
14. As a class discuss your results and the obstacles each team faced.
15. Compare the muffling devices to chevrons. The students’ muffling devices changed the sound by utilizing the shape and type of materials, whereas chevrons smooth the temperature difference between the air coming out of the engine and air outside to quiet sound. Conclude the activity by letting students know that the design, testing, and implementation of actual aircraft chevrons took over a decade to complete, and that ongoing research is still being conducted on reducing aircraft noise.

Time: 60 minutes

Materials:

- Paper towel tube
- Two disposable plastic cups
- Scissors
- Tape
- Miscellaneous Materials: (i.e. Styrofoam cups, paper, cardstock)
- Smartphone or similar device

Suggested items:

- Sound (Decibel) meter*
- Oscilloscope*
*app versions available

NEXT GENERATION SCIENCE STANDARDS

- K-2-ETS1-3
- 1-PS4-1
- 3-5-ETS1-3
- 4-PS3-2
- MS-PS4-2
- MS-ETS1-4



Figure A. Constructed speaker system with phone.

Background Information

Since the 1960s, NASA engineers have worked to reduce aircraft noise that can be generated from many different sources. Although most of that noise comes from engines, other noise-generating airplane components include the landing gear, where the engines and airframe or body meet, as well as “high lift devices” such as wing flaps.

NASA research has produced a variety of technology solutions, including seamless, acoustic duct liners to keep sound from bouncing off seams inside the engine inlet, and the use of asymmetrical chevrons, scalloped or serrated edges, surrounding the engine core and exhaust. Reducing fan speed and exit velocities on nozzles will also reduce generated noise levels.

The **chevron** is a noise-reducing technology NASA helped to develop that is now being used on commercial jet engines.

A chevron is a sawtooth shape designed into the ends of the casing around the outside of the jet engine and/or into the interior engine nozzle itself. (See Figure B on first page). The noise we hear from jet engines mainly comes from turbulent air created by two streams of air – one hot and one cold – mixing at the back of the engine. The air coming out of the jet engine itself is extremely hot, while the air flowing around the outside of the engine case is much cooler. When the stream of hot air leaving the inside of the engine meets the stream of cooler air from outside the engine, the air becomes turbulent and noise happens!

NASA discovered that the chevrons can smooth out the point where the two air streams meet, reducing turbulence and therefore the noise.

Since the beginning of chevron development, many different styles and shapes have been tried and used. Earlier chevrons had a more symmetrical shape. As you can see from Figure B the chevron shape looks the same all the way around. However, as chevron technology has matured, some newer designs have a less symmetrical shape. Figure C shows chevrons on the engine casing and the nozzle; the chevrons on the top of the casing are deeper than those on the bottom.

For more information, please visit the following website:
<https://www.nasa.gov/sites/default/files/atoms/files/chevrons-educator-guide-v5.pdf>

Silencing the Sound of Supersonic Aircraft

For the first time in decades, NASA aeronautics is moving forward with the construction of a piloted X-plane, designed from scratch to fly faster than sound with the latest in quiet supersonic technologies. This mission – originally known as the Low-Boom Flight Demonstrator, now the X-59 Quiet SuperSonic Technology – will be to demonstrate the ability to fly supersonic, yet generate sonic booms so quiet, people on the ground will hardly notice them, if they hear them at all.

The answer to how the X-plane's design makes a quiet sonic boom is in the way its uniquely-shaped hull generates supersonic shockwaves. Shockwaves from a conventional aircraft design coalesce as they expand away from the airplane's nose and tail, resulting in two distinct and thunderous sonic booms. But the design's shape sends those shockwaves away from the aircraft in a way that prevents them from coming together in two loud booms. Instead, the much weaker shockwaves reach the ground still separated, which will be heard as a quick series of soft thumps – again, if anyone standing outside notices them at all.

For more information please visit the following website:
<https://www.nasa.gov/lowboom/new-nasa-x-plane-construction-begins-now>

For more information and activities relating to sound, please visit:
<https://www.nasa.gov/aeroresearch/stem/seeing-sound>

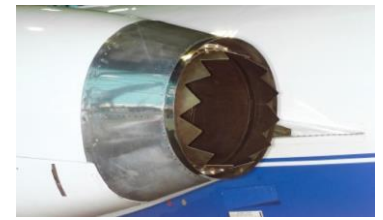


Figure B. An early chevron test article inside an engine nozzle



Figure C. Final asymmetrical shape—in place on engine casing and nozzle.

More Information:

NASA web story on chevron research:
https://www.grc.nasa.gov/WWW/Acoustics/testing/facilities/NATR_chevron.htm

NASA video on chevrons with researcher James Bridges:
<https://www.youtube.com/watch?v=xnjlFKNaICg>

NASA Tests Tech to Make Airplanes More Quiet:
<https://www.nasa.gov/press-release/nasa-technologies-significantly-reduce-aircraft-noise>

Common Sound Levels

Jet plane at takeoff	110-140dB
Loud rock music	110-130dB
Chain saw	110-120dB
Thunderstorm	40-110dB
Vacuum cleaner	60-80dB
Normal voices	50-70dB
Whisper	20-50dB
Purring cat	20-30dB
Falling leaves	10dB
Silence	0dB