Lab 13: Make a Model
Electromagnetic Spectrum

LAB

What you'll learn …

Visible light has varying frequencies, depending on the color. One way to represent this is through a model.

What you'll do …

First, make some calculations. Then, use construction paper of different colors. Create a model depicting the different wavelengths of visible light. (Light is part of the electromagnetic spectrum).

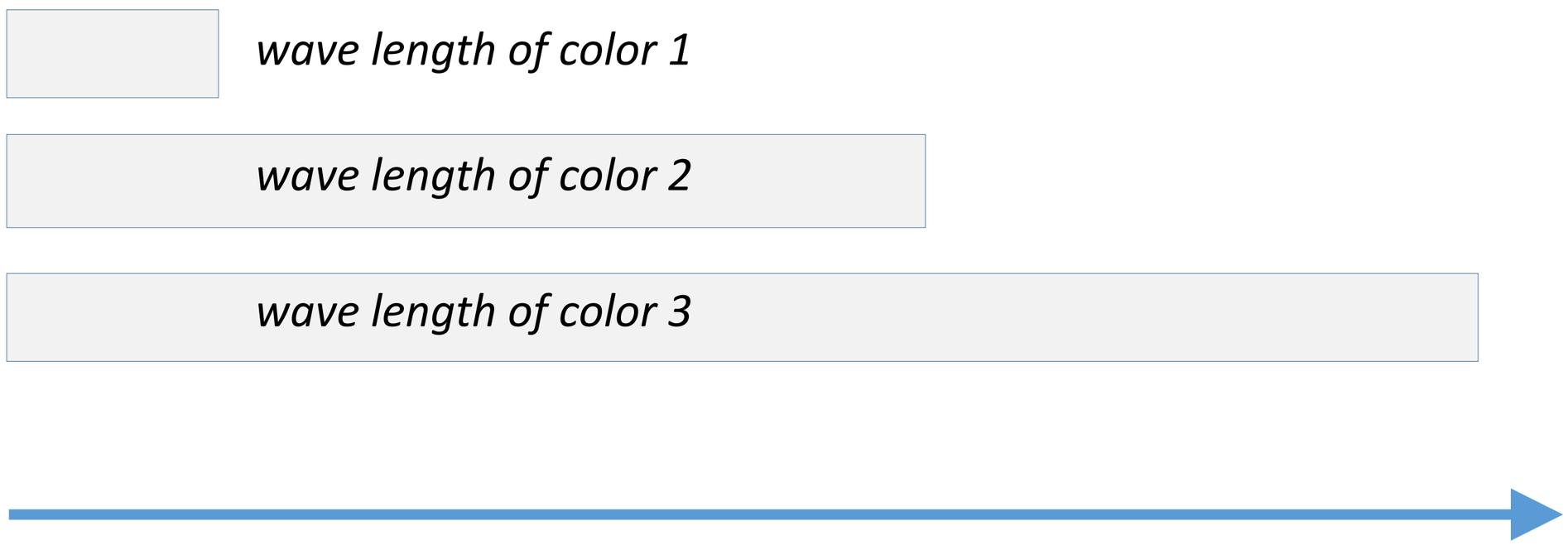
Things you'll need …

Construction paper, scissors, marker, ruler (meter stick), and tape. The paper needs to be white, red, orange, yellow, green, blue, violet, and black.

Other considerations …

In a vacuum, all waves of the electromagnetic spectrum travel at the same speed. They travel at 300,000 km/s. BUT … they have different wavelengths.

Illustration



Science Concepts

Before starting, read and summarize each paragraph below.

The length of things in science is usually written in meters (m). Often, the numbers are written in scientific notation. The reason lengths are stated in meters is to make comparisons easy. Scientific notation can also make comparisons easier.

The measurement of meters is one of the important standardized measurements in the SI system. Using a prefix in front of the word "meter" is a convenient way to talk about really long things, or really short things. Light waves are only nanometers long.

For this lab, you need to be familiar with the prefix "nano" – and also the prefix "milli" – which will be used with the word meter. Nanometer means one billionth of a meter. This is very short – too short to see. Millimeter means one thousandth of a meter.

Light waves are too short to create a construction paper model of them. So, you will multiply the wave length of each color in the spectrum by one million! This part of the math is very easy. You will simply substitute mm (millimeters) for nm (nanometers).

Step-by-Step

1

Do some math. Convert the wavelengths of each color listed. Convert from meters to nanometers. To do this, you will multiply each value by **$\underline{10^9}$**.

Remember that one billion nanometers is the same thing as one meter.

$\underline{10^9}$ is one billion – or 1,000,000,000.

For example, the wavelength of the color violet is **4 x 10^{-7}** meters long. To convert this number into nanometers, multiply by **$\underline{10^9}$**.

4 x 10^{-7} (m) multiplied by **10^9 (nm/m)** equals **$\underline{\text{4 x } 10^2 \text{ (nm)}}$.**

$\underline{4 \times 10^2}$ is the same thing as **$\underline{\text{4 x 100}}$**, *so* … **$\underline{\text{400 nm}}$**.

2

Do some more math. 400 nm is simply too short to see. There is no way to cut-out a piece of construction paper that is only 400 nm long. So, for your model, you will multiply all the numbers by one million!

NOTE: Doing this step is simple. You just have to replace nm with mm.

After performing step 1 for all of the colors, switch out the metric unit of nanometers with millimeters.

For example, switch $\underline{\text{nm}}$ on **400 (nm)** to **(mm)** … resulting in **$\underline{\text{400 (mm)}}$**

Adapted Material. Attribution and gratitude to Rachel Hovey (Derby High School, KS)

Step-by-Step

3 **Now, do the fun part.**

Use the colored paper to represent the colors of the visible light.

NOTE: Use black paper to represent ultraviolet and the white paper to represent infrared.

Measure and cut about 3 cm wide strips that represent the length for each wave. You may have to tape strips together to make them long enough.

Lay the strips down on the table side by side in the proper order of length. Tape it at one end so you have a sheet of waves.

Make sure each strip is labeled with its wavelength and title. For example, "*Infrared 1,000 nm*."

4 **Prepare for discussion.**

- ❑ Why did we make a *scale model* of these waves?
- ❑ How many times longer is the infrared wave than the ultraviolet wave?
- ❑ Some radio waves are 3 meters long. If we were to add this to our model how long would the strip have to be?

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Complete the Table

Wave	Wavelength in meters	Calculation 1	Conversion Wavelength in nanometers	Model Scale Wavelength in millimeters
Infrared	1×10^{-6}	$(1 \times 10^{-6})(10^{9}) = 1 \times 10^{3}$	**1,000 nm**	**1,000 mm**
Red	7.5×10^{-7}			
Orange	6.3×10^{-7}			
Yellow	5.8×10^{-7}			
Green	5.3×10^{-7}			
Blue	4.5×10^{-7}			
Violet	4.0×10^{-7}	$(4 \times 10^{-7})(10^{9}) = 4 \times 10^{2}$	**400 nm**	**400 mm** 2
Ultraviolet	3.0×10^{-8}			

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More About This …

Types of radiation (Wikipedia Extract)

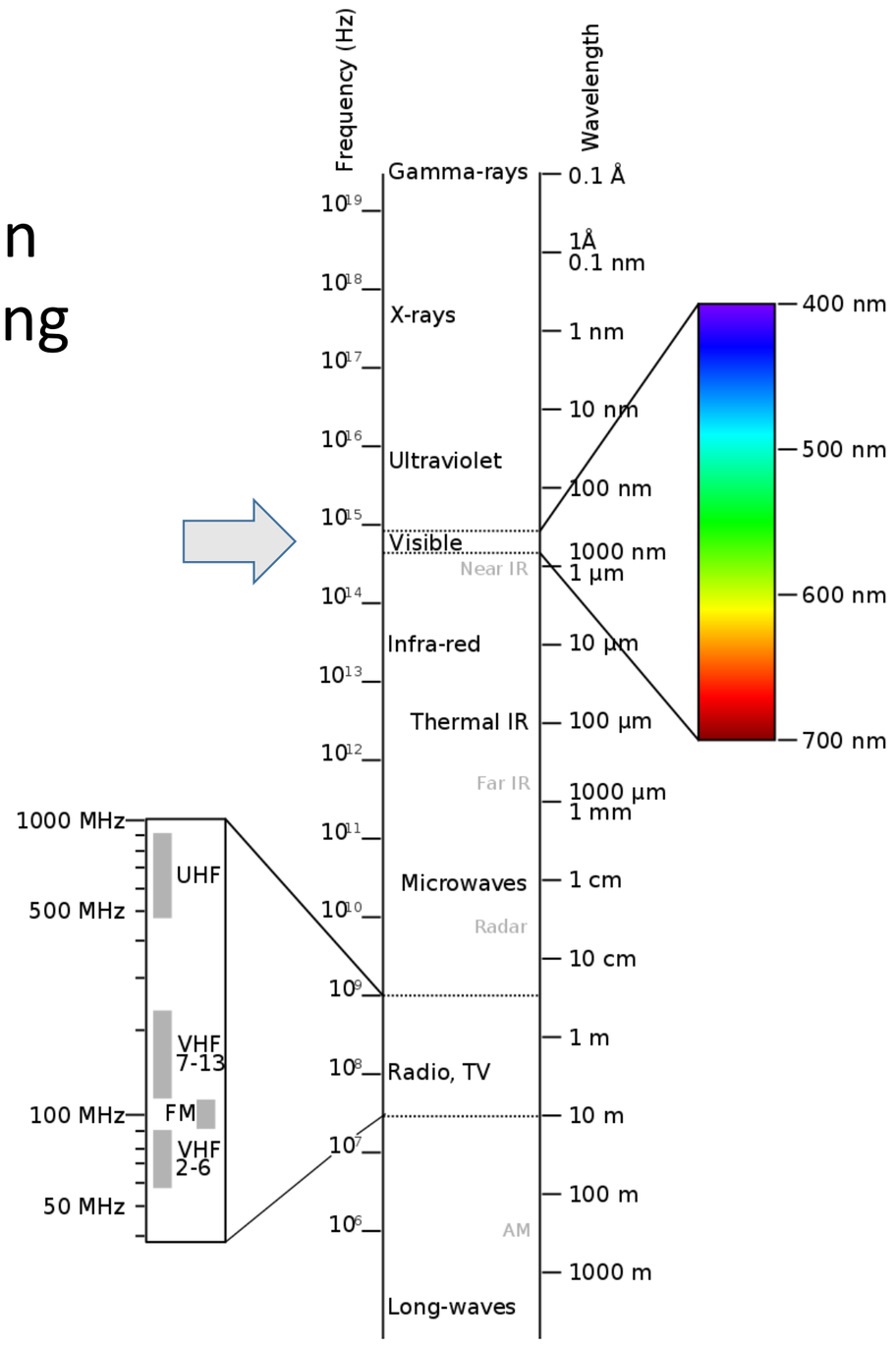
Boundaries

A discussion of the regions (or bands or types) of the electromagnetic spectrum is given below. Note that there are no precisely defined boundaries between the bands of the electromagnetic spectrum; rather they fade into each other like the bands in a rainbow (which is the sub-spectrum of visible light). Radiation of each frequency and wavelength (or in each band) has a mix of properties of the two regions of the spectrum that bound it. For example, red light resembles infrared radiation in that it can excite and add energy to some chemical bonds and indeed must do so to power the chemical mechanisms responsible for photosynthesis and the working of the visual system. https://en.wikipedia.org/wiki/Electromagnetic_spectrum

Regions of the spectrum

The types of electromagnetic radiation are broadly classified into the following classes:

1. Gamma radiation
2. X-ray radiation
3. Ultraviolet radiation
4. Visible radiation
5. Infrared radiation
6. Terahertz radiation
7. Microwave radiation
8. Radio waves



By Original:PenubagVector:Victor Blacus - Own work based on: Electromagnetic-Spectrum.png, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=22428451

Show-Off Your Smarts!

Instructions

- Complete as an individual or small group.
- Discuss your ideas/answers/responses in a small group.
- Select one person to present your responses to the class.

Q1. List three places visible light exists, then describe how information from this topic is relevant to you and others in those locations.

Describe how information from this topic is relevant at each location …

Location 1	
Location 2	
Location 3	

Q4. How would you explain these concepts to a smart scientist from 1,000 years ago who did not (*yet*) know this information? 40 words or more.

Make a Poster – Or Make Notes

In the space provided here, create/draw a poster which conveys the concepts you have learned on this topic. Or, alternatively take notes.