Level	Is Radio Wave Technology Safe?
High School	
Time Required	**Lesson Summary**
180 - 240 min.	Students will investigate and discuss the health effects of radio frequencies and present their argument in an eye-catching presentation using a presentation design app.

Standards

NGSS

HS-PS4-2 Evaluate questions about the advantages of using a digital transmission and storage of information.

HS PS4-4 Evaluate the validity and reliability of claims in published materials of the efforts that different frequencies of electromagnetic radio have when absorbed by matter.

Vocabulary	Objectives
Electromagnetic radiation Frequency Ionizing/ Non-ionizing radiation Hertz Energy (in terms of waves)	• Students will be able to research the validity of scientific claims in media and evaluate the quality of the arguments presented on the health effects of radio waves emitted from everyday technology. • Students will present their conclusions using digital software.

Materials

Student computers

Pre-Requisites

This lesson can be done with the class unit on electromagnetic waves or at the teacher's discretion, provided students are familiar with electromagnetic waves and the properties of frequency and energy.

Safety Considerations
None

Pacing Notes
Day 1 – quick write, exploring radio EMF, class discussion, video clip on RF radiation Day 2 – video, quick write, reliability presentation, project research Day 3 – quick write, soundbyte-ing research worksheet, digital poster Day 4 – gallery walk, final journal entry

Before the Lesson
The teacher should attempt each activity on their own before use in class, including using an EMF app and creating an example of the final product of a digital one-pager or research poster in a design app such as Canva or Adobe Spark before assigning it to students.

Assessments	Classroom Instructions
Pre-Activity Assessments	**Introduction/Bellringer**
Their grade should be based on their effort.	**Quickwrite** **Ask:** "Do you think our devices such as phones and Bluetooth lead to cancer or disease?" Have students complete their responses in their notebooks or in the journal worksheet provided. Students will document their feelings about the potential health effects of radio wave radiation at three points during this project, before researching, after researching, and after seeing other students' projects. They will have the opportunity to reflect on any information they found particularly persuasive and how they determined the credibility of each claim they encountered. Be sure your students understand there is not going to be a "right" or "wrong" answer to this question.
Activity Embedded Assessments	**Activities**

This should not be given a grade. Instead assess student's ability to follow directions and meet behavior expectations. Correct any students who are not following directions. Students should be graded on how well they work in a group. Students should be graded for the completeness of their answers.	**Day 1** 1. RF readings (4 to 10 min) a. Have some volunteers in the class download an EMF detector app such as "Ultimate EMF Detector" or "ElectroSmart" from the App or Play Store on their phones. b. Students will work in small groups to explore the readings around the classroom, around various parts of campus, and around various devices they see and use such as airpods, phones, laptops, etc. c. Be sure to let administrators and neighboring teachers know if your students will be working outside of the classroom. d. Give them a specific time limit to return to their seats so the groups stay on task. Be sure they note their high and low readings and where they found them. 2. Whiteboard/Chart paper/Butcher paper discussion (20-25 min) a. Have the following directions posted on the board or projector in the classroom for student groups to seamlessly move to their next task. You can have the students use chart paper or butcher paper for this task or whiteboard, depending on what you have available. <u>Directions:</u> *Everyone will have at least 1 job, some will have 2!* ***Manager*** *- Gets markers and chart paper/whiteboard for the group* ***Secretary*** *- Writes the group's responses to each question on the poster (write big)* ***Reader*** *- Reads the directions out loud for the group* ***Captain*** *- Keeps the group on task and makes sure the right person does each job* *On your group's poster, answer the following questions. You do not need to copy the question.* ● *What was the approximate range of EMF your team saw?* ● *Where did you detect the highest electromagnetic frequencies? Be precise.* ● *What observations did you notice while looking at the sensor near a device? What devices gave off the most EMF?* ● *Were you able to find a place with no EMF?* ● *What are some points of confusion or questions your group still has about this experiment or what this means for your health?*

Assess student understanding by having students answer the following questions either as a discussion or written on paper. What did the readings on the	b. Go around the room allowing each group to share the answers on their paper. Encourage questions between classmates. c. Say: Does anyone think they know what "EMF" is and how it is related to concepts you learned in science class already? Allow students to hold misconceptions at this point without correcting them, and welcome differing opinions if the students can behave respectfully and give evidence to their beliefs. Guide the class' understanding with your own questions to eventually lead them to reconcile radio waves as the most likely culprit of their observations of EMF from the experiment. Students will need to understand that while their devices sense and emit only a small part of the radio spectrum, that part of the spectrum is the most common for the wireless frequencies they use from day to day. Their phones are not ideal EMF sensors, however, we can see that EMF is everywhere. On the other hand, we do not know the context of our data. **What is a "healthy" amount of non-ionizing radiation, what are the long-term effects of exposure, and where will tomorrow's technology take us?** These are the questions the students will be investigating for this project. 3. Closure for day one: a. Video clip: How much radiation are you getting from your phone? (10 min) This video shows the host using a microwave leakage sensor to test a phone for radiation. The meaning of the readings on the sensor and how microwaves cook food are explained and given context. The host follows up by explaining the difference between ionizing and non-ionizing radiation and tests the phone with a Geiger counter as well. https://www.youtube.com/watch?v=rKRTyEWj-EA (last accessed 6/12/23)

sensor mean? How do microwave oven use EM energy to cook food? How are ionizing and nonionizing radiation different? How are they the same? If you use this version grade the answers to the Checks for Understanding questions. Do not grade student answers but instead focus on how well they express their ideas.	If preferred, this same video can be found here, trimmed to 7.5 minutes and with check for understanding questions in EdPuzzle. Teachers can choose to assign this video for inside or outside of class. https://edpuzzle.com/media/62d606b84a5af84163d2c8ec (last accessed 6/12/23) **Day 2** 1. Introduction/bellringer (5 min.) **Quickwrite** Have students write in their notebooks or in the worksheet provided in response to the question, "What do you know about researching facts on Google? What are some ways to tell if a source is good? What are some signs that a source is not so good?" Be sure students are not just thinking about what they might have been taught in school about reliable sources online, but also let students consider trends in media, such as TikTok, and what made that trend seem particularly true or fake. At the end of the 5 minutes, have students volunteer some of their insights on this prompt. Make a running list on the board of the strategies suggested that will help them for this project. 2. Optional recap (~5 min) a. Video on the health effects of cell phones b. After the video allow students to ask questions or offer comments. Hold a short discussion on these topics.

Collect and grade the worksheet. More time can be given outside of class as homework. Students should be encouraged to find interesting sources outside of class but should avoid wasting class time.	3. Reliability presentation (10 min) Go through the pages of information with your students before they research. 4. Project Worksheet: Is Radio Wave Technology Safe? (15 min) a. This worksheet can be done online or can be printed for students to fill out by hand if needed. They will need access to the internet for this activity. b. Begin this assignment together as a class for questions 1-7. This will help students become acclimated to looking at scientific publications. The teacher may need to read aloud or rephrase some of the abstract to help students comprehend. c. After answering questions 1-7, the teacher can demonstrate using the citation tool in Google docs or Word for the class before moving on. **Note:** The article referenced for these questions is still debated and cited by those opposed to radio EMF. Students can use this article to support their arguments or else find problems with the conclusions drawn by the studies cited in it. 5. Research – Project Worksheet: Is Radio Wave Technology Safe? (15 – 30 min.) 6. The remainder of the worksheet is designed for the students to complete independently. The teacher can decide to make this project individual or in pairs/groups. The students will need very structured time limits during class for research or else they will fall behind. Teachers may find it appropriate to assign some research for outside of class. a. Teachers will go over Part 2 of the worksheet with the class. Read over the directions together with the class. Students should be directed to look for quotes or images that they intend to use for their final presentation. b. Have students work in 5 minute increments to complete the worksheet. At every 5 minute mark, check in with a show of hands to see how many sources they have collected. c. During this time teachers should actively monitor and assist students in finding and citing sources. Images and screenshots can be inserted into the document digitally. Students may want to add each site used to their

	bookmarks folder. d. Be sure the class focuses only on *collecting research* at this point. They do not begin creating the final presentation at this time. **Day 3** (*Note: This lesson can be completed after students have had time to complete the research worksheet and receive feedback.) 1. Introduction/bellringer (5 min) **Quick write**
Do not grade their answer but rather on their ability to depend their position.	Question: "Is radio frequency technology safe?" Has your opinion on this changed at all? What new information have you learned since the last class, and what made that information impactful for you? Have students complete this second quick write in their notebooks or on the worksheet provided about their opinion on the safety of radio frequency technology. Be sure they reflect about any new information they have learned since the first day and why that information was impactful for them.
Collect and grade this page at the end of the project.	2. Soundbyte-ing Research Worksheet (15 min) a. Inform the class they will now need to communicate their research clearly and concisely for their audience. b. Pull up the Soundbyte-ing Research Worksheet and go over the directions and example with the class. Explain their audience, being other students, will have a short attention span. They will need to say their points as impactful as possible. c. Give students time to complete this in class. The teacher will need to assist students as they work. 3. Using a Digital Design a. App 25 min. to introduce app, Additional time will be needed for students to complete their projects. It is at the teacher's discretion whether this time will be given inside or outside of class. b. It is important that the teacher has made an example of this project for themselves so they can confidently demonstrate how to use the app for the class. The Canva website (www.canva.com) is completely free for educators and students, integrates with classroom software, and will allow multiple students to collaborate on the same project if

	needed. Adobe Spark works similarly. c. When the class has completed their Soundbyte worksheet, they can now decide how they will present their research. Infographics are a great way for students to quickly and easily communicate multiple points in an easy to read one-pager. Students may also like a social media-style presentation or video. d. Demonstrate how the students can choose a template based on how much data they are presenting. The presentation will need a title and the name of the author(s). Images from their research can be copied and pasted into their digital design. Existing images in their template will need adjusting, or deleting. Students should resize the finished project so that it appears attractive and complete. Finally, show students where to add their works cited. Citations do not have to be visible on the main page of the presentation. e. Encourage students to try a creative way to present their project. It is common for students to ask to use a more familiar software, such as PowerPoint, but remind those students that they are at school to learn many skills, including design. The new app may prove useful for other interests and projects, so it is a good experience for them.
Post Activity Assessments	**Closure**
Create a rubric for the presentation. Distribute it and discuss with students before grading projects.	**Gallery Walk and Discussion** The gallery walk should be done after the class has had sufficient time to complete their digital presentations. Students can work in groups or individually. Have students set up their projects on their laptops or tablets around the room. Teachers may find it useful to complete this gallery walk in the library or technology lab or another place on campus where students can get out of the regular classroom. Once the projects are set up, give students sticky notes to write positive/constructive comments for each project they view. The amount of time given for the gallery walk will depend on the size of the class. If the class is particularly large, then it may not be necessary that students look through every single project. Give the class a set time limit for the gallery walk so they do not waste time. When the gallery walk is finished, allow a minute or two for students to read comments on their work. These notes can be kept or discarded. Next, have students place a sticky note on the best

	project(s). The top winners will get a round of applause from the class. **Ask:** What did you see on the winning projects that stood out to you? Take comments from students, and encourage dialogue from the winning authors about their process. **Ask:** Was anyone's mind changed during this project? What did you learn about radio wave radiation? Help students construct specific details in their responses here. Finally, have the class clean their gallery walk and return to their seats for the final reflection.
5 min.	**Quickwrite** Have students complete the prompt in their notebooks or on the worksheet provided. Question: "Is radio frequency technology safe?"Did you learn anything interesting from a classmate's presentation? What new skills have you learned about researching scientific information and presenting it to others? Was there anything you would do differently if you had more time?

Culturally Inclusive/Responsive Components

This project encourages all students to have an equal voice in discussion activities and allows for differing opinions on a topic that does not have a clear and definite answer. The final presentation component of this project will also allow students to express themselves creatively in science class, using art, design, film, or music.

Educator Resources

RF Spectrum Management: An Introduction to the Radio Frequency Spectrum Management at National and International Levels, Sandra Cruz-Pol, PhD, 2019 (This book may be available at a university library or could be requested at a local library.)

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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

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