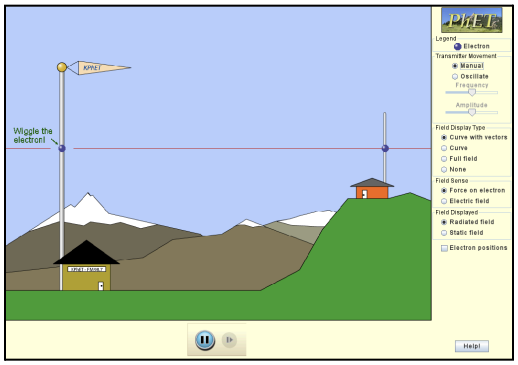
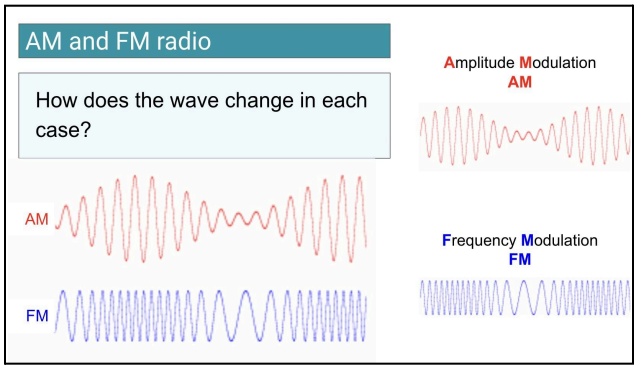
MAKING WAVES with radio

FACILITATOR GUIDE
FM & AM Radio





Overview

Wiggling electrons in a transmitter antenna generate radio waves that transmit information to a receiving antenna. This activity is designed to help you guide learners through a computer-based simulation with PhET, where they will explore how changes in frequency and amplitude impact radio waves and their ability to transmit signals. Learners will manipulate variables within the simulation to observe how electron movement in the transmitter antenna influences electron movement in the receiving antenna. This interactive activity enables learners to visualize how adjusting frequency and amplitude can alter the transmission of information.

Learning Objectives

- Electrons moving (wiggling) in a transmitter antenna create radio waves that can travel through space.
- Radio waves carry information from a transmitter to a receiver using changes in frequency and amplitude.
- Frequency describes how fast electrons wiggle, while amplitude describes how much they wiggle.
- Changing the frequency of electrons affects the type of radio wave that is transmitted (e.g., AM versus FM).
- Changes in amplitude impact the strength or intensity of the transmitted radio wave.

Materials

- Computer or tablet with access to the PhET Simulation: Radio Waves & Electromagnetic Fields.
- FM & AM Radio presentation slides [link]
- Reading and Drawing worksheet: *From Waves to Music: How Radios Work*

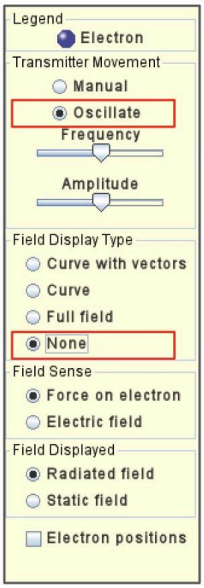
Activity Procedure

Setup the context. Ask the prompt on **Slide 1** to motivate this activity:

- *How do you think your radio "catches" sounds from far?* Invite learners to share their ideas, and mention that the goal of this activity is to answer this question.

Introduce the simulation

1. Go to the simulation (tinyurl.com/bddepdbk) and display it so every learner can see it.
2. Ask learners to share the different parts of the system they observe represented in the simulation.
3. Use probing questions to see if learners know what an electron is. If they don't, you can describe it as: "*a tiny particle in every atom that has an electric charge. An electric charge is a property that causes forces between particles, like the magnetic forces between two magnets. For example, electrons have a negative charge, and that allows them to move through materials like wires and create electric currents, which power our devices*".
4. Ask learners to predict what they think will happen if they wiggle the electron in the transmitter antenna, as suggested by the simulation. Accept their responses and run the simulation using the settings shown in the image on the right.

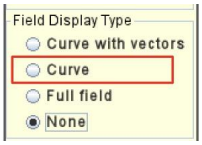


5. Next, change the frequency of the electron and then the amplitude, using the following prompts on **Slide 2**:
    - *How does the motion of the electron on the first pole/antenna when we:*
        - *increase the frequency ?*
        - *increase the amplitude ?*

6. Use learners' ideas to come up with a definition of frequency and amplitude.

7. Introduce radio waves by mentioning that when electrons wiggle, they generate radio waves, which are a form of electromagnetic radiation.

8. Change the Field Display Type to Curve, as shown in the image on the right. Run the simulation to show the waves radiated from the electron on the transmitter antenna.



9. Ask learners if they think there is a relationship between the radio waves generated by the electron in the transmitter antenna and the electron in the receiving antenna. Accept all responses.

10. Mention that their task is to use the simulation to explore that question as they answer the prompts on **Slide 3:**

    - If we **change** the **frequency** of the electron of the first antenna, what happens to the electron on the second antenna?
    - If we **change** the **amplitude** of the electron of the first antenna, what happens to the electron on the second antenna?

11. Provide each pair of learners with a device that has access to the simulation. Give them around 15 minutes to use the simulation and answer the questions.

12. Invite learners to share their findings. Use the simulation in front of the classroom to reflect some of the ideas shared by the learners.

Introduce AM and FM radio

13. Use the prompt on **Slide 4** to consider the differences between AM and FM:
    - *How does the wave change in each case?*

14. On **Slide 5,** have learners use their new ideas about radio to predict the motion of the electron on the receiving antenna based on the pattern of radio waves they observe.

15. Explain that radio waves generated by electrons in a transmitter antenna can travel long distances and affect electrons in receiving antennas. Mention that you have a reading that describes how radios transform the motion of electrons in the receiving antenna into music.

16. Distribute the reading and ask learners to develop a flow diagram to explain this process.

Content Background

When electrons wiggle moving back and forth in a transmitter antenna, they generate electromagnetic radiation in the form of radio waves. These waves radiate outward through space and can cause electrons in distant antennas to wiggle as well. This property of radio allows us to transmit information over long distances. By changing the frequency and amplitude of the wiggling electrons, we can create electromagnetic waves with specific frequencies and amplitudes, which are then used to carry information. The frequency of a wave refers to how fast the electrons oscillate, or how many times they move back and forth per second. The amplitude refers to the strength or height of the wave, which indicates how powerful the signal is. Together, these properties determine how radio waves transmit information and can be varied or modulated to carry different types of data.

In AM (Amplitude Modulation) radio, the amplitude of the wave is varied while the frequency remains constant, allowing information to be transmitted by changing the strength of the signal. This makes AM radio ideal for long-distance broadcasts, as the modulated amplitude can travel further, especially at night. However, because the amplitude is more easily affected by environmental interference (like electrical noise or weather), AM radio is more prone to static and lower sound quality. In contrast, FM (Frequency Modulation) varies the frequency of the wave while keeping the amplitude constant. This makes FM signals more resistant to interference and provides clearer sound quality, particularly for music. However, the shorter range of FM signals and their susceptibility to being blocked by obstacles like buildings or mountains limit its broadcasting reach.

List of Terms Related to this Activity

Amplitude: Amplitude is the height difference between the top (or bottom) and center of a wave. Larger waves have higher amplitude and more energy.

Frequency: This describes an electromagnetic radio wave that oscillates in a set amount of time. When talking about waves, frequency is the number of waves that pass through a fixed place in a set amount of time. The unit measure for frequency is called hertz (Hz), where 1 Hz means one wave passes through per second. Higher frequencies result in more oscillations per second, which can affect the type of signal transmitted.

Wavelength: The distance between two consecutive peaks (or troughs) of a wave, inversely related to the frequency. Longer wavelengths correspond to lower frequencies, while shorter wavelengths correspond to higher frequencies.

Electromagnetic wave: A type of wave that consists of oscillating electric and magnetic fields and travels through space. Radio waves are a form of electromagnetic waves used for communication.

Modulation: The process of varying a property of a wave, such as amplitude or frequency, to encode information. AM (Amplitude Modulation) and FM (Frequency Modulation) are two common types of radio modulation.

Transmitter: A device that generates and sends out radio waves by making electrons oscillate in an antenna.

Receiver: A device that captures radio waves and converts them back into sound or other data by detecting the wiggling electrons in its antenna.

Radio frequency: The range of electromagnetic waves specifically used for radio communication, typically from 3 kHz to 300 GHz.

Signal Interference: External noise or obstacles that disrupt the transmission of radio waves, which can affect the clarity of the signal, especially in AM radio.

Carrier Wave: A high-frequency continuous electromagnetic wave that can be modulated with a signal to carry information, commonly used in radio transmissions.

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