Lesson	Spectrum Management
9	

Time Required	Lesson Summary
125 minutes (2.5 – 50 minute class periods)	Students will investigate the local users of the spectrum and learn about additional users which are not in their area. Then students will work in small groups to create a priority list of spectrum users. The lesson will conclude by students comparing and contrasting their priority list to the priorities set by the federal government.

Standards Addressed

- **Next Generation Science Standards (NGSS)**
  - HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy
- **West Virginia Standards**
  - Economics SS.C.23 Examine the opportunity costs in ever-present scarcity for individuals, businesses and societies to understand how to make choices when facing unlimited wants with limited resources
  - Economics SS.C.27 Describe how households, businesses and government interact in a free-market economy.
- **New Mexico Standards**
- Social Studies Content Standard IV: Students understand basic economic principles and use economic reasoning skills to analyze the impact of economic systems (including the market economy) on individuals, families, businesses, communities and governments.
- Benchmark 4-A Students will analyze the ways individuals, households, businesses, governments and societies make decisions, are influenced by incentives and the availability and use of scarce resources, and that their choices involve costs and varying ways of allocating.
- Performance standard 4 Analyze and evaluate the impact of economic choices on the allocation of scarce resources.

Vocabulary	Objectives
However if	• Students will determine what types of devices use the spectrum • Students will allocate a limited resource and explain the reasoning behind

students did not complete lesson 4 these are new words to them. Software defined radio (SDR), interference, polarization, directionality, gain, coax choke	their decisions • Students will understand how the government allocates the same resource and discuss the similarities and differences

Materials

- RTL-SDR dongle kit https://www.amazon.com/gp/product/B00VZ1AWQA/ref=ppx_yo_dt_b_asin_title_o01_s00?ie=UTF8&psc=1
- Download the free technical guide from the web site

Pre-Requisites

Students need to know about the electromagnetic spectrum, electromagnetic waves, and how the RTL-SDR dongle works.

Safety Considerations

None

Pacing Notes

This lesson is planned to last two and a half 50 minute class periods. Below is a suggestion of the activities which can be accommodated in each class period.

Day 1 – Explain how the dongle works and scan the spectrum, students create categories for local and additional spectrum users

Day 2 – Students create priority list of users, students investigate the governments allocation chart and identify the priorities

Day 3 - Students compare and contrast the two priority schemes.

Before the Lesson

Make sure you have set up the hardware and software as described in chapters 1 and 2 of the windows-based technical guide.

Print the spectrum management sheet, the how the government makes the rules page (or make available on your web page), the additional users of the spectrum sheet (or make it available on your webpage, and make the allotment chart available to students on your web page. The chart can be found here https://www.ntia.doc.gov/page/2011/united-states-frequency-allocation-chart (last accessed Oct. 9, 2022)

Assessments	Classroom Instructions
Pre-Activity Assessments	*Introduction*
	While you are taking attendance have students brainstorm all the devices they have that use the electromagnetic spectrum. After you are finished with administrative duties. Ask students to share things from their list and create a list on the board. To save time ask students to only share things which are not already written on the board.
Activity Embedded Assessments	
After explaining it to students and showing them a scan. **Ask**: How does the RTL-SDR dongle receive the radio wave? **Ask**: How is a picture made from the waves?	**Provide Background Information** 1. If you **did not** use Lesson one: Argumentation and radio waves in your classroom spend several minutes explaining to students how the RTL-SDR dongle receives radio waves. 1. Scanning the spectrum Follow the instructions in the technical guide chapter 2 to scan the spectrum. Explain to students what you are doing and what they are seeing. **Say:** This antenna is receiving radio frequency waves that are in the area. Those waves are invisible but with the help of this dongle and some downloaded software those signals are visualized into the image you see on the screen. This image is referred to as a "waterfall". The peaks occur at frequencies where there is a signal. The stuff between those peaks is referred to as "noise". This "noise" can be caused by a lot of things including bad reception from the antenna, and less powerful signals from

	things such as microwaves. We will learn more about these less powerful signals during this lesson. In order to not over load the system scan 50Mhz at a time starting a 88 MHz and going up to 1600 MHz. Hint: To make the intervals easier to calculate make the first scan a little larger, 88-140 MHz. To increase student participation have a different student come up and preform each scan using your computer. To cut down on the time spent on this activity it is not necessary to scan the entire frequency range. As long as each student who wants to scan the spectrum is given the opportunity to try it you may eliminate some of the scanning. Each time a section is scanned: **Ask**: Do you recognize any of these broadcasters? (Local radio stations use the frequency in the call sign so students may be able to identify some of the peaks. After the class has scanned the required frequencies point out that this section of the spectrum is defined by certain frequencies. Tell students that there is a limited amount of spectrum available for use. Point out that every peak that was detected was created by a single broadcaster. Therefore, there can only be a certain number of broadcasters before the broadcasts start overlapping and interfering with one another.
While students are working in small groups walk around. Observe students, are they all actively engaged in the learning activity? Approach the ones that are not and have a conversation with them. **Ask**: What is your group doing now? **Ask**: What would you like to contribute to this task?	2. Categorizing the users of the spectrum in the area Government agencies, public safety and private businesses use radio frequencies to communicate with members of their organization and sometimes with the general public. These frequencies are a matter of public record and as such can be found on the web pages listed on the spectrum management page. Hand out the Spectrum Management page. Students should work in pairs or groups of three for this activity. Students will first read through the list of broadcasters, create categories, and finally place each broadcaster into one of the categories they created. Frequently remind students that they need to provide an explanation for each category.
	3. Identifying additional broadcasters

Check that students understand they are not assigning frequencies but rather establishing priorities. **Ask**: What does this percentage represent? **Ask**: Which category of spectrum user do you think needs the greatest percentage of frequencies? Why did you choose that category?	Say: Now that you have created categories based on the registered users in the area you are going to learn about some additional users of the spectrum. Determine if these users fit into existing categories or if you need to create new ones to accommodate them. Remember to have a reason for each category. Instruct students to stop when finished with this activity and wait for you to provide additional information before moving on. 4. Creating an allocation system Explain to students that the government allocates the frequency bands based on a set of rules. Those rules have been created over many years by two government agencies. Tell them the allocation process is much more complicated than determine the importance of each use of the spectrum. This activity is meant to be a model of the process. Like all models this one has strengths and weaknesses.
As students are working walk around and ask questions similar to the following: **Ask**: Which categories currently have the greatest amount of government allocation?	Distribute the How the Government Creates the Rules page. Either have students read this silently to themselves or have students take turns reading it out loud. Explain that they are not going to be allocating specific frequencies to users because as mentioned in the handout that requires a lot of time and input from several people. Instead they will be identifying which users should be given priority by assigning them the largest percentage of the useable spectrum. Again, have students stop after completing this activity so you can provide additional information before they move on.
Ask: What similarities have you found between the two allocation priorities? **Ask**: What differences have you found? **Ask**: Why do you think those exist?	5. Investigating the existing allocation system Direct students to the government allocation chart. They should estimate the percentage of the spectrum assigned to each of the categories in the table. This is not going to be an exact value and will probably vary from one group to another. That is okay, the purpose of the activity is to gain an understanding of the users and the amount of spectrum allocated. It is important that the percentages add up to 100. Then they should assign a ranking to each category. The higher the percentage, the higher the rank. This represents the US government priorities when it comes to spectrum usage.

	6. Comparing and contrasting There is no need to stop students between the previous activity and this one. They can move forward at their own pace.
Post Activity Assessments	*Closure*
The answers will help you determine is students understand how spectrum is allocated.	**Exit ticket** Students should answer the following questions on a sheet of paper and submit to you as they exit the room. How does the government make allotments of spectrum?

Culturally Inclusive/Responsive Components

If you have students who have moved to the US from another country give them an opportunity to share about how decisions are made in their government.

Stress to students that your classroom is a safe place and it is not appropriate to criticize other cultures. They should be allowed to ask questions as long as there is no judgement included in the question.

Accommodations

Your students ability level should be taken into consideration when creating the group sizes. If your students are all have grade level reading levels and are motivated to participate in activities you could have pairs of students work together. However, if you have a variety of reading and motivation levels in your class a group of 3-4 students would be appropriate.

Educator Resources

None

Optional Extension Activities

After student groups have created their allocation system you could have students present this information to the class. Then students could discuss the choices made and groups could revisit their allocation percentages.