

Level	Everyday Radio Frequency Technologies	
Middle School		
Time Required	Lesson Summary	
200 minutes (four 50-minute class periods)	During this lesson, students will investigate the different technologies they may use every day that rely on radio frequencies. Students will brainstorm types of technologies that use these frequencies. After sharing their thoughts, students will work in small groups to research the device and create a presentation. Groups will share their presentations with the class.	
Standards		
HS-PS4-2 Evaluate questions about the advantages of using a digital transmission and storage of information.		
Vocabulary	Objectives	
Bluetooth NFC (Near-Field Communication) RFID (Radio-Frequency Identification) UWB (Ultra Wideband)	- Students will better understand the technologies they interact with that rely on radio frequencies. - Students will collaborate with peers to develop and share a presentation of the technology they researched.	
Materials		
Articles that can be shared with students: https://www.pcmag.com/how-to/what-is-ultra-wideband-uwband https://www.explainthatstuff.com/rfid.html https://www.techtarget.com/searchmobilecomputing/definition/Near-Field-Communication https://electronics.howstuffworks.com/bluetooth.htm		
Pre-Requisites		
Students need to know the bands of the electromagnetic spectrum including the relative frequency and wavelengths of the bands. Students should also be able to understand and use the metric prefixes as EM spectrum wavelengths and frequencies rely heavily on these prefixes.		
Safety Considerations		

None	
Pacing Notes	
Day 1 – brainstorming about radio frequency technologies, presentation (including video) on radio technologies Day 2 – group research Day 3 – finish research and create presentation Day 4- presentations	
Before the Lesson	
Before the lesson, read over the Everyday Radio Technology Frequencies presentation to familiarize yourself with some types of radio frequency technologies. Also, print out or supply a digital copy of the student pages.	
Assessments	Classroom Instructions
Pre-Activity Assessments	Introduction
	Put up a diagram of the electromagnetic spectrum. Have students answer the following on a small sheet of paper while you take care of administrative tasks. What do you remember about the EM spectrum? Compare and contrast visible light and radio waves.
Activity Embedded Assessments	Activities
If students aren't able to explain things about the EM spectrum pause the lesson and reteach this concept.	Day 1 Have a short whole class discussion over the answers to the introduction questions. Consider asking some of the following questions in addition to your own. What is the electromagnetic spectrum? How does the energy in the spectrum travel from one place to another?

As students share ideas, ask them questions about why they think it uses radio waves and how they could test if it's using radio waves.

What changes as you move right to left across the diagram?
What changes as you move left to right across the diagram?

2. Hand out the student video sheet. This page contains questions on each of the videos. It is recommended this is used more as a notes page rather than a paper to collect and grade.
3. Go through the presentation, including the videos, with your students.
4. After the presentation tell students that these were just some of the many ways radio waves are used. Challenge them to come up with a list (without using any research mechanism) of all the uses of radio waves.
 - a. Give students ~ five minutes to brainstorm by themselves.
 - b. Have students share their ideas in one of the following ways:
 - Go around the room and have each student talk about their idea(s).
 - Have a gallery walk where students display their idea(s) on post it notes or white boards. Students can walk around the room reading ideas and then the class can discuss what they saw.
 - Ideas can be shared digitally on a platform like Jam Board or a digital word cloud. Discussions can be held through comments students type into the platform. This method would work best for remote learning.
5. Conclusions – Day 1
 - a. For an exit ticket, ask students to answer one of the following questions on paper or in digital format:
 - How is this device making lives easier or better?
 - What do you think a future use of this device could be?
 - What safety or security concerns do you have?
 - How do you think the device works or how do you think it is constructed?

Day 2

- I. Introduction
 - a. While you are working on administrative tasks have students rank the uses of radio frequencies according to their

preference as a research topic.

2. Group assignment

- a. This could be done randomly, by student choice, or by topic interest. Groups of 3 are optimal.

3. Research

- a. Each group should have a different topic
- b. Hand out the research guide. Students can use the guide to help them research the device assigned to their group. The guide also has a rubric for their final project. Tell students the items on the guide are suggestions and the back side of the paper can be used for any additional information.
- c. The group should divide up the research and work independently.

4. Day 2 Conclusions

- a. Exit ticket. Students should write down one thing they learned and one thing they still have questions about on a small sheet of paper.

Day 3

1. Student research continues.

2. Presentation creation

- a. After 20 minutes, inform students that they should begin working on their presentation for Day 4. Presentations can be in a paper format where students make a poster of the information or they can be digital in format where students make a slideshow of their research.

3. Conclusions – Day 3

- a. Have students either place their projects in a designated area or upload them to the electronic platform of their choosing.

Day 4

As students work, walk around asking them questions:

- Why do you think radio waves are used instead of another EM wave?
- Why do you think that was invented?
- How do you think that works?
- What problems do users encounter or what could be added to make it better?
- What scientists contributed to this research or invention?

Continue to ask the same questions as yesterday.

	1. Give students a few minutes to organize themselves within their groups. 2. Students share their presentations with the class. a. Give each group 5-10 minutes to share their findings and offer time for other students to ask questions. b. For larger classes or classes with limited time, students could also share work as a Gallery Walk. During the Gallery Walk, the poster would be on display and students can walk around and see each one. Have students write one item from each poster as an exit ticket.
Post Activity Assessments	Closure
	Have student read the following articles: • https://www.wikiwand.com/en/Roberto_Landell_de_Moura • https://lemelson.mit.edu/award-winners/luis-von-ahn Have students write three takeaways from each article and three questions they had about each article.
Culturally Inclusive/Responsive Components	
Have students read about Roberto Landell de Moura, a Brazilian Catholic priest that developed long distance audio transmission, the beginnings of wireless communications. https://www.wikiwand.com/en/Roberto_Landell_de_Moura Have students read and discuss the work of Luis von Ahn. Born in Guatemala, he saw how learning English could lead to more work opportunities. This led him to develop the app Duolingo, helping millions of people worldwide learn new languages. He also invented CAPTCHA, a method to make websites more secure. https://lemelson.mit.edu/award-winners/luis-von-ahn	
Educator Resources	
Background information	

What Makes Radio Frequencies Different?

1. Wavelength

- Radio waves have the longest wavelengths in the electromagnetic spectrum.
- They range from about 1 millimeter to over 100 kilometers.
- In contrast:
 - Visible light: ~400–700 nanometers (much shorter!)
 - X-rays: Even shorter, down to fractions of a nanometer

Longer wavelength = lower energy, and it also affects how we build instruments to detect them.

2. Frequency

- Radio waves have low frequencies, typically from 3 kHz (kilohertz) to 300 GHz (gigahertz).
- Frequency is inversely related to wavelength:
$$\text{frequency} = \frac{\text{speed of light}}{\text{wavelength}}$$

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This low frequency means the energy per photon is very low — so radio waves don't carry much energy compared to X-rays or UV.

3. Energy

- Because they have low frequency and long wavelength, radio waves have low photon energy.
- This means:
 - They don't damage tissue (unlike X-rays or UV)
 - They can pass through dust clouds and the atmosphere much more easily

That's why radio telescopes can work on the ground, while many other types of telescopes (e.g. UV or X-ray) must be in space.

4. Penetration and Transparency

- Radio waves can penetrate clouds, dust, and even some walls.
- They're not easily scattered or absorbed by Earth's atmosphere.
 - This is why we can detect radio signals from space even when it's cloudy or daytime.

Microwaves

- Wavelength: Shorter than radio but still long (1 mm – 30 cm)
- Penetration:

- Can pass through clouds, light rain, and dust
 - Used in radar and satellite communication
- Atmospheric Transparency:
 - Mostly transparent, though some are absorbed by water vapor and oxygen
- Use in Astronomy:
 - Observed from the ground, but some bands require high-altitude observatories or satellites

Infrared (IR)

- Wavelength: Just longer than visible light (~700 nm – 1 mm)
- Penetration:
 - Can't pass through thick clouds or dense dust
 - Does penetrate some space dust, allowing us to see into star-forming regions
- Atmospheric Transparency:
 - Partially blocked by water vapor in the atmosphere
 - Best observed from dry, high-altitude locations or space telescopes
- Use in Astronomy:
 - Useful for viewing cool stars, nebulae, and galaxies
 -

Visible Light

- Wavelength: ~400–700 nanometers
- Penetration:
 - Blocked by clouds, dust, and many atmospheric particles
 - That's why it's cloudy or dark during storms or at night
- Atmospheric Transparency:
 - Earth's atmosphere is mostly transparent to visible light (called the "optical window")
- Use in Astronomy:
 - Most traditional telescopes use visible light, but only from clear-sky locations

Ultraviolet (UV)

- Wavelength: ~10–400 nanometers
- Penetration:
 - Blocked by Earth's atmosphere
 - Doesn't penetrate clouds or dust well
- Atmospheric Transparency:
 - Almost completely absorbed by the ozone layer
- Use in Astronomy:
 - Must be observed using space telescopes (e.g., Hubble)

X-rays

- Wavelength: ~ 0.01 –10 nanometers
- Penetration:
 - Can penetrate flesh, paper, and light materials
 - Blocked by Earth's atmosphere
- Atmospheric Transparency:
 - Totally opaque — no X-rays reach the ground
- Use in Astronomy:
 - Need space-based X-ray telescopes to study black holes, supernovae, etc.

Gamma Rays

- Wavelength: < 0.01 nanometers (shortest)
- Penetration:
 - Extremely penetrating, passes through most materials
 - Highly energetic and dangerous
- Atmospheric Transparency:
 - Completely blocked by Earth's atmosphere
- Use in Astronomy:
 - Detected only from orbiting satellites, e.g., Fermi Gamma-ray Space Telescope

5. Sources in the Universe

Radio frequencies are produced by very different kinds of astrophysical events than visible light:

- Spinning neutron stars (pulsars)
- Cold gas clouds
- Cosmic microwave background radiation
- Emissions from planets and galaxies

Many of these do not emit visible light, so radio telescopes allow us to "see" things we'd otherwise miss entirely.

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Below is a list of the lesson titles included in the series. All lessons can be accessed from this web page, <https://superknova.org/educational-resources/>.

Middle School

Introduction to Satellites
Weather Predicting
Introduction to Radio Wave Communication
The Importance of Radio Astronomy
Cubesat Model Building
Understanding FM Radio
Radio Frequency Technology
Who Decides if You Get 5G?

High School

The Uses of Radio Waves and Frequency Allocation
Is Radio Technology Safe?
Diffraction of Radio Waves
Measuring Sea Surface Temperatures with Satellites
Marine Animal Tracking and Bathymetry
How to Design Your Own Crystal Radio
How Radio Waves Changed the World
Simple Wireless Communication
Seeing and Hearing the Invisible
Local Wireless Radio Frequency Communication
Investigating the Internet Connection
The Geometry of Radio Astronomy

Informal

Modeling Radio Astronomy

