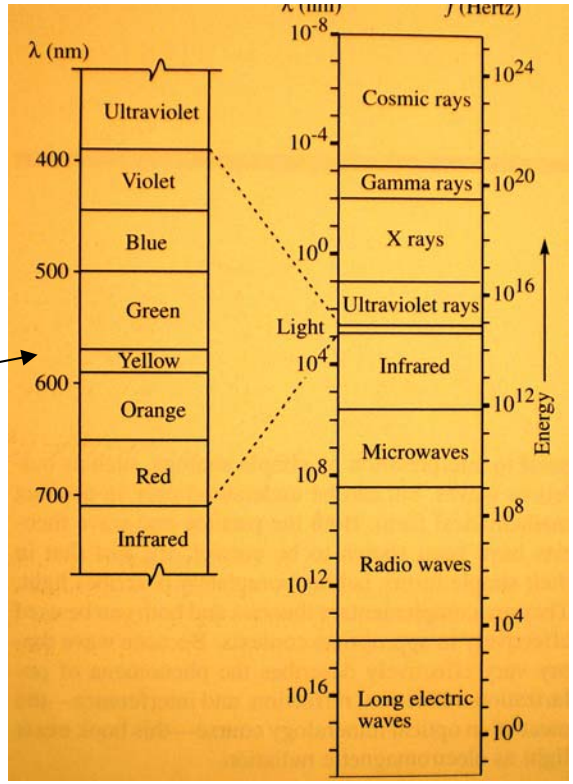
ESS 439: Lab 1. Review of nature of light

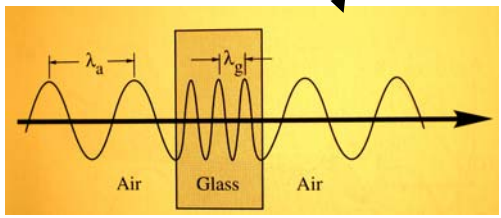
Optical mineralogy is the science that deals with the interaction between crystalline minerals (and glass) and visible light.

•Electromagnetic radiation: Photons and waves

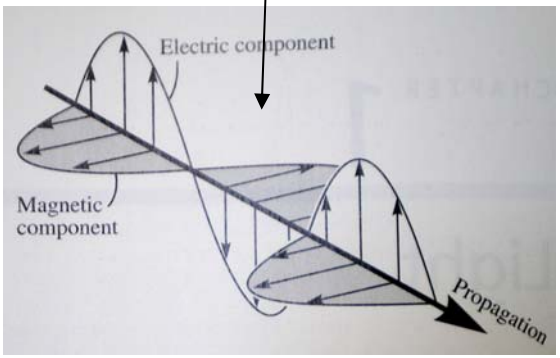
•Visible light from uv (*λ* ~ 400 nm) to ir (λ ~ 700 nm)



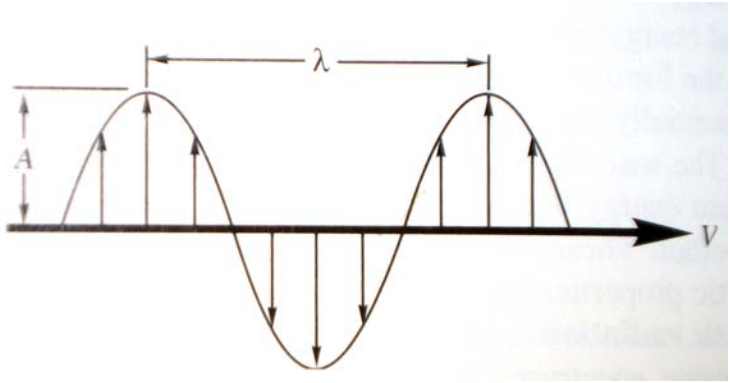
Velocity *(v)* = 3 x10^{10} cm s^{-1} in vacuum



Electric vector vibrates perpendicular to the direction of propagation



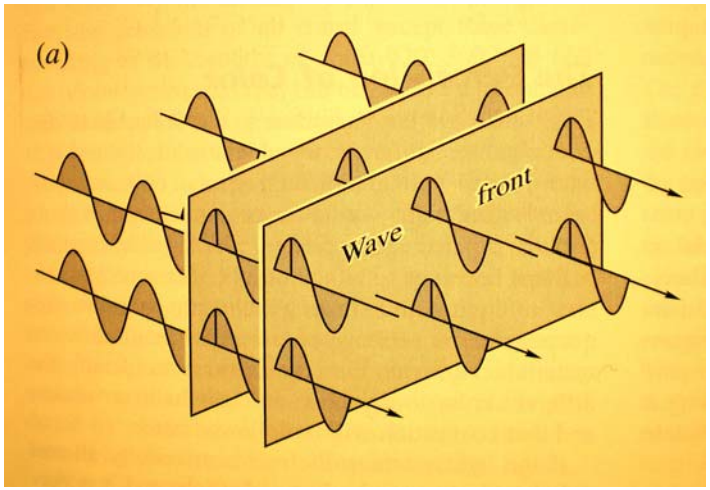
Wavelength (*λ*)
Amplitude (A)
Intensity (∞A^2)
Frequency *f* = *v*/*λ* (s^{-1})
***v*/*λ* is constant**



Wave front: surface that connects similar points on adjacent waves

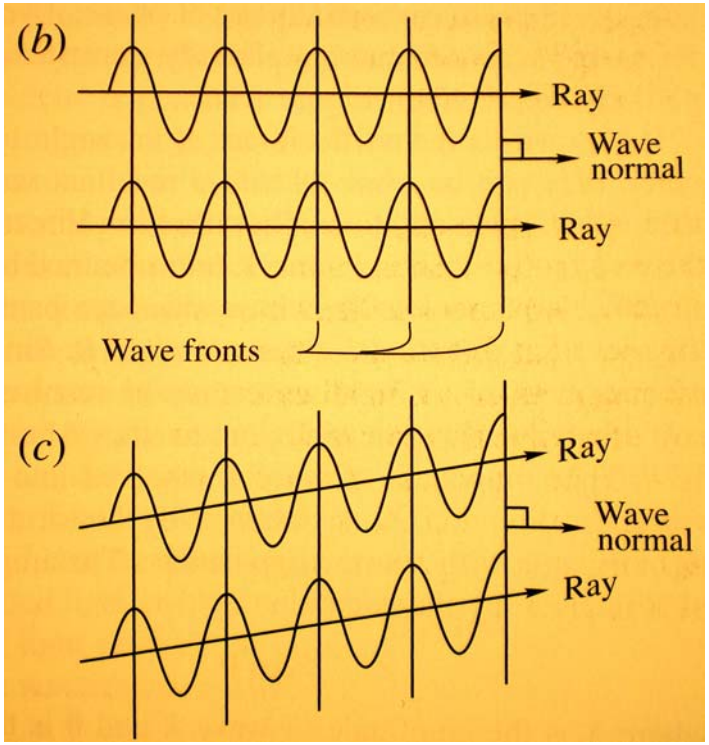
Wave normal: Line ⊥ wave front

Ray: direction of propagation



Isotropic medium: velocity of light is same in all directions (wave normal = ray direction), e.g., glass and isometric crystals)

Anisotropic medium: Velocity is different in different directions (wave normal and ray direction are not parallel), e.g., all non-isometric crystals)

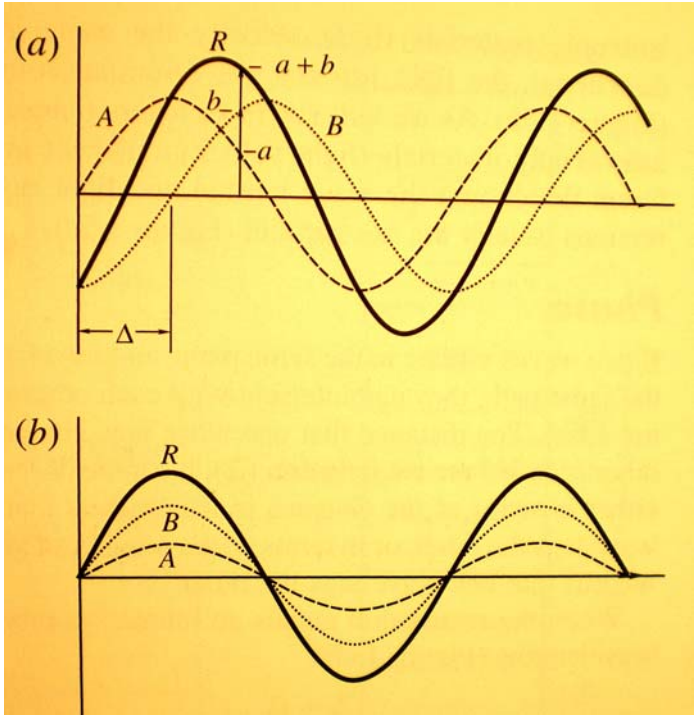


Light waves (cont.)

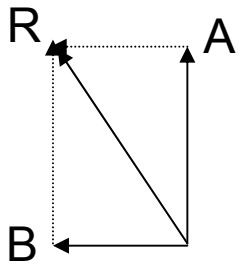
(1) Interference of waves

Retardation *(Δ)* $\Delta = i\lambda$
In phase when *i* is an integer and
Out of phase when *i* is a fraction

When i = ½ complete cancellation



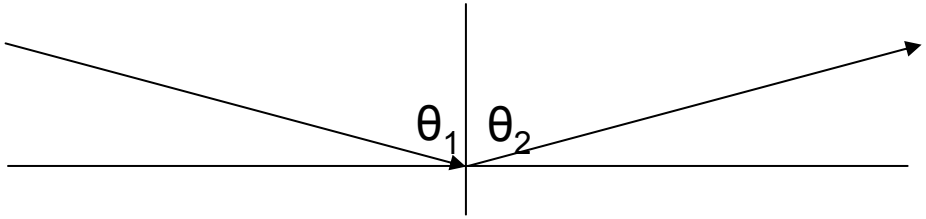
(2) Resolution of waves



(3) Color: Monochromatic light (single wavelength), e.g., Na vapor λ = 589 nm
Polychromatic (aka. “white”) light: multiple wavelengths

Light waves (cont.)

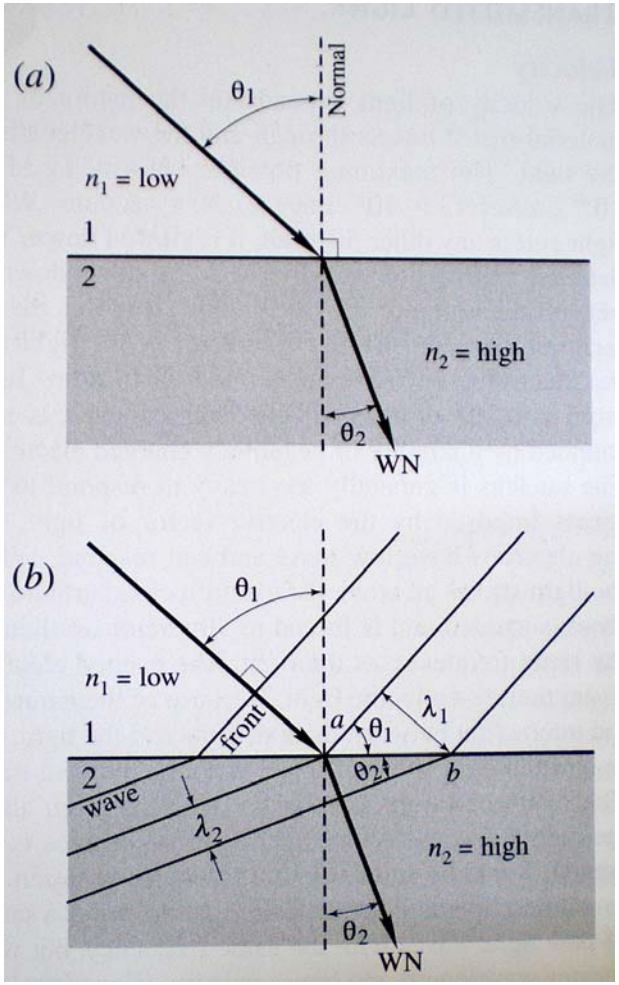
Reflection



Refraction: "bending" of light as it passes from one medium to another—function of differences in refractive index (n)

$n = v_{vac}/v_{med}$

n ≥ 1.0
In air, n = 1.0003
Minerals: n ranges from ~1.4 to ~2.0



Snell's law:

Sin $\theta_1/\sin\theta_2 = n_2/n_1$

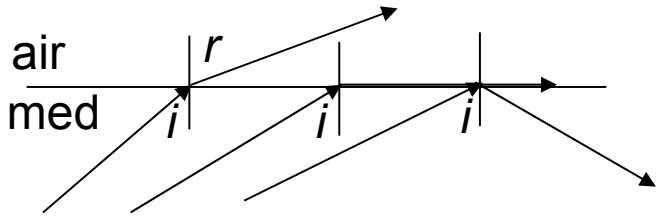
Light waves (cont)

Critical angle and internal reflection

$\sin r = (n_i / n_r) \sin i$

when $r = 90°$ $\sin r = 1$

Critical angle: when $(n_i/n_r) \sin i = 1$



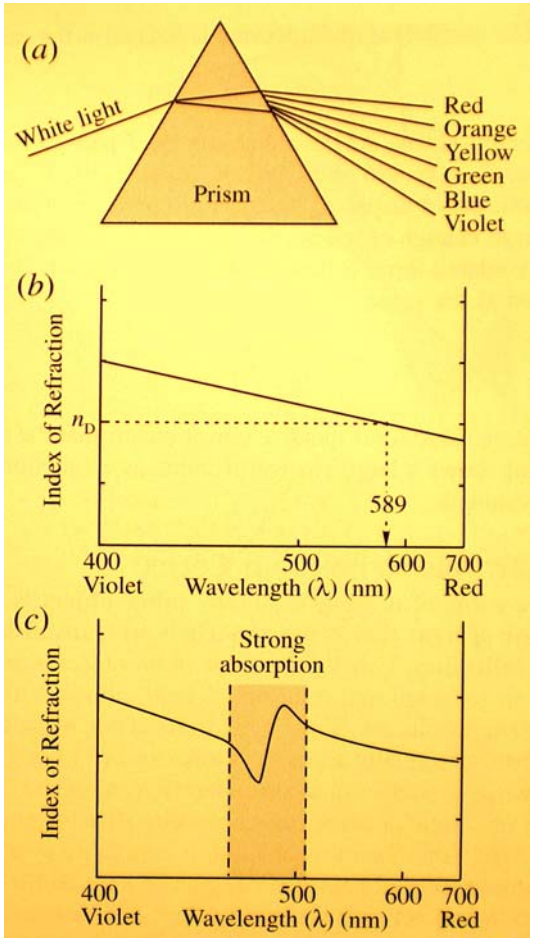
Dispersion

Recall: $v \propto \lambda$

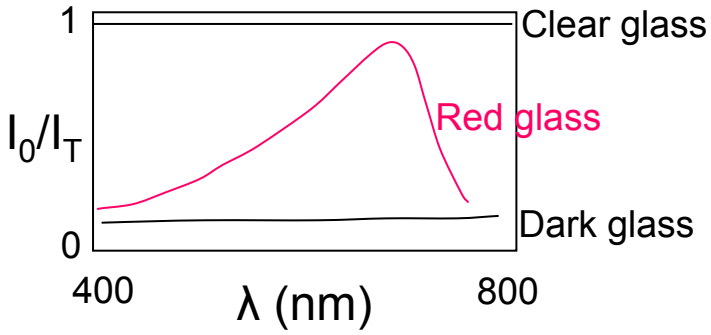
$n \propto 1/\lambda$

$n \propto 1/v$

n_D is the value reported in tables



Absorption and color



Lambert's law: $I_0/I_T = e^{-kt}$

where I_T = int. of transmitted light

I_0 = int. of incident light

t = thickness

k = absorption coefficient

Light Waves (cont.)

Polarization of light

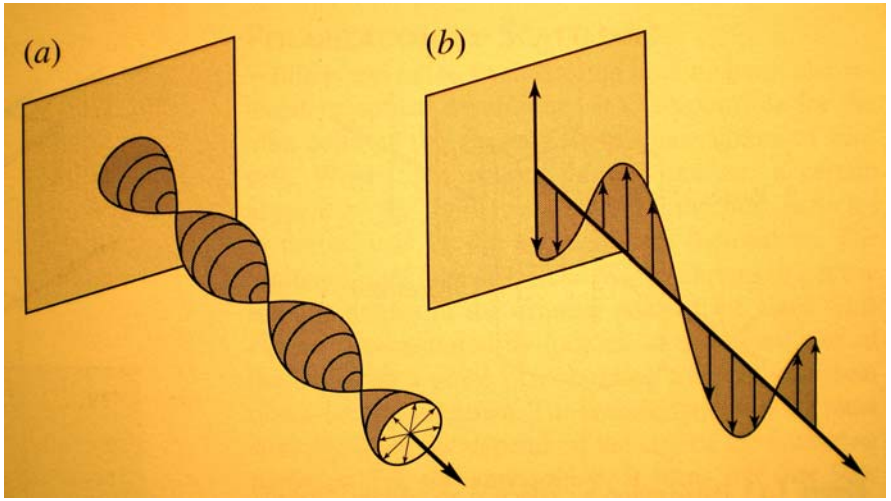
In routine optical mineralogy we use polychromatic (white) light provided by a tungsten lamp with a blue filter. On occasion, for precise determination of refractive index *(n)* we use monochromatic light provided by a sodium vapor lamp (λ = 589 nm).

Light is polarized, i.e., it is constrained to vibrate in a single direction, in our case an East-West direction. Referred to as "**plane polarized light**" and the direction of vibration of the polarized light is called the **PRIVILEGED DIRECTION**

Polarization may be produced by:

1) selective absorption using polaroid film

2) Double refraction using a Nicol prism made from calcite



Polarizing microscope