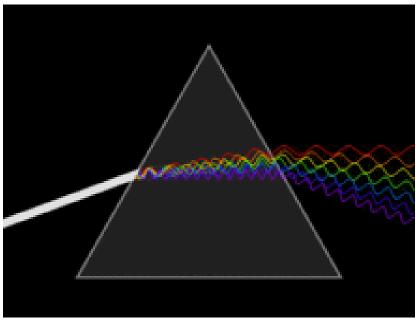
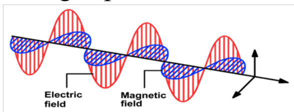
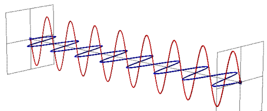
5.A.1 Electromagnetic Waves



Electromagnetic (EM) Radiation

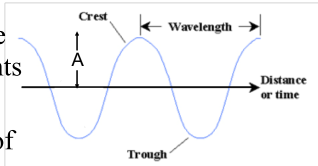
Energy having perpendicular electric AND B-field components changing polarity as it propagates through space.





Note: often EM radiation is drawn as a wave, but that represents fluctuating fields, NOT the radiation's true path.

EM Wave Characteristics



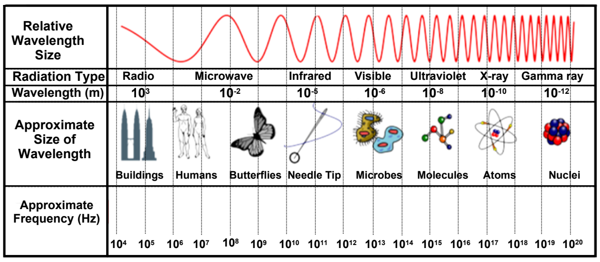
Wavelength (λ): distance between equivalent points of a wave.

Frequency (f): number of waves passing a point every second. Units: cycles/second (s^{-1}) or Hertz (Hz).

Amplitude: height from axis to crest OR trough.

EM Spectrum

Covers a wide range of frequencies (Resource P. 7).



Wave Equation

Frequency and wavelength are unified through wave speed:

$\lambda = \frac{v}{f}$	λ = wavelength (m) v = wave speed (m/s) f = freqency (Hz or s^{-1})
AP Equation	

This applies to ALL types of waves, but since EM radiation travels at the speed of light in a vacuum (3.00 E 8 m/s) you might use:

$c = \lambda f$	c = vacuum speed of light (3.00 E 8 m/s)

EM Example:

What frequency is radiation of λ = 8.72 E – 2 m?

$$\lambda = \frac{v}{f}$$

$$f = \frac{v}{\lambda} = \frac{3.00\,E\,8\,m/s}{8.72\,E-2\,m} = 3.44\,E\,9\,Hz$$

What type of radiation is it? (Use your Resource.)

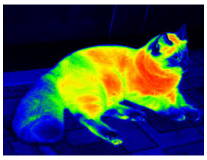
Between microwave and infrared radiation.

Radiation Types

Radio Waves – Long wavelength carriers for TV and radio stations. Also generated by lightning, stars, quasars, and galaxies.

Microwaves – Produced by special vacuum tubes – used for communication, heating food, and speed guns used to time baseball pitches and speeding motorists.

Infrared (IR) – Associated with heat emissions. Water absorbs IR waves and warms up. Also keeps Earth warm by the Greenhouse Effect.



Warm Kitty

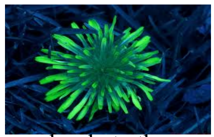
Radiation Types

Visible Light – A narrow range of wavelength (390 – 700 nm) allows us to see colors.

What would it look like if we could see beyond this?

Snakes can see directly in IR (they see warm objects – food species). We have receptors that feel IR radiation.

Some insects can see in the ultraviolet range (which many flowers give off).



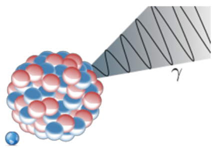
Human eye sensitivity conforms closely to the spectrum of wavelengths emitted by the sun.

Radiation Types

Ultraviolet (UV) – Just beyond the visible spectrum – higher energy. Sun emits UV; ozone in atmosphere absorbs it. Welding produces lots of UV – wear a mask.

X-Rays – Discovered when a fluorescent material illuminated in a lab for no apparent reason.
High energy – used for imaging bones.
Produced by high-energy electron bombardment of atoms.
Old-school televisions made X-Rays: "Don't sit too close!"

Gamma Rays – High energy, short frequency radiation. Generated during radioactive decay of unstable nuclei. Symbol = γ.



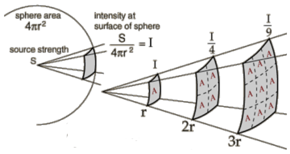
Radiant Power Loss

Luminosity (W/m^2) drops off proportionally to the inverse square of the source distance.

$$P \propto \frac{1}{r^2}$$

$$\frac{P_1}{P_2} = \frac{r_2^2}{r_1^2}$$

More Useful



Ex: If a light's power is 3.3 W/m^2 measured 1.0 m away, what is the power at 4.4 m?

$$\frac{P_1}{P_2} = \frac{r_2^2}{r_1^2}$$

$$P_2 = \frac{P_1 \bullet r_1^2}{r_2^2} = \frac{3.3W/m^2 \bullet 1.0m^2}{(4.4m)^2} = 0.17W/m^2$$

Homework

5.A.1 Booklet Problems.
Due: Next Class.