Level	Simple Wireless Communication
High School	
Time Required	**Lesson Summary**
180 minutes (3 – 60-minute class periods)	Students will build a spark gap transmitter which generates pulses of radio waves that can be detected with an AM radio receiver.

Standards

NGSS

HS-PS2-5 - Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

HS-PS2-4 Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.

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 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
Electromagnetism Electromagnet Radio Waves AM radio Transmitter Receiver Wireless communication Telegraph Morse code	• Students will be able to construct a spark gap transmitter and test it using a radio receiver. • Students will be able to explain the operation of the spark gap transmitter. • Students will be able to use their transmitter to communicate using Morse code.

Materials

For each group:

- Wooden board, approximately 12” x 12”
- 3" x 1" x 1" block of wood
- Strip of 3" to 5" bendable metal (or a can lid)
- Another strip of bendable metal, 1 inch long. Could be substituted with a large metal paper clip.
- Magnet wire (at least 10 meters)
- 2 iron screws, 3” long
- 3 small screws
- 9-Volt battery
- 2 alligator clip electrical jumper cables
- Screwdriver
- Wood glue
- Sandpaper
- (Duct tape can also be useful)

Class set:

● RTL-SDR dongle kit (one teacher’s kit would be sufficient)
Amazon.com: Nooelec NESDR Mini 2+ 0.5PPM TCXO RTL-SDR & ADS-B USB Receiver Set w/Antenna, Mount & Female SMA Adapter. RTL2832U & R820T2 Tuner. Low-Cost Software Defined Radio for Windows, Mac OS & Linux (1/11/23)
Or
Amazon.com: Nooelec NESDR Smart HF Bundle: 100kHz-1.7GHz Software Defined Radio Set for HF/UHF/VHF Including RTL-SDR, Assembled Ham It Up Upconverter, Balun, Adapters (last viewed 1/11/23)

● Download the free technical guide from the web site https://superknova.org/wp-content/uploads/2022/12/SDR-technical-guide.pdf (last viewed 1/11/23)

Alternative: AM radio receiver

Pre-Requisites

Students need to be familiar with the relationship between electricity and magnetism, the operation of electromagnets, and the electromagnetic spectrum.
Designing an electromagnet lab should precede this lesson.

Safety Considerations
Working with electricity involves the risk of creating short circuits, overheating the components, and electric shock. Emphasize safety and monitor work closely. It is advisable to let the students construct their circuit with only a battery holder and inspect the circuit before you provide them with batteries.
Pacing Notes
Day 1 – introduce the assignment, put students in groups, and go over safety and the directions. Students plan and begin to construct their devices. Day 2 – Students complete the construction, test, and redesign of their devices. Students practice coding and decoding messages in Morse code. Day 3 - Students research the history of wireless communication including modes of communication used by different cultures before the advances in technology. They prepare presentations summarizing their research, demonstrating their device, and explaining how it operates.
Before the Lesson
Ensure that the signals produced by student devices are contained and will not interfere with any receivers in the vicinity of your classroom. Transmitting without a license is illegal. Follow the instructions in chapters 1 and 2 of the technical guide to set up the RTL-SDR dongle in your classroom. Prepare some working samples of the device to help students understand the task and for use by any groups that are not able to get their device to operate properly in the allotted time.

Assessments	Classroom Instructions
Pre-Activity Assessments	**Introduction**
Use students' responses to assess their level of understanding of electromagnets and reteach concepts if necessary.	As you are attending to administrative tasks have students respond to the following prompt on a small piece of paper. Describe the process of constructing an electromagnet. Identify the factors that affected its strength.
Activity Embedded Assessments	**Activities**
	1. Divide students in groups.

	a. Use your observations from previous labs to ensure that all groups will be fully engaged and work well together. 2. Introduce the project with an engagement activity a. Provide students with Morse code cards. Display a message in Morse code and ask students to decode it. b. You may also demonstrate to use a Morse code app on a smartphone so they can practice on their own.
Ask: Who can summarize the safety instructions I just gave you?	3. Go over safety when working with electricity.
Walk around while students are creating their plan. Answer any questions they have and encourage students to not help their group members at this time.	4. Display a completed work sample (see teacher's key) or play a video showing the construction of the device. One example can be found here: https://www.youtube.com/watch?v=qNY31O1bSXE (last viewed 1/11/23) 5. Distribute lab instructions 6. Provide the lab material for each group (except the batteries) 7. Ask: Does anyone have a question about any of your materials? 8. Give students approximately 5 minutes to create their plan.
Walk around while groups are sharing. Ensure students are creating a list of similarities and differences.	9. Once most of the students are done with the individual plan, instruct them to discuss their plans with their group. Give them about 10 minutes for this activity.
While students are working on their	10. Once students have finished sharing their ideas have them work as a group to create a first draft of their plan.

plan walk around and monitor conversations. Make sure every student is allowed to get their way at least once in the plan.	
Walk around and answer questions. Monitor behavior and use of computers.	11. Give students about 20 minutes for their research. 12. Students will work with their group to revise the plan. When they are finished they will bring it to you for approval. Inspect the plan for any dangerous decisions. If it is safe approve it by signing the paper. As long as the plan is safe it is important to allow students to build it even if you know it won't work. They will learn more from making a mistake than by you telling them they are wrong. 13. Once students have completed the building of their plan they should raise their hand. Inspect it for safety and as long as it passes give them a battery. 14. Students will need to test their design. When the first group is at this point stop the whole class and go over the directions. 15. If a group tests and it doesn't work have them go back and redesign. Be sure to collect their battery first. You will need to approve any changes they make by signing the paper a second time. If a group is still unsuccessful give them some help in getting it to work. 16. Once all groups have a working apparatus pair them up. Have one group transmit a coded signal and the other group can decipher. Then switch. Caution students to keep the messages G rated. 17. Whole class discussion

Collect the papers and grade.	To ensure full participation, have an object that students can safely toss to each other. A student who answered a question or shared will pass the object to another student who has not yet participated. Ask the following questions: ● What did you learn about the engineering process as you completed this activity? ● What are some jobs in wireless communications that you may be interested in? ● Share one thing about wireless communications that you learned from other groups' presentations. ● Anything else related to this activity you would like to share?
Post Activity Assessments	**Closure**
As you facilitate the discussion, take note of students' answers and identify areas you need to address in future lessons. Accept all answers without judgment and ask follow up questions. Grade the presentation	Students research the history of wireless communication including modes of communication used by different cultures before the advances in technology as well as the current advances in radiocommunications. Groups prepare presentations (posters, slide shows, etc.) summarizing their research and placing their project in historical context. Groups also demonstrate their device, explain how it operates, and discuss the challenges they faced and how they resolved them. Students also include a Morse code message for their classmates to decode.
Culturally Inclusive/Responsive Components	
● The activities in this lesson are completed in groups. The teacher must ensure equitable participation for all students. This starts with thoughtful assignment of students in groups as well as roles within the groups. Often, during hands-on activities, girls take the role of a reader, recorder, or just observe the boys' work. The teacher should intervene and ask the group to assign hands-on tasks to each team member. ● Some students with special needs may struggle with academic tasks but excel in lab activities and should be encouraged and praised. The teacher should ensure that they	

are teamed up with classmates who can explain the written instructions.

- It is a well-established fact that women and some minority groups are underrepresented in science and engineering careers. We as educators need to understand the reasons and see the issue through the eyes of our students. One way we can do this is to ask them. A post-lab activity may include asking the students to create a survey for their classmates and other individuals in their family and social circle. They can include questions targeting interest in and knowledge about science and engineering careers as well as obstacles and reasons for rejecting such careers. Students then can distribute the survey and share their findings.
- Students may be asked to research the contributions of their culture in the field of wireless communications and include these in their presentations.

Educator Resources

HISTORY, THEORY, & CONSTRUCTION OF THE "ELECTRIC TELEGRAPH"
http://w1tp.com/pertel.htm (last viewed 1/11/23)

How to make a simple Wireless Telegraph/Spark Gap Transmitter video
https://www.youtube.com/watch?v=qNY31O1bSXE (last viewed 1/11/23)

How to build the simplest radio transmitter - the spark gap radio
https://www.youtube.com/watch?v=izCV1WrPFds (last viewed 1/11/23)

A brief history of long-distance communication
https://www.wilsonamplifiers.com/blog/a-brief-history-of-long-distance-communication/ (last viewed 1/11/23)

The international Morse code chart and decoder chart can be found on this web page
https://www.sarcnet.org/international-morse-code.html (last viewed 1/11/23)

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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
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