RADIO EXPLORERS

Messages from Space

FACILITATOR GUIDE

MAKING WAVES with radio

Learning objectives

1. Radio waves are different from sound waves—they do not require air, water, or another medium to travel.
2. We take advantage of the properties of radio waves to communicate over vast distances, even through space.

Materials

- **Remote key finder.** Many options are available online, but make sure the transmitter activates both a **sound** and a **light** on the receiver. We suggest a remote key finder with a loud beep (>100dB).
- **Vacuum chamber.** Many options are available, but we recommend looking for a larger one to hold bigger sources of sound waves. Consider a coffee saver vacuum chamber that is big enough to fit objects that you want to test.
- **Sponge** to serve as a base for the sound source in the vacuum chamber and mechanically isolate the sound waves from the chamber walls.
- **Balloons** to show the effect of less air in the vacuum chamber.
- **Tinfoil** to demonstrate the remote key finder's signal can be blocked.
- Activity guide and information sheets.
- A smartphone running the *Sound Detector* app (recommended).
- QR code sign for the *Sound Detector* app (optional).
- Additional sound sources (optional).

These are the materials you will need if you want to offer a Sound Wave Detector make-and-take experience for participants.

- Multiple copies of the *Build a Sound Wave Detector Instructions*
- Plastic wrap
- Rubber bands
- Plastic or paper cups with a strong enough lip to make a ring that won't collapse
- Scissors to cut the cup and plastic wrap to fit
- Fine-grain salt

Safety

Facilitators should always be mindful of scissors and other sharp objects when working with public audiences. While facilitators can preset sound-making devices for low volumes, be careful of loud sounds, especially for sensitive participants.

Training Videos

Facilitators should review the training video for this activity for facilitation guidance and examples of specific materials. The *Making Waves with Radio* content training video will provide additional background content to help in the facilitation of this activity.

Activity Training Video: https://vimeo.com/776686819

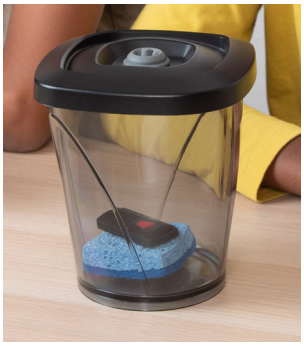
***Making Waves with Radio* Content Training Video:** https://vimeo.com/776685410

***Making Waves with Radio* Content Training Video (Spanish):** https://vimeo.com/776686149

Advance Preparation

Before you begin

Test out your vacuum chamber. Of course, no vacuum chamber you can purchase off the internet is going to provide a perfect vacuum. Try your sound sources inside the chamber to determine ones that will be most affected by the reduction of air in the chamber.



Precut your sponge to act as a cushion under your sound source in the vacuum chamber. You want to make sure your sound source is not in physical contact with the walls of your vacuum chamber to prevent sound from being mechanically conducted to the chamber walls. Fastening sound sources to the sponge with a loop of tape can help secure them while pumping out the air.

Check the batteries on your remote key finder and determine how far the signal can travel. Knowing the maximum transmission distance will be helpful if you decide to have learners test out the strength of the remote key finder.

Blow up a few balloons to equal size and tie them off. We suggest starting with small balloons that will easily fit inside your vacuum chamber before and after they expand.

Install the Sound Detector app on your smartphone—it is available on both Apple's App Store and the Google Play Store. The app is the best way to measure the decrease in sound level during the activity. We recommend having the app installed on at least one smartphone.

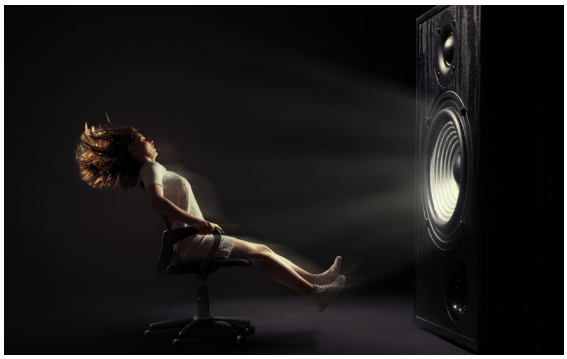
Download the Sound Detector App

Download on the App Store

GET IT ON Google Play

Content Background

What we perceive as sound is produced when molecules bump into one another and vibrate. The louder the sound, the more vibration. Sound waves are **mechanical waves** and "travel" as more molecules bump into the vibrating molecules at the sound source. Eventually these vibrations reach our eardrums and cause us to hear.



Adobe Stock

While sound and radio waves both carry energy, they are very different. Our ears cannot hear radio waves because there are no vibrations to trigger our ears. Radio waves do not need vibrating molecules of air, water, or other matter to travel. Radio waves are one type of **electromagnetic wave**—like visible light or microwaves—and can travel in a vacuum at the speed of light.

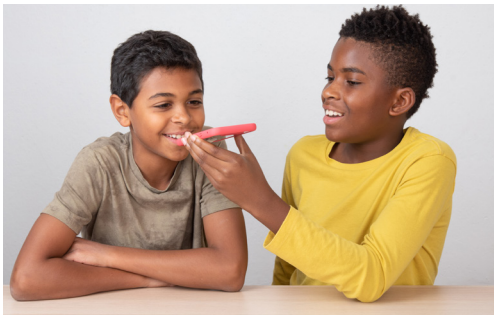
Radio waves also travel much faster than sound waves—186,000 miles per second (300,000 kilometers per second) for radio waves versus 0.2 miles per second (0.3 km per second) for sound waves. These differences make radio waves ideal for communicating over long distances on Earth and throughout space.

Notes to the Presenter

Given the importance of participants perceiving differences in sound level, you might want to try to find a quiet space (without much talking or random, unpredictable noises) to facilitate the activity.

Museum floor facilitation (up to 15 minutes)

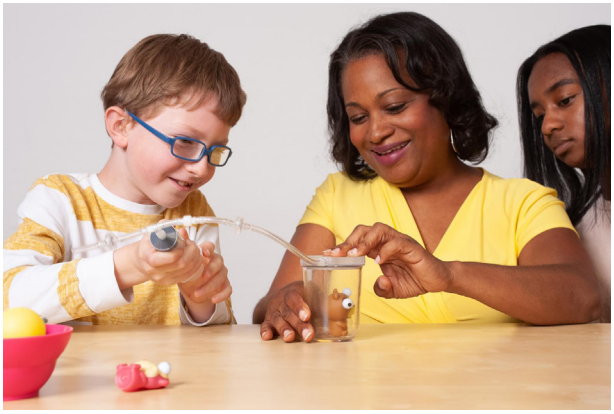
- Assist participants in exploring the vacuum chamber using the balloons. Use two inflated balloons of the same size and place one in the chamber and one outside.
- Ask participants what they think will happen to the balloon in the chamber before you start to remove the air. With less air in the chamber, the molecules of air in the balloon can push out and expand the balloon.
- Have participants play with the remote key finder. Ask questions about where the signal is transmitted from and how far they think the signal travels. Then allow them to test out their hypotheses by moving the receivers away from the transmitter—or even blocking the signals with tinfoil.
- Now place the remote key finder receiver in the chamber on your precut sponge and close the top. Listen closely to the sound made by activating the remote key finder before removing the air from the chamber. We also recommend measuring the sound level with the *Sound Detector* app. Now pump out the air and repeat your observations. Ask participants what they notice. What happens to the sound? Does the loudness reading on the *Sound Detector* app change? What happens to the LED light on the receiver? Are radio waves still getting through?
    - The *Sound Detector* app can be a great measurement tool for your participants as well. Consider using the QR code sign to encourage learners to download and install the app to assist in the investigation.



- Use the tinfoil to wrap the transmitter to demonstrate to participants that the radio waves between the transmitter and receiver can be blocked.
- **Extension:** *Sound wave detector* — This is a great make-and-take if you have enough materials to go around. Building and demonstrating a sound wave detector is not absolutely necessary to compare the effects of the vacuum chamber on sound and radio waves, but it is a visible phenomenon that will assist participants in their understanding of sound.
    - Try setting up a separate area for participants to create the sound wave detector a bit away from the vacuum chamber.
    - To save time, you may want to consider precutting the plastic wrap to sizes necessary to cover cups.
    - Consider having a pre-built sound detector ready to use as a model while facilitating.

- Encourage participants to investigate their surroundings with the sound wave detector: try different sound sources; move around sound sources by trying above, below, or beside; and try moving closer and farther away.
- Brave facilitators can also have participants experiment with the volume of their own voice and the sound wave detector. What happens to the salt when you whisper versus talking loudly to the detector?
- This is a good time to remind participants that they can sense some sound waves and electromagnetic waves with their own "built-in" detectors—their ears and eyes, respectively.

- **Extension:** Consider having alternative sources of sound waves, including a Bluetooth speaker, music box, or a windup buzzer, for participants to observe the effects of the vacuum chamber. Remember, these sources will have to be small enough to fit inside your vacuum chamber.
- **Extension:** Check out **Molecules in Motion** (https://www.nisenet.org/catalog/molecules-motion) from the *Explore Science: Let's Do Chemistry* toolkit for more suggestions on using vacuum chambers with learners. That activity uses squishy toys and balls to show the physical effects of a vacuum. In space, there is little to no air pressure, but there is a lot of air pressure here on the surface of Earth. The vacuum pump removes air from the chamber, creating a model of what it's like in space. Encourage participants to make connections to space and explore how familiar objects might change if they rose through the atmosphere toward space. Pairing the changes of common objects in the vacuum chamber with those of the sound sources may assist facilitators in making further connections to the simulated space environment.



Tips for facilitating with younger participants

- Very young children may not grasp the concept of radio waves, but will still enjoy experimenting with materials and sound. Encourage children to spend more time with the sound wave detector paired with a variety of sound sources and their own voice.

Common Questions

Are radio waves passing through my body?

Learners may realize that the radio waves are traveling through their bodies when playing with the remote key finder. Many learners find this unsettling. Radio waves are a type of nonionizing radiation, just like visible light. This means radio waves do not directly damage our cells the way other types of radiation do, like gamma radiation. In addition to human-made sources, radio waves are produced by outer space, the sun, and even the Earth itself.

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