

SDCC Independent Study of Electricity & Magnetism
Week 7
Electromagnetic Waves and The Light Spectrum

Wave Propagation of Light

Faraday's Law — A changing magnetic field produces a changing electric field.

Maxwell's Hypothesis — A changing electric field produces a changing magnetic field.

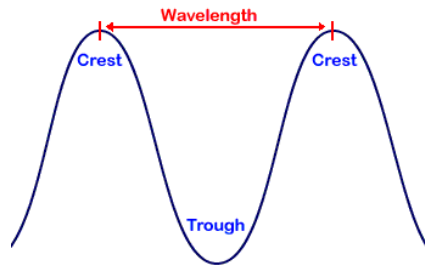
Therefore, a changing electric field causes a changing magnetic field which, in turn, causes another changing electric field and so on. This can produce a wave of changing electric and magnetic fields.

Light is a wave of oscillating (changing) electric and magnetic fields and has many of the same properties that other waves have like diffraction.

Properties of Light

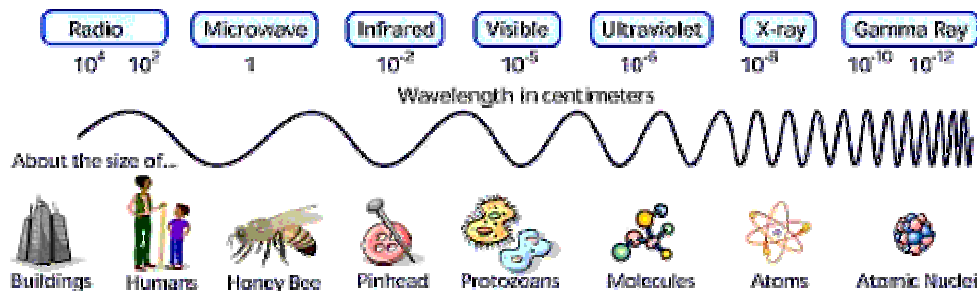
Speed of Light — Electromagnetic waves always move at a velocity of $c = 186,000$ miles/sec in a vacuum.

Frequency — Like other waves, light has an associated frequency and wavelength related by the equation $f = \lambda/c$. Where f = frequency, c = speed of light, λ = wavelength.



(courtesy NASA)

The range of frequencies is called the electromagnetic spectrum. Different frequencies have different properties.



(courtesy NASA)



White light is made up of all colors in the visible spectrum as shown above in the Dark Side Of The Moon album cover by Pink Floyd.

Radio — Used to transmit information for radios and cell phones.

Infrared — Efficient at heating materials. Emitted from warm objects (like humans).

Visible — The part of the spectrum we can see (red to blue).

Ultraviolet — Emitted by sun and causes sunburns.

X-rays — Can penetrate the body so is used for imaging body for medical purposes.

Gamma rays — High energy radiation. Used for detection of cracks in engineering.

E&M Wave Production

When a charged particle is moved back and forth, this causes a changing magnetic field that makes a changing magnetic field. This is one way light is produced.

Antennae are used to accelerate electrons back and forth to produce radio waves.

These radio waves interact with the electrons in your antennae to induce a current in your radio, which produces the sounds in your speakers. The information can be transmitted in two ways: changing the frequency (FM) or changing the amplitude (AM) of the light.

Thermal Emission — A warm body emits light because of the accelerating electrons in the material. The hotter the object, the more energetic the energy. Humans emit IR, the sun emits visible and UV. This thermal radiation is continuous along the spectrum. In other words, the sun emits all visible wavelengths, not specific wavelengths.

Emission from gas — Elements emit specific wavelengths specific to the atom. This can be used to find specific atoms in light coming from distant galaxies.

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Homework

1. What is your favorite radio station? Look on a radio and figure out the frequency of the radio waves for your favorite station (Hint: kHz = 1000 Hz, MHz = 1,000,000Hz). What is the wavelength of the light?
2. Use your spectrometers to observe the following objects:
 - yellow street lamp.
 - halogen lamp.
 - neon light.
 - non-yellow street lamp.
 - light bulb.
 - a burning match.
3. Using colored markers or crayons draw what you find in the different lamps.
4. From the spectrum of the light bulb, do you think that a light bulb emits IR and UV light? Why do you think the City of San Diego uses the yellow street lamps instead of light bulbs?
5. What differences are there in the spectra of a burning match and a light bulb. Why is this?