Level	Investigating the Internet Connection
High School	
Time Required	**Lesson Summary**
3.5 – 50 min. class periods (175 min)	In this lesson, students use their knowledge of the electromagnetic spectrum to study the transmission of radio waves. Students will create an investigation that tests various WiFi speeds throughout the school campus. Finally, students will use their data to create a graphic representation of their data to share with other members of the school community including their classmates and the faculty and staff.
Standards	
	NGSS HS-PS4-5 Waves and their Applications in Technologies for Information Transfer. 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. PS4.C Information Technologies and Instrumentation. 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**
Wavelength Frequency Electromagnetic wave Radio Waves Law of reflection	• Students will understand and utilize the wave characteristics and behavior of electromagnetic waves. • Students will understand the limitation of the radio wave range.

Federal Communications Commission	

Materials

- Charged phones.
- Poster supplies: including markers, colored pencils, graph paper, rulers, meter sticks, scissors, and glue sticks.
- Student computers
- Download the FCC speed test app: https://www.fcc.gov/BroadbandData/consumers#speed-test (last accessed 8/12/23)
- It may be useful to print out the following charts:
  Radio frequencies allocated by the US government:
  https://www.transportation.gov/sites/dot.gov/files/pictures/2003-allochrt-05172017%200419PM.png (last accessed 8/12/23)
- The radio spectrum section of the electromagnetic spectrum magnified:
  https://www.transportation.gov/sites/dot.gov/files/pictures/Electromagnetic%20Spectrum%20Cropped%2005082017%200310PM.png (last accessed 8/12/23)

Pre-Requisites

Students should be familiar with the electromagnetic spectrum and radio waves.

Safety Considerations

Crossing streets or parking lots by foot while looking at a cell phone can be hazardous and should not be done while conducting this activity.

Pacing Notes

Day one:

Day two: Investigation

Day three: Create a poster

Day four (1/2 class) - presentations

Before the Lesson	
Talk to other teachers and administrators about the project. Get approval for students to move around the building in small groups.	
Assessments	**Classroom Instructions**
Pre-Activity Assessments	**Introduction**
This paper can be collected and graded.	While you are taking care of administrative tasks have students complete the following. Compare and contrast visible light and radio waves.
Activity Embedded Assessments	**Activities**
Monitor student papers and the discussion. If a lot of students don't seem to be familiar with the electromagnetic spectrum go back and re-teach. The student sheet should be collected at the end of class and graded.	**DAY 1** 1. Discussion about the electromagnetic spectrum a. Consider using the questions below or come up with your own. What is the electromagnetic spectrum? How does the energy in the EM spectrum travel? What is special about visible light? How is visible light different from radio waves? 2. Introduction to WiFi a. Hand out the student sheet, Introduction to Wi-Fi Go over the instructions before starting the video b. Play this very short video for the class. https://www.youtube.com/watch?v=xmabFJUKMdg

	Students should answer the questions during the video. c. Speed test Students need a cell phone for this activity. Allow students without phones to form a group with someone who has a phone. Students need to go to the web page on their paper and test the speed of the internet. d. Class discussion Hold a short class discussion consider using some of the following questions in addition to your own. What download speed did you get? What upload speed did you get? Why do you think different web pages provided different speeds? What is the quality of the wireless in our school? 3. Investigation a. Group creation Either assign groups or allow students to select their group. It is important that there be a functioning cell phone in each group. No more than four students per group. b. Hypothesis creation Hand out the Internet Connection page and go over directions. The groups should come up with a testable hypothesis as quickly as possible. You should have students bring their hypothesis to you for approval before allowing the group to work on their procedures. c. Conclusion for day 1: Procedures After getting their hypothesis approved groups should work on their procedures. They should turn those into you before leaving the classroom.
Collect the Internet page as students leave the classroom. You could grade this or you could just use it as a formative assessment and make comments on the page so groups can improve their work.	
	Day 2 1. Return the Internet Connection page to groups and give them 5 to 10 minutes to revise their work. Students should bring the paper to you when they think they have made the necessary changes.
Make sure you have gotten permission for your students to	

leave the room without you. Monitor student behavior in the halls. If possible get some volunteers (teachers, admins, parents) to help monitor behavior in other parts of the school. Create a rubric for the presentation and give it to students after they are finished collecting their data.	2. Remind students of the rules for leaving the classroom to collect data. 3. Distribute the rubric for the presentation and go over your expectations with students. 4. Exit Ticket Students should write one thing they learned and one thing they still have a question about on a small piece of paper. This should be collected as students exit the room.
	Day 3
Walk around while students are working and ask the following questions. What are you working on? How are you contributing to your presentation? Is there something else you would like to include? How did your group arrive at your conclusion?	1. Go over the expectations and rubric with students. 2. Poster creation. This can be a physical poster or a digital poster. Allow students to express their personalities through their presentation choices.
	Day 4 (Half the period)
Grade the	1. Give groups five minutes to organize themselves.

presentations and posters according to your rubric.	2. Go over your expectations for group presentations. 3. Group presentations.
Post Activity Assessments	**Closure**
Collect at the end of class.	As a final reflection, give the following prompt: *How might some groups of people be limited by internet speed or internet access?*

Educator Resources

Understanding Science is an excellent resource for teaching the scientific method https://undsci.berkeley.edu/

Step-Up Poster on discussion norms: (English and Spanish)
https://higherlogicdownload.s3.amazonaws.com/APS/2c0c9f07-6428-4f8e-b9aa-a76098a80cd0/UploadedImages/StepUp-English-Poster.pdf (last accessed 8/10/23)

https://higherlogicdownload.s3.amazonaws.com/APS/2c0c9f07-6428-4f8e-b9aa-a76098a80cd0/UploadedImages/StepUp-SPANISH-Poster-rev.pdf (last accessed 8/10/23)

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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
Diffraction of Radio Waves

High School

The Uses of Radio Waves and Frequency Allocation
Is Radio Technology Safe?
Who Decides if You Get 5G?
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