SOL 5.3 -- LIGHT ENERGY

Key concepts:

a. transverse waves;
b. the visible spectrum;
c. opaque, transparent, and translucent;
d. reflection of light from reflective surfaces;
e. refraction of light through water and prisms

WAVES & PARTICLES

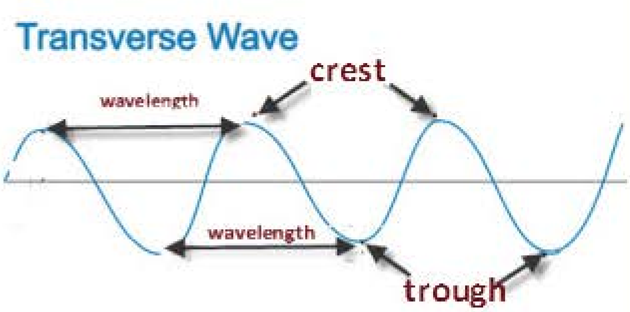
- Light has properties of both a wave and a particle. Recent theory identifies light as a small particle, called a photon. A photon moves in a straight line. In both the light wave and photon descriptions, light is energy.

Remember:

Light is energy.
Light is both particle and wave.
Light travels in straight lines.
Light travels best through empty space (unlike sound).
Light travels faster than sound.
Sunlight reaches Earth in only 8 1/2 minutes.

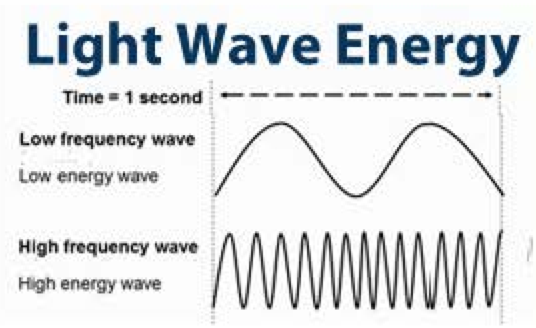
- Because light has both electric and magnetic fields, it is referred to as electromagnetic radiation.
- Light waves move as transverse waves and travel through a vacuum at a speed of approximately 186,000 miles per second (2.99 x 108 meters per second).
- Compared to sound, light travels extremely fast. It takes light from the sun less than 8½ minutes to travel 93 million miles (150 million kilometers) to reach Earth.
- Unlike sound, light waves travel in straight paths called rays and do not need a medium through which to move.
  - A ray is the straight line that represents the path of light.
  - A beam is a group of parallel rays.

WAVELENGTH & FREQUENCY



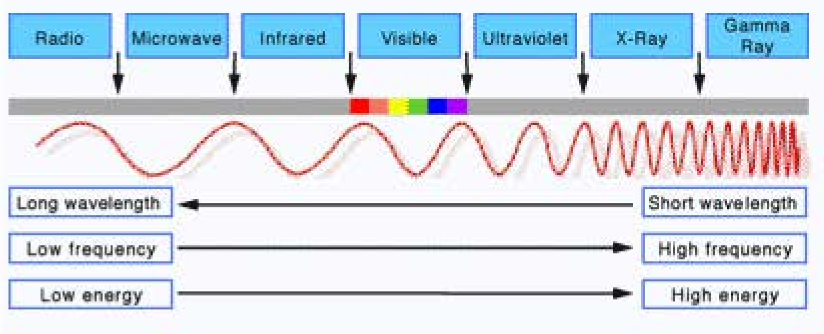
- Light waves are characterized by their wavelengths and the frequency of their wavelengths
- The size of a wave is measured as its wavelength, which is the distance between any two corresponding points on successive waves, usually crest-to-crest or trough-to-trough. The wavelength can be measured from any point on a wave as long as it is measured to the same point on the next wave.
- Frequency is the number of waves passing a given point every second. The greater the frequency, the greater the amount of energy.

ELECTROMAGNETIC SPECTRUM

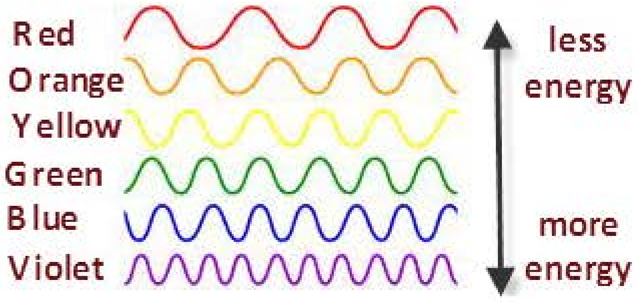


- Light waves are waves of energy.
  - The amount of energy in a light wave is proportionally related to its frequency: high frequency light has high energy; low frequency light has low energy.
  - The more wavelengths in a light wave in a given period of time, the higher the energy level.

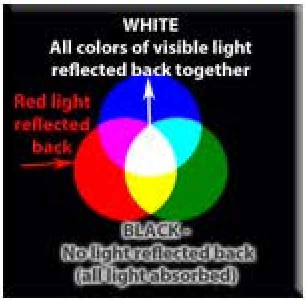
- Thus **gamma rays** have the **most** energy, and **radio waves** have the **least**.
- Of visible light, **violet** has the **most** energy and **red** the least.



- The entire range of electromagnetic radiation (light) is called the **electromagnetic spectrum**.
- The only difference between the various types of electromagnetic radiation is the **amount of energy**.
- **Sunlight** consists of the entire electromagnetic spectrum.
- The wavelengths detectible by the **human eye** represent only a very small part of the total electromagnetic spectrum.



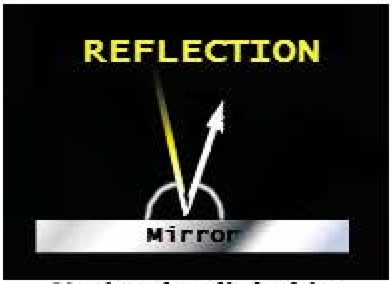
- We see **visible light** as the colors of the **rainbow**. Each color has a different wavelength.
- **Red** has the **longest wavelength** and **violet** has the **shortest wavelength**.
- The colors of the visible spectrum from the longest wavelength to the shortest wavelength are: red, orange, yellow, green, blue, and violet (**ROYGBV**). Most scientists no longer include the color indigo, which used to be included between blue and violet.



- Black and white are not spectral colors. **Black** is when a material absorbs all the visible light and no light is reflected back. Black is a total **absence** of reflected light. **White** is a reflection of **all visible light** together.

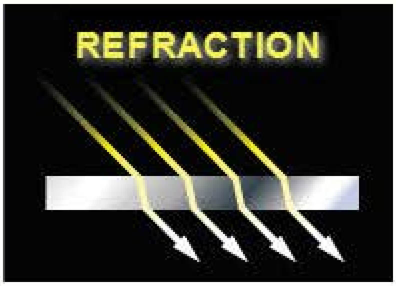
REFLECTION (BOUNCING BACK)

- Light travels in straight paths until it hits an object, where it bounces off (is **reflected**), is bent (is **refracted**), passes through the object (is **transmitted**), or is **absorbed** as heat.



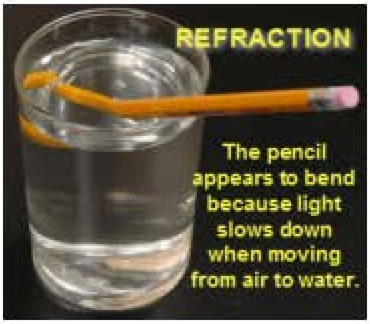
Notice that light hits and reflect off the mirror at the same angle.

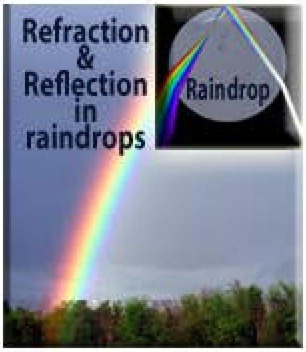
- The term **reflected light** refers to light waves that are neither transmitted nor absorbed, but are thrown back from the surface of the medium they encounter. If the surface of the medium contacted by the wave is **smooth and polished** (e.g., a mirror), each reflected wave will be **reflected back** at the **same angle** as the incident wave. The wave that strikes the surface of the medium (e.g., a mirror) is called the incident wave, and the one that bounces back is called the reflected wave.



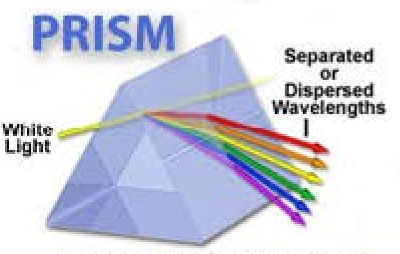
REFRACTION (BENDING)

- Refraction means the bending of a wave resulting from a change in its velocity (speed) as it moves from one medium to another (e.g., light moving from the air into water). The frequency of the wave does not change.
- The amount of bending of the light wave (refraction) depends on:
  - The density of the material it is entering;
  - The wavelength of the light wave; and
  - The angle at which the original light wave enters the new medium.
- Some examples of refraction are when:
  - Refraction causes a setting sun to look flat.
  - A spoon appears to bend when it is immersed in a cup of water. The bending seems to take place at the surface of the water, or exactly at the point where there is a change of density.
  - Shadows on the bottom of a pool are caused because air and water have different densities.
  - A glass prism disperses white light into its individual colors. As visible light exits the prism, it is refracted and separated into a display of colors.





- A rainbow is an example of both refraction and reflection. Sunlight is first refracted when it enters the surface of a spherical raindrop, it is then reflected off the back of the raindrop, and once again refracted as it leaves the raindrop.
- A prism can be used to refract and disperse visible light. When the different wavelengths of light in visible light pass through a prism, they are bent at different angles (refracted). Dispersion occurs when we see the light separated into a display of colors: ROYGBV.
- Dispersion is the separation of light. Dispersion occurs with transparent surfaces that are not parallel to each other, such as a prism or gemstone facets.



As visible light exits the prism, it is refracted and separated into a display of colors.

TRANSPARENT, TRANSLUCENT, OPAQUE

- Light passes through some materials easily (transparent materials), through some materials partially (translucent materials), and through some not at all (opaque materials). The relative terms transparent, translucent, and opaque indicate the amount of light that passes through an object.

  - Examples of transparent materials include clear glass, clear plastic food wrap, clean water, and air.
  - Examples of translucent materials include wax paper, frosted glass, thin fabrics, some plastics, and thin paper.
  - Examples of opaque materials include metal, wood, bricks, aluminum foil, and thick paper.