Wi-Fi Detective

FACILITATOR GUIDE

MAKING WAVES with radio

Learning objectives

1. Radio waves are invisible and all around us.
2. Radio waves transfer energy that can be reflected or absorbed, or pass through materials.
3. Different devices use different radio frequencies.

Materials

- **Wi-Fi router.** We suggest a dual-band router (2.4 GHz and 5 GHz) for a richer experience, but a single-band one is sufficient
- **Metal baking sheet**
- **Large piece of cardboard.** A plastic cutting board or lid from a large plastic bin will also work
- **A smartphone** running the Wi-Fi Detector app
- Activity guide

The above materials will let you test for blocking and reflection of the Wi-Fi signal, but to go further and explore polarization, you will need:

- Metal baking rack with parallel gaps. Do not use one with a crisscrossing grid pattern
- Large piece of cardboard
- Copper tape
- Scissors

Safety

Take care cutting the copper tape. An extension cord to the Wi-Fi router may be necessary, so consider proper cord management using clips or tape to prevent tripping accidents.

Training Videos

Facilitators should review the training video for this activity for facilitation guidance. 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/776687657

***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

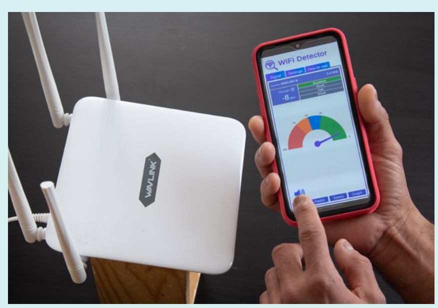
Make some time to choose and potentially prepare your Wi-Fi router. You may already have a router installed in your space, but if you don't, consider one of the low-cost options online.

You can use Wi-Fi routers in your space if they have a publicly available network. Simply join the network as you normally would with any mobile device. Public Wi-Fi networks do not require a password, but may include some click-through responses in a browser to work. Please keep in mind this may connect your smartphone to the internet if you plan on letting participants use the device.

For a new Wi-Fi router, just plug it in to start broadcasting a Wi-Fi signal. It does not need to be configured or connected to the internet to be used in the activity. Use a smartphone, tablet, or laptop to note the new Wi-Fi network name that appears when the router is plugged in.

The *Wi-Fi Detector* app is only available in the Google Play Store; it is not available in the Apple App Store. Make sure to download and install the app to start testing on an Android smartphone. Once you have identified or set up a source Wi-Fi router, experiment with the app to see how the signal changes.

Finally, try to set up a testing area with at least 1 to 2 meters between the router and the mobile device running the app. This will provide a lot of space for participants to try out materials between the router and the testing device.



Download the WiFi Detector App

GET IT ON Google Play

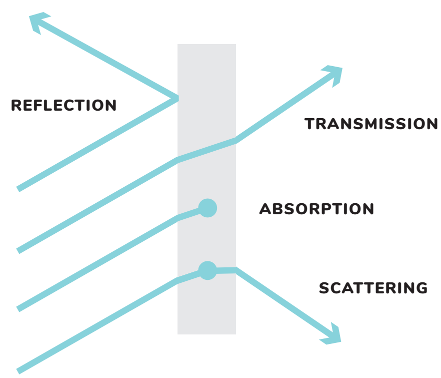
Content Background

Adobe Stock

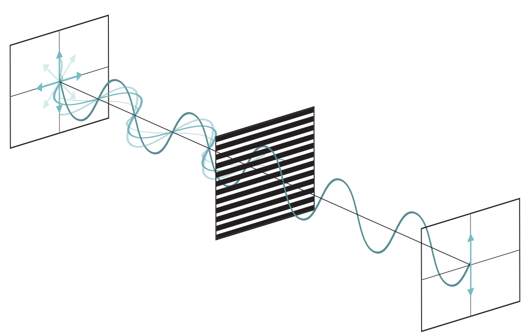
A Wi-Fi router uses radio waves to transmit data to smartphones, tablets, and other wireless devices. Wi-Fi most commonly uses the 2.4 GHz (ultrahigh frequency) and 5 GHz (superhigh frequency) radio bands. A Wi-Fi router using a 2.4 GHz band has a longer transmission range but offers slower data transfer speeds. The 5 GHz band covers a shorter distance but provides faster speeds. A dual-band Wi-Fi router is one that broadcasts radio waves on both bands.

Wi-Fi uses higher frequencies than other common radio technologies like AM and FM radio. At such high frequencies, Wi-Fi's radio bands experience relatively high absorption and work best when the pathway between the transmitter and receiver is not obstructed. This type of transmission is often referred to as line of sight use—as the transmitter can "see" the receiver. Many common obstructions such as walls, home appliances, etc. may greatly reduce the range and signal strength of Wi-Fi routers.

Electromagnetic waves, including radio waves, can interact with materials in several ways—as demonstrated by this activity. A wave can be completely or partially reflected, redirecting it. A wave can also be absorbed, sometimes completely reducing its strength. Waves can also pass through materials, shown by transmission and scattering, sometimes changing the direction and/or strength of the wave.



Electromagnetic waves also oscillate with a specific orientation in space. Radio waves are usually polarized—meaning that part of the wave moves in predominantly one direction—up and down, for instance.



A wire grid—like the metal baking rack—will absorb energy from electromagnetic waves that oscillate along the length of wires. The electromagnetic waves that oscillate perpendicular to the wires will be transmitted.

Notes to the Presenter

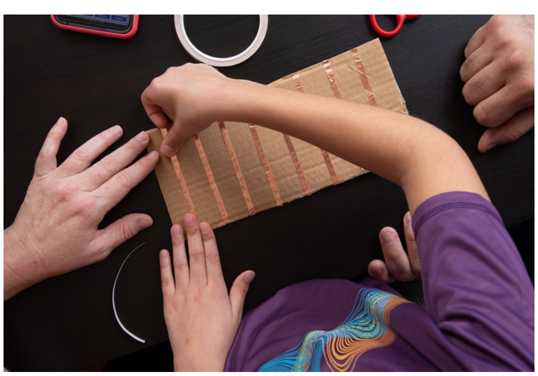
We suggest a setup where the Wi-Fi router and the smartphone running the *Wi-Fi Detector* app are set upon platforms on opposite sides of a long table.

Museum floor facilitation (up to 15–20 minutes)

- Once you have your activity space set up and your Wi-Fi router is transmitting, connect your smartphone to the Wi-Fi router and open the *Wi-Fi Detector* app to begin collecting data about the connection. To connect to the router, you will need to go into the smartphone's Wi-Fi settings and select the router's network name. As mentioned in the Advanced Preparation section, your setup may differ depending on your router choice.
- Place the smartphone running the app in a spot of your choice. Remember, you can manage the app yourself or have someone watch the device for you to monitor the connection.
    - Learners can also download and use the app on their own smartphone. See the QR code printouts included in the activity materials.
- Use the sound feature on the app or have participants directly observe the graph of signal strength over time. We recommend only one smartphone at a time use the sound feature.
- After about a minute of testing you should have an average signal strength for your setup. Now invite participants to explore the radio waves between the router and monitoring device. How do they know there are radio waves there? Ask them if they can interfere with the signal? Does it matter what type of material they use to try to block the radio waves?
- The metal baking sheet should have a noticeable effect on the signal. Alternatively, you can wrap a large piece of cardboard in tinfoil to have a similar blocking effect to the metal baking sheet. What about a lid from a large plastic bin? Don't be surprised if learners attempt to block the radio waves with their own bodies. What happens?

- Once blocking has been established, ask participants if they can figure out how to increase the signal strength. Is distance a factor? What about trying other ways to use the metal baking sheet? This is a great opportunity to talk about reflection. Holding the metal baking sheet on the opposite side of the smartphone from the router might increase the Wi-Fi signal strength—but holding it flat in between the smartphone and the router may also have an effect.
- This would be a good place to stop with most participant groups. But if your group seems eager to learn more, consider going further with an investigation on polarization.
- **Going further:** *Polarization*
    - The radio waves coming out of the router have an orientation. While the metal baking sheet can block waves of any orientation, the metal baking rack has a different effect. Ask your participants to make a guess at what will happen before they try placing the baking rack between the router and the monitoring device.
    - Consider suggesting participants try the rack with the gaps in both vertical and horizontal orientations to investigate the effect further.
    - For longer experiences in a class or camp, you may want to consider having learners build their own grating with cardboard and copper tape or tinfoil. The spacing between the rows necessary to block a radio wave on the 5 GHz Wi-Fi band will be smaller than the one needed for a radio wave on the 2.4 GHz band.






Common Questions

Is 5 GHz Wi-Fi the same as 5G?

5 GHz and 5G sound similar, but they are not the same technology. 5G is the fifth-generation mobile network technology, which increases the speeds and bandwidth of cellular networks. 5G also uses a wider band of frequencies than a 5 GHz Wi-Fi router, from roughly 1 to 50 GHz.

Are radio waves passing through my body?

Learners may realize that the radio waves are traveling through their bodies when trying to block the Wi-Fi signal. 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.

If radio waves are all around us, why can't I sense them?

Radio waves are too long for our eyes to see. As the longest type of electromagnetic waves, radio waves are much longer than the waves that make up visible light. Our eyes have evolved to be precisely tuned to the properties of visible light waves. Radio and television, cell phones, GPS, radar, Wi-Fi, and Bluetooth all use radio waves. It takes a lot of radio waves to make these devices work! That means radio waves are all around us, all the time. Though we can't see radio waves, we can observe them all around us in our functioning technology. Every time a text arrives, a car radio turns on, or you connect to the internet without any wires, that demonstrates that radio waves are everywhere.

Developed with funding from the National Science Foundation under Award Number 2053160.

Photos and illustrations by Emily Maletz Graphic Design for the NISE Network unless noted.

This material is based on work supported by the National Science Foundation under award number #2053160. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the view of the National Science Foundation.