Ram Seshadri MRL 2031, x6129

seshadri@mrl.ucsb.edu; http://www.mrl.ucsb.edu/∼seshadri/teach.html

Light

Some basics:

Electromagnetic radiation has electric and magnetic field components that are perpendicular to each other and to the direction of propagation. The propagation velocity is c, and this is constant for all electromagnetic radiation in vacuum: $c \sim 3 \times 10^8$ m/s.

c is related to the vacuum permittivity ϵ_0 and the vacuum permeability μ_0 in the following manner:

$$c = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$$

c is equal to the product of the frequency and the wavelength:

$$c = \nu\lambda$$

The energy of any light photon is proportional to the frequency of the photon so:

$$E = h\nu$$

where ν is in Hz (s^{-1}) and h is the Planck constant $h = 6.63 \times 10^{-34}$ Js. It is also possible then to write:

$$E = \frac{hc}{\lambda}$$

Electromagnetic radiation with different frequencies have correspondingly, different energies and wavelengths. Visible electromagnetic radiation ("light") has wavelengths ranging from 400 to 700 nm.

Light and metals — reflection:

Since metals have free electrons, all energies are absorbed and re-emitted. Hence the reflectivity. Yellow/red metals such as Cu and Au are so colored because they absorb a little in the blue.

Refraction:

The refractive index n of a material is the ratio of the velocity of light in vacuum (always c) to the velocity of light in that material v:

$$n = \frac{c}{v}$$

If the material has a dielectric constant ϵ and permeability ν, then

$$v = \frac{1}{\sqrt{\epsilon\mu}}$$

Therefore:

$$n = \frac{\sqrt{\epsilon\mu}}{\sqrt{\epsilon_0\mu_0}} = \sqrt{\epsilon_r\mu_r}$$

Since for most substances, $\mu_r \sim 1$,

$$n \sim \sqrt{\epsilon_r}$$

Even transparent materials reflect some portion of the light that falls on them. If the light falls normally from a medium of refractive index n_1 to the medium if refractive index n_2, then the proportion of light reflected is

$$R = \left(\frac{n_2 - n_1}{n_2 + n_1}\right)^2$$

Color:

The color of a material is due to the light that is reflected by it. If a material absorbs at one end of the spectrum, its color is usually the other end. There are (usually) three processes by which a material may be colored: Absorption withing atomic or defect levels, absorption across the band gap, and due to patterning (interference or diffraction as in a soap film or a peacock's feather).