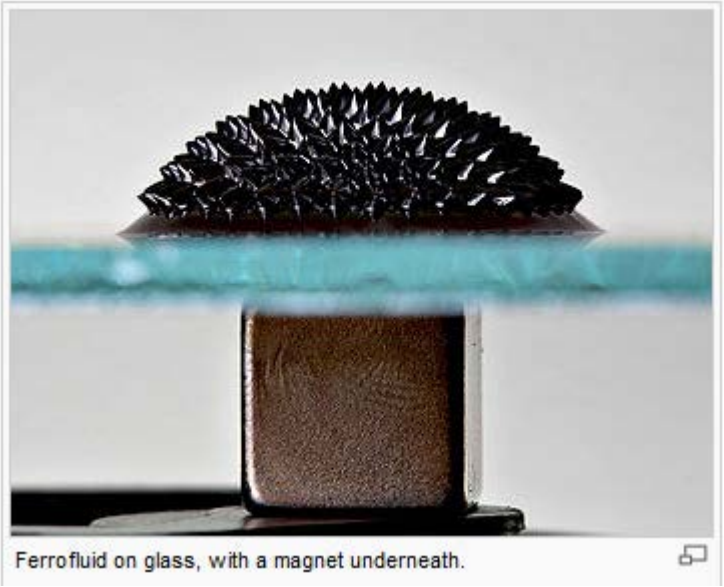
Activity 2: Physics and the Visual Arts

Why? An appreciation for and understanding of the physical processes that underpin the visual arts can be satisfying for an artist and lead to production of some unique pieces such as ferrosculptures: (Check some of these out on YouTube.)



Ferrofluid on glass, with a magnet underneath.

From Wikepedia

www.nextechnews.com/content/binary/WindowsLiveWriter/FerroFluidgetsevenmoreamazingFullonmovin_91B2/ferrofluid%5B2%5D.jpg

Learning Objectives:

- Understand the relationship between the electromagnetic spectrum and visible light
- Know the relationship between wavelength and frequency
- Know the relationship between frequency and energy
- Become familiar with the properties and behavior of electromagnetic radiation

Concepts and Vocabulary:

- Wavelength, frequency
- Intensity
- Speed of light
- Reflection
- Refraction
- Dispersion
- Diffraction

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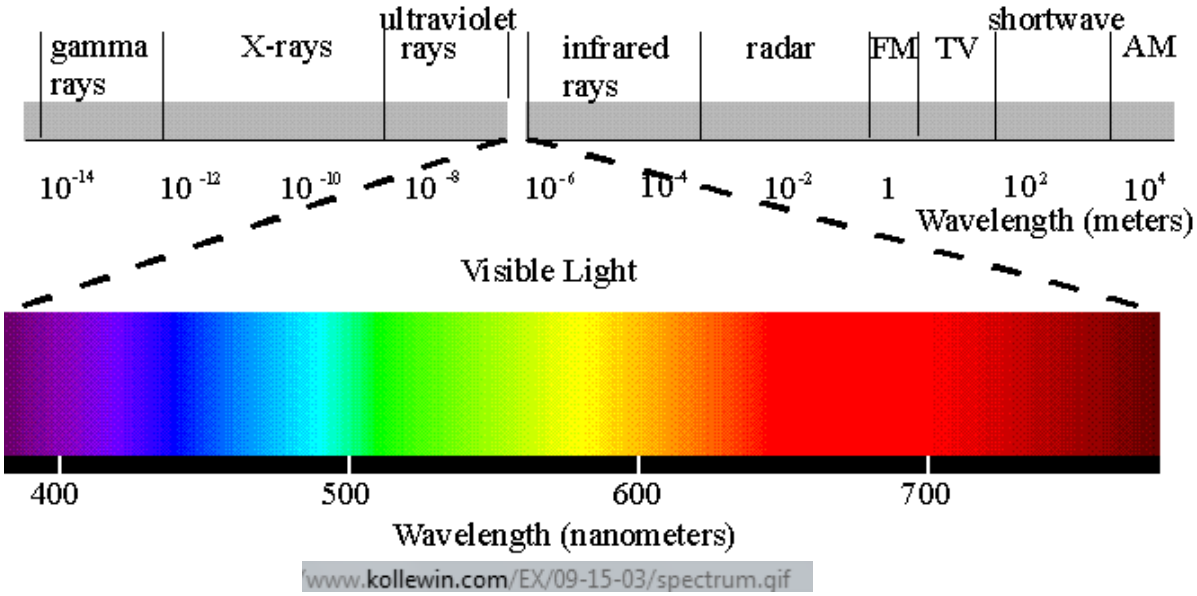
Critical Thinking Questions:

1. For the visual arts, which of the five senses is the most important? Explain.

2. The ability to see works of art results from a complex interplay of light and the rods and cones of your retina. Below list anything you know about the properties of light. (It's ok if you don't know much – that's why we are here!)

Model 1 The Electromagnetic Spectrum

What we call "light" is a very small portion of the electromagnetic spectrum that our eyes respond to:



Note that 400 nanometers (nm) is the same as 4×10^{-7} meters; we'll practice more with scientific notation later. Electromagnetic radiation (abbreviated E_M) is NOT the same as radioactivity; its definition is that it is propagated as a wave at the speed of light in a vacuum. Below is a diagram that shows the important characteristics of E_M.

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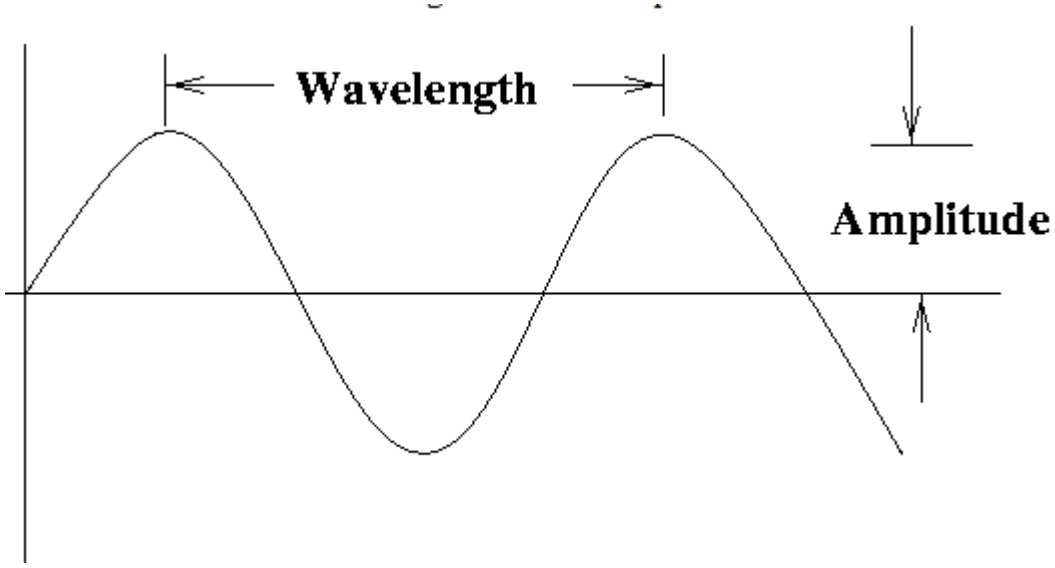
Wavelength, frequency, intensity, and energy of light



Key questions:

1. Describe how you can determine wavelength of a wave.

2. Repeat for amplitude, which is also known as intensity.

3. Frequency is defined as cycles per unit time; it can be thought of as how many wavepeaks pass a given point in a defined period of time, often seconds. The units of frequency are "per second", shown in equations as $\frac{1}{\text{sec}\,ond}$ or second^{-1}. Frequency is also sometimes expressed in units of Hertz (Hz), which is also cycles/second. What electronic devices have you purchased where you are interested in Hz?

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Type of electromagnetic radiation	Wavelength (λ, meters)	Frequency (ν)	$\lambda \times \nu$	Energy (joules)
X ray	1.00×10^{-11}	3.00×10^{19}		1.99×10^{-14}
Shortwave radio	5.00×10^{2}	6.00×10^{5}		3.98×10^{-28}
Infrared	3.75×10^{-5}	8.00×10^{12}		5.30×10^{-21}
TV	4.20×10^{1}	7.14×10^{6}		4.74×10^{-27}
Ultraviolet	2.80×10^{-7}	1.07×10^{15}		7.10×10^{-19}
Orange light	6.00×10^{-7}	5.00×10^{14}		3.32×10^{-19}

4. Look at the chart above. Which type of E_M has the shortest (smallest) wavelength? The longest? HINT – remember a bigger negative exponent is a smaller number.

5. Which E_M has the highest (largest) frequency? The smallest? What is the relationship that you observe between wavelength and frequency?

6. What symbol is used to represent wavelength? Frequency?

7. Use a calculator that has scientific notation, or Excel to perform the following calculation. Multiply wavelength by frequency and record the result in column 4 in the table above. In a calculator, you enter the wavelength of the X ray as 1.00 EE (or EXP) -11 and its frequency as 3.00 EE 19. In Excel, enter as 1.00e-11 and 3.00e19. What do you notice about the result?

You have just shown one of the fundamental equations for E_M; the product of wavelength and frequency is equal to 3×10^{8}, which is the speed of light in a vacuum in meters/second. The equation is shown as $\lambda \times \nu = c$ (which is the symbol for the speed of light).

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8. Which of the above types of E_M has the highest energy? The lowest? Remember, a larger negative exponent is a smaller number. Is this in line with what you expected?

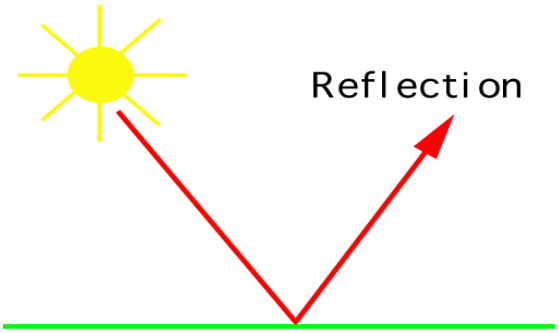
9. Is the wavelength of blue light longer or shorter than red light? So is it more or less energetic?

Model 2 Behavior of Light Waves (Most the following diagrams are from http://theory.uwinnipeg.ca/mod_tech/node110.html.) Others are noted.

All of the following behaviors are important in how we perceive works of art.

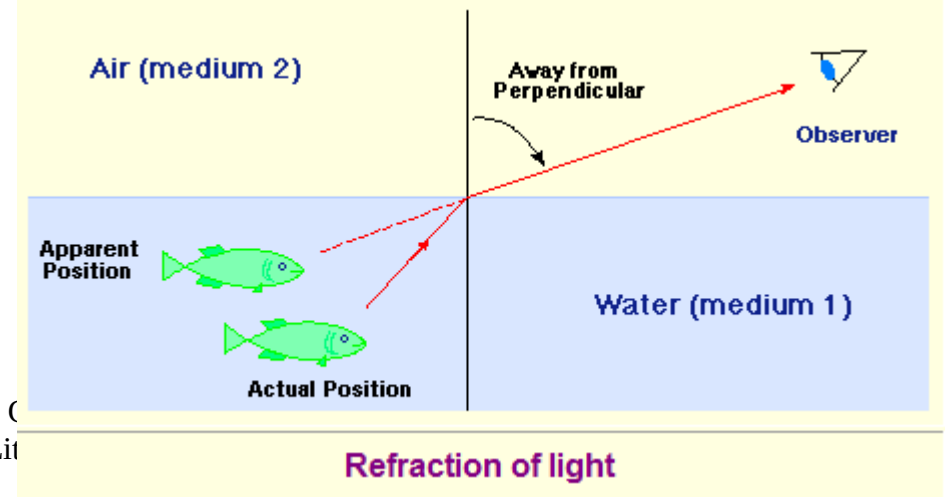
1. **Reflection** is the property of light that allows us to see; the light reflected off surfaces is bounced to our retinas.

http://www-cs-faculty.stanford.edu/~eroberts/courses/soco/projects/1997-98/ray-tracing/images/reflection.gif



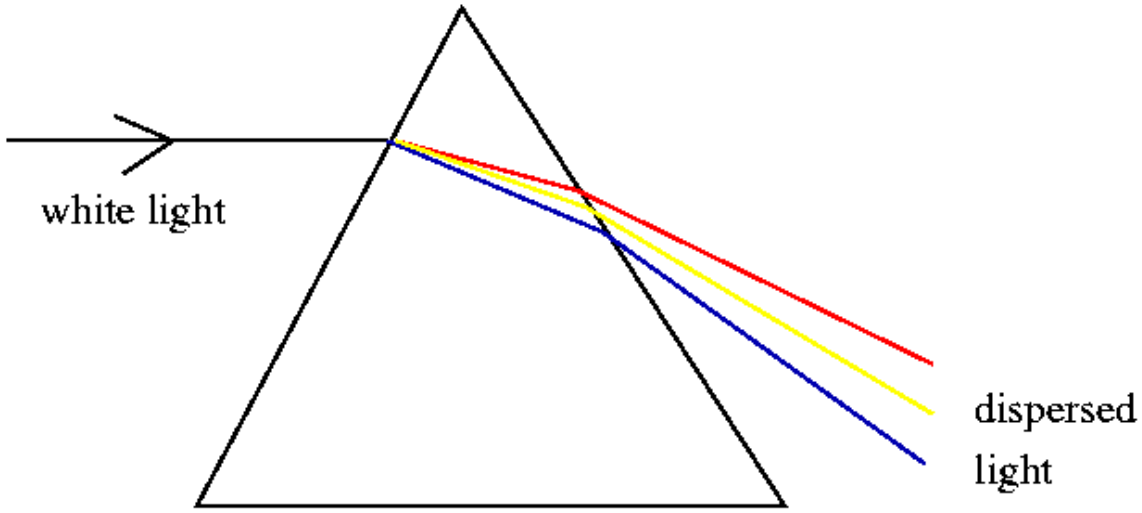
2. **Refration** is a change in the direction of light rays as they travel between two media of different densities. This property is illustrated below in the image of a pencil in a glass of water.

http://media.log-in.ru/i/pencilIn_in_water.jpg

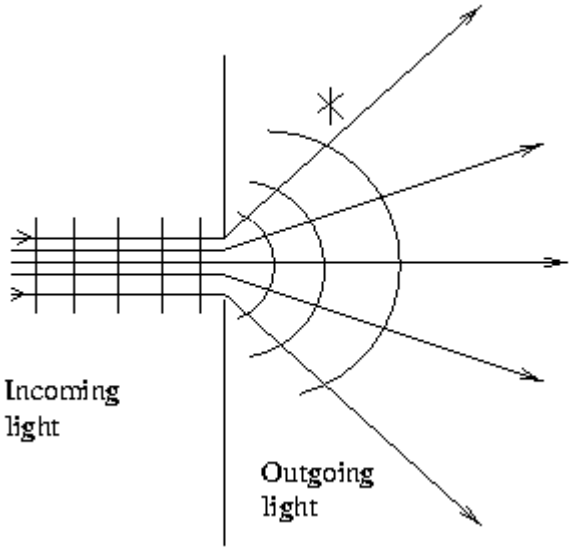


http://csep10.phys.utk.edu/astr162/lect/light/ref-diff.html

3. **Dispersion** is the breaking up of light into its component colors, usually through a prism.



4. **Diffraction** is the property of light that allows it to bend around corners when passing through an opening.



Question:

1. What properties of light do you think are important in the formation of a rainbow? Explain.

DONE!

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