February 14, 2005

- **Exam #1**
  - Wednesday, 7 pm, B104 Angell
- **Office Hours:**
  - Today, 1:10 – 2:15 pm, A223 Cook

Happy Valentine's Day!

Spectroscopy:
Intro/Background

Chem 221
Instrumental Analysis
Spring 2005

Definition and Overview

- The study of the interaction of *electromagnetic radiation (EMR)* with matter
- **Scope and Purview:**
  - ***Properties of EMR***
  - ***Atomic and Molecular Interactions with EMR***
  - ***Instrumentation***
  - ***Molecular Spectroscopy***
    - Infrared Absorption Spectrophotometry
    - Luminescence Spectrometry
    - Raman Spectroscopy
  - ***Atomic Spectroscopy***
    - ✓ Absorption
    - ✓ Emission

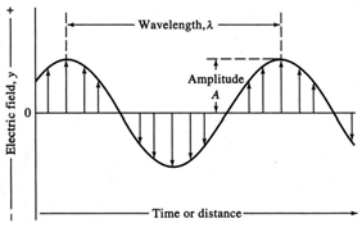
Electromagnetic Radiation (EMR)

- So, just what is **EMR?**
  - an *oscillating* electric and magnetic field which travels through space
  - a discrete series of "particles" that possess a specific energy but have no mass

BOTH!

It's a Wave!

- Consider an oscillating electric field:



Characterized by:

λ - wavelength
A - amplitude
ν - frequency

Wave Properties of EMR

- The product of λ and ν is constant:

$$\lambda \times \nu = c$$

Since ν has units of sec^{-1} and λ has units of length, their product, c, is the *velocity* of the wave:

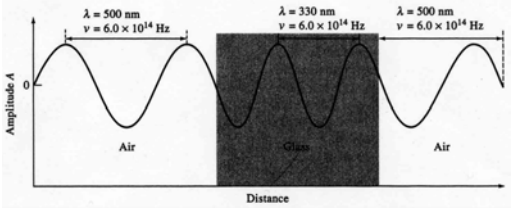
-***in a vacuum***, *all EMR* travels at a velocity of:

2.99792458 x 10^8 m/s (= c)

("The Speed of Light")

Propagation Velocity

- What happens as an EMR wave propagates from a *vacuum* into another medium?



Wavelength ***decreases***; Frequency is ***unchanged***; Velocity ***decreases***

Refractive Index (n_i)

- Quantifies the magnitude of the EMR velocity decrease in a particular medium:

$$n_i = c/v_i$$

Refractive Index
- varies with:
  - -medium
  - -frequency of EMR
  - ($n\uparrow$ as $\nu\uparrow$, generally)

EMR propagation velocity

Propagation Direction

- Propagation *direction* can also change:

Reflection

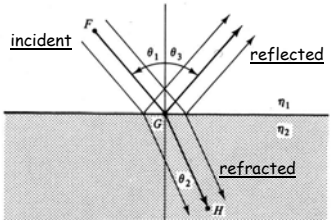
For $\theta_1 = 0^o$: Fresnel Eqn

$$\frac{I_R}{I_o} = \frac{(n_2 - n_1)^2}{(n_2 + n_1)^2}$$

Refraction

Snell's Law:

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$$



Scattering

- Most EMR is *transmitted* through a medium (no direction change)
- BUT: a *small* amount is **scattered** isotropically:
  - **Rayleigh Scattering**
    - *Elastic (no energy loss)*
    - Due to interactions with "particles" $<< \lambda$
      - ✓ e.g., molecules, aggregates, etc.
    - Scatter intensity (I_S) $\propto \lambda^{-4}$ (blue sky!)
    - I_S increases with increasing particle size

Diffraction

- EMR can also be "bent" as it passes through a *narrow* (width $\approx \lambda$) opening or barrier: