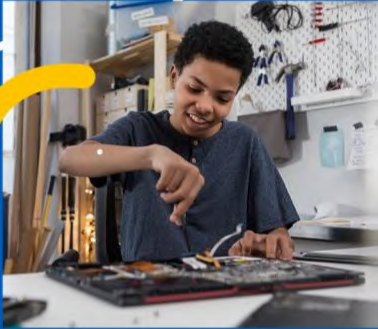


NEXT ENGINEERS



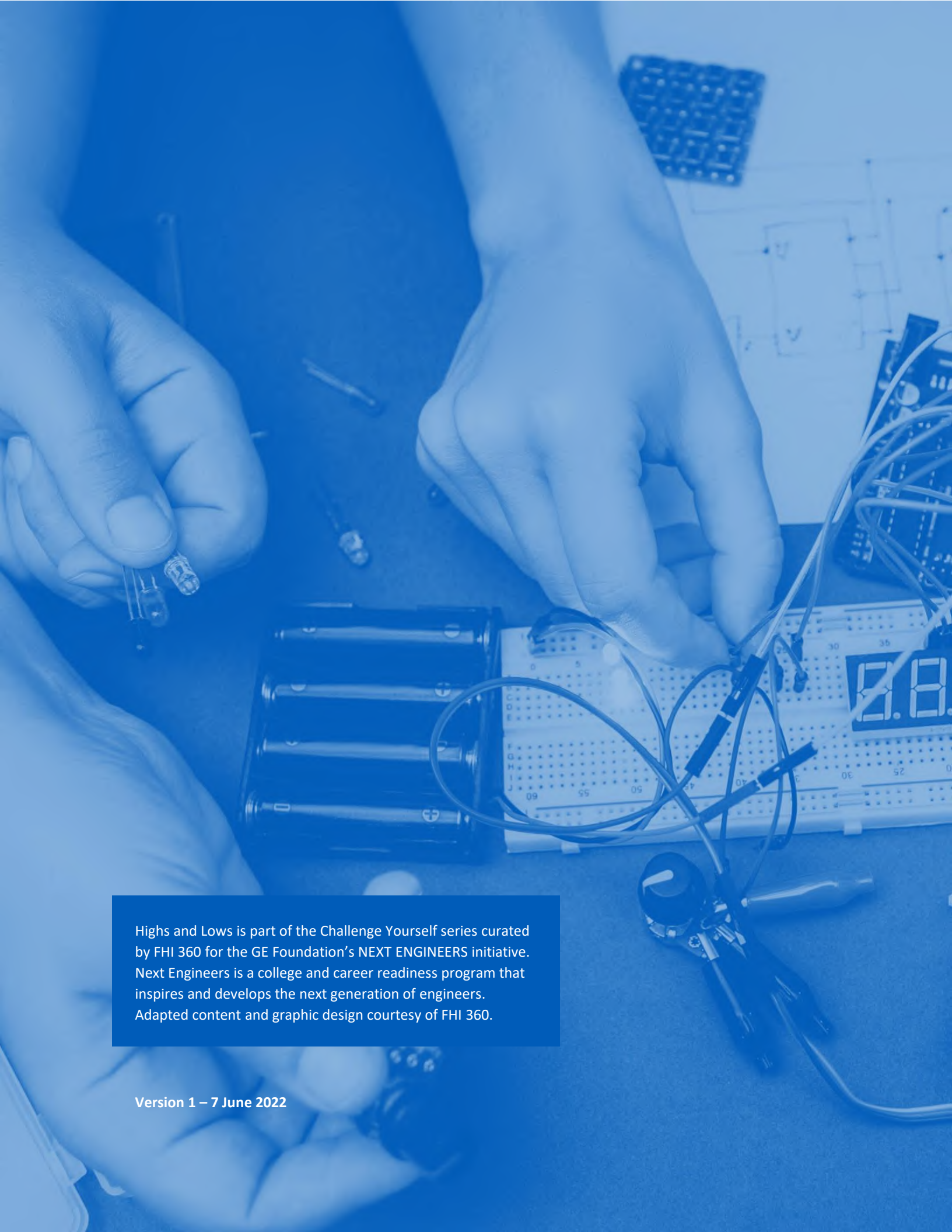
CHALLENGE YOURSELF

Helpful Sounds Part 2: Highs and Lows

Acoustic Engineering



GE Foundation



Highs and Lows is part of the Challenge Yourself series curated by FHI 360 for the GE Foundation's NEXT ENGINEERS initiative. Next Engineers is a college and career readiness program that inspires and develops the next generation of engineers. Adapted content and graphic design courtesy of FHI 360.

Version 1 – 7 June 2022



Helpful Sounds Part 2: Highs and Lows

NERD OUT

How low can you go?

Have you ever literally ‘felt the beat’? That is, have you felt rather than heard a sound? This happens when sound waves have a frequency too low for you to hear. They are called **infrasounds** and have frequencies below 20 Hz (the lower bound of human hearing).

There are many natural sources of infrasound, including volcanic eruptions, thunder during severe storms, earthquakes, and some animals like elephants which use it to communicate with each other. Find out more about how elephants do this by visiting the Elephant Listening Project’s page *Deep into Infrasound* (<https://elephantlisteningproject.org/all-about-infrasound/>).

Scientists and engineers have designed infrasound sensors that are used to give advance warning of earthquakes, volcanic eruptions, and even avalanches from many hundreds of kilometers away. They can also be used to track the location, direction, and speed for severe storms like hurricanes.

A network of monitoring stations scans the globe for atmospheric and subterranean (under the ground) nuclear explosions. Find out more about this network and how it works by watching the video called *The Infrasound Network and how it works* (2:16) (<https://www.youtube.com/watch?v=GVWOA5pZG6o>)

The reflection of man-made infrasound is used to peer below the surface of the planet and investigate its internal structure. We can identify possible locations of oil and natural gas resources as well as distinctive rock formations in which different minerals are likely to be found.

Seeing through sound

While infrasound is sound, we cannot hear because it is too low, **ultrasound** is sound we cannot hear because its frequency is too high. It is above the 20 000 Hz threshold of human hearing. However, just because we cannot hear it does not mean that other animals can’t. Below is a summary of the frequencies that different animals can hear.

You will notice that bats can hear very high pitches sounds. They produce these sounds and then listen for the echo that bounces off different objects in their environment. By analysing how long the echo takes to return and how the frequency of the echo differs from the original sound, bats can ‘see’ through sound. This is called **echolocation**.



DID YOU KNOW

Blue and fin whales have been observed to produce infrasonic calls to communicate. Because of their very low frequencies, these waves can travel many hundreds of kilometers through the ocean.

Rhinos and alligators also produce infrasound to communicate.



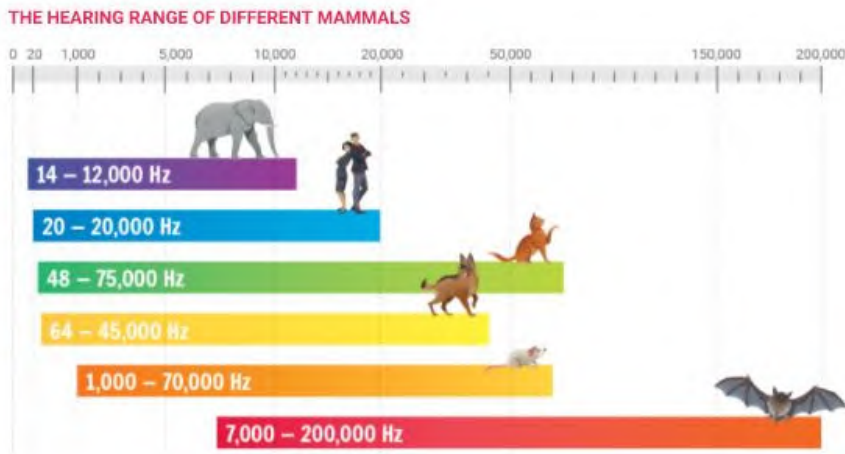
WATCH

While we cannot hear infrasound, these sound waves can often affect us negatively. To find out more, watch *How to See Ghosts (using Infrasound)* (13:43) (<https://www.youtube.com/watch?v=tMSXdCWbRHw>).



To find out more about echolocation watch the following videos:

- *Echolocation* (4:33) (<https://www.youtube.com/watch?v=laeE4icRYp4>)
- *What Is Echolocation?* (6:19) (<https://www.youtube.com/watch?v=K-zrBalt-38>)



The hearing range of different animals by Salote is used under fair use
<http://gbssalotea.blogspot.com/2018/03/can-you-hear-that-summary.html>

Not to be outdone, however, humans have devised our own echolocation systems which we call SOund NAVigation and Ranging or **SONAR**. They also use ultrasound to image environments which we cannot see with light. Active SONAR systems send out pulses of sound and then listen for the echoes. The time taken for the echoes to return and how their frequency has been changed allows these systems to produce visual maps of the environment and the motion of other objects in it. Submarines use SONAR to navigate. Sometimes SONAR systems are used on ships to create detailed images of the ocean floor.

Watch the video called *How SONAR Works* (3:21) (<https://www.youtube.com/watch?v=jlXrm6gjGq8>). If you want a deep dive into SONAR as used on a nuclear submarine, watch the video called *How Sonar Works (Submarine Shadow Zone)* (26:41) (<https://www.youtube.com/watch?v=AqqaYs7LjIM>)

What's inside?

Besides being able to see what's 'out there', we can also use sound to see what 'in here'. Engineers have designed machines that use ultrasound to image the inside of the human body. They are imaginatively called ultrasound machines!

They use special crystals called **piezoelectric crystals** to produce sounds of very high frequencies. A small electric current causes the crystals to vibrate very quickly. The resulting sound waves penetrate the skin and are then reflected in different ways by different internal organs and structures. These 'echoes' are picked up by the very same piezoelectric crystals which turn the echoes back into electronic signals. These signals are processed by a computer to produce the image we see on screen.



HAVE A THINK

How do you think bats are able to tell if an object in their environment is moving towards or away from them?

HINT: What do you hear as an ambulance approaches you and then drives past?



GET ACTIVE

If you have a mobile device, download a free decibel meter app like 'Decibel Meter' for iOS or 'Sound Meter' for Android.

These apps also let you analyze the frequencies of sounds. What's the lowest and highest frequency sound that you can make?



DID YOU KNOW

RADAR works in a very similar way to SONAR except that it sends out and listens for the echoes of electromagnetic radio waves, not sound waves.



To learn the basics of how ultrasound works, watch the following videos:

- *How Ultrasound Works* (1:40)
(<https://www.youtube.com/watch?v=l1Bdp2tMFsY>)
- *Fundamentals of Ultrasound 1* (7:14)
(<https://www.youtube.com/watch?v=cl7ULKNhVcw>)



Ultrasound image of a fetus by Nevit Dilmen is licensed under a CC BY-BY-SA 3.0 licence

https://commons.wikimedia.org/wiki/File:Pregnancy_ultrasound_110316153736_1538380.jpg

Functional ultrasound makes use of the Doppler effect to not just image the inside of the body but to also measure the hardness and softness of different tissues as well as the movement of blood inside blood vessels. Learn more about functional ultrasound by watching *How Functional Ultrasound Works* (2:05) (https://www.youtube.com/watch?v=5H9_7xiYHgo).



WATCH

Piezoelectric crystals are truly fascinating. To find out more, watch *Piezoelectricity - why hitting crystals makes electricity* (9:33) (<https://www.youtube.com/watch?v=wclXA8lqYl8>).



GET ACTIVE

How about making your own piezoelectric crystals? It's much easier than you think. Learn how by watching *Collin's Lab: Homebrew Piezo* (4:39) (<https://www.youtube.com/watch?v=K3G2QM5a-9U>).

