

## Electromagnetic Spectrum

### Student Objectives

The student:

- knows that the Sun's energy is transferred to Earth by electromagnetic waves
- understands that there are eight main types of electromagnetic waves that are classified on the electromagnetic spectrum by their wavelengths
- will explain how each of the types of electromagnetic radiation is used or found in our everyday lives.

### Materials:

- electromagnetic spectrum chart (1 per student)
- internet access
- reference books
- overhead projector, computer with LCD projector or other presentation equipment
- chart paper, construction paper and other materials for creating presentation visuals

### Key Words:

compressional waves  
electromagnetic spectrum  
frequency  
gamma rays  
hertz  
infrared waves  
microwaves  
photon  
radio waves  
speed of light  
transverse waves  
visible light  
ultraviolet light  
x-rays

### Time:

1- 2 class periods for research and presentation preparation (could be assigned as homework)  
1 class period for presentations

### Background Information

Electromagnetic radiation can be described in terms of a stream of massless particles, each traveling in a wave-like pattern and moving at the speed of light. Each massless particle contains a certain amount (or bundle) of energy. Each bundle of energy is called a photon, and all electromagnetic radiation consists of these photons. The only difference between the various types of electromagnetic radiation is the amount of energy found in the photons. Radio waves have photons with low energies, microwaves have a little more energy than radio waves, infrared has still more, then visible, ultraviolet, x-rays, and the most energetic of all, gamma rays.

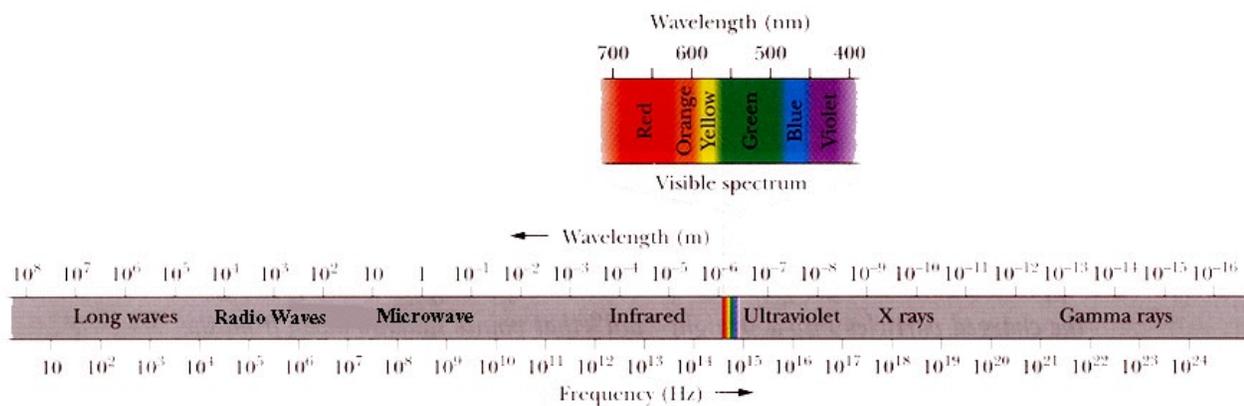
Electromagnetic radiation from space is unable to reach the surface of the Earth except at a very few wavelengths, such as the visible spectrum and radio frequencies. Astronomers can get above enough of the Earth's atmosphere on mountain tops or by flying their telescopes in an spacecraft, to observe some infrared wavelengths.

The small portion of the electromagnetic spectrum that we can detect with our eyes is

called the optical spectrum. This spectrum ranges in color from reds and oranges up through blues and purples. Each of these colors actually corresponds to a different energy of light and make up only a small portion of the electromagnetic spectrum—visible light. Of all the colors in the visible spectrum, red light is the least energetic and blue is the most. Beyond the red end of the visible part of the spectrum lie infrared and radio waves, both of which have lower energy than visible light. Above the blue end of the visible spectrum lies the higher energies of ultraviolet light, x-rays and gamma rays.

Light can be described not only in terms of its energy, but also its wavelength, or its frequency. There is a one-to-one correspondence between each of these representations. X-rays and gamma-rays are usually described in terms of energy, optical and infrared light in terms of wavelength, and radio in terms of frequency. This is a scientific convention that allows the use of the units that are the most convenient for describing whatever energy of light is being observed.

Wavelength is the distance between two peaks of a wave, and it can be measured with a base unit of meters. Frequency is the number of cycles of a wave to pass some point in one second. The basic unit of frequency is cycles per second, or Hertz. In astronomy, gamma rays are often measured in electron volts, or eV.



### Procedure (research and presentation preparation)

- Lead a classroom discussion on transverse waves, electromagnetic radiation, and the electromagnetic spectrum. Some points to cover are:
  - Transverse waves can travel through a vacuum such as space (compressional waves such as radio waves have to travel through a medium).
  - Only a few frequencies of radiation are able to penetrate our atmosphere from space, mostly the visible spectrum and the radio frequencies.
  - Electromagnetic radiation is a wave of massless particles (photons) of energy that travel at the speed of light.
  - The amount of energy in the photons varies with the different wavelengths (frequencies); conversely, all types of electromagnetic radiation are basically the same except for their frequency (wavelength) and therefore the amount of energy in the photons.
  - The longer wavelengths have photons with less energy, the shorter wavelengths

- have photons of greater energy.
- The small part of the electromagnetic spectrum that we can detect with our eyes is the optical spectrum.
  - The frequency of a wave is the number of wave crests that pass a point during one second.
- 2. Divide the students into eight groups.
- 3. Explain that they will be researching one of the eight types of electromagnetic energy in the spectrum and reporting their findings to the class. Tell the students that their presentations will be rated by the rest of the class on these criteria:
  - content knowledge (Do they know what their electromagnetic energy is about?)
  - creativity & originality (Did they present their knowledge in an interesting and original way?)
  - interest level (Was the presentation interesting to watch?)
- 4. Assign each group a type of electromagnetic energy:
  - radio waves
  - microwaves
  - infrared waves
  - visible light
  - ultraviolet light
  - x rays
  - gamma rays
  - cosmic waves
- 5. Give the class time to research and prepare their presentations. They should begin by answering the questions in their Science Journal, then use that information as the content knowledge for their presentation.
- 6. Assist as necessary.

### **Procedure (presentation day)**

1. Hand out copies of the rating sheet and have each student “x” out the presentation that they are doing (they can not assess their own presentation).
2. Have them rate the other seven presentations on a scale of 1 - 10 (with 10 being the highest) for each of the three criteria.
3. After the presentations, announce the group with the highest combined score, and lead a classroom discussion of what they did to make an effective presentation.

### **Key Words & Definitions**

- **compressional waves** – waves such as sound waves that require a medium to transfer energy
- **electromagnetic spectrum** – the full range of frequencies, from radio waves to gamma rays, that characterizes light
- **electromagnetic waves** – waves that transfer radiation. These waves are created by electrically charged particles that move; since they are transverse waves, they can travel through a vacuum such as space.
- **frequency** – a property of a wave that describes how many wave patterns or cycles pass

by in a period of time. Frequency is often measured in Hertz (Hz), where a wave with a frequency of 1 Hz will pass by at 1 cycle per second.

- **gamma rays** – the highest energy, shortest wavelength electromagnetic radiations; usually, they are thought of as any photons having energies greater than about 100 keV.
- **hertz** – The derived SI (international standard) unit of frequency, defined as a frequency of 1 cycle per second
- **infrared waves** – electromagnetic radiation at wavelengths longer than the red end of visible light and shorter than microwaves (roughly between 1 and 100 microns). Almost none of the infrared portion of the electromagnetic spectrum can reach the surface of the Earth, although some portions can be observed by high-altitude aircraft or telescopes on high mountaintops.
- **microwaves** – electromagnetic radiation which has a longer wavelength (between 1 mm and 30 cm) than visible light, but shorter than radio waves. Microwaves can be used to study the Universe, communicate with satellites in Earth orbit, and cook popcorn.
- **photon** – a tiny particle or bundle of radiant energy
- **radio waves** – electromagnetic radiation which has the lowest frequency, the longest wavelength, and is produced by charged particles moving back and forth. The atmosphere of the Earth is transparent to radio waves with wavelengths from a few millimeters to about twenty meters. Radio waves are used to broadcast radio and television as well as being emitted by stars and gases in space.
- **speed of light** – 186,000 miles per second
- **transverse waves** – waves such as light waves that can transfer energy in a vacuum without a medium
- **visible light** – electromagnetic radiation at wavelengths which the human eye can see. We perceive this radiation as colors ranging from red (longer wavelengths; ~ 700 nanometers) to violet (shorter wavelengths; ~400 nanometers.).
- **ultraviolet light** – electromagnetic radiation at wavelengths shorter than the violet end of visible light. The atmosphere of the Earth effectively blocks the transmission of most ultraviolet light.
- **x-rays** – electromagnetic radiation of very short wavelength and very high-energy. X-rays have shorter wavelengths than ultraviolet light but longer wavelengths than gamma rays.

### Related Research

1. Should the federal government be allowed to control the frequency bandwidths for communication (for example television, cell phones and radio)? Support your argument.
2. How are thermograms (infrared photographs) used to help in energy efficient building design?
3. Defend the importance of gamma rays in treating cancer, even though many patients suffer serious side effects to such treatment.
4. If radio waves are not compressional waves like sound waves, explain what their role is in enabling us to hear music from a radio station.
5. How is the depletion of the ozone layer related to increased ultraviolet radiation? What measures can we take to stop the depletion of the ozone layer? What can we do to

- prevent exposure to ultraviolet radiation?
6. Keep an “electromagnetic journal” for a week. Record each time you observe or come in contact with electromagnetic radiation. Record the date, time, what type of radiation you observe, and a brief explanation of the incident.

### **Related Reading**

- *This Strange Quantum World & You* by Patricia Topp (Blue Dolphin Publishing, 1999)  
Patricia Topp explains in clear, developmentally appropriate language how the world can seem solid yet is really light and energy, and how this is relevant in the world of kids and leading-edge physicists alike.

### **Internet Sites**

**[http://imagine.gsfc.nasa.gov/docs/science/know\\_11/emspectrum.html](http://imagine.gsfc.nasa.gov/docs/science/know_11/emspectrum.html)**

NASA’s Imagine the Universe site. Information on the electromagnetic spectrum and the different frequencies of waves on it.

**<http://spaceplace.nasa.gov/en/kids/chandra.shtml>**

NASA’s The Space Place website featuring The Land of The Magic Windows. Students can ‘see’ the different parts of the electromagnetic spectrum through NASA photos of the universe.

### Electromagnetic Spectrum

#### Florida NGSS Standards & Related Subject Common Core

			.1	.2	.3	.4	.5	.6	.7	.8	.9	.10	.11	.12
<b>Grade 6</b>														
<b>Earth Systems &amp; Patterns</b>	# 7	SC.6.E.7	X											
<b>Forces &amp; Changes in Motion</b>	# 13	SC.6.P.13	X											
<b>Grade 7</b>														
<b>Forms of Energy</b>	# 10	SC.7.P.10	X		X									
<b>Grade 8</b>														
<b>Earth in Space &amp; Time</b>	# 5	SC.8.E.5											X	
<b>Language Arts Standards</b>	<b>Sixth Grade:</b> LAFS.6.SL.1.1, LAFS.6.SL.2.4 <b>Seventh Grade:</b> LAFS.7.SL.1.1, LAFS.7.SL.2.4 <b>Eighth Grade:</b> LAFS.8.SL.1.1, LAFS.8.SL.2.4													

#### Sixth Grade Benchmarks

##### Science–Big Idea 7: Earth Systems and Patterns

- SC.6.E.7.1 - Differentiate among radiation, conduction, and convection, the three mechanisms by which heat is transferred through Earth’s system.

##### Science–Big Idea 13: Forces and Changes in Motion

- SC.6.E.13.1 - Investigate and describe types of forces including contact forces and forces acting at a distance, such as electrical, magnetic and gravitational.

##### Language Arts–Standards for Speaking & Listening

- LAFS.6.SL.1.1 - Engage effectively in a range of collaborative discussions with diverse partners on grade 6 topics, texts, and issues, building on others’ ideas and expressing their own clearly.
- LAFS.6.SL.2.4 - Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.

#### Seventh Grade Benchmarks

##### Science–Big Idea 10: Forms of Energy

- SC.7.E.10.1 - Illustrate that the sun’s energy arrives as radiation with a wide range of wavelengths, including infrared, visible, and ultraviolet, and that white light is made up

of a spectrum of many different colors.

- SC.7.E.10.3 - Recognize that light waves, sound waves, and other waves move at different speeds in different materials.

### **Language Arts–Standards for Speaking & Listening**

- LAFS.7.SL.1.1 - Engage effectively in a range of collaborative discussions with diverse partners on grade 7 topics, texts, and issues, building on others’ ideas and expressing their own clearly.
- LAFS.7.SL.2.4 - Present claims and findings, emphasizing salient points in a focused, coherent manner with pertinent descriptions, facts, details and examples; use appropriate eye contact, adequate volume, and clear pronunciation.

### **Eighth Grade Benchmarks**

#### **Science–Big Idea 5: Earth in Space and Time**

- SC.8.E.5.11 - Identify and compare characteristics of the electromagnetic spectrum such as wavelength, frequency, use, and hazards and recognize its application to an understanding of planetary images and satellite photographs.

### **Language Arts–Standards for Speaking & Listening**

- LAFS.8.SL.1.1 - Engage effectively in a range of collaborative discussions with diverse partners on grade 8 topics, texts, and issues, building on others’ ideas and expressing their own clearly.
- LAFS.8.SL.2.4 - Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.

### **National Next Generation Science Standards - Sixth to Eighth Grade Standards**

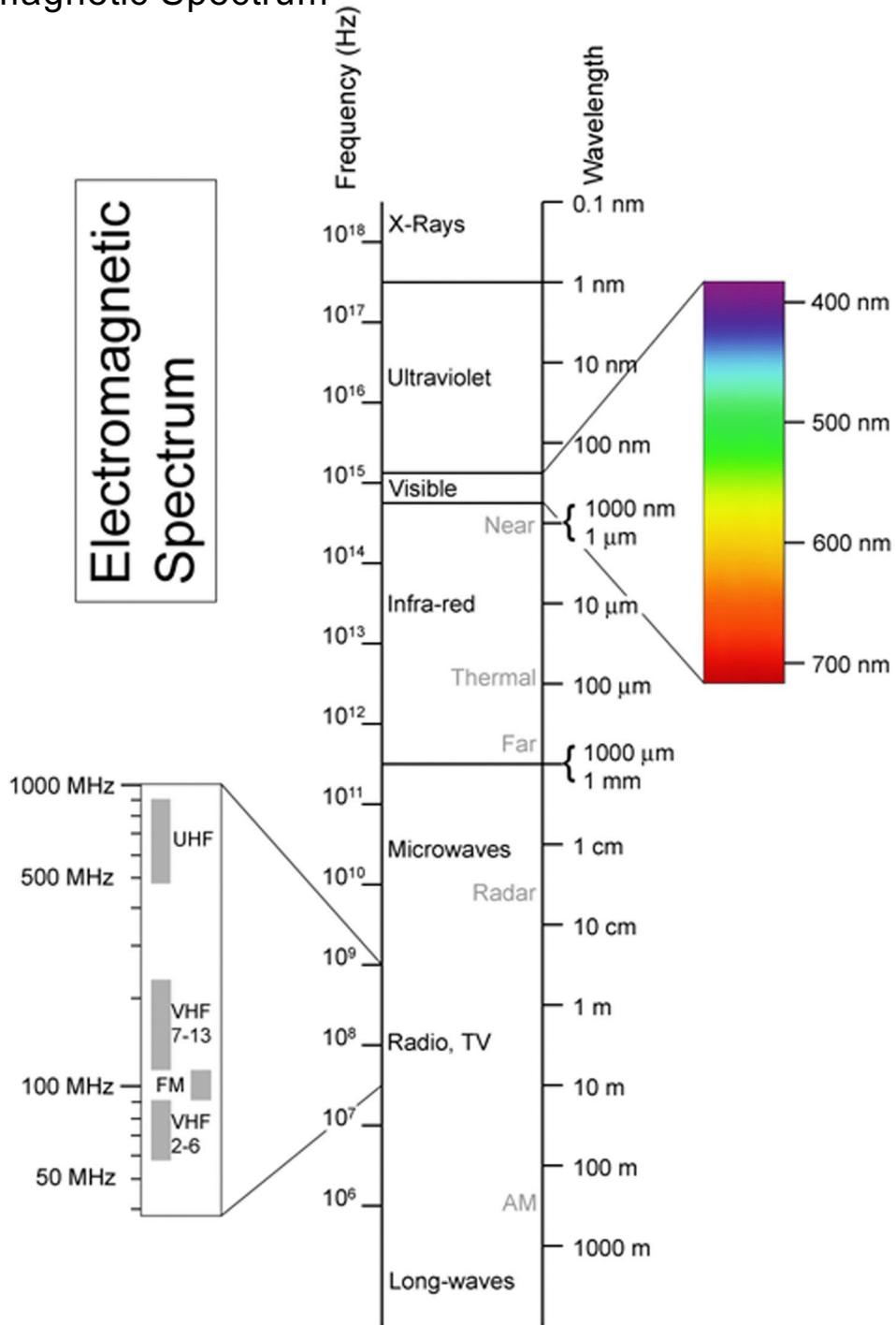
Note: Related Common Core Language Arts Standards are listed in the Florida section above.

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Rate each group on a 1 - 10 scale (with 10 being the highest) for each of the three categories.  
Total each groups score across.

	<b>Content Knowledge</b>	<b>Creativity &amp; Originality</b>	<b>Interesting?</b>	<b>Total Score</b>
<b>Radio Waves</b>				
<b>Microwaves</b>				
<b>Infrared Waves</b>				
<b>Visible Light</b>				
<b>Ultraviolet Light</b>				
<b>X Rays</b>				
<b>Gamma Rays</b>				
<b>Cosmic Rays</b>				

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