Level	How to design your own crystal radio
High School	

Time Required	Lesson Summary
3 – 50 min. class periods (150 min.)	Students will research how a radio sends and receives AM and FM signals. Students will then design and construct a crystal radio. Finally, students will demonstrate their knowledge of how a radio works using electromagnetic radiation by creating a presentation, flier, or poster to showcase their expertise.

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.

HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

HS-PS4-3 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

Vocabulary	Objectives
Radio Waves Wavelength Amplitude Encode Decode Crystal Radio Am and FM Signals Frequency Diode	• Students will be able to construct and evaluate how components of a crystal radio relate to the communication system. • Students will also research and compile information on how radio works using electromagnetic radiation by presenting their findings through a flier, google slides, video or a poster.

Materials

*For a class set of **30 students**.*

- 10 Empty Paper Towel Roll or Sturdy Water Bottle/Shampoo Bottle
- 25 feet of Aluminum Foil
- 2 Wire Cutters
- Markers
- Tape
- Scissors
- 10 Germanium Diode (1N34A)
- Hook Up Wires (22 gauge)
- Magnet/Copper Wire (28 gauge)
- 30 Alligator Clips
- Piezoelectric earphone or Speaker/Rechargeable Power Speaker
- 100 Brass Fasteners
- Printed Student Worksheets
- Ruler
- Graph Paper
- 10 Cardboard Sheets
- Computer for Research

Pre-Requisites

Students need to understand electromagnetic waves and their different properties. Students may also need to understand the difference between mechanical vs electromagnetic waves. Students will need to know the relationship between wavelength, frequency, and wave energy.

Safety Considerations

Students need to be careful when using scissors to cut holes or wires.

Pacing Notes

Day 1- Discussion about communication, research, sketch

Day 2 – Alan Turing video and discussion, build radios

Day 3 – finish radio, test, demonstrations

Before the Lesson	
Make sure to purchase the equipment to build a crystal radio. Make sure to build one yourself first to help troubleshoot for students.	
Assessments	**Classroom Instructions**
Pre-Activity Assessments	**Introduction**
These answers can be graded for completion.	1. Have students write answers to the questions below. How did people communicate in the past? How do we communicate now? Do you think there are any places in the United States where there are no cell phones or Wi-Fi use? Why or why not? 2. As students are answering questions, you can finish taking attendance. Walk around the classroom to observe and possibly comment on what students are writing on their paper. 3. Have students think-pair-share their work with their shoulder partners or someone close by. Use equity cards to randomly choose a few students to share their answers to the class. If time permits, have students briefly discuss what they think are pros and cons for the old versus the modern forms of communication.
Activity Embedded Assessments	**Activities**
Walk around while students are working. Ask: What did you just finish?	**Day 1** 1. **Crystal Radio Lab** a. Hand out the Crystal Radio Lab sheet and go over the directions. Assign students to groups (3 is optimal, 4 is acceptable). b. Students should divide up the research and decide how they are going to present their research. c. Once those decisions are made students should work independently.

Ask: What are you working on now? Ask: Can you tell me what that means? Collect the sketch and make revision suggestions on the paper. You will be returning this to students the following day. Listen to student responses. If they aren't able to produce the answers in a large group. Break them into smaller groups and have them work together to write down the answers. Then return to the large group setting and discuss the questions.	2. **Conclusions: Sketch of the crystal radio** Students should work with their group the last 5-10 minutes to create a sketch of their crystal radio and a materials list. **Day 2** 1. **Introduction** a. Video on Alan Turing https://www.youtube.com/watch?v=ynTAFPukXBk b. Discussion Hold a class discussion about the video. Consider asking the questions below in addition to your own. What was Alan Turing credited for discovering? How did Alan Turing die? What was he convicted of, and what was his sentence? Do you think this was fair or nor fair? Why or why not? Do you think being recognized on the 50 bank note for England made a difference? Why or why not? 2. **Return the crystal radio sketch**

Walk around while students are working. Ask: What did you just finish? Ask: What are you working on now? Ask: Can you tell me what that means?	Students should make any necessary revisions. 3. **Build the radio** Students will gather all the materials needed either partly from home or everything from the teacher. Teachers should only provide material to students after the team demonstrates that they have a good grasp of how they plan to build their crystal radio.
	Day3
Walk around while students are working. Ask: What did you just finish? Ask: What are you working on now? Ask: Can you tell me what that means?	1. **Finish the radio** Groups should be given 10 minutes to complete their radios. 2. **Testing the radio** Students should test their radio as soon as complete. 3. **Redesign and rebuild** Students should redesign in order to improve the sound. 4. **Demonstrations** a. Go around the room and have each group demonstrate their radio for the class. b. Students will be given a small piece of paper or sticky note to vote for which two teams they think had the best quality of sound and whose crystal radio looks the most creative.

Post Activity Assessments	**Closure**
The teacher will grade the crystal radio. Teachers will also collect their flier, poster, or Google slides presentation. Teachers should create a rubric to show students what they would like to see in the final product.	The closure for this lesson is the conclusion section in the Crystal Radio Lab. Students will answer questions to summarize their understanding of how a radio works and reflect on their construction of the crystal radio. The teacher will also tally the votes up to decide which team the class voted as having the best sound quality for the crystal radio and the most creative design. You can provide extra credit as an incentive here or a free homework pass.
Culturally Inclusive/Responsive Components	
Students will be watching the YouTube video, https://www.youtube.com/watch?v=ynTAFPukXBk It is important to give students time to process their own thinking first after watching the video. Have students write down their answers to the questions referenced in day 2 above. After students have at least 5 minutes to formulate their own individual answers, have students turn to their AB partners to share.	

Before having students share their thoughts aloud in class, please remind students that this is a safe zone and that they will respect each other's thoughts and beliefs. Remind everyone that we are a small family and to be open minded that everyone has different experiences and perspectives.

All web pages last accessed 4/3/23

Educator Resources

Materials from XUMP:
Mini Hobby Speaker - 2 inch 4 Ohms
Micro Speaker - 8ohm 1W with leads
Alligator Clips
24AWG Stranded Copper Wire - Four Colors - 10m each
Wire Stripper Tool
10 pack Piezo Electronic Alarm Buzzers with Leads - 1.5V

Additional Articles:
https://www.wellpcb.com/diy-walkie-talkie.html
https://www.teachengineering.org/lessons/view/duk_amradio_tech_less
https://sci-toys.com/scitoys/scitoys/radio/radio.html
https://www.wikihow.com/Make-a-Crystal-Radio
https://www.explainthatstuff.com/radio.html
https://science.nasa.gov/ems/05_radiowaves
https://www.pbs.org/education/blog/ten-black-scientists-that-science-teachers-should-know-about-and-free-resources
https://medium.com/swlh/richmazzola-how-do-cellphones-work-a-story-of-physics-towers-and-the-government-8369aa7226b1

Videos
https://www.youtube.com/watch?v=VqdcU9ULAIA
https://ca.pbslearningmedia.org/resource/nvwtp-sci-physicstexting/wgbh-nova-what-the-physics-the-physics-behind-texting/

Alan Turing
https://www.turing.org.uk/
https://www.nytimes.com/2019/06/05/obituaries/alan-turing-overlooked.html

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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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