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Printed on 9/18/2017

# It's Not all Visible

## A lesson about the electromagnetic spectrum

By C. Bailey, S. Brown, Y. Diaz, M. Farrell, C. Letcher, J. Swift, and M. Zahreddine

## Focus on Inquiry

The student will investigate and construct explanations regarding the uses and applications of the electromagnetic spectrum. Students will also choose a model useful in demonstrating their understanding of the electromagnetic spectrum.

## Lesson Content Overview

Students will explore the various types of electromagnetic radiation with the use of a sorting activity. Students will then create a model to represent the EM spectrum, including the names of the parts of the spectrum and the uses and applications of each frequency of the spectrum.

| Duration | Setting | Grouping | PTI Inquiry Subskills |
|---|---|---|---|
| 80 minutes | Classroom | 3-4 Students, Individual | 3.3, 3.4, 3.6, 4.2, 5.2, 5.7, 5.8, 7.3 |

| Lesson Components | Estimated Time | Inquiry Subskills Used | Technology Used | Level of Student Engagement | Brief Description |
|---|---|---|---|---|---|
| ***Engage*** | 10 min | 5.2 | Internet, SmartBoard/ Student Computer | 2 | Student will explore a satellite photograph and see a visual representation of 8 different wavelengths. |
| ***Explore*** | 10 min | 3.3 | none | 3 | Students will use a card sort to determine the different parts of the EM spectrum and will use their graphic organizer to explain the differences within the spectrum. |
| ***Explain*** | 10-15 min | 7.3 | none | 2 | Through a series of guided questions students will describe the electromagnetic spectrum |
| ***Expand/Elaborate*** | 30 min | 3.4, 4.2, 5.7, 5.8 | none | 3 | Students will use their correctly matched and ordered cards to select and create a model that is useful for understanding the electromagnetic spectrum. |
| ***Evaluate*** | 15 min | 3.3, 3.6 | none | 1 | Students will complete a short quiz to check for understanding |

**Level of Student Engagement**

| | | |
|---|---|---|
| 1 | Low | Listen to lecture, observe the teacher, individual reading, teacher demonstration, teacher-centered instruction |
| 2 | Moderate | Raise questions, lecture with discussion, record data, make predictions, technology interaction with assistance |
| 3 | High | Hands-on activity or inquiry; critique others, draw conclusions, make connections, problem-solve, student-centered |

## Next Generation Science Standards – Inquiry

NGSS Practice 3: Planning and Carrying Out Investigations
NGSS Practice 4: Analyzing and Interpreting Data
NGSS Practice 6: Constructing explanations
NGSS Practice 8: Obtaining, Evaluating and Communicating Information

## Next Generation Science Standards – Content

**HS-PS4-4.:** Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

## Florida Science Standards – Nature of Science

**SC.8.N.3.1** Select models useful in relating the results of their own investigations.

## Florida Science Standards – Content

**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.

# Materials and Advance Preparation

## Materials List

Class set:

- Scissors (one per student)
- Coloring pencils, crayons or markers
- Ruler (one per group)
- Model materials (may include: string, yarn, string licorice, or any other similar material)
- One piece of copy paper per student or one poster per group

Student materials:

- Blackline Master # 1 (one set per group of 3-4)
- Blackline Master # 2 (one per student)
- Blackline Master # 4 (one per student)

## Blackline Masters

1. Electromagnetic Spectrum Card Sort
2. Check For Understanding: The Electromagnetic Spectrum
3. Check For Understanding: The Electromagnetic Spectrum ANSWER KEY
4. Electromagnetic Spectrum Model Rubric

## Advance Preparation

1. Make sure the Chromoscope website (http://chromoscope.net/) is operational and that students will be able to access it.
2. Make copies of Blackline Masters (print the cards in color if possible)
3. Cut out matching cards and place each set in an envelope (leave one copy uncut to use as an answer key)
4. Collect any materials needed for model activity

# Lesson Information

### Learning Objectives

1. The student will be able to compare, and/or contrast the variety of types of radiation present in radiation from the Sun.
2. The student will be able to identify and/or compare characteristics of the electromagnetic spectrum including relative wavelengths, frequencies and energy levels.
3. The student will be able to identify common uses and/or applications of electromagnetic waves.
4. The student will be able to select and create a model that is useful to interpret the results of their investigation of the electromagnetic spectrum.

### Prior Knowledge Needed by the Students

- Basic understanding of the types of radiations from the Electromagnetic Spectrum.
- Visible light and its color spectrum.
- A basic understanding that different waves have different levels of energy.
- Students should be familiar with the parts of a wave and the terms “frequency” and “wavelength”

### Background Information

The Electromagnetic Spectrum is a range of different types of radiations that includes radio waves, microwaves, infrared, visible light, ultraviolet, x-rays and gamma rays. Each range of the EMS (Electromagnetic Spectrum) has several applications and uses in everyday life. All the radiation types are distinguished by their own wavelength and frequency; radio waves having the longest wavelength and lowest frequency while gamma rays have the shortest wavelength and highest frequency. Visible light is the only radiation that can be seen and when it passes through a prism, it separates into different colors. The colors of the rainbow are in a specific order based on their wavelength (red, orange, yellow, green, blue, indigo, and violet).

# Lesson Procedure

***Engage***

1. Students can use http://chromoscope.net/ to view an interactive picture of the Milkyway Galaxy to explore the picture at 8 different wavelengths.

**Guiding questions**

1. What happen when you move the slider up and down?
   Students may answer: It changes the picture of the galaxy. It changes the colors. You can see "stuff" that were not there before. It creates a line of light in the center.
2. Can you distinguish objects in the galaxy as you change the slider from one to the other?
   Students may answer: Yes, I can see some dust, stars, clouds, and different lights.

***Explore***

1. Each group of students will receive 1 envelope. Inside the envelope are the different types of Electromagnetic waves and pictures that correspond to each energy type. (**Blackline Master #1).**
2. Allow students to match the pictures to the definition of the type of Electromagnetic wave they belong to (based on prior knowledge). Instruct students to keep the cards on their desk once they have them matched.
3. Once students have all pictures and Electromagnetic wave types matched, have them raise their hands for you to come to check their work. Instruct students to keep the cards together once they have the order correct.
4. If there are incorrect matches, silently un-match those words and have students correct them until all pairs are correctly matched.
5. Once all students have the cards matched, ask them to put them in order by wavelength. This can be done by asking students to put them in order of lowest energy to highest energy.
6. Once students have attempted to order them, either check each group or give students a picture of the entire spectrum to self-check.

***Explain***

1. Some questions you might ask students and possible correct answers include:
2. Where does the radiation of the electromagnetic spectrum originate from?
   - The Sun is where radiation of the electromagnetic spectrum originates.
3. Are all wavelengths and frequencies the same? Explain your reasoning.
   - All wavelengths and frequencies are NOT the same.
   - The higher the frequency the shorter the wavelength.
4. Are there different types of waves in the spectrum?
   - There ARE different types of waves in the electromagnetic spectrum. Students may list some or all of the types of waves identified below:
     - Radio waves have the longest wavelength and the lowest frequency.
     - Microwaves are high frequency and often focused into beams.
     - Infrared waves are the part of the electromagnetic spectrum to which we are most often exposed. It is invisible but can be felt in the way of heat.
     - Visible light waves are the part of the electromagnetic spectrum that we can see. Some students may cite the Roy G Biv to remember the colors within the electromagnetic spectrum. Some may make reference to the rainbow.
     - Ultraviolet waves are part of the electromagnetic spectrum that is invisible to humans but many insects use this wavelength.
     - X-Ray waves are invisible and often used in the medical field.
     - Gamma waves have the shortest wavelength and highest frequency. These are also often used in the medical field.
5. Are they in a specific order? How is that order determined? What would that order be?
   - They are in a specific order.

- They are usually ordered by the wavelength from longest wavelength (radio waves) to shortest wavelength (gamma waves).
- Radio waves, microwaves, infrared waves, visible light, ultraviolet waves, x-ray waves, gamma rays

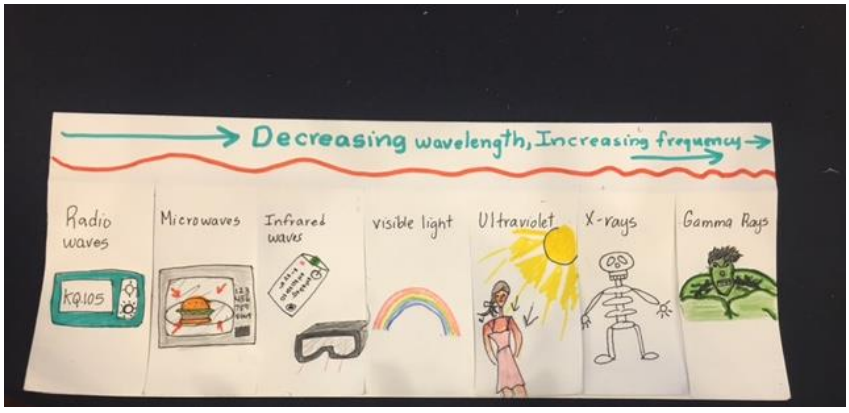
6. Which electromagnetic wave has the longest wavelength? Which electromagnetic wave has the shortest wavelength?
   - Radio waves have the longest wavelength
   - Gamma waves have the shortest wavelength.
7. What wave property increased as the wavelength decreased?
   - Energy increases as the wavelength decreases.
8. What happens to the energy as the wavelength decreases?
   - The order of the colors in the visible light spectrum are red, orange, yellow, green, blue, indigo, and violet.
9. What is the order the colors in the visible light spectrum? Where would the infrared and ultraviolet fit in the electromagnetic spectrum?
   - Infrared and ultraviolet waves are the wavelengths that surround the visible light waves that we are able to see. Both of these are invisible.

***Expand***

Students will use their correctly matched and ordered cards to select and create a model that is useful for understanding the electromagnetic spectrum. Students may choose to draw a picture, draw a poster, create a digital picture, create a foldable, or other relevant model that shows the entire spectrum. Students may choose to create a model using different materials to represent the waves such as, markers, string, yarn, thin licorice, or other thin bendable material. Students should use color to include visible light spectrum (ROYGBIV). There is a rubric available on **Blackline Master #4** to evaluate any/all of these potential products.

*Instructions for a foldable are as follows:*

1. Students take a piece of paper and fold it in half (hot dog). Lay a ruler down along the top of the folded side and fold it back up over the ruler, make six even cuts to make seven even flaps.
2. After discussing the instructions for the foldable, have the students cut and label all the parts of the foldable.
3. When students have their foldable cut and they can use the cards in the correct order to fill up each section of the foldable.
4. Parts of the foldable should include:
   a. Name of wavelength range
   b. Definition and world applications for the specific wavelength
   c. Nonlinguistic representation for each wavelength.
   d. A visual representation of the wavelength across the spectrum




*Example of a possible foldable model for students to create (credit M. Zahreddine).*

***Evaluate***

***FORMAL EVALUTION***

Check for understanding (Blackline Master 2)

***WRAP UP.***

Conclude the lesson by watching the Electromagnetic Spectrum Song Mr. Parr video, which summarizes the lesson: https://www.youtube.com/watch?v=P_PVz8HrrCI

You could include an exit ticket referencing the video.

***Additional Resources***

Go to https://science.nasa.gov/ems/ to download the EMS book pdf, which gives a tour of the electromagnetic spectrum.

## CITATION OF SOURCES

**Sources Sort Card Pictures:**

**Antenna and Radio Waves -**
Sherman, P. (n.d. ). Antenna & Radio Waves. Retrieved July 25, 2017 from
**http://www.wpclipart.com/signs_symbol/assorted/assorted_3/antenna_and_radio_waves.png**

**Microwaves –**
Essjay (2006). Microwave_Mindspillage. Jpg. Retrieved July 25, 2017 from
https://commons.wikimedia.org/wiki/File:Microwaved_mindspillage.jpg

**Infrared Waves –**
Lucas. J (2015). What is infrared? Retrieved January 25, 2017 from **www.livescience.com/50260-infrared-radiation.html**

**Visible Light –**
Lucas. J (2015). What is visible light? https://www.flickr.com/photos/hawk684/108139247 https://www.livescience.com/50678-visible-light.html

**Ultraviolet Waves –**
Kates, P. (2006). Sunburn. Retrieved on July 25, 2017 from https://www.flickr.com/photos/hawk684/108139247/
EconomicsGuy. (2008) Northern lights, Greenland.jpg. Retrieved on January 25, 2017 from
https://commons.wikimedia.org/wiki/File:Northern_Lights,_Greenland.jpg

**Xray Waves –**
Rotemdan. (2006). X-ray.jpg. Retrieved July 25, 2017 from https://commons.wikimedia.org/wiki/File:X-ray.jpg

**Gamma Waves -**
LeadSongDog. (2008). PET Normal brain.jpg. Retrieved July 25, 2015 from
https://commons.wikimedia.org/wiki/File:PET_Normal_brain.jpg

__✓__ Yes, I cited all materials and resources used in this lesson.

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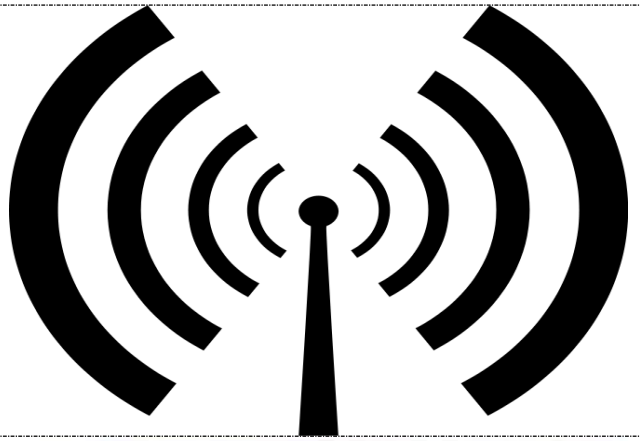
Lesson authors' signatures

## Blackline Master # 1 Electromagnetic Spectrum Card Sort



# Radio Waves :

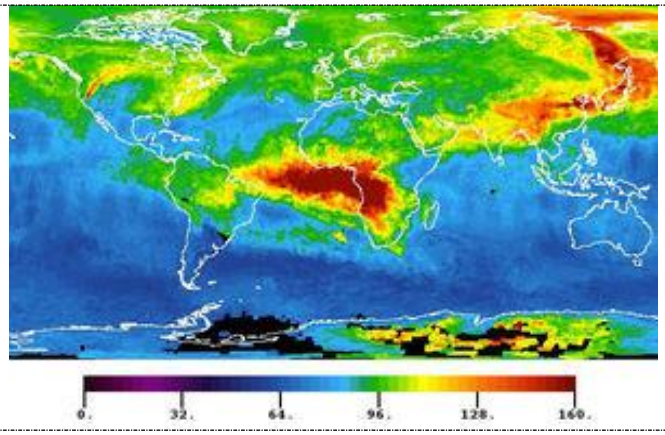
This is part of the EM spectrum that emits the longest wavelengths and lowest frequency of radiation waves.

Examples of radio waves include long distance communication, television transmission, satellites, walkie talkies, and listening to the radio.

# Microwaves :

This is part of the EM spectrum that is basically a high frequency radio wave which is easily focused into narrow beams.

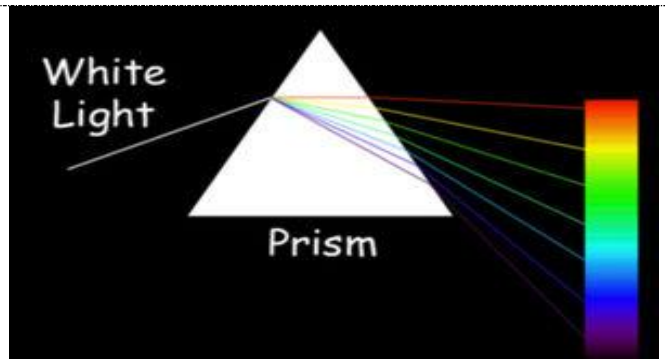
Examples of microwaves include cell phone transmission, blue tooth, wifi, xbox, cooking, and radar.




# Infrared Waves :

This is part of the EM spectrum we are most often exposed to. It is invisible to humans, but we feel it as heat.

Examples of Infrared waves include changing the channels on our televisions, thermal imaging for weather reporting, remote controls, room heaters, and night vision goggles.




## Visible Light Waves:

This is part of the EM spectrum that humans can see (ROY-G-BIV – Red, Orange, Yellow – Green – Blue, Indigo, Violet)., and visible light falls in the middle of the spectrum.

Examples of visible light waves include rainbows.

## Ultraviolet Waves :

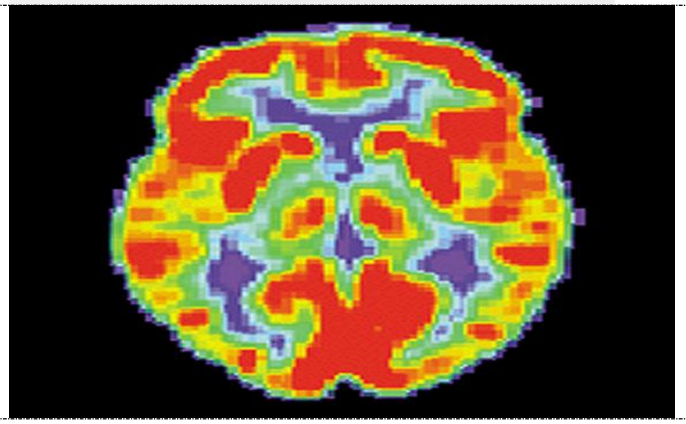
This is part of the EM spectrum that is invisible to humans, yet many insects use this.

Examples of ultraviolet waves include the auroras, sunburn, a cause of skin cancer, and black lights.

## X-ray Waves :

This is part of the EM spectrum that is invisible to humans and is known to affect cell division.

Examples of x-rays include medical diagnosis, radiation therapy, measuring construction integrity, laser refinement, archeology, and TSA monitoring.



## Gamma Waves :

This is part of the EM spectrum that has the shortest wavelength and highest frequency of radiation waves.

Examples of gamma waves include medical radiation treatment, CT scans, and sterilizing medical tools.

## Blackline Master # 2 Check For Understanding: The Electromagnetic Spectrum

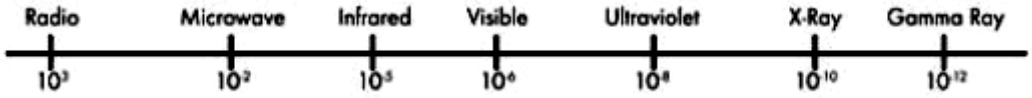
1. If Rick is talking on his cellphone what type of wave is his cellphone using to connect and communicate? *(SC.8.E.5.11)*
    a. gamma rays
    b. microwaves
    c. radio waves
    d. visible light

2. A thunderstorm has just passed and the sun is coming out. Maria is at the school track field and she observes a rainbow at a distance. What type of electromagnetic wave is causing this phenomena? *(SC.8.E.5.11)*
    a. infrared rays
    b. ultraviolet waves
    c. x-rays
    d. visible light

3. You are going on vacation during summer to Hawaii and you pack some sunscreen to protect your skin from a sunburn. The sunscreen is protecting your skin from which wavelength? *(SC.8.E.5.11)*
    a. radio waves
    b. x-rays
    c. ultraviolet light
    d. gamma rays

4. Jimmy is doing a poster of the electromagnetic spectrum and he needs to show the relationship between the frequency and wavelength of the EMS waves. Which statement best describes that relationship? (*SC.8.E.5.11*)
    a. The wavelength decreases as the frequency decreases.
    b. The wavelength increases as the frequency increases.
    c. The wavelength decreases as the frequency increases.
    d. The wavelength and frequency remains constant.

5. Which one is an example of a conceptual model in science? *(SC.8.N.3.1)*
    a. The frequency of a wave.
    b. The wavelength of a gamma ray.
    c. The electromagnetic spectrum.
    d. The amplitude of a wave.




**Extended Thinking** -Using the diagram above answer the following question.

When you are sick the doctor gives you a treatment or order some medicines. He has to assign you several tests and make you go through a process of examination to help you get better. Identify one region of the electromagnetic spectrum used by medicine and explain how is used. (*SC.8.E.5.11*)

## Blackline Master # 3 Check For Understanding: The Electromagnetic Spectrum (Answer Key)

1. If Rick is talking on his cellphone what type of wave is his cellphone using to connect and communicate? *(SC.8.E.5.11)*
    a. gamma rays
    b. microwaves
    c. radio waves
    d. visible light

2. A thunderstorm has just passed and the sun is coming out. Maria is at the school track field and she observes a rainbow at a distance. What type of electromagnetic wave is causing this phenomena? *(SC.8.E.5.11)*
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    c. x-rays
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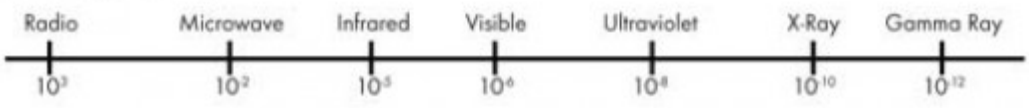


**Extended Thinking**- Using the diagram above answer the following question.

When you are sick the doctor gives you a treatment or order some medicines. He has to assign you several tests and make you go through a process of examination to help you get better. Identify one region of the electromagnetic spectrum used by medicine and explain how is used.
x-rays =broken bone scanning, gamma rays= cancer treatment/ chemotherapy

## Blackline Master #5 – EM Spectrum Model Rubric

| CATEGORY | 4 | 3 | 2 | 1 |
|---|---|---|---|---|
| **Graphics - Clarity** | Graphics are all in focus and the content easily viewed and identified. | Most graphics are in focus and the content easily viewed and identified. | Most graphics are in focus and the content is easily viewed and identified. | Many graphics are not clear or are too small. |
| **Graphics - Relevance** | All graphics are related to the topic and make it easier to understand. All borrowed graphics have a source citation. | All graphics are related to the topic and most make it easier to understand. All borrowed graphics have a source citation. | All graphics relate to the topic. Most borrowed graphics have a source citation. | Graphics do not relate to the topic OR several borrowed graphics do not have a source citation. |
| **Labels** | All items of importance in the project are clearly labeled with labels that can be easily read. | Almost all items of importance in the project are clearly labeled with labels that can be easily read. | Several items of importance in the project are clearly labeled with labels that can be easily read. | Labels are too small to view OR no important items were labeled. |
| **Content - Accuracy** | At least 3 accurate facts are displayed in the project for all 7 types of electromagnetic radiation. | At least 2 accurate facts are displayed in the project for all 7 types of electromagnetic radiation. | At least 1 accurate fact is displayed in the project for all 7 types of electromagnetic radiation. | Less than 1 accurate fact is displayed in the project for each of the 7 types of electromagnetic radiation. |
| **Attractiveness** | The project is exceptionally attractive in terms of design, layout, and neatness. Color is used throughout the project. | The project is attractive in terms of design, layout and neatness. There is a good deal of color. | The poster is acceptably attractive though it may be a bit messy. Color is scarce. | The poster is messy or very poorly designed. It is not attractive. No color is used. |