Properties of Light

Objectives

MSPS4-2

- Learn about light energy and the electromagnetic spectrum
- Learn the properties of light
- Review the parts of a wave
- Discover the relationship between brightness and amplitude, color and frequency

Vocabulary

- light
- light wave
- electromagnetic spectrum
- visible light
- crest
- trough
- amplitude
- wavelength
- frequency
- brightness

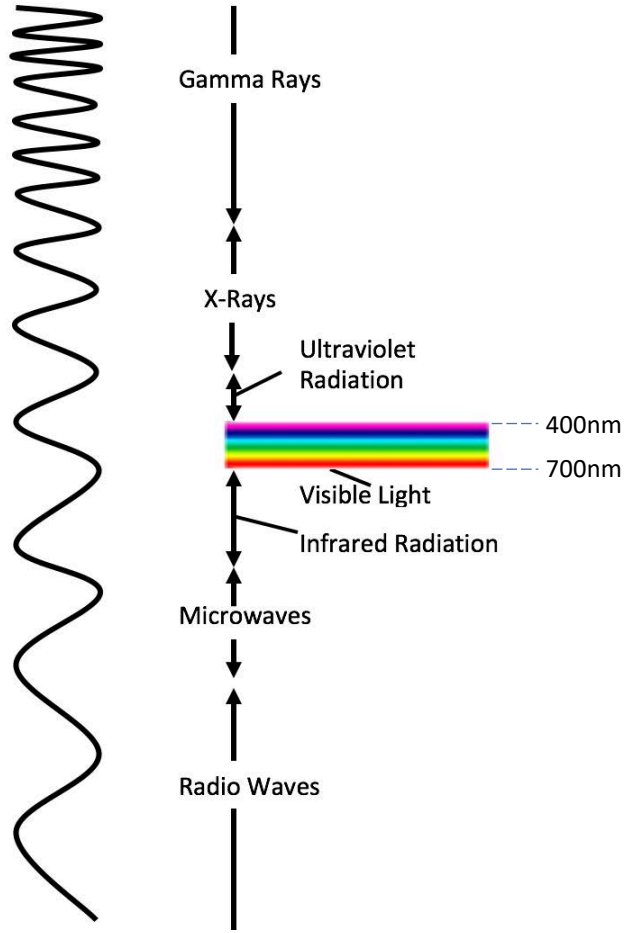
What is light?

Make a list of all the words that come to mind when you think of light.

Light

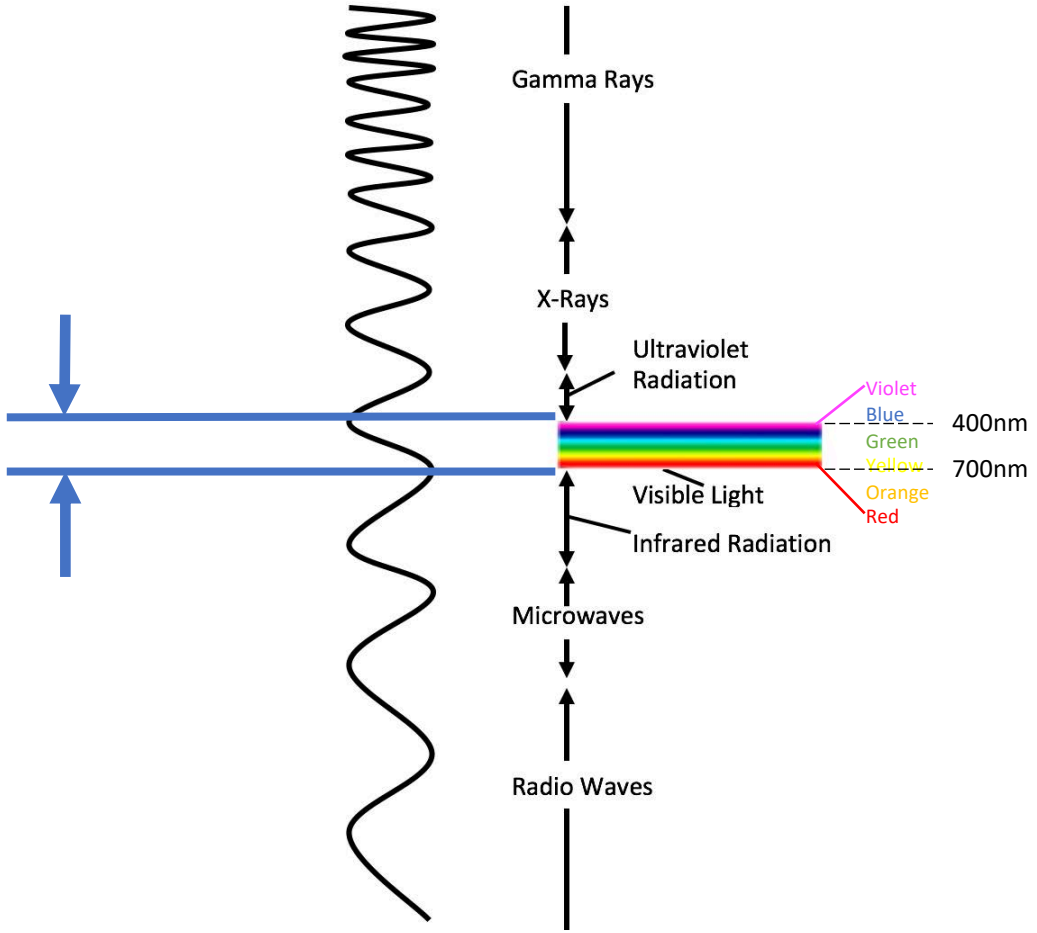
When you think of light, you probably think of what your eyes can see. But the light that our eyes can see is just the beginning; it is only a small a sliver of the total amount of light that surrounds us.

The **electromagnetic spectrum** is the term used by scientists to describe the entire range of light that exists. From radio waves to gamma rays. Most of the light in the universe is, in fact, invisible to us!



Light We Can See

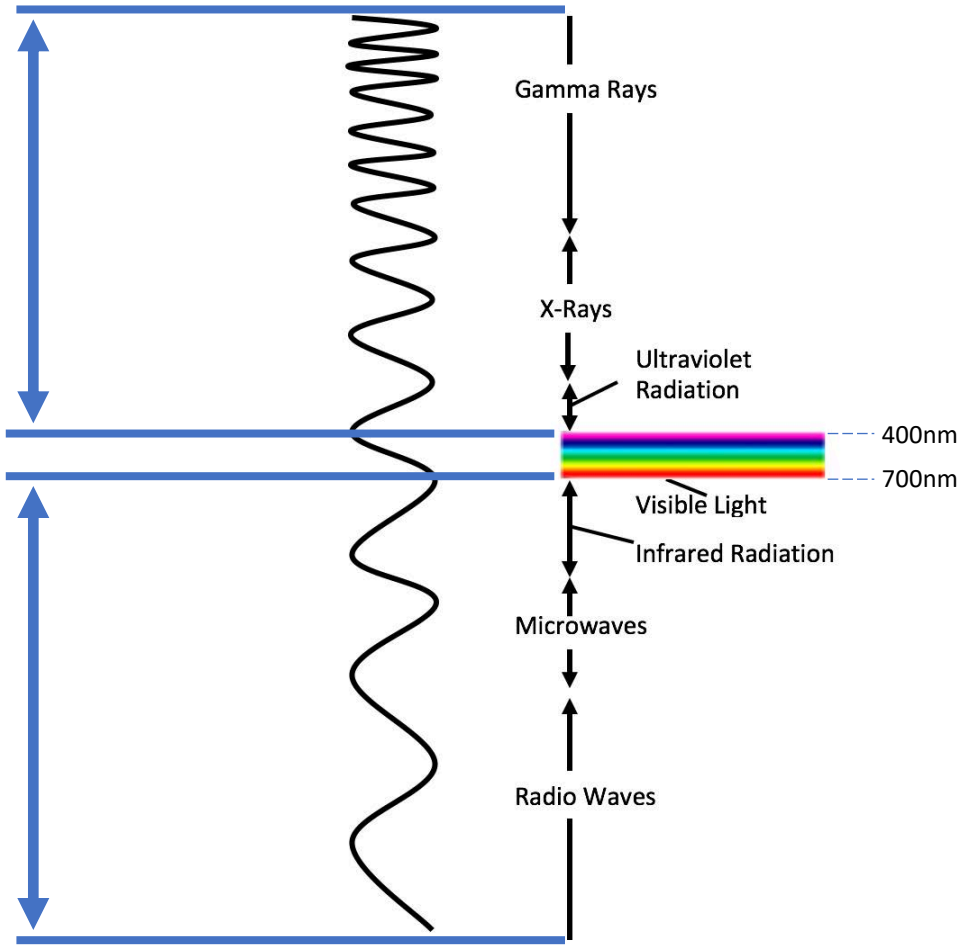
In the entire electromagnetic spectrum of light, the only light humans can see is right In the middle. This part of the electromagnetic spectrum is called **visible light**.



Light We Can't See

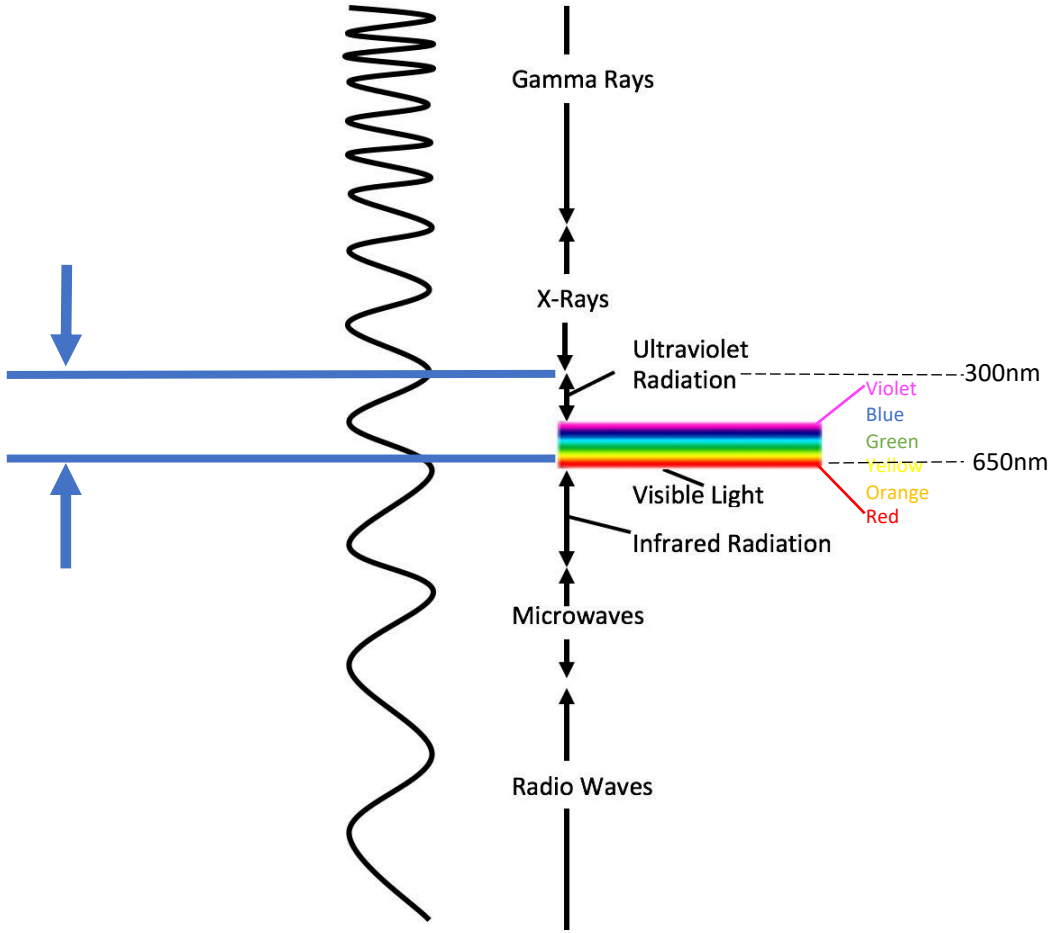
In the entire electromagnetic spectrum of light, the light humans cannot see is all the rest… which is a lot!

We don't have x-ray vision, or night vision (Infrared), and we can't see Ultraviolet (UV) light coming from the sun, or the microwaves coming from our ovens, or the radio waves going to our car radio.



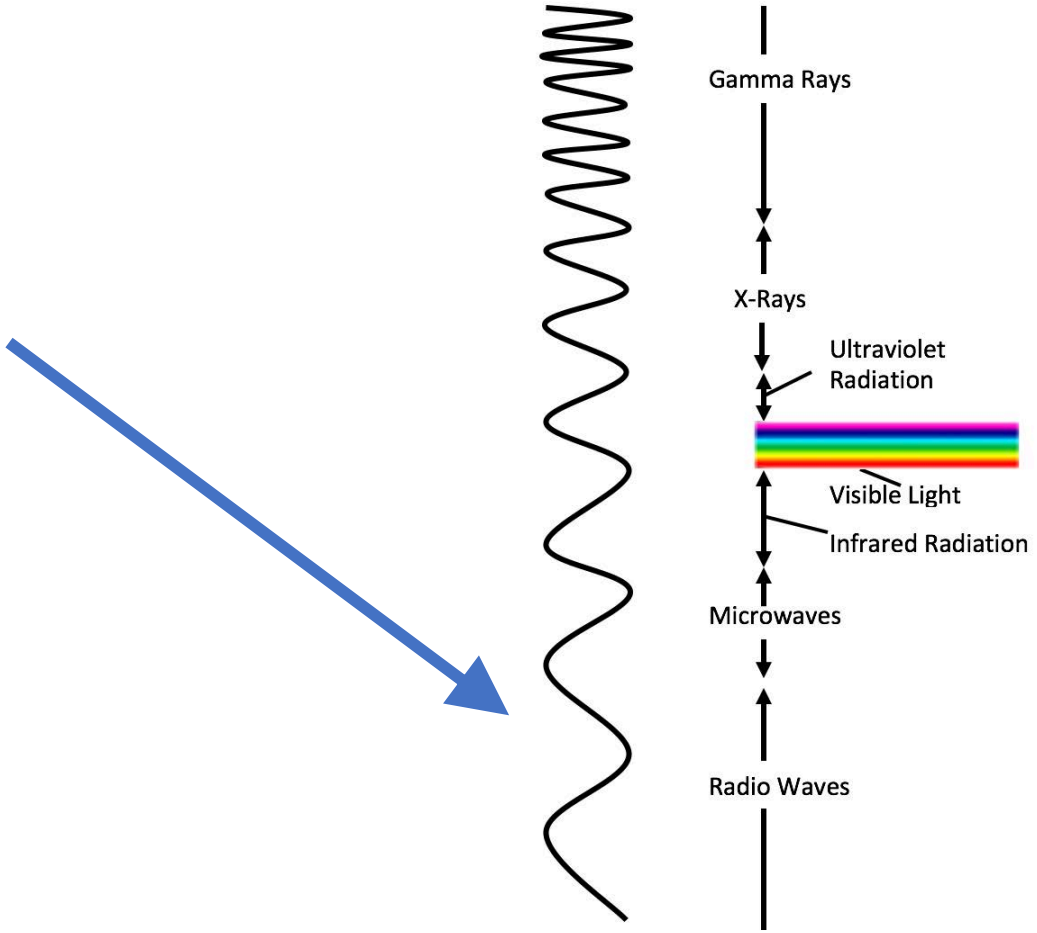
But Some Animals Can

Bees and many other insects can see light waves that range from 300nm to 650nm. This means they can see ultraviolet light but they cannot see the color red. Many patterns on flowers are invisible to humans but are like bullseyes for insects.



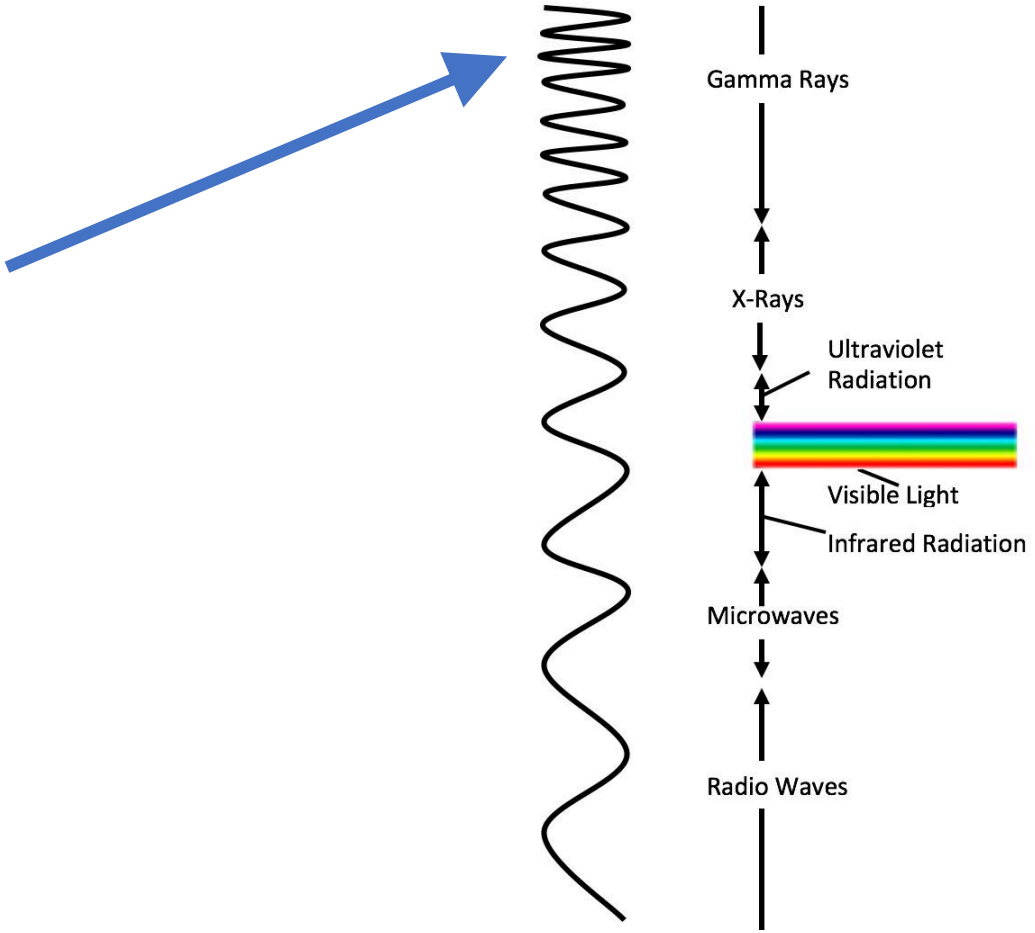
Light Has Energy

Low energy light waves have very **long wavelengths**. Radio waves, for instance, can have wavelengths many miles long. Because they are low in energy, they are harmless to humans and pass through our bodies all the time without us being aware.



Light Has Energy

On the other end of the spectrum, very-high energy light waves have extremely ***short* wavelengths**, which can be much smaller than the diameter of an atom. Gamma rays and x-rays are examples of high-energy light. They are deadly to all life, and even exposure to very low intensities is known to cause cancer.

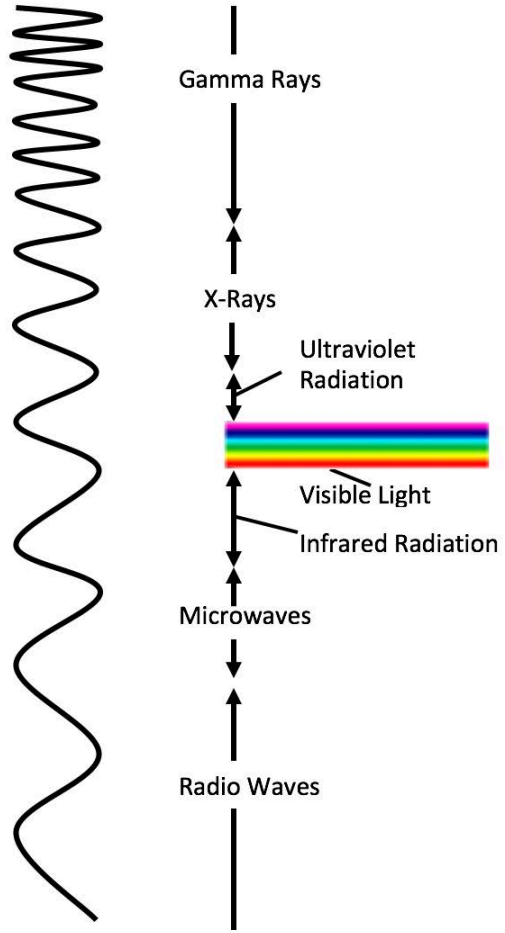


Why is Light Described in Wavelengths?

Light is a **wave** of alternating electric and magnetic fields.

(That's why this is called the electromagnetic spectrum!)

Waves all have similar properties, which can be described with **frequency, amplitude, and wavelength.**



Parts of a Wave

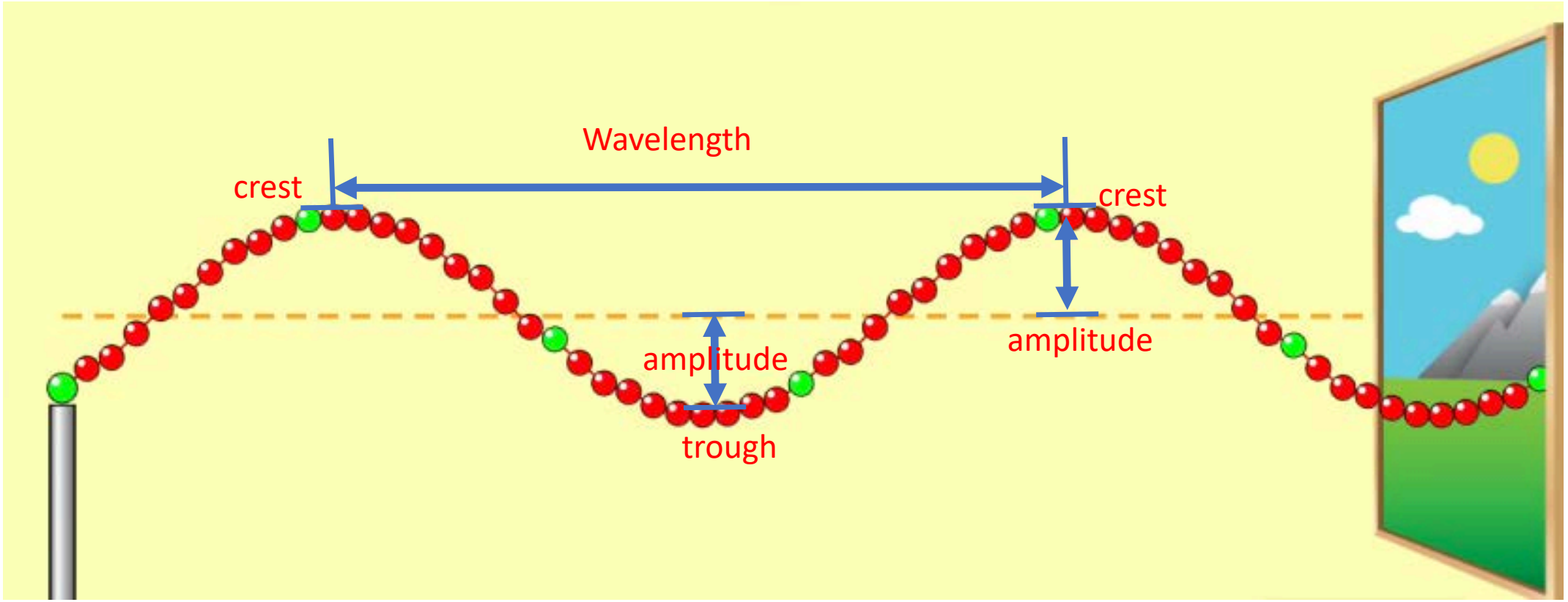


Photo Credit: PhET Interactive Simulations: https://phet.colorado.edu

Wavelength

Wavelength is the distance from the peak (crest) of one wave to the peak (crest) of the next. The wavelength of this wave is about 5 centimeters.

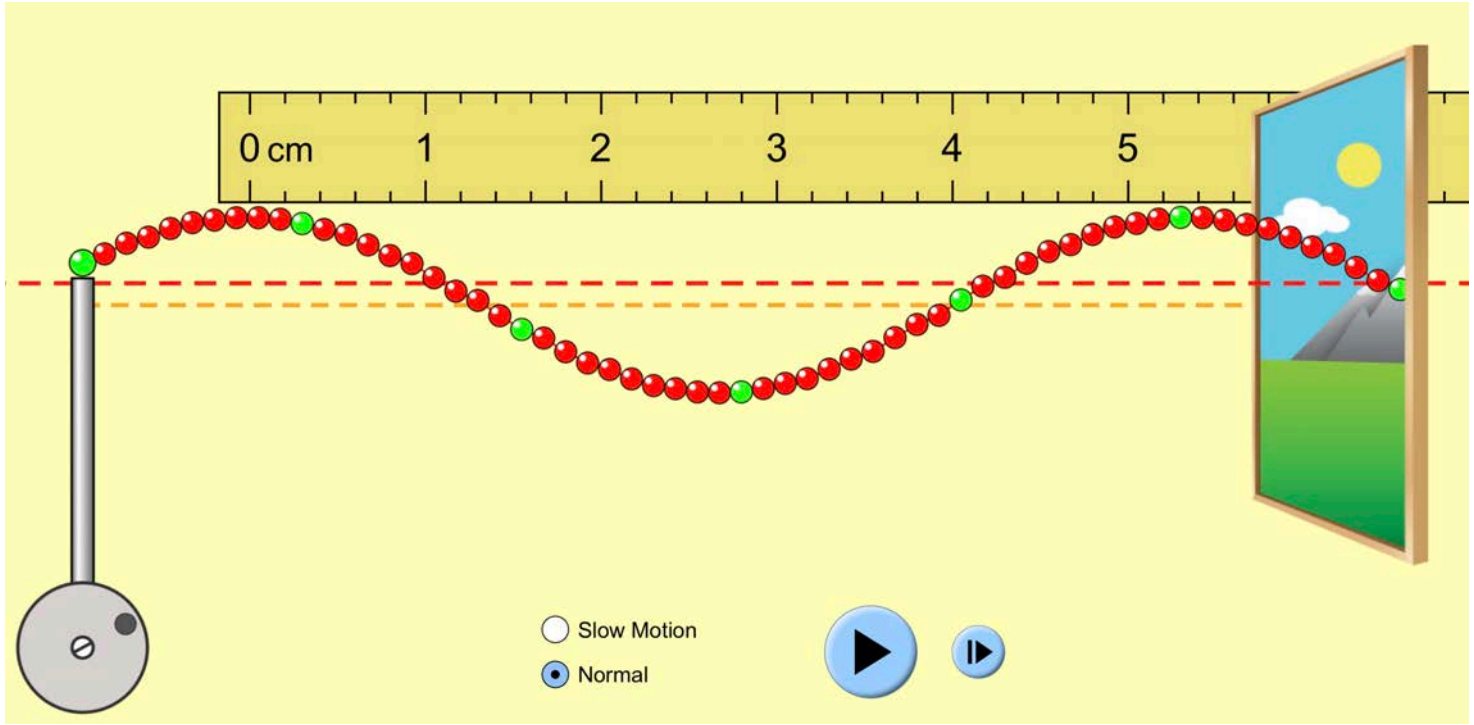
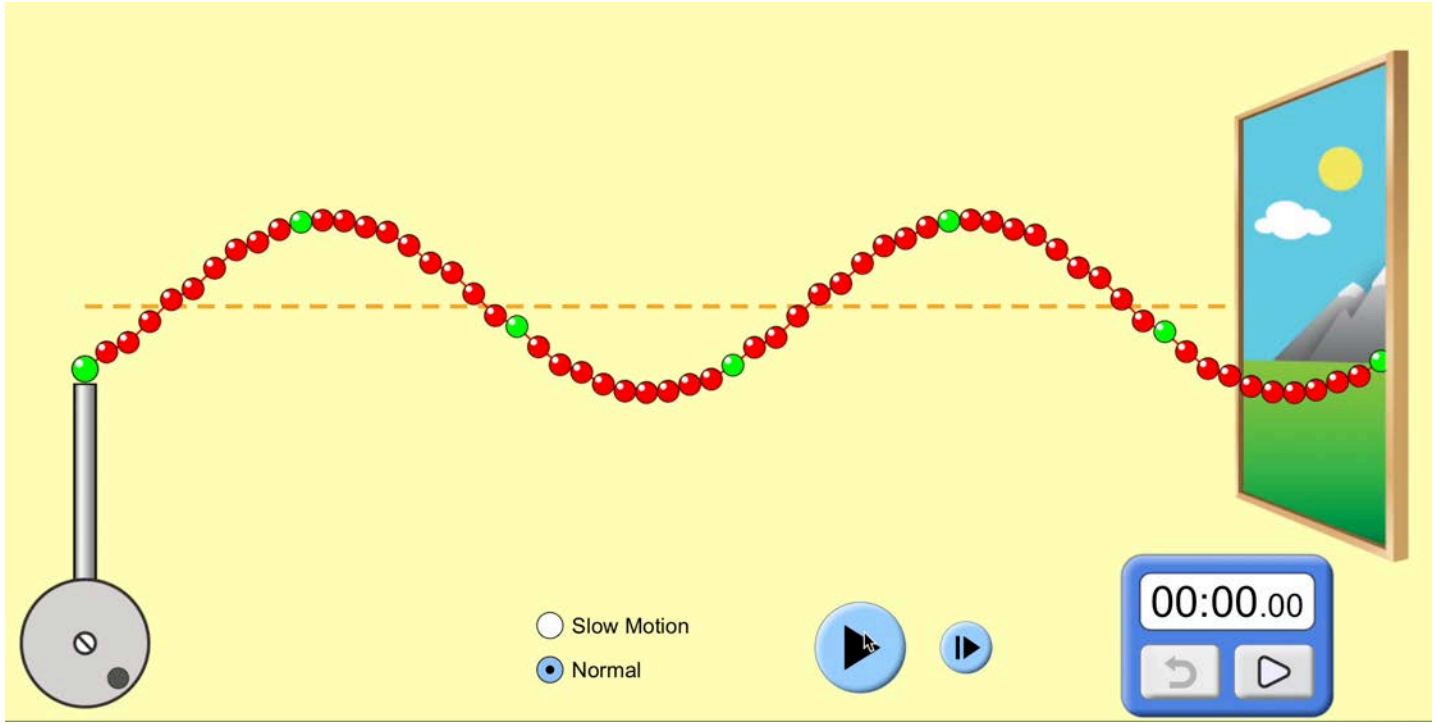


Photo Credit: PhET Interactive Simulations: https://phet.colorado.edu

Frequency

Frequency counts the number of waves that pass by a point in one second. Frequency is measured in Hertz. This wave passes the window two times in one second, so its frequency is 2 Hz.



Video Credit: PhET Interactive Simulations: https://phet.colorado.edu

Amplitude

Amplitude is the distance from the crest height of a wave to the middle. The amplitude of this wave is .5 centimeters.

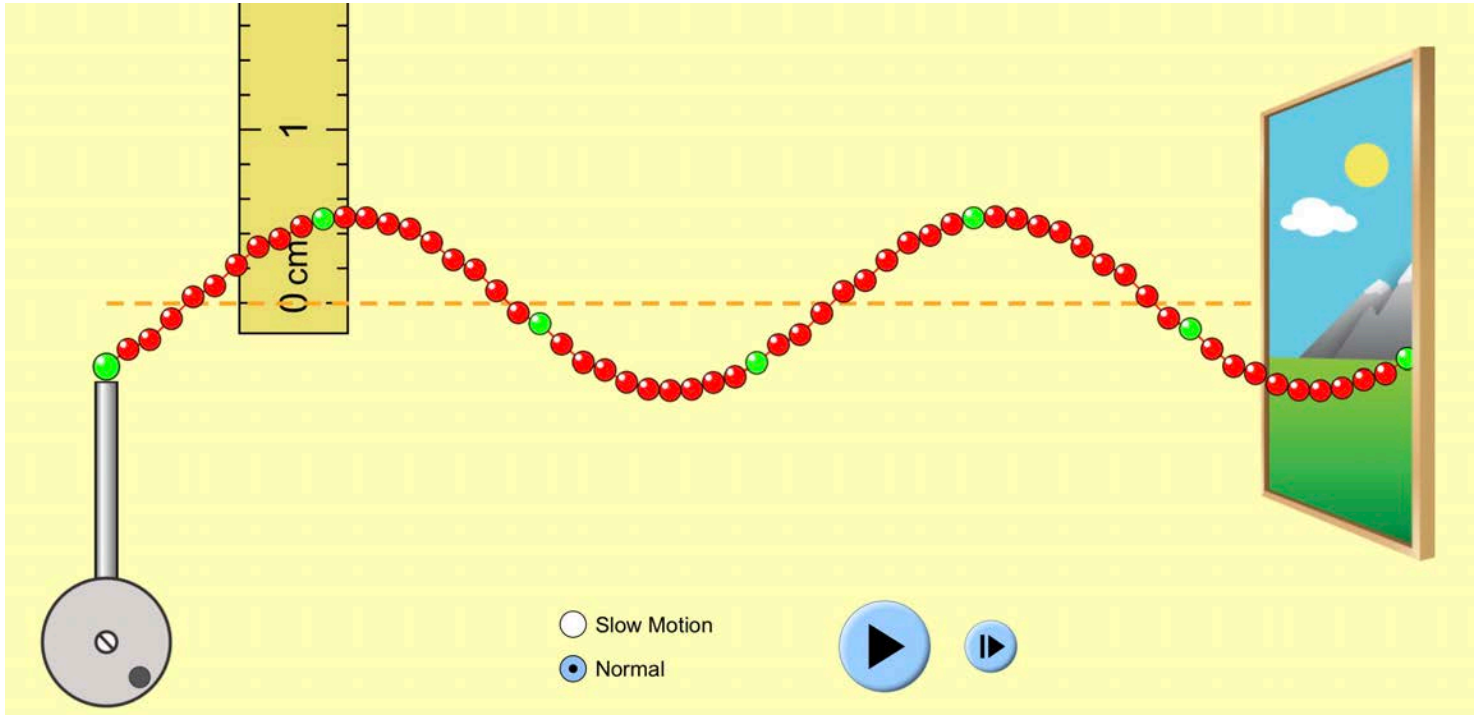
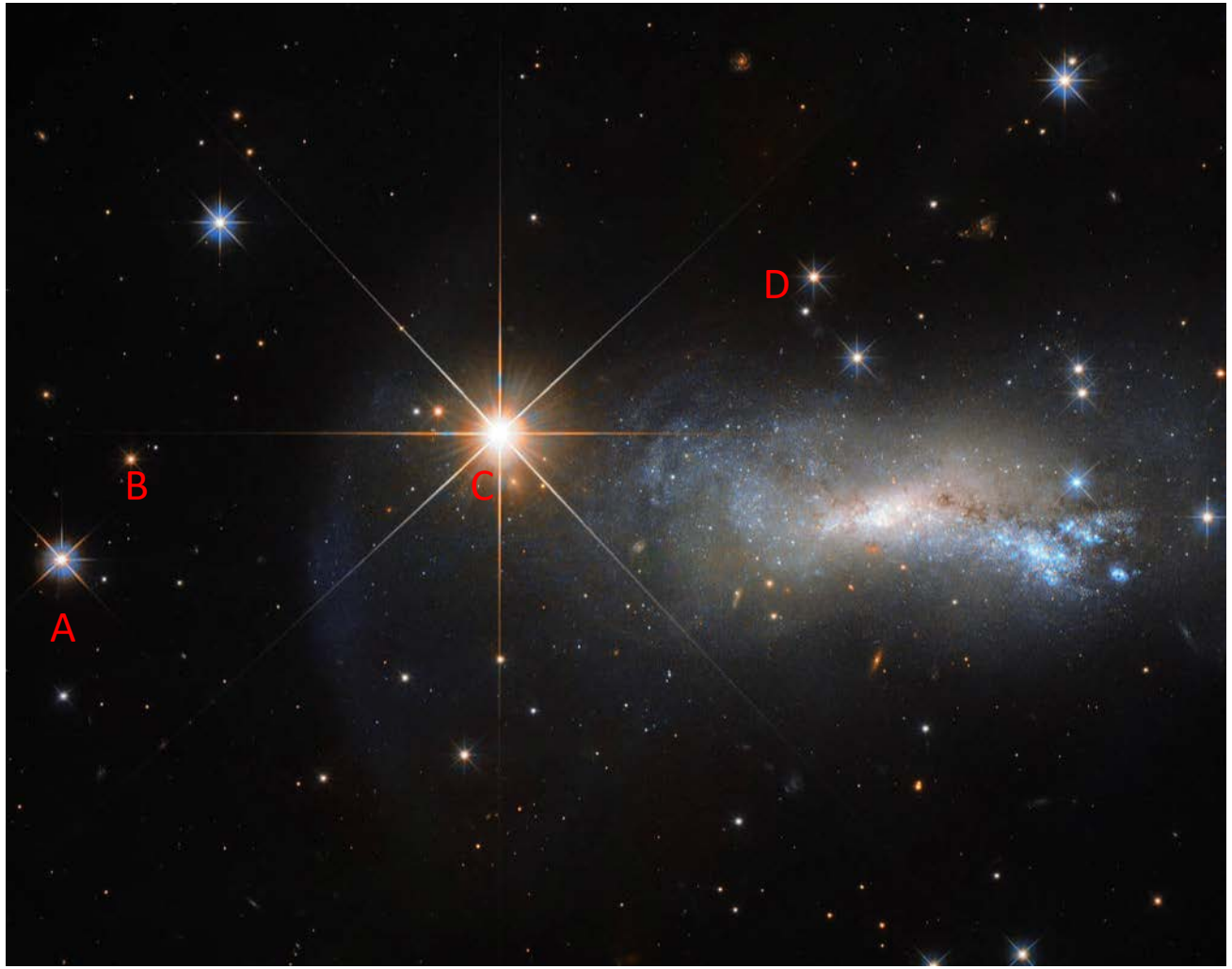


Photo Credit: PhET Interactive Simulations: https://phet.colorado.edu

Amplitude & Brightness

The amplitude of a wave directly correlates to the brightness/intensity of the light relative to other light waves with the same wavelength. The higher the amplitude the brighter and more intense the light appears .

In this NASA image, if we assume all stars have the same wavelength, which star has a greatest amplitude?



What do wavelength and frequency tell us about a light wave?

Wavelength and frequency tell us where on the Electromagnetic Spectrum a light wave falls. If the light wave is visible, we can also tell what color it is. Wavelengths are measured in nanometers (nm) and frequency is measured in Terahertz (THz). Visible red colors have the longest wavelengths measuring about 740 nm with frequencies around 405 THz.

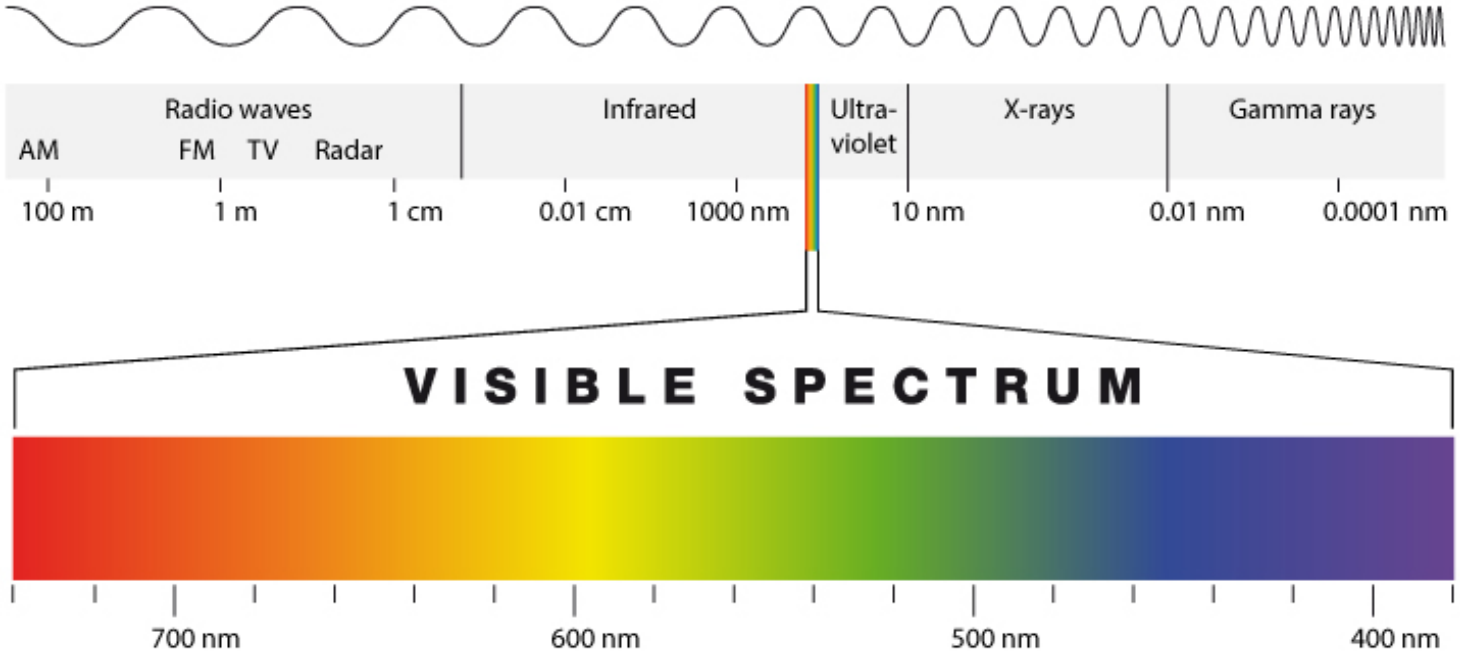


Image courtesy of NASA

How are wavelength and frequency related?

Longer waves travel slowly and have less energy (low frequency). Red colors have longer waves.

Shorter waves move faster and have more energy (high frequency). Blue colors have shorter waves.

Orange, yellows and greens fall in between.

Black and white are not colors because they do not have specific wavelengths.

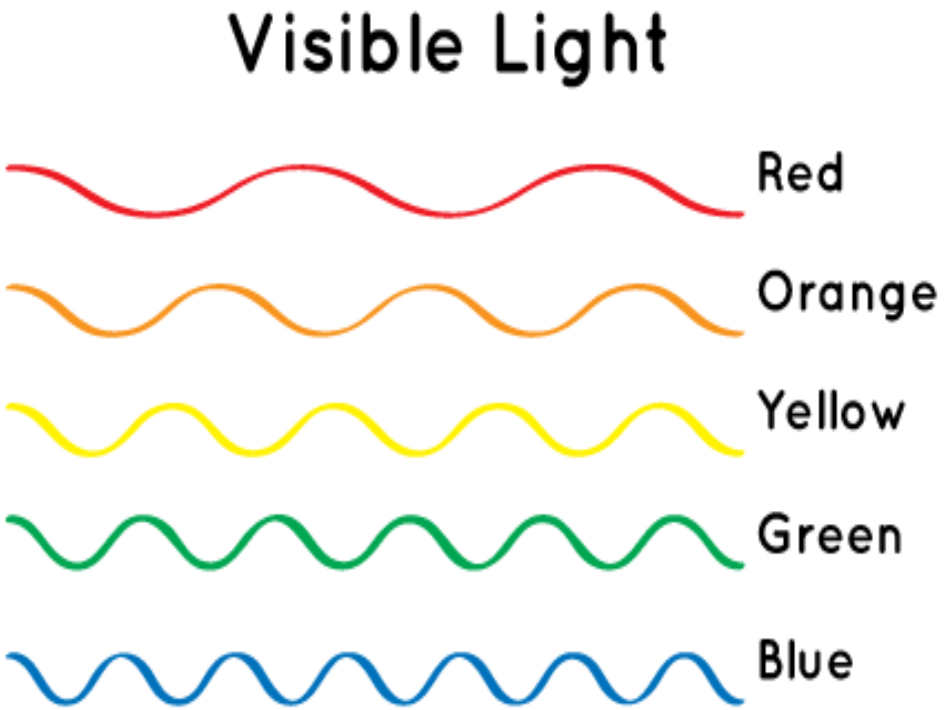


Image courtesy of NASA

Within the visible spectrum of light, do the colors in this image emit high or low frequencies, short or long wavelengths?

Speed of Light

Speaking of wave speed, light is one of the fastest things in the universe! Hence, the saying, “superman travels at the speed of light”. **Light <u>does not</u> need a medium to travel in**. In a vacuum like space, light clocks in at about 300,000 kilometers per second or 186,000 miles per second.

If you traveled at the speed of light, you could circle the Earth 7.5 times in one second!

Light Travels in Straight Lines

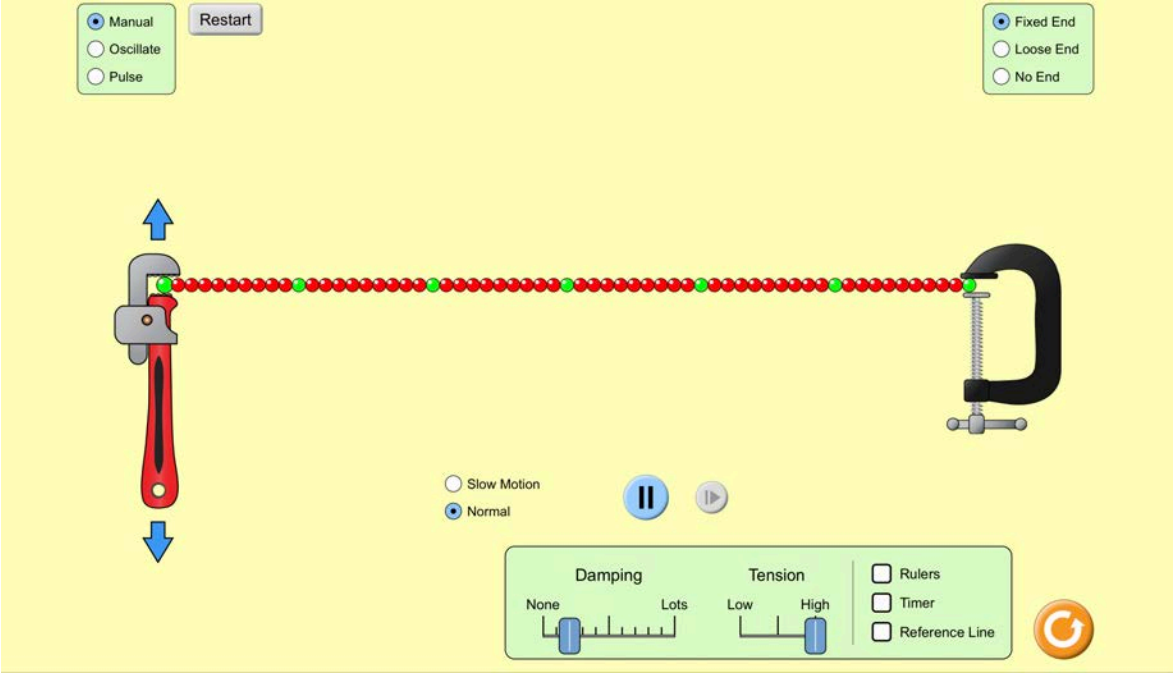
Light travels in straight lines (rays) until it interacts with something.

When light goes between one material and the next it will sometimes bend at the interface.

Shadows are evidence of light travelling in straight lines. An object blocks light so that it can’t reach the surface where we see the shadow. Light fills up all of the space before it hits the object, but the whole region between the object and the surface is in shadow.

Optional Learning Activity: Wave Simulator

Use this online wave simulator and the waves worksheet as a guide to learn more about light waves.
https://phet.colorado.edu/sims/html/wave-on-a-string/latest/wave-on-a-string_en.html



(Credit to PhET at UC Boulder for this great tool!)

Optional Learning Activity/Demo: Light Direction

Conduct a quick demonstration to see that light travels in a straight line.

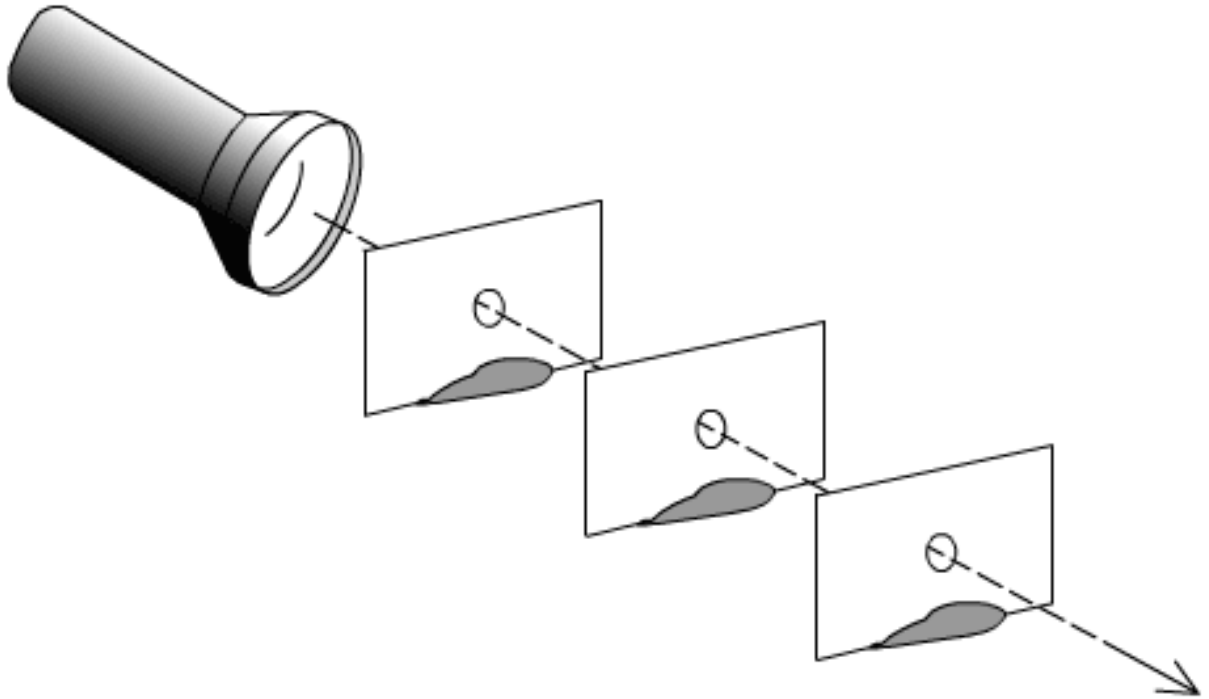


Image Credit: NASA