Level	LOCAL WIRELESS COMMUNICATION
High school	

Time Required	Lesson Summary
150 Minutes (3-50 minutes periods)	The students will learn about the fundamentals of the electromagnetic spectrum but emphasis will be placed on Radio frequencies. There will be an explanation of the use of these frequencies in science, wireless communication, and modern applications. Students will learn about transmitters, receivers, Ham radio, amplitude modulation (AM), and frequency modulation (FM). Finally, the RTL-SDR dongle will be presented to the students and how it works. An activity for tuning and identifying local radio broadcasting using the RTL-SDR dongle will be done.

Standards

NGSS

HS-PS4-3 Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.

HS-PS4-4 When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.

HS-PS4-5 Photoelectric materials emit electrons when they absorb light of a high enough frequency.

HS-PS4-5 Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.

Vocabulary	Objectives
Electromagnetic waves	• Students will develop an understanding of the fundamentals

(EM) Wavelength Frequency Radio Frequency (RF) Software-defined radio (SDR) Antenna Amplitude modulation (AM) Frequency Modulation (FM) Ham Radio/Amateur Radio	of radio frequencies • They will be able to describe the many uses of these wavelengths in modern society.

Materials

- RTL-SDR dongle kit (such as the one seen here, https://www.amazon.com/gp/product/B00VZ1AWQA/ref=ppx_yo_dt_b_asin_title_o01_s00?ie=UTF8&psc=1)
- PC with windows 7 or newer

Pre-Requisites

Introductory theory of the electromagnetic waves and the spectrum is very useful. Since RF will be introduced in this lesson, previous discussion would be useful but not required.

(Optional) Previous installation of the required software for the RTL-SDR dongle would be useful. The procedure requires a couple of minutes, so the group of students may help each other in the process.

Safety Considerations

None.

Pacing Notes

Day 1 – metric review, class discussion on the EM spectrum, direct instruction on the EM spectrum

Day 2 – demonstration by a member of the local Ham radio club

Day 3 – Identifying local broadcasters

Before the Lesson	
Make sure student computers have the required software.	
Assessments	**Classroom Instructions**
Pre-Activity Assessments	**Introduction**
The pages can be collected and graded.	While you are taking care of administrative tasks have students review basic metric conversions. Hand out the student metric conversion page and have them complete the practice problems alone or with a partner.
Activity Embedded Assessments	**Activities**
Listen to what students are saying during this discussion. Help students make connections between everyday things and these topics.	**Day One** 1. Discussion on the electromagnetic spectrum. The teacher will make open questions to the students about the different ranges of the EM spectrum. **Ask**: Have you heard of gamma rays? **Ask**: What about x-rays? **Ask**: Have you used a microwave? **Ask**: Have listened to a radio station? **Ask**: Have you seen a rainbow? **Ask**: Is there something in common for these phenomena? Allow students to put forth theories and have those theories challenged by other students. If the students do not come to this point eventually **Say**: All the previously mentioned phenomena are electromagnetic waves. 2. Direct instruction on the electromagnetic spectrum. a. Stop after page 4 and hand out the wave equation practice sheet. Have students work with a shoulder

Walk around while students are working on the wave equation problems and ask questions such as: How did you find that answer? Do you have all the information you need? Explain to me your process for solving that problem. Use these tickets to plan your future lessons.	partner on the problems. Go over the answers before proceeding. b. Stop after page 13 and show this short video on the James Webb Telescope. There are questions to accompany the video on the same page as the wave equation practice. https://www.youtube.com/watch?v=QNY6DPZNZII 3. Conclusions for day one – Exit ticket Have students write down one thing they learned and one thing they still have questions about. They should give this to you as they exit the classroom. **Day Two** 1. Introduction Show the following videos to students at the beginning of class. Instruct them to create four questions from these videos which are appropriate to ask the guest speaker. https://www.youtube.com/watch?v=wDn-6SDxyD4&t=23s https://www.youtube.com/watch?time_continue=352&v=8x6x_6mDVIQ&feature=emb_logo 2. **Optional** – Talk and demonstration from a Ham Radio licensed club member If the opportunity is available, this activity is strongly encouraged. A Ham radio licensed member could be invited to the classroom to give a talk. It would be best if the speaker brings a few club members so that all of them can set up their equipment in different areas of the room. This

While students are working walk around and ask some of the following questions. What are you doing now? How did you do the last task? Can you explain to me what you have done so far? What questions do you have for me?	will allow all students to see how the equipment works and perhaps even get to try it. This could motivate the students to pursue Ham Radio as a hobby, or related professions in the future. However, if this is not possible you may skip day two entirely. 3. Day two conclusions Have students create a list of all the situations in which being a Ham radio operator would be beneficial to society. **Day Three** **1.** Introduction a. Provide students with the document "Instructions for the Installation of supportive software and the SDR software". b. Have students install this on their computers while you take attendance. **2.** Local broadcasting with the RTL-SDR dongle a. Hand out the Local Broadcaster Activity Page. b. Go over instructions c. Create groups of 2 to 3 students d. Allow students to work on the assignment.
Post Activity Assessments	**Closure**
	At the end of the third day have a discussion about the careers which use the content and skills students have learned about during the lesson.

Culturally Inclusive/Responsive Components

Students are encouraged to work in groups. But if some students prefer to work individually, they must communicate with the teacher. Activity with the RTL-SDR dongle could be used apart and complete the activity if needed.

The teacher should be attentive to students with special needs. Make sure they perform the activities, and if possible, integrate them into the working groups.

Some groups may be underrepresented in science and engineering professions. Ham radio, engineering, science, and related professions discussed in the lesson should be strongly promoted to all students but specials effort should be used to entice individuals from these groups.

Educator Resources

- Windows based RTL-SDR Technical Guide (PDF document).
- Scientific notation and prefixes table from the Society for Cable Telecommunications Engineers (SCTE)

https://www.claytonschools.net/cms/lib/MO01000419/Centricity/Domain/244/TechTips_Tables_Metric-SciNot.pdf

- "What is Ham Radio?"

https://www.youtube.com/watch?v=wDn-6SDxyD4&t=23s

- Amateur Radio: A hobby for the 21st Century

https://www.youtube.com/watch?time_continue=352&v=8x6x_6mDVIQ&feature=emb_logo

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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