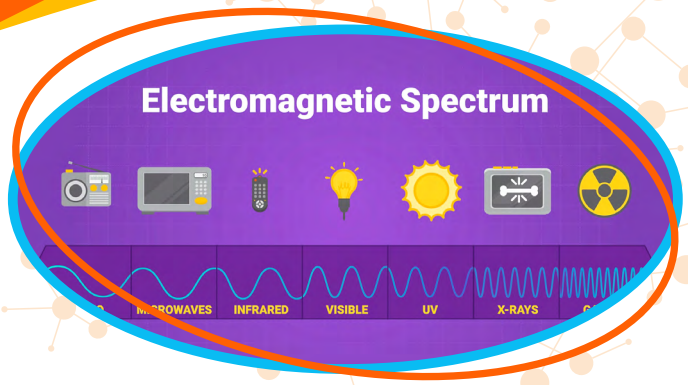
GENERATIONGENIUS
ALWAYS QUESTION. ALWAYS WONDER.



LESSON PLAN

ELECTROMAGNETIC SPECTRUM

GRADES 6-8

SUMMARY

Students use evidence from multiple sources (data table, hands-on investigation, and Generation Genius video) to develop an explanation that the amplitude of waves in microwave ovens is proportional to their energy.

NEXT GENERATION SCIENCE STANDARDS CORRELATION

MS-PS4-1. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.

Science & Engineering Practices	Connections to Classroom Activity
Using Mathematics and Computational Thinking	• Students use a data table showing the wattage, frequency, and cooking time of different microwave ovens to support the claim that the amplitude of waves is proportional to their energy.

Disciplinary Core Ideas	Connections to Classroom Activity
PS4.A: Wave Properties A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude.	• Students engage in a hands-on exploration of waves to build understanding of basic wave properties, including wavelength, frequency, and amplitude.

Cross Cutting Concepts	Connections to Classroom Activity
Patterns	• Students use a data table showing the wattage, frequency, and cooking time of different microwave ovens to identify the pattern that microwave oven cooking time is proportional to the wattage of the oven.

DURATION

90 min.

MATERIALS

- 6 ft. of rope, approximately ¼ in. diameter (1 per pair)
- Optional: Microwave oven and microwavable popcorn

ENGAGE

Ask students if they have ever microwaved a bag of popcorn and whether they have used different microwave ovens to do so. (*Optional*: Bring a microwave oven into your classroom and pop some popcorn to share with the class during or after this discussion.) Ask whether they have noticed that different microwaves take different amounts of time to pop the same amount of popcorn. Ask students why they think this is true, and have them share their ideas with a partner. Tell students that, together, you are going to figure out why some microwave ovens cook food faster than others. Explain that to do so, they will need to learn some things about how microwave ovens work and what is different about different microwave ovens.

Ask students how they think microwave ovens cook food. Students may have many different ideas, but some students are likely to share the idea that microwave ovens somehow use waves to cook food. Tell students that they will be learning about a special type of wave called an *electromagnetic wave* and that microwaves are one part of the electromagnetic spectrum. You can use the Before Discussion questions to probe students' background knowledge. Ask students why they think some microwave ovens cook food faster than others, and have them share their ideas with the class. Students might use terms such as power or energy to support their ideas. Ask students how they can tell how much "power" a certain microwave has, and point out that every microwave oven has a sticker on it that lists some important information about that particular microwave. Project the image below, or use an image of the specification sticker from the microwave in your classroom.

Tell students you have some data that will help them start to make sense of the information on this sticker. Ask students to create a t-chart and then write *Notice* on one heading and *Wonder* on the second. Tell them to record observations in the notice column and questions in the wonder column. Share the data table. Students are likely to notice that the frequency is the same for all four ovens but the rated output varies. They are also likely to notice the pattern that cooking time decreases as the rated output increases. Students may wonder what the value and units for frequency and output really mean.

Cook Times for Microwave Pop Corn (3.3 oz) for Different Microwave Ovens

Microwave Model	Microwave Frequency (MHz)	Rated Output (W)	Cook Time (min:sec)
A	2,450	600	3:35
B	2,450	800	2:45
C	2,450	1000	2:05
D	2,450	1200	1:50

After students have a chance to review the data, ask them to share their observations with a partner. Next, ask students to share observations and questions publicly with the class. Record their observations and questions on a display board for the class (e.g., projection screen, white board, dry erase board, chalkboard). Tell students you are going to do an activity that will help them answer some of their questions.

EXPLORE

Give each pair of students 6 feet of rope, and tell them they will be using the rope to model waves and their properties. Tell students to work with their partner to make a simple wave with their rope. Then ask students to change their waves so that more waves pass a certain point each second. Ask whether any students know a term for the property. If not, then introduce the term *frequency*. Ask students how they were able to increase the frequency of their waves or what they had to use more of to make that change. Help students understand that more energy was being transferred by the higher frequency waves.

Next, ask students to make waves that are longer or shorter than their original waves. Introduce the term *wavelength*. Now ask students to adjust the frequency of their waves and to notice what happens to the wavelength as frequency increases and decreases. Students should notice that increasing the frequency of the wave reduces the wavelength, and vice versa.

Finally, ask students to make waves that are bigger or smaller than their original waves. Ask whether any students know a term for the property. If not, then introduce the term *amplitude*. Ask students how they were able to increase the amplitude of their waves or what they had to use more of to make that change. Help students understand that more energy was being transferred by the higher amplitude waves. Ask students whether they can think of another type of wave where amplitude is important. Some students might be able to relate amplitude to the volume of sound waves, and this relationship can support student understanding.

EXPLAIN

WATCH THE GENERATION GENIUS ELECTROMAGNETIC SPECTRUM VIDEO AS A GROUP

Revisit the data table and remind students that the class is trying to figure out why some microwave ovens cook foods faster than others. Use the first two After Discussion questions to highlight the key ideas from the video that students need to make sense of the microwave oven data. Ask students to share any new questions they have. Students might also still have questions about the units listed on the data table. Tell students that the basic units for frequency are Hertz, or cycles per second, and that the prefix *mega* means 1 million. Therefore, the frequency units used in the table represent millions of waves per second. Tell students you will discuss the Rate Output units after you talk more about frequency.

Students might also ask whether the waves in different microwave ovens have different wavelengths or different amplitudes. Ask students to recall from the videos that the wavelength and frequency of electromagnetic waves are related to each other. Therefore, if all the waves have the same frequency, then they must all have the same wavelength.

Tell students that now they will need to think about what the output represents and how it might explain the different cooking times. Tell students that *W* represents the unit of Watts, which is a measure of energy per time. Ask students how this might relate to the cooking times in the data table. Have students share their ideas with a partner. Then ask students what wave property could explain why certain microwave ovens deliver more energy to heat food than others. Have students share with a partner and then with the whole class. The goal of this discussion is to help students understand that the energy of the waves in different microwave ovens is proportional to the amplitude of those waves. That is, a microwave oven with a higher wattage output is generating waves with higher amplitude.

ELABORATE

Share this prompt with students, and have them respond orally or in writing:

> *Sound waves at normal levels allow us to take in information from the world around us. However, very loud sounds can damage structures in our ears and lead to permanent hearing loss. Ocean waves always cause changes to coastlines, but large waves caused by storms can cause significant damage. Tsunamis, which are very large waves caused by earthquakes or volcanoes, can be devastating to coastal areas. Use what you have learned about waves to explain why large ocean waves and loud sound waves can both cause damage.*

EVALUATE

There are multiple ways to assess your students' understanding of this topic. The exit ticket is an opportunity for students to use the science ideas they built in the lesson in a new context. Alternatively, you can use the Kahoot! quiz (which provides downloadable scores at the end of the game) and/or the paper quiz. All these resources are located right below the video in the assessment section.

EXTENSION

Smartphones include built-in light intensity sensors to provide data for adjusting screen brightness and photographic flash settings in different light conditions. Students can use a free smartphone app to access readings from these sensors and investigate the intensity of light from different sources or under different conditions. Students might investigate the effect of different light sources (sunlight vs. incandescent bulbs vs. fluorescent bulbs), distance from a light source, or other factors.