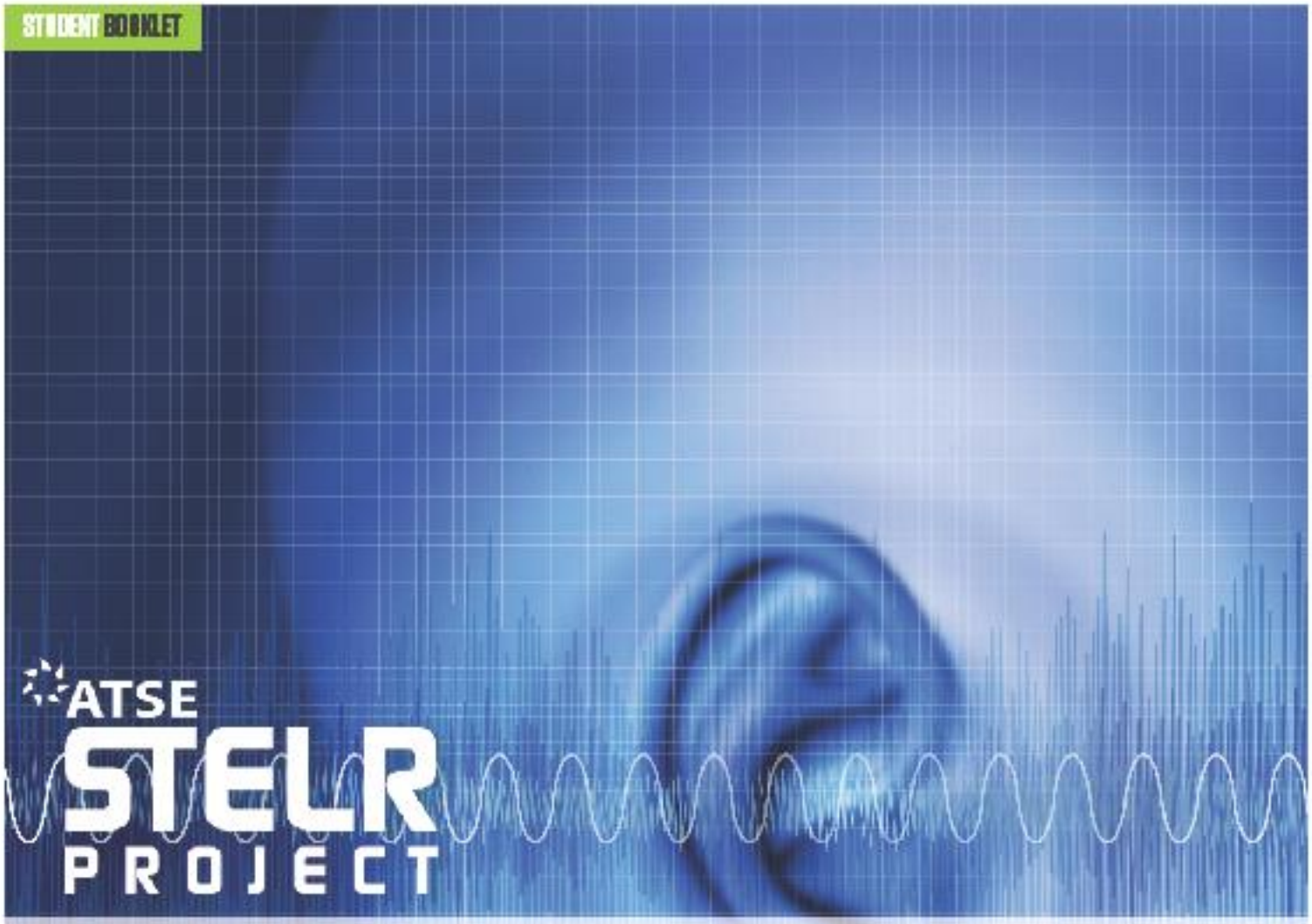
STUDENT BOOKLET



ATSE

STELR PROJECT

SENSING SOUND

CONTENTS

INTRODUCTION

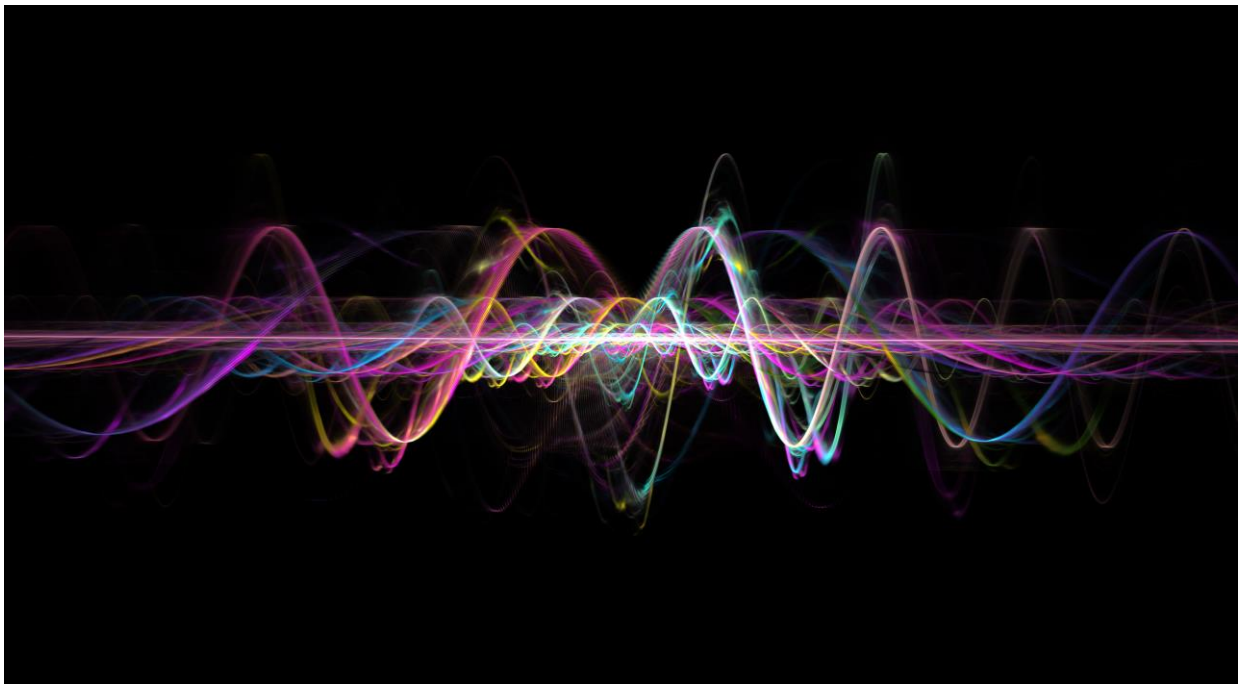
This unit introduces sound and hearing in the context of to health and technology. It highlights key ideas in physics and biology as they relate to sound, connects to the Australian National Curriculum, and focuses on the Australian context where possible. Each module contains online learning activities, videos, simulations, small and large group discussions, and practical activities. This unit begins with a survey to assess your prior knowledge, and includes end of unit projects and a career section.

- Survey: What I know about sound and hearing
- Sound and Hearing Word Cloud

Your first task in this topic is to complete this survey, which is designed to find out what you currently know about sound and hearing.

SURVEY: WHAT I KNOW ABOUT SOUND AND HEARING.

Before getting started with the activities, complete this short survey. It will help evaluate what you already know and get you thinking about the upcoming lessons. Choose the best answer for each question.



1. Sounds are made of

☐ electrical impulses.

☐ vibrations.

☐ All of the above.

☐ I don't understand the question or I am not sure.

2. Sound travel fastest in

☐ a solid.

☐ a liquid.

☐ air.

☐ I don't understand the question or I am not sure.

3. You can see and hear lightning at the same time.

☐ True

☐ False

4. Hearing loss is caused by:

☐ loud music.

☐ a virus or a disease.

☐ hereditary factors.

☐ All of the above.

☐ I don't understand the question or I am not sure.

5. Most sounds are heard by humans as

☐ vibrations.

☐ resonance.

☐ frequency.

☐ kinetic Energy.

☐ I don't understand the question or I am not sure.

6. It is possible to hear sounds in Space.

☐ True

☐ False

7. Humans can detect sounds in this range:

☐ 0-60 decibels

☐ 0-120 decibels

☐ 0-150 decibels

☐ 20-80 decibels

☐ I don't understand the question or I am not sure.

8. Having 2 ears helps humans to detect

☐ loudness of a sound.

☐ pitch of a sound.

☐ direction of sound.

☐ frequency of a sound.

☐ I don't understand the question or I am not sure.

9. Damage to hearing is permanent.

☐ True

☐ False

SOUND WORD CLOUD

Question 1. Your task will be to create a SOUND word cloud. You can use Wordle or Word It Out, by clicking on one of the programs below. Paste your word cloud in the space below.

www.wordle.net
www.worditout.com

Question 2. Sound and Hearing exist in our everyday lives and can be described through our everyday experiences and at a scientific level. Construct a mind map to identify all the ideas and concepts you know about **Sound and Hearing.**

THE SCIENCE OF SOUND

- The Physics of Sound: Source
- The Physics of Sound: Travel
- The Biology Hearing

Explore the physics and biology of hearing through online videos, activities, practical investigations, role-plays, and discussions.

KEY IDEAS

Key Ideas about how sound is made:

- The production of sound requires an object to vibrate.
- Sound is a travelling vibration that requires a medium (e.g., air, water or solid objects) to travel in. Sound can't travel in space.
- Sound can vary in pitch (or frequency) and loudness.
- The pitch (or frequency) of sound is related to the speed of vibration of the sound source. The more vibrations per second, the higher the pitch.
- The loudness of sound is related to the size of vibration of the sound source: the larger the size of vibration, the louder the sound.

Key Ideas about how sound travels:

- Sound is the transmission of kinetic energy from particles in the source to particles in the medium in which the sound travels.
- Sound travels as a travelling disturbance (wave) due to collisions in the material in which it moves.
- Soundwaves are disturbances called longitudinal waves; the particles in the material vibrate forwards and backwards in the forward-moving wave direction.
- Sound is pressure waves of compressions (high pressure) and rarefactions (low pressure) travelling away from a vibrating source.

Key Ideas about the biology of sound:

- Speaking and hearing are resonance effects. The mouth and nose cavity acts as a resonating chamber for speech; the ear canal acts as a resonating chamber for hearing.
- We use two ears to judge the direction of a sound source.
- Humans can detect sounds within a range of 0-120 decibels.

THE PHYSICS OF SOUND: SOURCE

Sound is a type of energy created when something vibrates. The size and speed of the vibration affects the loudness and the rate at which sounds travels. Sound also needs to travel in a medium (i.e., a solid, a liquid, or a gas) so that the waves can move through something.

Watch the video below and answer the following questions.

Vibration in a Ruler
www.youtube.com/watch?v=dDshiu5um9g

Activity 1: Vibrate a ruler at the end of a table and compare what happens when you change the length of the ruler that extends past the table.

Question 1: Discuss what happens to the sound when you change the length of the ruler that extends off the table. Write this relationship in one sentence.

Activity 2: Explore how sound travels through different media. In this activity you will compare how sound travels in a solid verses a gas by tapping your finger on your desk. In pairs, you will be taking turns tapping your finger on the desk and listening through two different media: the air and the table.

Question 2. Use the table below to record your observations.

Table: Sound traveling through a solid and a gas

Trial	Observation
Hearing the tapping through the air	
Hearing the tapping through the table	

Question 3: Describe which states of matter are represented by the air and table.

Question 4: Discuss with your partner any differences in sound between the two trials. Discuss what you think is happening and why. Record your ideas.

THE PHYSICS OF SOUND: TRAVEL

Sound needs a medium (i.e., a solid, a liquid, or a gas) through which the waves can move. While you are watching the video below, write down three key points about how sound travels.

Transmission of Sound
www.youtube.com/watch?v=GkNJvZINSEY

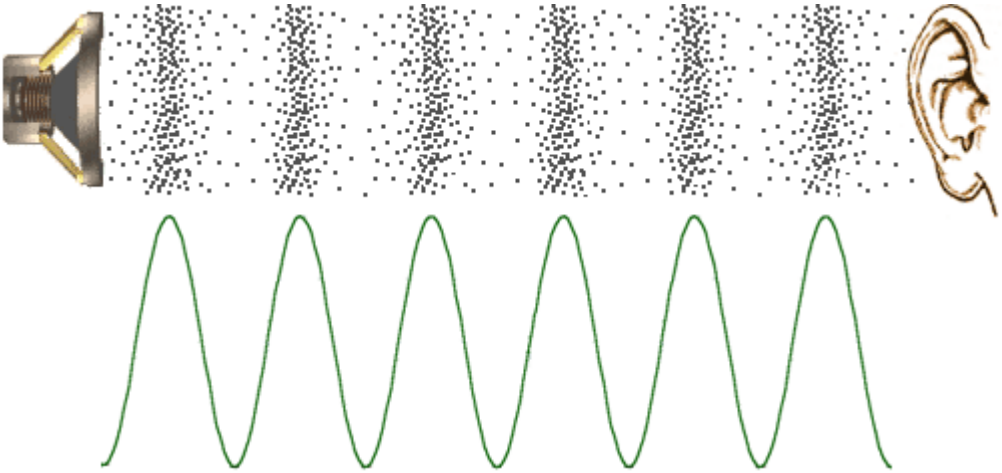
Question 1: Discuss your three key points with your partner and record your ideas below.

Question 2. Using a slinky, demonstrate how sound travels as transverse and longitudinal waves. Draw a diagram comparing them.

Question 3: Discuss the difference in how the particles vibrate in transverse and longitudinal waves and record your ideas below.

Question 4: Draw an annotated diagram to represent what the particles look like as sound moves as a longitudinal through a solid compared to how they would move through air.

Activity: Creat a role-play demonstrating how sound travels.



Role Play: In groups of 4-6, design a role-play showing how sound travels from a source of vibration (e.g., a loudspeaker) to the human ear. Ask your teacher for some hints for your representation. Once your initial Role-Play model is completed, address the following challenges: Compare how sound would travel through a table verses in air. Remove the particles in your model and determine if sound can be transmitted.

Question 4: Discuss with your group the strengths and weaknesses of role-play demonstrating how sound travels, and record your ideas below.

THE BIOLOGY OF HEARING

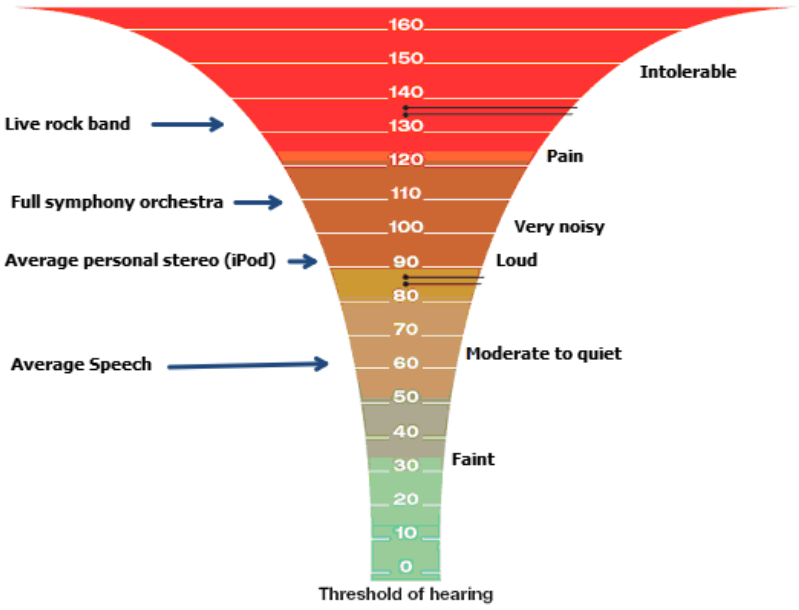
Hearing takes places when sounds waves are detected by your ear as changes in the air pressure, vibrate on your eardrum, causing nerve cells to be activated and interpreted by your brain as sound. Our ears help us detect sounds, and we are sensitive to a certain frequency range. While you are watching the video below, notice how concepts of physics and biology are used to explain sound detection. Write down three key points about how the human ear detects sounds.

How we Hear
www.youtube.com/watch?v=flIAxGsV1q0

Question 1: Compare your key points with your partner and record your ideas below.

HUMAN HEARING

The range of human hearing is related to the hair cells in the cochlea. Draw an annotated diagram to represent this range, showing the the base (highest frequency) to the apex (lowest frequency). Include a scale of the range of frequency in Hertz.



Question 2: The intensity of sound is measured in decibels. Animals have varying abilities to detect sounds in their environment, with human having a range of 0-120 decibels and an ability to detect changes of intensity at 1 decibel. Review the diagram to the left and notice the various thresholds of hearing for humans. Discuss with your partner the highest intensity you have experienced and record your ideas below.

Question 3: While age is a factor for hearing loss, sounds damage hearing over time. The amount of damage that occurs depends on how long the sound it and how long you listen for. Use the internet to research at least three other ways that hearing loss occurs. Summarize your ideas below.

SOUND AND HEARING

- How well do you Hear?
- Design Challenge

Explore the limitations of humans hearing and what you can do to improve your hearing health. Participate in a Design Challenge, integrating principles in physics and biology to design the ideal space for sound.

KEY IDEAS

- Humans have a specific range of hearing (i.e., from 0-120 decibels) due to the physical structure of their inner ears.
- Hearing loss is permanent and can only be improved with use of hearing aids and/or cochlear implants.
- Hearing damage is effected by degree of loudness and length of exposure to loud sounds.
- There are a number of ways to ensure safe hearing.
- Hearing aids amplify sounds.
- Cochlear implants restore hearing.

TEACHER'S NOTES

The **Design Challenge** allows students to explore a specific scenario and apply scientific principles in their design. As an extension, students represent how their design features operate at a molecular level, depicting how sound travels through different materials. They may present their final project in a variety of media.

HOW WELL DO YOU HEAR?

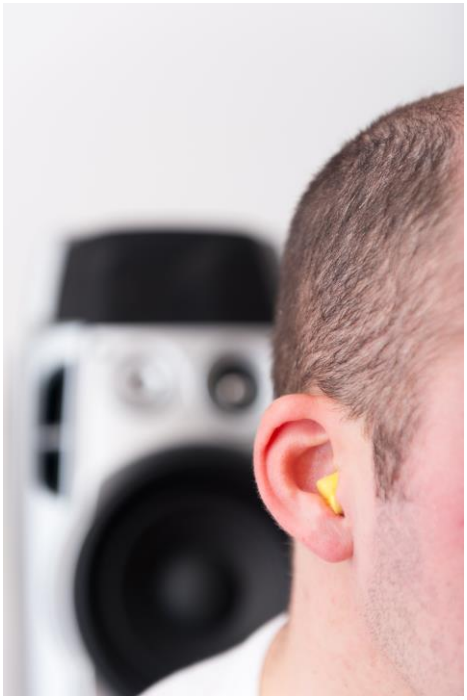
Start with a quick hearing test! The video below introduces you to a range of frequencies, from high to low. Watch the video and hit the stop button as soon as you are able to detect the sound. Try this at home with your parents and grandparents to compare the frequencies everyone can detect.

VIDEO **Hearing Test Simulator**
www.youtube.com/watch?v=h5l4Rt4Ol7M

Beyond a certain range, hearing becomes uncomfortable and prolonged exposure to loud sounds can cause damage to the delicate hair cells in the cochlea. Over time, we tend to lose our sensitivity to sounds, and this can be accelerated by overexposure to loud noises. View the video below to learn how our detection of sound frequencies can change over time.

VIDEO **How Old are your Ears?**
www.youtube.com/watch?v=VxcbppCX6Rk

Question 1: While age is a factor for hearing loss, exposure to loud noise damages hearing over time. The amount of damage that occurs depends on how long the exposure is. Use the internet to research at least three other ways that hearing loss occurs. Summarize your ideas below.



Protecting Your Hearing: Professor Peter Blamey and Dr. Elaine Sauders have made extraordinary contributions to the field of hearing. Together they combine research development and innovation to produce hearing aid technologies.

Question 2: Review the information on this website and write down two additional things you can do to protect your hearing:

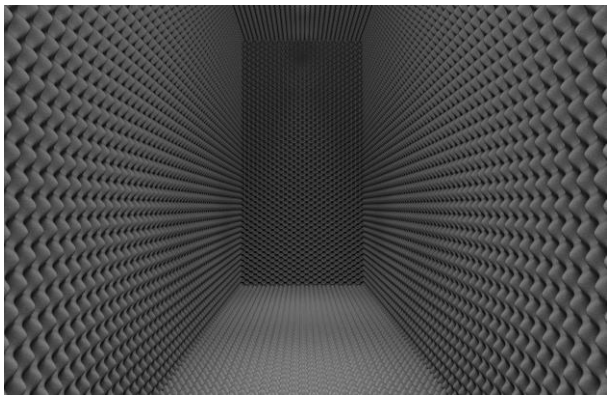
www.blameysaunders.com.au/advice/hearing-damage

Question 3: Review the table, connecting sound level to exposure limit per day. Choose three different activities you would engage that involve exposure to sound over average speaking levels (i.e., 60 dB). Use the internet to determine the sound levels for those activities. Examples might include: listening to music using headphone, playing a musical instrument, attending a concert). (Thorne 2006, Hodgetts et al 2007)

Sound Level	Exposure Limit per Day
85 dB	4 hours
91 dB	2 hours
94 dB	1 hour
97 dB	30 minutes
100 dB	15 minutes
103 dB	7.5 minutes
106 dB	3.75 minutes

Activity	Exposure Limit per day (h)	Sound Level (dB)

Question 4: For each of the activities you regularly participate in, determine whether the sound level is in the safe zone. Discuss with your partner on strategies to minimize noise damage.



Activity	Recommended Sound Level (dB)	Strategies to minimize noise damage:

Optional Activity: If you have a soundmeter (or an app), measure the level of sound emitting through your headphones, etc. Share your results and discuss the risk to your hearing.

Hearing Test Activity: Do you find yourself or someone you know struggling to follow a conversation in a crowded room, to hear over the phone, watch TV louder than others, stand close to people to hear them? Online hearing tests are designed to help people determine whether a visit to an audiologist is actually necessary. The following online tests determine your ability to distinguish between similar sounding words. Choose either one to experience an informal online hearing test – get your headphones ready! (Note the Blamey Sauders test requires an email address).

Starkey Hearing Age Test Simulator www.starkey.com.au/online-hearing-test

Blamey Saunder's Hearing Test www.blameysaunders.com.au/online-hearing-test

Question 5: Discuss your results with your partner. Compare the design of the tests. Do you think they are accurate tests? What do you think the tests are attempting to measure? What physics and biology principles do these tests employ?

Question 6: **Hearing Aids** are devices that help amplify sound. View the video on how hearing aids work. Identify the four main components of a hearing aid and how each works. Record your ideas below.

How Hearing Aids Work

www.youtube.com/watch?v=wJh6pZmAGqs

Question 7: **Cochlear Implants:** Whereas hearing aids amplify sound, cochlear implants restore the ability to detect and interpret sound. Cochlear implants are electronic devices that connect directly to the auditory nerve, bypassing any damage to the inner ear. View the video on how cochlear implants work. Identify the 4 main components of a cochlear implant and explain the role for each. How does this compare with the hearing aid? Who would be a candidate for a cochlear implant?

Cochlear Implants
www.youtube.com/watch?v=zeg4qTnYOpw

Reflect: What does music feel like to you? Shared your ideas with your partner.

Sensations of Sound: On Deafness and Music
https://www.nytimes.com/2017/11/03/opinion/cochlear-implant-sound-music.html?smid=fb-share

DESIGN CHALLENGE

The design of rooms and buildings influence how sound travels - sometimes this is welcome, other times, less so! You've likely experienced outside noise from your bedroom that disrupted your sleep, or noise from an adjoining classroom that was disruptive to your in-class essay assignment. Alternately, you've probably have been to presentations in a school gym that were difficult to hear, or at a very noisy public swimming pool. What are the design features in a room or building that influence sound? How can you design a room that is best suited to its purpose, to either reduce, amplify, or direct sound?

Using the physical knowledge of sound production and how it travels in different media, along with the biological principles of detecting sound, choose one of the scenarios below to design a room suited to its purpose.

Project instructions

This project involves you working in a group of 3 or 4 to investigate **ONE design strategy** that might be used.

You will select from one of the following design scenarios below:

- Scenario 1 *An auditorium that projects sound without the need of a microphone.*

- Scenario 2 *A bedroom in a house that reduces outside noise, including that from adjoining rooms.*

- Scenario 3 *A soundproof room in a house that is suited to the practicing and production of music.*

- **Scenario 4** *A home theatre that both amplifies the sound and reduces sound going into other rooms.*

- **Scenario 5** *An indoor public swimming pool that reduces amplified noise.*

- **Scenario 6** *A restaurant that reduces the background noise of multiple conversations.*

- **Scenario 7** *Ear protection that you can wear in places where there is prolonged exposure to loud sounds.*

Your final product will need a:

1. Title
2. Introduction (research your scenario and the related scientific concepts – 150 words)
3. Aim (including your design scenario, the key issues in your scenario, the features you will use to address these issues)
4. Diagram to give a context to your scenario and the features of your design principles (e.g., properties of sound production, travel, and detection, choice and application of materials, etc.). You may produce this on paper or digitally. Remember to annotate your diagram.
5. Description of intended effect of design features, based on scientific principles of sound. Choose one of your design features and represent how sound is effected (using particle or wave theory) by your design.
6. Discussion (summarizing main challenges, design features, and how principles of physics and biology influence sound in your specific scenario).
7. References of resources you have consulted.

How to submit your project

Your project can be submitted as a paper or digital multimedia report, including a poster, PowerPoint Slideshow, video or standard lab report.

Question 1: Represent your scenario and design features.

Question 2: Represent how one of your design features influences sound using at a particle level (e.g., using the particle or wave model).

Question 3: Submit your final project (e.g., photograph of your poster, PowerPoint Slide, video or standard lab report).

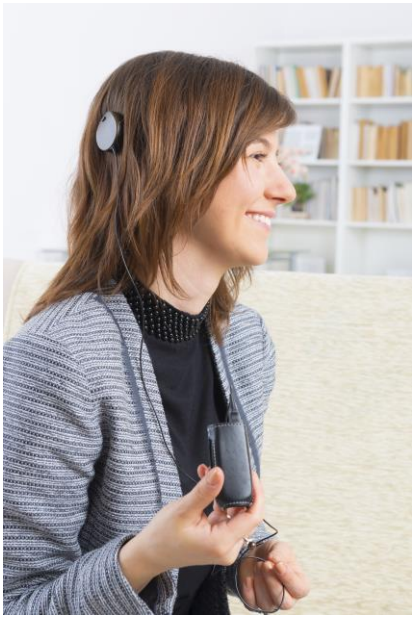
CAREERS

Learn how famous Australian scientists pioneered hearing science and technology, using the creative processes of scientific thinking, and how current scientists and engineers are continuing to apply these discoveries to address other medical issues.

KEY QUESTIONS

- What is the difference between science and technology?
- How do science and technology complement one another?
- What are the key attributes of scientific thinking?

CAREERS



The Bionic Ear: The invention of the bionic ear follows a trajectory of inspiration, persistence, and creativity.

Watch this video to learn about the journey of Australian inventor Professor Graeme Clark and his quest to find a solution for hearing: www.abc.net.au/archives/80days/stories/2012/01/19/3411629.htm

Question 1: From Professor Clark's experience, discuss some of the key processes of scientific thinking and record your ideas below.

Systems engineer, Ivana Popvac works for Cochlear Limited, a company that produces Cochlear implants to help people with nerve deafness to hear. Talking about what inspires her, Ivana states:

"I think my passion for the cause is my most valuable attribute; it gives me a clear vision of what needs to be done and motivates me to succeed because I know the end result is helping more people hear."

VIDEO	Ivana Popovac, Systems Engineer at Cochear Limited **www.youtube.com/watch?v=nBiJ-2eOiQQ&feature=youtu.be**

Question 3: Watch the video and describe the differences between science and technology and how Ivana's team is combining the two to address hearing problems.

Extending the Bionic Ear: Professor Peter Blamey was invited to work with Graeme Clark to refine and extend the application of the bionic ear. With the entrepreneurial influence of his business partner, Dr. Elaine Saunders, together they have applied the science to expand the technology, and develop a business model for sustainable distribution to those who need it.

Dr. Peter Blamey, 2016 Clunies Ross Award Recipient
www.youtube.com/watch?v=bcMMaeIHWiQ

Dr. Elaine Saunders, 2016 Clunies Ross Award Recipient
www.youtube.com/watch?v=MYjUnEx0HjA

Question 4: Watch the videos and describe the key contributions and ongoing applications of their work.

Question 5: Describe the nature and outcomes of science, technology, invention, and collaboration.

The Future Health Factfile features contemporary applications of science and technology to solve medical-related issues. Review the Profile on Michael Raivars, an electrical engineer on Page 5 of the Factfile below.

Future Health Factfile
www.stelr.org.au/future-health-1/

Question 6: Describe the project Michael is currently working on, his education background and what continues to inspire him. What is his advice to those considering careers in the biomedical industry?

GLOSSARY

Term	Meaning

Thank you from our partners

ORICA

Cochlear®