

Five Stars Pathway Afterschool Science Curriculum



Exploring the Electromagnetic Spectrum





Exploring the Electromagnetic Spectrum

Age Range

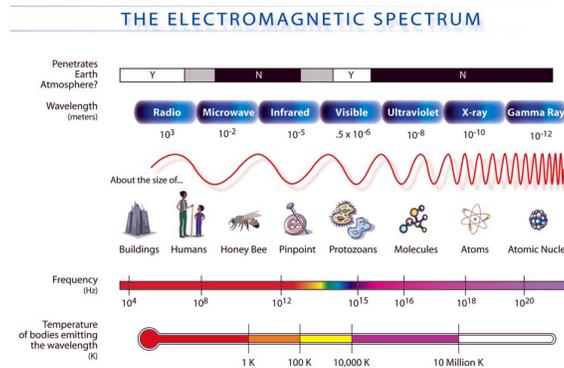
Ages 10+

Duration

35 minutes, plus 10 minutes set-up time

Participants

~ 15



Special Notes

This lesson is adapted from the GEMS Space Science Sequence “Energy from the Sun” lesson, originally developed by UC Berkeley’s Lawrence Hall of Science.

Overview

Participants create a poster of the electromagnetic (otherwise known as EM) spectrum which can be used for subsequent lessons. This lesson begins with a demonstration using a diffraction grating to break up white light from an overhead projector or LCD projector into the component colors of the visible light spectrum. Then participants explore the invisible light of the electromagnetic spectrum and create icons of familiar everyday objects to represent them.

Activity Goals

Participants will:

1. Learn that the visible light our eyes can detect is part of a larger spectrum of electromagnetic energy.
2. Be able to identify ways that they use different parts of the electromagnetic spectrum in everyday life.

Advance Set-Up

Before the lesson, you will need to set up an overhead projector or LCD projector with diffraction grating to project the visible light spectrum. In addition to the instructions below, please view the demonstration videos for an illustration of how to set up the diffraction grating with an overhead projector (<http://youtu.be/hMLVLNe9XbE>) or LCD projector (<http://youtu.be/Jac5WEDPnJk>).

Set-up (with photos) continued on next page



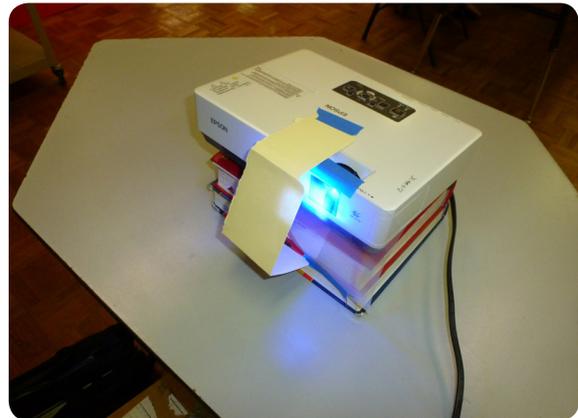
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Advance Set-Up continued

1. Choose a wall on which to project the spectrum and tape up the butcher paper.
2. If using an overhead projector:
 - Set up the overhead projector so that the light shines onto the middle of the butcher paper.
 - Place the two file folders side-by-side on the base plate of the projector so each folder covers only one-half of the projector plate. Position the file folders so that there is a gap of about 2 cm (or about $\frac{3}{4}$ ") between them. The projector should now project a small vertical slit of white light onto the paper.
3. If using an LCD projector:
 - Set up the LCD projector so that the light shines onto the middle of the butcher paper.
4. Connect the LCD project to a computer. Load the Diffraction Slit PowerPoint [http://multiverse.ssl.berkeley.edu/Portals/0/Documents/FiveStarsCurriculumDocs/EM_Spectrum_Poster_Slit_for_LCD_Projector.pptx] on the computer and project onto the butcher paper. The projector should now project a small vertical slit of white light onto the paper.
5. Tape the diffraction grating sheet over the lens of the projector. Use tape on the top edge of the grating only, so it can be flipped on and off of the projector lens as necessary. With the grating in place over the lens, two rainbow spectra will appear, one on either side of the projected slit of white light. If this is not the case, rotate the grating by 90° until you see the two spectra and then tape the grating in place.
6. You need to eliminate the rainbow spectra on the right of the visible light slit as you face the butcher paper. To do this, put a strip of folder and tape it loosely over the diffraction grating so that the rainbow spectra on the right disappears or is less prominent.
7. After completing the setup, flip the diffraction grating up (so that it is not covering the lens). You are now ready to go!



Overhead Projector Setup



LCD Projector Setup



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Materials

- 1 sheet of large white butcher paper (approximately 6 feet long or 2 meters) and at least 2 feet tall
- Bold-colored (red, orange, yellow, green, blue, indigo, violet, black) markers for writing on the butcher paper
- Tape
- A blank wall (for taping up the butcher paper)
- 1 sheet of diffraction grating (about 10 cm x 10 cm; or 4" x 4"); (when not in use keep diffraction grating between the protective sheets it came in). Can be ordered from <http://www.teachersource.com/product/single-axis-diffraction-grating/light-color>

For Projector Set-up

Overhead projector:

- 2 file folders including one cut into a strip

LCD projector:

- Computer with diffraction slit PowerPoint presentation
- 1 file folder cut into a strip

NOTE: For more information about setting up the diffraction grating with either an overhead or LCD projector, please see instructions in Advance Preparation and view the short set-up videos at <http://bit.ly/17il3Wm>. There is also a demonstration video of creating the poster at <http://bit.ly/1Q936NT>

Lesson Plan

1. Ask participants: What color is sunlight? How do they know? Could sunlight be more than one color? How do they know?
2. Turn on the overhead projector with the diffraction grating off the lens. Point out the slit of white light that they can see on the butcher paper.
3. Explain that a diffraction grating is a special piece of scored plastic that can be used to carefully analyze light. Flip the diffraction grating in place over the lens of the projector. Ask the class to observe what happens when the light passes through a diffraction grating. Then ask participants to describe what they see [another slit of light with rainbow colors]. Tell participants that for the purposes of this lesson, we are going to ignore the white visible light slit.
4. Ask individual participants to come up to the poster and use the colored markers to color the visible light spectrum. As they are drawing, ask participants to describe what they see and emphasize that scientists often observe and replicate what they see. After all the colors are included on the poster, have a participant label the 'Visible Light' portion of the spectrum on the poster.
5. Begin to fill in the parts of the electromagnetic spectrum that are not visible, starting with ultraviolet (UV) light. Where might the ultraviolet part of the spectrum be on the poster? Ask a student to come up and guess on which side the UV light might be found. Have student explain their answer. [Since "ultra" means "beyond," ultraviolet is above the violet part of the visible light spectrum.] Have the student write "ultraviolet" and "UV" on the poster to the right of the visible light spectrum. Ask the participants what associations they have with ultraviolet light and/or where they come across UV light in their lives. Some responses may include: ultraviolet light in sunshine, sunglasses and sunscreen that protect us against UV light. Have student draw a picture (with a caption) representing UV light underneath the label on the poster.



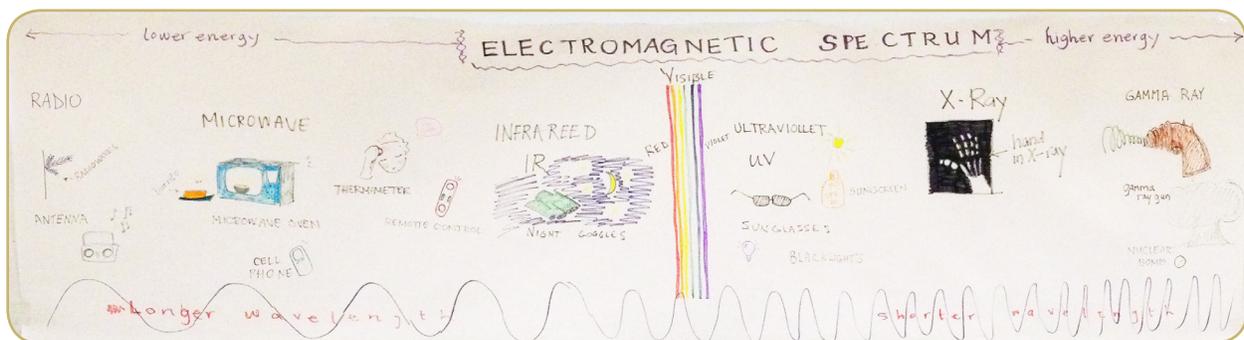
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Lesson Plan continued

- Next, ask another student to identify where infrared, or IR light, would be found in relation to the visible light spectrum. [Since “infra” means “below,” the infrared light can be found below the red part of the spectrum.] Have student use a black marker to label “infrared” and “IR” to the left of the red spectrum. Ask participants what associations they have with infrared light. Some possible answers include: night vision goggles, heat-seeking technology, and TV remote controls. Explain that people emit heat which can be seen in infrared light. Have student draw a picture (with a caption) representing IR light underneath the label on the poster.
- Continue adding other parts of the electromagnetic spectrum to the poster in the same way. Some everyday associations that may be used are:
 - Microwave (to the left of infrared): microwave ovens, cell phones
 - Radio (to the left of microwaves): radios
 - X-ray (to the right of ultraviolet): medical and dental x-rays
 - Gamma ray (to the right of x-ray): nuclear power
- Tell participants that all light—both visible and invisible—is made up of particles called photons, which travel in waves. All wavelengths of light travel at the same speed (186,000 miles per second; it takes 8.3 minutes for light to travel from the Sun to the Earth) but photons from different parts of the electromagnetic spectrum have different amounts of energy. Gamma-ray photons have the most energy, and radio photons have the least energy. The amount of energy in a photon is related to the length of the wavelength. This means that gamma rays have the shortest wavelength and radio waves have the longest wavelength of light. Even within the visible light spectrum, red light has longer wavelengths and less energy than violet light. Participants can use the attached chart as a reference for drawing the relative wavelengths of light on the poster.



A completed poster.



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Discussion

Our eyes can only see visible light, but there is actually a whole spectrum of light that is invisible to us unless we use specialized tools. The entire range of light is called the electromagnetic or EM spectrum. The EM spectrum includes radio waves, infrared light, visible light (which can be broken down into the colors of the rainbow), ultraviolet light, x-rays and gamma rays. The Sun emits light from all parts of the EM spectrum. We use different parts of the EM spectrum in our everyday lives. Scientists use specialized tools such as telescopes to observe astronomical objects in different kinds of light.

Further Resources

- **NASA Tour of the Electromagnetic Spectrum:** includes short videos and PDF book that explore the different parts of the EM spectrum—
<http://missionscience.nasa.gov/ems/>
- **What is the Electromagnetic Spectrum?**—
<http://earthsky.org/space/what-is-the-electromagnetic-spectrum>
- **More Than Your Eyes Can See** Dr. Michelle Thaller from Spitzer Space Telescope explains infrared light—
http://www.spitzer.caltech.edu/video-audio/145-ask_ir-Infrared-More-Than-Your-Eyes-Can-See
- **How the Sun Sees You:** Video shows what people look like to an ultraviolet camera and how too much Sun can damage our skin—
<http://youtu.be/o9BqrSAHbTc>



*This lesson is adapted from UC Berkeley's
Lawrence Hall of Science GEMS Space
Science Sequence, grades 6-8.*

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