To our teachers:

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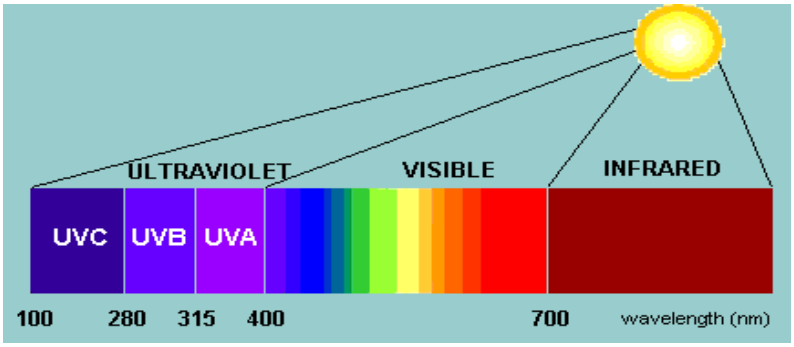
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	Wisconsin Public Service SolarWise for Schools and the Center for Renewable Energy Advanced Technological Education	

THE ELECTROMAGNETIC SPECTRUM

Student Lesson & Response Guide

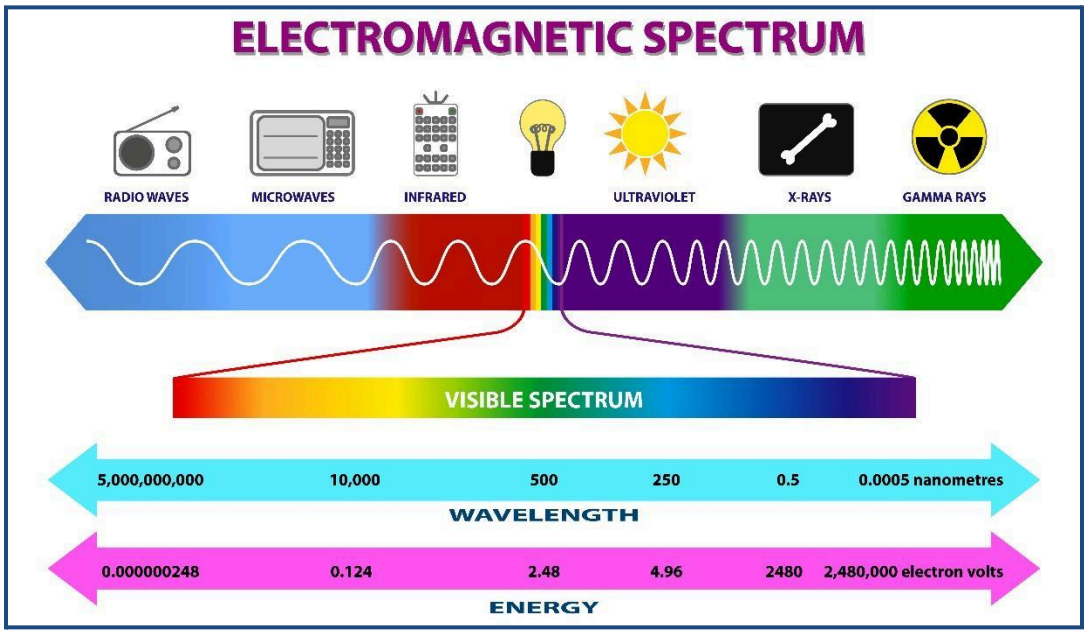
As you know, there are many kinds of energy in the universe. The energy given off from the sun is radiant energy, scientifically called electromagnetic radiation. Produced by nuclear reactions at the core of the sun, this energy streams from the surface of the sun in waves of different lengths. The shortest and longest wavelengths are invisible to our eyes, but the medium wavelengths are the visible radiation we call sunlight. Most of the sun's energy is released in these visible wavelengths. The radiation given off from the sun—the **solar spectrum**—is shown below in Illustration 1.

Illustration 1. This the radiation given off from the sun, also known as the **solar spectrum**. *(Illustration courtesy of the Australian Radiation Protection Agency)*	

All substances have kinetic energy expressed by vibrations of their atoms or molecules. These vibrations result in radiation. The **electromagnetic (EM) spectrum** is just a name that scientists give all of the different types of radiation when they want to talk about them as a group (see Illustration 2). Electromagnetic radiation is energy that spreads out as it travels. Visible light radiation that comes from a lamp in your house or

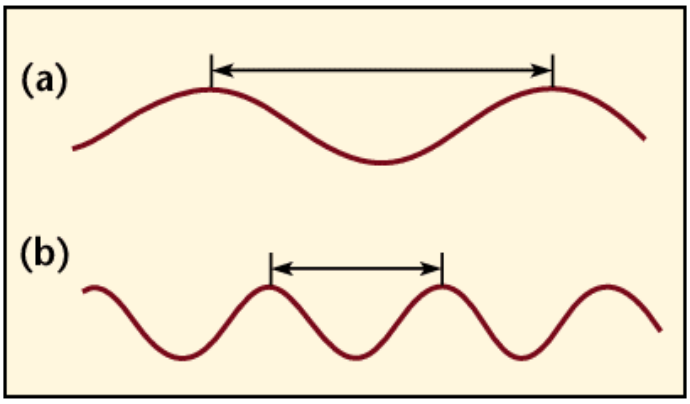
radio wave radiation that comes from a radio station are two types of electromagnetic radiation. Other examples of EM radiation are microwaves, infrared and ultraviolet radiation, X-rays, and gamma rays. Hotter, more energetic objects and events create higher energy radiation than cool objects. Only extremely hot objects or particles moving at very high speeds can create high-energy radiation like X-rays and gamma rays.

Illustration 2.



You may think that radio waves are completely different than X-rays and gamma rays. They are produced in very different ways, and we detect them in different ways. But are they really different from each other? The answer is no. Radio waves, visible light, X-rays, and all the other parts of the electromagnetic spectrum are fundamentally the same. They are all forms of electromagnetic radiation.

So far in this discussion, you have read the words, waves, radio waves, microwaves, and wavelength. All substances give off electromagnetic radiation in the form of electromagnetic waves. The motion of different waves (Illustration 3) enables us to classify them into different parts of the electromagnetic spectrum.

Illustration 3. Wave Motion Wave (a): has a **longer wavelength** and a **lower frequency** Wave (b): has **shorter wavelength** and a **higher frequency** (*Illustration courtesy of the University of California—Berkeley)*	

Waves are measured by their length (wavelength) in meters. They are also measured by the number of waves which pass a point in space each second (their frequency). Electromagnetic waves vary in their lengths from very short waves (billionths of a centimeter) to very long waves (hundreds of kilometers). It is important to remember that the various kinds of electromagnetic radiation differ only in their wavelength and frequency. They are alike in all other respects.

However, some electromagnetic radiation is strong enough to penetrate certain substances (skin, for example) while other forms are not. Similarly, some electromagnetic radiation is capable of causing damage to molecules and cells. You may know that people are cautioned to limit their time in the sun for this reason, since exposure to ultraviolet radiation can cause skin cancer.

In this lesson, you will review the basic properties shared by all types of electromagnetic radiation. Then you will research some characteristics and uses of radiation from one of seven specific regions of the EM spectrum. Finally, you and your classmates will present your research findings, offering you a well-rounded look at the electromagnetic spectrum.

Portions of the preceding text courtesy of the National Energy Foundation and the National Aeronautics and Space Association

Materials: Computer with Internet access

Procedure:

1. First, take notes from your teacher on six basic properties common to all types of electromagnetic radiation in the spaces below:

Properties of Electromagnetic Radiation

1-1) *** Answer**

1-2) *** Answer**

1-3) *** Answer**

1-4) *** Answer**

1-5) *** Answer**

1-6) *** Answer**

2. In a group, you will research characteristics, uses, and facts about one of seven regions of the EM spectrum, and report on what you have learned. Your teacher will let you know which region of the spectrum is yours to research.

3. Locate the page that follows that is labeled with <u>your</u> region of the electromagnetic spectrum. Use the four points on the page to guide your research and record your explanations. The information on this page will form the basis for your group presentation.

4. Your group will produce a PowerPoint or poster as the focal point for presenting your group's research findings. Your teacher will provide you with information about the:

- length of time you will have in class to do research
- resources available to you in class to complete your presentation
- length of time you will have in class to work on your presentation
- time requirements for your presentation
- order of presentations
- grading requirements for your research and presentation

5. In class, each group will present the information they have researched. As each group makes its presentation, take notes and answer the questions on the six (empty) pages which follow that your group did not use for its research.

6. Your instructor will summarize and emphasize important features about the electromagnetic spectrum when all presentations are complete. Take notes for this summary on the page labeled **The Electromagnetic Spectrum In Review**.

1. Radio Waves

1. Define radio wave radiation:

*** Answer**

2. Where are radio waves found on the EMS compared to the other six forms of radiation? In your description, compare and contrast its *wavelength*, *frequency*, and *energy* with those of other regions of the EMS.

*** Answer**

3. Are there human health risks from exposure (or overexposure) to radio wave radiation? If so:

- describe the main risk(s)
- describe common sources of exposure (or overexposure)
- describe a technology, device, or behavior that can be used for protection, or to decrease exposure

*** Answer**

4. How are radio waves used in cell phone wireless communication technology?

4a. Provide a thorough written explanation below. In your written explanation, make references to the hand drawing you provide for 4b.

*** Answer**

4b. Provide a thorough hand drawing that supports your written explanation for 4a (paste in a scan or photograph of your hand drawing).

2. Microwaves

1. Define microwave radiation:

*** Answer**

2. Where are microwaves found on the EMS compared to the other six forms of radiation? In your description, compare and contrast its *wavelength*, *frequency*, and *energy* with those of other regions of the EMS.

*** Answer**

3. Are there human health risks from exposure (or overexposure) to radio wave radiation? If so:

- describe the main risk(s)
- describe common sources of exposure (or overexposure)
- describe a technology, device, or behavior that can be used for protection, or to decrease exposure

*** Answer**

4. How are microwaves used in a microwave oven to quickly heat food?

4a. Provide a thorough written explanation below. In your written explanation, make references to the hand drawing you provide for 4b.

*** Answer**

4b. Provide a thorough hand drawing that supports your written explanation for 4a (paste in a scan or photograph of your hand drawing).

3. Infrared

1. Define infrared radiation:

*** Answer**

2. Where is infrared radiation found on the EMS compared to the other six forms of radiation? In your description, compare and contrast its *wavelength*, *frequency*, and *energy* with those of other regions of the EMS.

*** Answer**

3. Are there human health risks from exposure (or overexposure) to radio wave radiation? If so:

- describe the main risk(s)
- describe common sources of exposure (or overexposure)
- describe a technology, device, or behavior that can be used for protection, or to decrease exposure

*** Answer**

4. How is infrared radiation technology used to enable people to “see” in the dark?

4a. Provide a thorough written explanation below. In your written explanation, make references to the hand drawing you provide for 4b.

*** Answer**

4b. Provide a thorough hand drawing that supports your written explanation for 4a (paste in a scan or photograph of your hand drawing).

4. Visible Light

1. Define visible light radiation:

*** Answer**

2. Where is visible light radiation found on the EMS compared to the other six forms of radiation? In your description, compare and contrast its *wavelength*, *frequency*, and *energy* with those of other regions of the EMS.

*** Answer**

3. Are there human health risks from exposure (or overexposure) to radio wave radiation? If so:
   - describe the main risk(s)
   - describe common sources of exposure (or overexposure)
   - describe a technology, device, or behavior that can be used for protection, or to decrease exposure

*** Answer**

4. How is visible light used to produce electricity through solar PV panel technology?

4a. Provide a thorough written explanation below. In your written explanation, make references to the hand drawing you provide for 4b.

*** Answer**

4b. Provide a thorough hand drawing that supports your written explanation for 4a (paste in a scan or photograph of your hand drawing).

5. Ultraviolet

1. Define ultraviolet radiation:

*** Answer**

2. Where is ultraviolet radiation found on the EMS compared to the other six forms of radiation? In your description, compare and contrast its *wavelength*, *frequency*, and *energy* with those of other regions of the EMS.

*** Answer**

3. Are there human health risks from exposure (or overexposure) to radio wave radiation? If so:

- describe the main risk(s)
- describe common sources of exposure (or overexposure)
- describe a technology, device, or behavior that can be used for protection, or to decrease exposure

*** Answer**

4. How is ultraviolet radiation used in tanning bed technology?

4a. Provide a thorough written explanation below. In your written explanation, make references to the hand drawing you provide for 4b.

*** Answer**

4b. Provide a thorough hand drawing that supports your written explanation for 4a (paste in a scan or photograph of your hand drawing).

6. X-ray

1. Define X-radiation:

*** Answer**

2. Where is X-radiation found on the EMS compared to the other six forms of radiation? In your description, compare and contrast its *wavelength*, *frequency*, and *energy* with those of other regions of the EMS.

*** Answer**

3. Are there human health risks from exposure (or overexposure) to radio wave radiation? If so:
   - describe the main risk(s)
   - describe common sources of exposure (or overexposure)
   - describe a technology, device, or behavior that can be used for protection, or to decrease exposure

*** Answer**

4. How is X-radiation used to produce an internal image of the body?

4a. Provide a thorough written explanation below. In your written explanation, make references to the hand drawing you provide for 4b.

*** Answer**

4b. Provide a thorough hand drawing that supports your written explanation for 4a (paste in a scan or photograph of your hand drawing).

7. Gamma

1. Define gamma radiation:

*** Answer**

2. Where is gamma radiation found on the EMS compared to the other six forms of radiation? In your description, compare and contrast its *wavelength*, *frequency*, and *energy* with those of other regions of the EMS.

*** Answer**

3. Are there human health risks from exposure (or overexposure) to radio wave radiation? If so:

- describe the main risk(s)
- describe common sources of exposure (or overexposure)
- describe a technology, device, or behavior that can be used for protection, or to decrease exposure

*** Answer**

4. How is gamma radiation used to treat cancer?

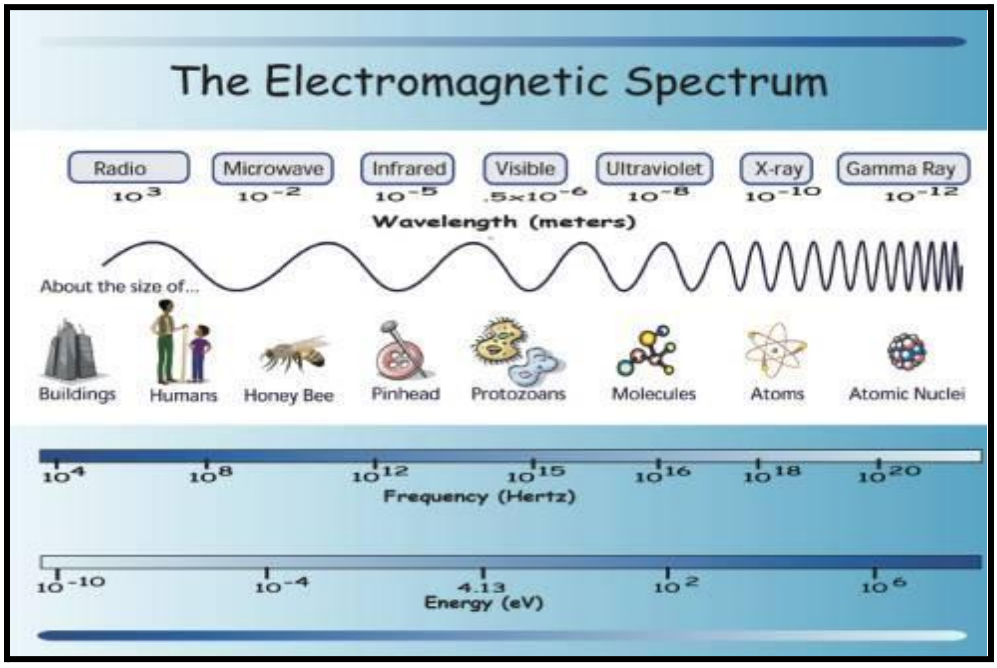
4a. Provide a thorough written explanation below. In your written explanation, make references to the hand drawing you provide for 4b.

*** Answer**

4b. Provide a thorough hand drawing that supports your written explanation for 4a (paste in a scan or photograph of your hand drawing).

The Electromagnetic Spectrum In Review

Illustration 4. *(Illustration courtesy of Sonoma State University)*



Question 1: Illustration 4 is another diagram of the Electromagnetic Spectrum. Note that the spectrum is diagrammed, from left to right, in order from:

Radio waves to **microwaves** to **infrared** to **visible light** to **ultraviolet** to **x-rays** to **gamma radiation**

Answer each of the following questions with the name of just one region of the Electromagnetic Spectrum.

1a. Which region contains waves of the *longest wavelength*?
*** Answer**

1b. Which region contains waves of the *lowest frequency*?
*** Answer**

1c. Which region contains radiation of the *lowest energy*?
*** Answer**

1d. Which region contains waves of the *shortest wavelength*?
*** Answer**

1e. Which region contains waves of the *highest frequency*?
*** Answer**

1f. Which region contains radiation of the *highest energy*?
*** Answer**

.

2. What is ionizing radiation? What is non-ionizing radiation? In your answer explain which types of radiation in the EMS are ionizing. Explain which types of radiation in the EMS are non-ionizing.

*** Answer**

2. What is background radiation? In your answer give several examples of natural background radiation. Also in your answer, provide several examples of man-made background radiation.

*** Answer**