Is your Microwave a Faraday Cage?

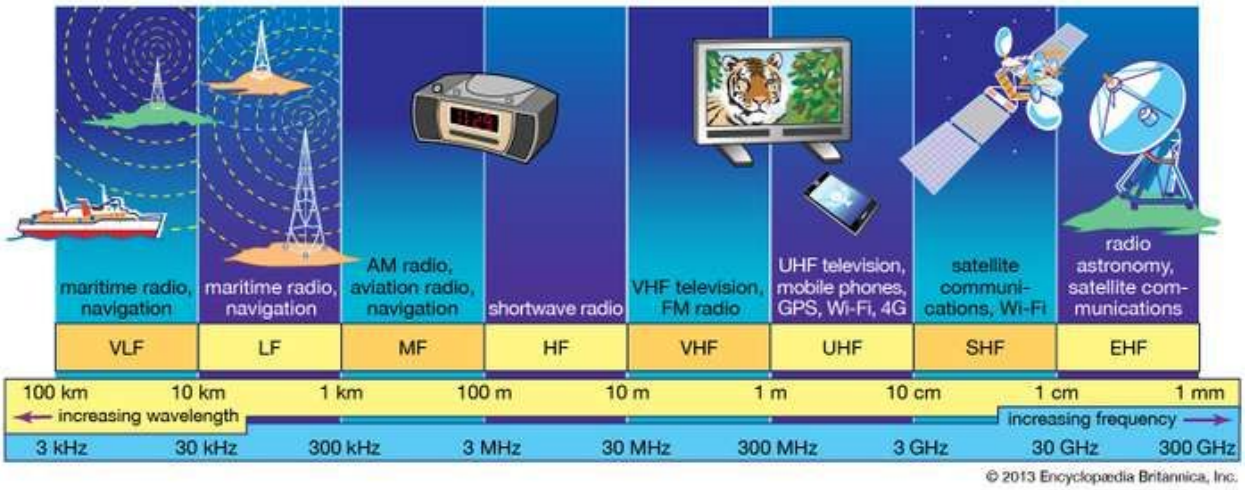
Suggested Age / Grade Level	Curriculum Covered	Duration
Grade 4 - 8	Energy, Technology, Electrical Systems	40-45 minutes

Learning goals

Students will explore energy and the electromagnetic spectrum in the world around them. The activity tests the connection between Frequency and Faraday Cages by testing Microwaves.

Fun Facts

- Common cell phone frequency is 700 MHz
- Common WiFi frequency is 2.4 GHz
- Most Microwaves operate at 2.45 GHz
- Microwaves work as Faraday cages to keep microwaves that heat your food from escaping. But Faraday cages also block waves from outside the Microwave getting in too.



https://www.britannica.com/technology/EHF

Key Terms

Faraday Cage - The cage is made of a metal screen which shields the contents inside the cage from electricity. The metal screen conducts electricity so when it comes in contact with an electric wave, it adds that electricity to the cage rather than allowing the wave to pass through. The metal screen set up in a Faraday cage only works if the holes in the screen are smaller than the wavelength of the incident wave (smaller wavelength = higher frequency)
Electricity - the movement of small charged particles. The participles are either Electrons (these particles are negatively charged) or Protons (positively charged).
Electromagnetic Field - a force field that surrounds a charged particle, such as an electron. They are produced by moving electric charges and it's a combination of both an electric field and a magnetic field. The electric field is produced by stationary charges and the magnetic field by moving charges (current).
Electromagnetic Wave - an invisible wave that transports energy. These waves are all around us and carry everything from radio signals to microwaves that heat our food!
Frequency - It's a measure of the movement of a wave; the number of times a wave passes a given point in one second. When you turn the dial on your radio, you're changing the frequency of the wave that your radio will pick up - each radio station has a different frequency!
Hertz - a measure of frequency. One Hertz means one wavelength passes a given point in one second.
GigaHertz = 1000 MegaHertz
MegaHertz = 1 million Hertz
Radiation - Invisible energy that can travel in waves or high-speed particles. That means that Electromagnetic waves are a form of radiation. There are two forms of radiation: Ionizing (this can cause harm to humans. Ex. by increasing risk of cancer) and Non-Ionizing (doesn't increase risk of cancer).
Non-Ionizing Radiation - includes relatively low-energy radiation (there isn't enough energy to ionize atoms or molecules) from power lines, radios, Microwaves, Infrared radiation, and others.

Ontario Curriculum Connections

Grade 4: Light & Sound, Technology
Grade 6: Electricity, transformation of energy
Grade 8: Systems

Activity Timeline (30 minutes)

- Watch video (1 minute)
- Hypothesis: Will a phone signal be able to get through the microwave by calling a cell phone that is placed in a closed microwave? (5-10 minutes)

    - Have students make predictions for two types of calls: Using the cellular signal and using the Wifi signal.
    - Discuss their predictions and what they mean - is your microwave an effective Faraday Cage?
- Phone Call 1: Turn off the Wifi signal of both cell phones. Place one cell phone in the Microwave and close the door. (3 minutes)
    - **Never turn on the microwave when the phone is inside!**
    - Call the phone inside the Microwave and observe whether it rings.
- Phone Call 2: Turn the Wifi signal back on for both phones. Place one phone back in the Microwave and close the door. (3 minutes)
    - **Never turn on the microwave when the phone is inside!**
    - Using an App like FaceTime (iPhones only) or WhatsApp (or any other one that allows for wifi calls) call the phone inside the Microwave.
    - Observe whether it rings.
- Have students perform the same experiment at home and bring in their data. (10 mins - can be done immediately if doing through virtual classroom, or assign for homework)
- Discussion (5 – 10 minutes)
    - If the phone rings: it means that the Microwave doesn't act as a Faraday Cage for that frequency (either the cell phone (700 MHz) or wifi (2.4 GHz))
    - What other variables could determine the results (age of Microwave, Frequency, etc.)
    - Have students determine whether their Microwave acts as a Faraday Cage.

Materials

- Microwave
- 2 cell phones; preferably with two options for calling: one through regular cell signal, one through wifi signal (FaceTime, Whatsapp, Facebook Messenger)
- Something to record your data (paper & pencil, tablet, computer)

Additional Setup Requirements

- Make sure the volume is turned up on the phone inside the Microwave.
- Place the cell phone face up so you can see the face light up if it receives the call.
- Accessing a Microwave may be tricky. If one is available in your school (lunch room, staff room, etc.) you can use that one as an example. Students who have

a Microwave at home can test theirs at home - either instantly if the lesson is being done virtually, or as homework if being done in the classroom.

References:

How StuffWorks: https://science.howstuffworks.com/radiation.htm
NASA Science: https://science.nasa.gov/ems/02_anatomy

Debrief

- You're probably only going to see about 50% of the participants not receiving calls while the phone is in the microwave. This is because microwaves aren't perfect Faraday cages and they "leak".
- Some factors that affect this experiment include: leak, older microwaves were less regulated, proximity to cell phone towers, position in the house
- If you remember the days of wireless house phones, standing in front of the microwave (if it was older) would mess up your call with a bunch of weird noises.
- This video will explain how/why microwaves can still allow phone calls: https://youtu.be/ot4_jVFXxUU