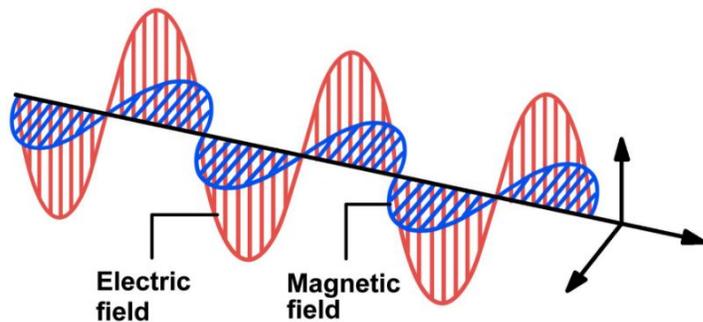


Nature of Light

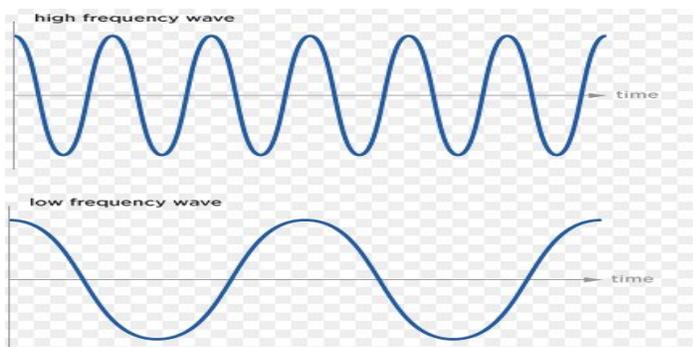
“And God said, ‘Let there be light; and there was light. And God saw the light, that it was good: and God divided the light from the darkness.’” Genesis 1:3-4

- Particle theory of light (Newton): light is a stream of tiny particles emitted by a light source
- Wave theory of light (Hooke, Huygens): light consists of waves
- Electromagnetic wave: light consists of two transverse waves oscillating at right angles to each other
 - 1) One wave consists of a rapidly oscillating electric field
 - 2) Other wave consists of a magnetic field oscillating at the same frequency as the electric wave



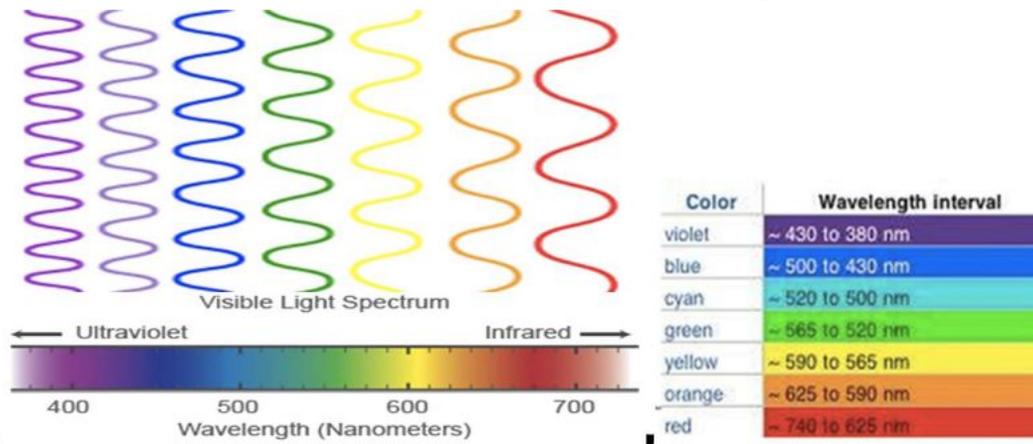
- Electromagnetic waves undergo reflection, refraction, diffraction, interference
- Electromagnetic waves do not need a medium and can travel through empty space
- All electromagnetic waves travel at 300,000,000 m/s in a vacuum
- Speed of light (in a vacuum): $c = \lambda \times f$

Low frequency waves → long wavelengths, high-frequency waves → shorter wavelengths

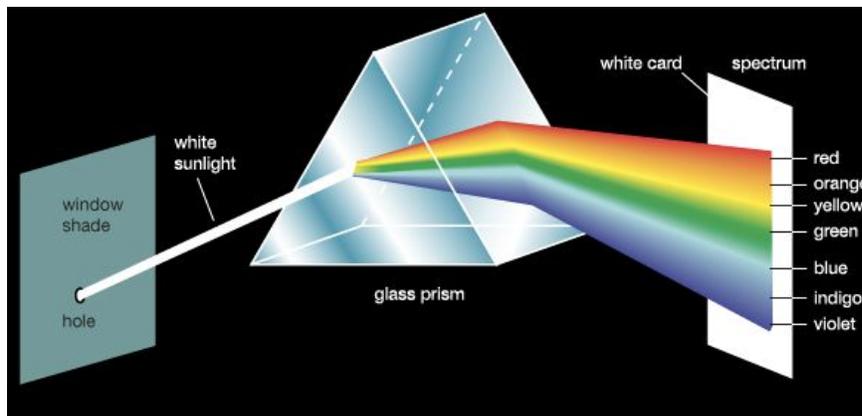


- Photoelectric effect: light above a certain frequency can knock e⁻ loose from certain atoms of certain metals
- Quantum theory of light: light has both a wave nature and particle nature; also called **wave-particle duality**
- photons: tiny bundles or packets of energy; amount of energy a photon contains depends on its frequency
 - when interacting with matter, photons act like particles
 - when traveling through space, photons act like electromagnetic waves

- Light: electromagnetic waves traveling as photons
- Visible light: electromagnetic waves that the human eye can see
Wavelength range from 770nm (red) - 390nm (violet)
Frequency range from <389 THz (red) - >769 bTHz (violet)
- Various frequencies of visible light are perceived as different colors
Visible spectrum: ROYGBIV (arranged in increasing frequency)



- White light: all frequencies of visible light enter the eye at the same time; black is the absence of color/no frequencies of visible light enter the eye
- Prism: separates white light into its component colors by refracting the light that passes through it; each frequency leaves the prism at a slightly different angle; dispersion

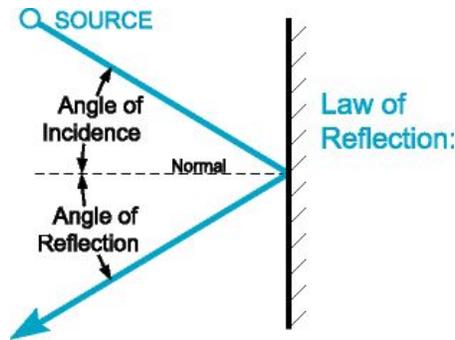


- Certain mixtures of frequencies can be perceived as an entirely new color
Additive primary colors: red, green, blue can reflect combinations of frequencies; always refers to light
Subtractive primary colors: magenta, cyan, yellow absorb light to produce illusions of color; always refers to pigment

Behavior of Light

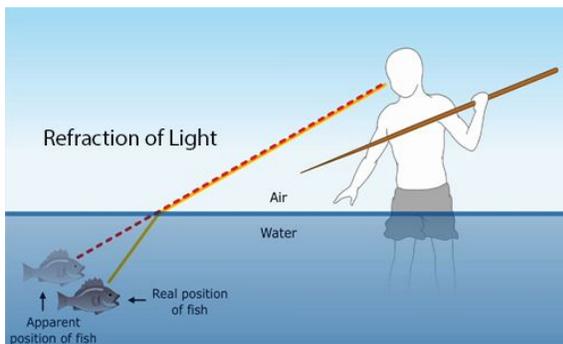
- Light waves can be reflected
Law of reflection: angle of incidence = angle of reflection

- Mirrors: can form virtual image - appears to be behind the mirror; real image - form in front of the mirror (flashlight beam reflected on wall)

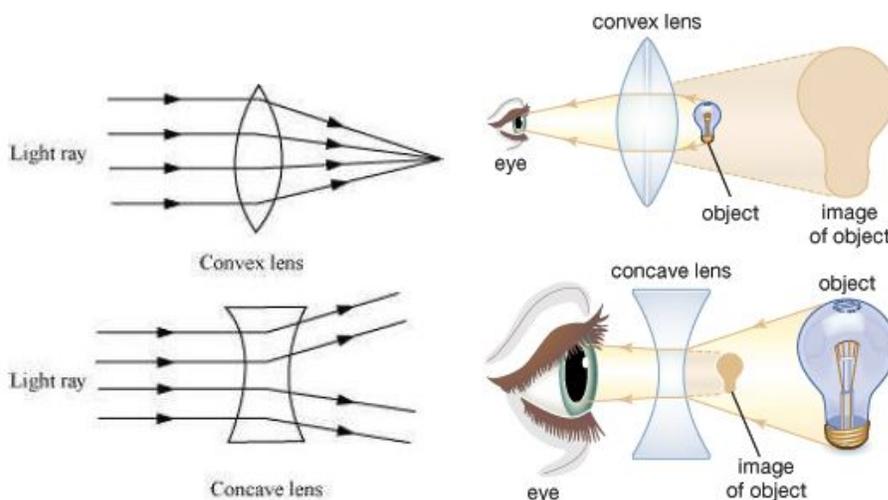


Law of reflection.

- Refracted light waves always bend toward the medium that slows them down (straw in glass of water)



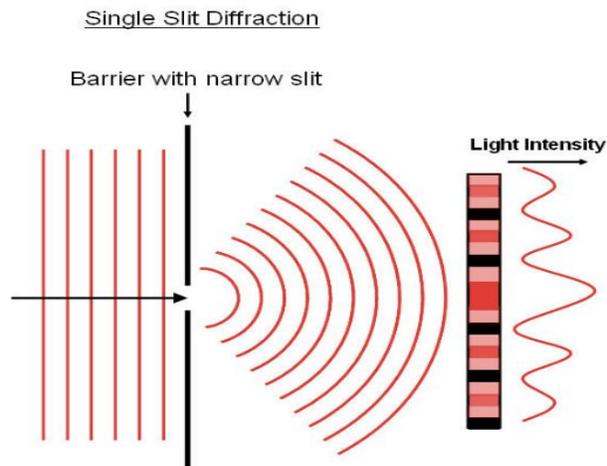
- Lens: glass or other substance specifically designed to refract light; varied thickness and curvature of lens alters path of light in different ways
- Convex lens: curves outward and causes rays of light passing through to bend inward and converge on a point; used to correct presbyopia
- Concave lens: curves inward and causes rays of light passing through to bend outward and cause objects to appear more distant; used to correct myopia



- Refraction of light responsible for several forms of optical phenomena

- mirage: light rays from a distant object are refracted by heated air so the object appears to be nearby; ex: heated air rises from the road refracts light from the sky back upward
- twinkling of stars: starlight traveling through atmosphere is refracted as it moves between areas of different air density
- rainbow: millions of water droplets disperse white sunlight into component colors; light rays leaving droplets form an angle of about 42° with the entering rays

- Interference: mutual reinforcement or cancellation
 - when light waves in phase, intensity is greater and light is brighter
 - iridescence: white light passes through thin film of soap bubble → some light reflects from film's outer boundary while some reflects from film's inner boundary → interference of wave frequencies
 - slit diffraction: light experiences slit diffraction as it passes through a narrow slit; antinodes: light fringes that result from constructive interference of light waves coming from different parts of the slit



- polarization: beam of light containing waves that are aligned in the same direction
- Ex: sunglasses polarize by selective absorption in which a special filter absorbs any light waves not vibrating in the desired plane → cuts down total amount of light passing through

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