Waves

- Characterized by Wavelength, Frequency, Amplitude, Speed

Wavelength ($\lambda$)
Frequency (ν)

ν Increases

λ Increases

Waves

Amplitude = A
here y = A \sin(x)

Interference

In Phase: Constructive Interference
Interference

Out of Phase: Destructive Interference

Light as a Wave

• Many wave-like properties:
  Interference & Diffraction
• Until about 1900 the wave model of light was fully accepted.

Light as a Wave

• Wavelength, frequency, speed related by:
  \[ c = \lambda \nu \]
  • \( c \) fixed (3 x \( 10^8 \) m/s)
  • \( \lambda \) (or \( \nu \)) specifies color of the light
  • NOT related to brightness
Light as a Particle

- In the early 20th century, several discoveries led to a particle model of light.
- **Photons**: "particles" of light
- Energy of a photon:
  \[ E = h \nu \]
  
  \[ h \text{ = "Planck's Constant"} \]
  
  \[ = 6.626 \times 10^{-34} \text{ J s} \]

Photon Energy

- A laser emits red light with wavelength of 633 nm (1 nm = 10⁻⁹ m)
- What is the energy of a photon at this wavelength?
- A particular laser has an output of 1 mW (10⁻³ J/s). How many photons are emitted per second?
Photoelectric Effect

- Shine light on metal
- See electrons emitted
- Detect # of electrons & kinetic energies.

![Photoelectric Effect Diagram]

\[ \text{Photons (} h \text{)} \rightarrow \text{Electrons} \]

\[ \text{Metal Surface} \]

\[ \text{Light in} \rightarrow \text{Electrons out} \]

Photoelectric Effect

- Experimental results NOT consistent with "wave model" of light.
- Postulate of photons ("particle model" of light) allows explanation. (Einstein, 1905)
Photoelectric Effect

- Light with $\nu = 1.3 \times 10^{15}$ s$^{-1}$ ejects electrons from cesium metal. If the kinetic energy of the electrons is $5.2 \times 10^{-19}$ J, what is the binding energy of electrons in cesium metal?

HINT: Conservation of Energy!