To our teachers:

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

THE ELECTROMAGNETIC SPECTRUM

INSTRUCTOR'S GUIDE

Grade Level:	High School, Technical College, Community College
Lesson Length:	2-4 class hours, depending on coverage and emphasis
Author:	Scott Liddicoat
Created:	October, 2023

Objectives:

- Students will understand the basic properties of all types of electromagnetic radiation.
- Students will conduct research on important information about a region of the electromagnetic spectrum:
  - general properties of that region of the EMS
  - a common use or application of technology that uses EMR in that region of the EMS
- Students will present an oral and visual report on their research.
- Students will understand the same information reported by other students on all other regions of the electromagnetic spectrum.

Teacher Notes

This activity, which will span 2-4 class periods depending on your approach, is specifically written for students to:

- gain core knowledge about electromagnetic radiation
- do assigned internet research and planning in a group setting
- give oral reports on their research in a group setting
- produce a visual guide to their oral reports in the form of a poster or PowerPoint
- center short, group oral reports for your class around their visual guide

Use your own introduction or the introduction written into this lesson to acquaint your students with the electromagnetic spectrum. You may or may not have to develop discussion around certain topics or vocabulary depending upon the level of knowledge your students already possess. For example, some students may have no understanding of what wave frequency is. Since the next thing you will do is provide students with notes on basic properties of all types of electromagnetic radiation, terms that students may not be familiar with found in those notes must be addressed.

After introducing EMR and the EMS, have students take notes on six properties fundamental to all forms of electromagnetic radiation. The six properties follow, and there is a place provided in the **Student Lesson and Response Guide** for students to word-process these notes. Take the time to discuss these properties and address student questions as necessary.

1. ***Electromagnetic radiation is a form of energy; it has no mass.***

2. ***Electromagnetic waves differ from other waves (sound waves, for instance) in that they do not need a medium to transfer their energy—they move through a vacuum.***

3. ***Electromagnetic radiation moves at the speed of light (300,000 km/sec).***

4. ***Electromagnetic radiation can also be described in terms of massless particles called photons. Each photon contains a certain amount (or bundle) of energy, and the difference between the various types of electromagnetic radiation is the amount of energy found in the photons.***

5. ***Electromagnetic radiation is given off whenever atoms are energized (the heating of a light bulb filament, for instance, or when fireworks are exploded), and by some atoms as they undergo radioactive decay.***

6. ***The various forms of electromagnetic radiation differ only in wavelength and frequency; they are alike in all other respects.***

After student note taking and any discussion of the notes is complete, students will begin research on a region of the electromagnetic spectrum. Assign each of seven groups to research one of seven different regions of the electromagnetic spectrum (or have groups choose their region). Every student has seven pages on which to word process notes. On one of the pages, each student will take notes on the points they must research and present on their assigned region of the EMS. The other six are pages on which to word process notes while other groups present their research.

At this stage you will have to communicate information about the:

- length of time students will have in class to do research
- resources available to students in class to do presentations (poster, PowerPoint, or other)
- length of time students will have in class to work on presentations
- time requirements for the presentation
- order of presentations (the order in which they are numbered is recommended)
- grading requirements for student research and presentation (recommend involvement by all members of the group as one requirement)

Once these expectations are clear, student research and planning takes center stage, and your job as facilitator begins. Assist students in performing their research and putting together a successful presentation.

There should be noticeable continuity from one student presentation to the next. Remind students to word process notes on the other six student presentations on the sheets provided in their **Student Lesson and Response Guide**. If you had students make posters (rather than produce PowerPoints), have them place their posters on a chalkboard ledge where the different regions of the electromagnetic spectrum may be put in order.

When student presentations have concluded, take time to summarize and emphasize important features of the electromagnetic spectrum. It is probably important and useful for you to review:

- the order of the seven regions of the spectrum
- any of the notes you provided students with earlier that seem to need review, reinforcement, or repetition
- any points made during student presentations that seem appropriate to review

A summary page titled **The Electromagnetic Spectrum In Review** is provided for review of some very fundamental concepts and some extensions.

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*?
Radio waves

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

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

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

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

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

Discuss and provide acceptable answers to the last two questions using the following definitions and information, or your own.

2. Define ionizing radiation and non-ionizing radiation. Which types of radiation in the EMS are ionizing? Which types of radiation in the EMS are non-ionizing?

Ionizing radiation is radiation that is strong enough to damage molecules and cells. Ionizing radiation includes the higher frequency forms of UV radiation, all X-radiation and all gamma radiation. Non-ionizing radiation includes the lower frequency forms of UV radiation, and all forms of radiation "below" (visible, IR, microwave, and radio wave radiation).

3. Define background radiation. In your definition, give several examples of natural background radiation. Also in your definition, provide several examples of man-made background radiation.

Background radiation is low levels of radiation from both natural and man-made sources that is always around us. Examples of natural background radiation include gamma radiation that penetrates our atmosphere from outer space, and radiation released from rocks, soil, and water. Examples of man-made sources of radiation include fallout from nuclear weapons testing, and radiation released into the environment from coal-burning power plants.

Finally, Take the time to review some things that should have become obvious during the presentations:

- all forms of electromagnetic radiation have important applications and uses
- exposure to non-ionizing radiation (lower frequency) forms of EMR is relatively harmless
- exposure to ordinary forms and amounts of radiation is not harmful (students have been exposed to all forms of EMR every day of their lives)
- among those forms to which we should limit our exposure, there are important and helpful uses
- we can harvest the energy in the electromagnetic radiation from the sun to produce power