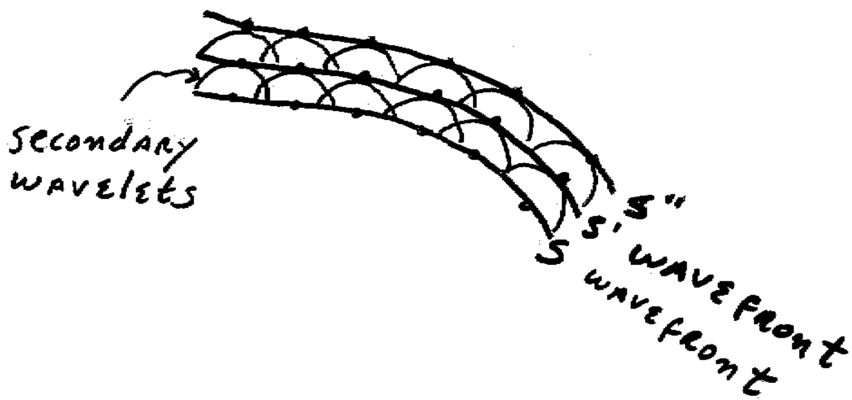
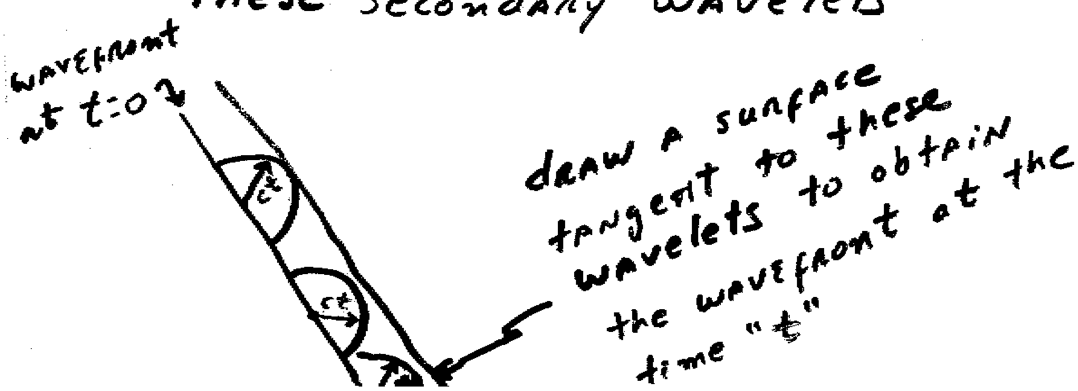
- LIGHT PROPAGATION: Huygens principle
- Reflection
- Refraction
  Snell's law
- Total internal reflection
- Exploiting the vectorial character of electromagnetic waves
  Polarization by reflection
  Brewster angle
- Chromatic Dispersion $n = n(\omega)$
-

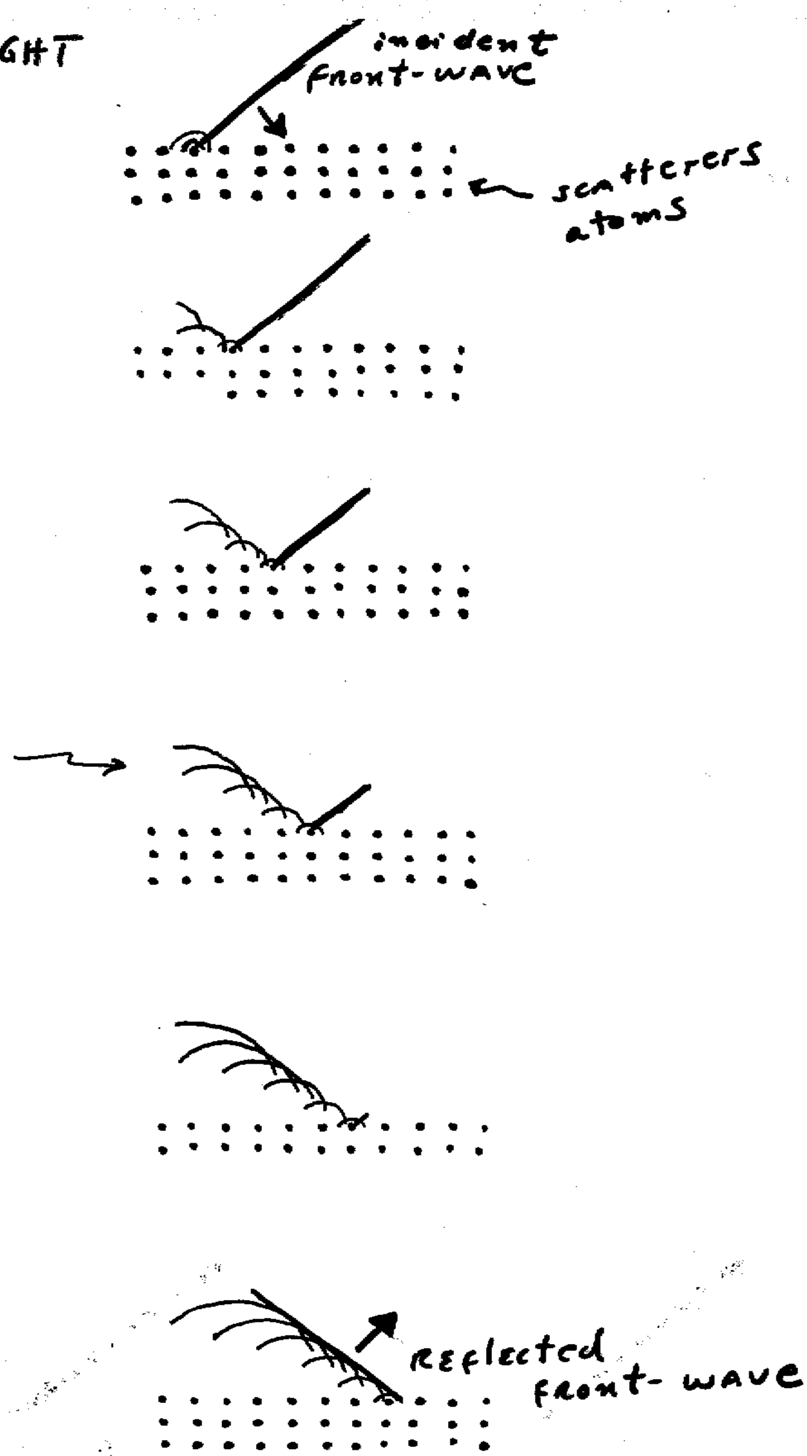
Huygens' principle:



All points of a wavefront serve as point sources of spherical secondary wavelets. After a time t, the new position of the wavefront will be that of a surface tangent to these secondary wavelets



REFLECTION of LIGHT as a result of scattering

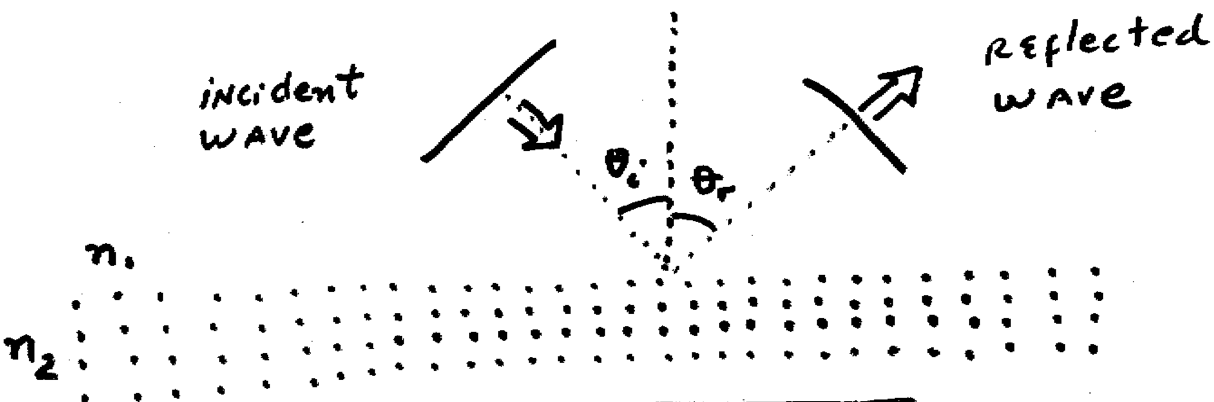


spherical wave-fronts emitted by the scatterers

As the incident wave reaches an atom, it emits an spherical wave-front

the envelope of the spherical wavefronts constitute the ve front of the reflected wave

A little bit of faith will help us to conclude that:

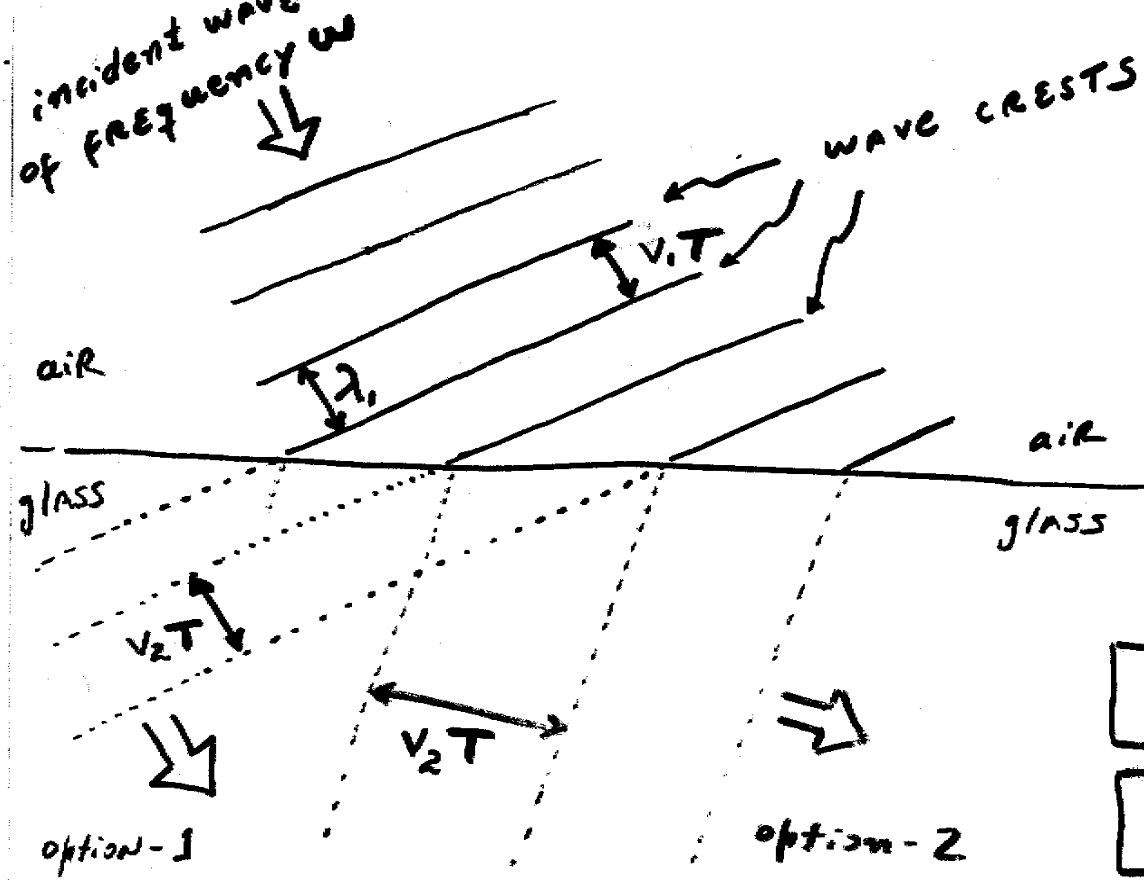


$$\boxed{\theta_i = \theta_r}$$

incident angle — reflection angle

Notice: The incident wave and the reflected wave travel in the same medium. So, both travel at the same speed $v_1 = \frac{c}{n_1}$

REFRACTION of light



$T = \frac{1}{f} = \frac{2\pi}{\omega}$

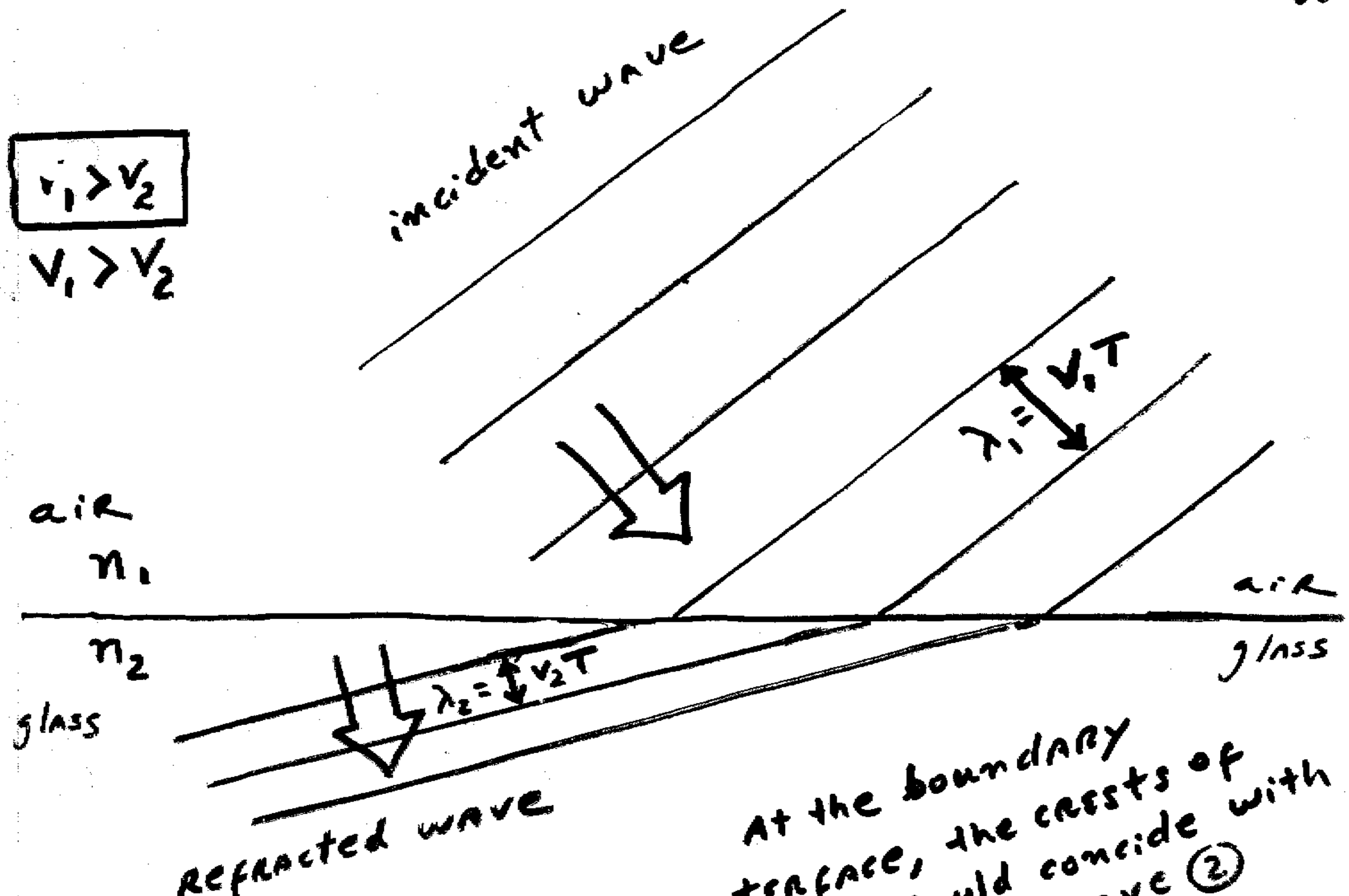
$\boxed{n_2 > n_1}$

$\boxed{V_2 < V_1}$

- which option is correct?
- what is the frequency of the waves propagating in the medium n_2?

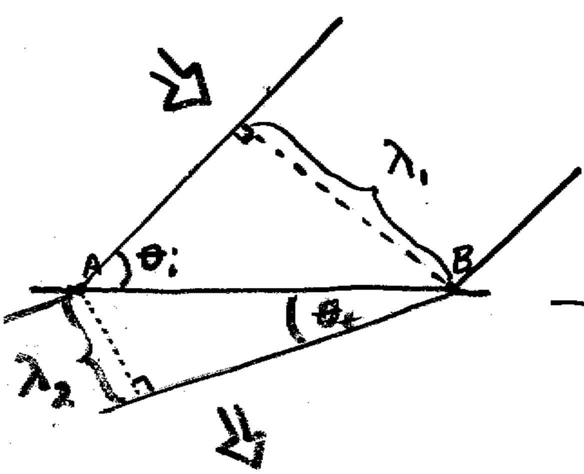
$\boxed{v_1 > v_2}$

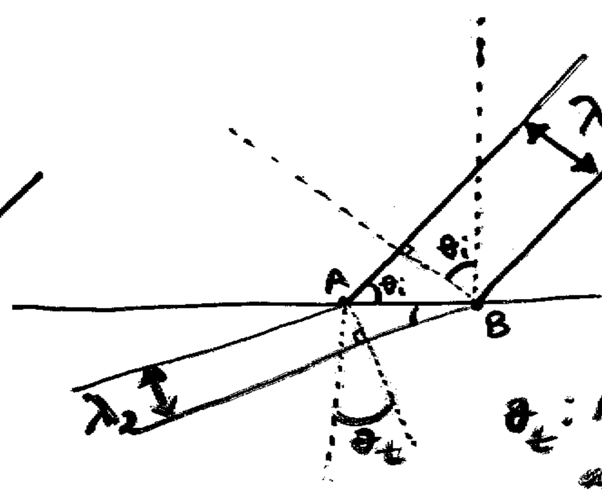
$V_1 > V_2$



At the boundary interface, the crests of wave 1 should concide with the crests of wave 2

θ_i : incident angle





θ_t : refraction angle

Notice:

$$AB \sin\theta_i = \lambda_1$$

$$AB \sin\theta_t = \lambda_2$$

$$\Rightarrow \boxed{\frac{\sin\theta_i}{\sin\theta_t} = \frac{\lambda_1}{\lambda_2}}$$

$$\lambda_1 = v_1 T$$

$$\lambda_2 = v_2 T$$

$$\Rightarrow \boxed{\frac{\sin\theta_i}{\sin\theta_t} = \frac{v_1}{v_2}}$$

$$v_1 = \frac{c}{n_1}$$

$$v_2 = \frac{c}{n_2}$$

$$\Rightarrow \frac{\sin\theta_i}{\sin\theta_t} = \frac{n_2}{n_1}$$

or

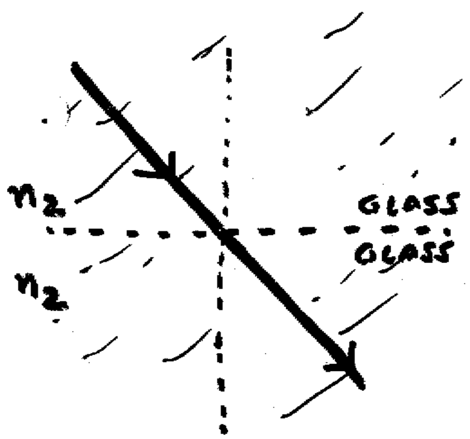
$$\boxed{n_1 \sin\theta_i = n_2 \sin\theta_t}$$

Snell's law

$$n_1 \sin\theta_1 = n_2 \sin\theta_2 \quad *$$

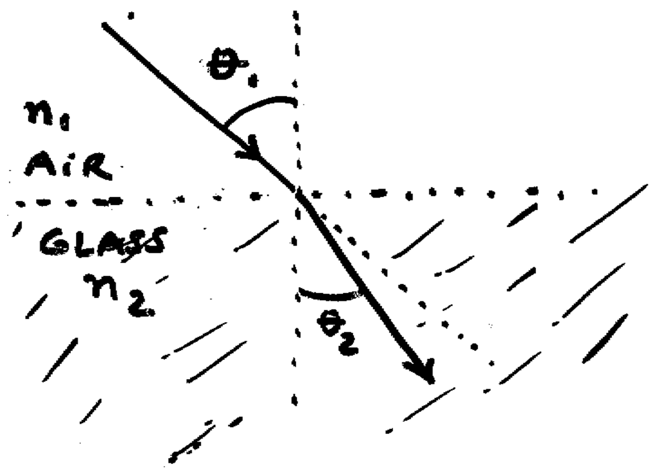
8F

CASE 1



$n_1 = n_2$

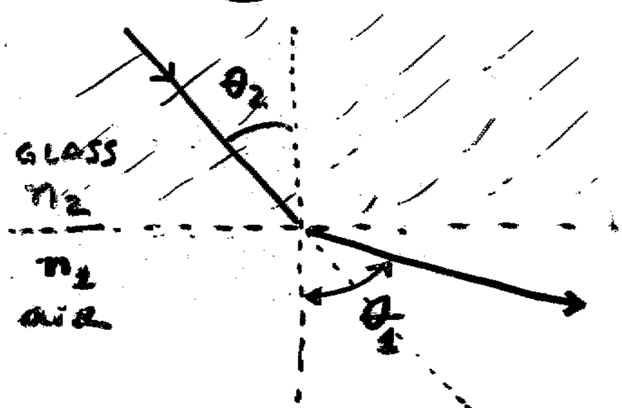
CASE 2



$n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$

$n_1 < n_2 \Rightarrow \theta_1 > \theta_2$

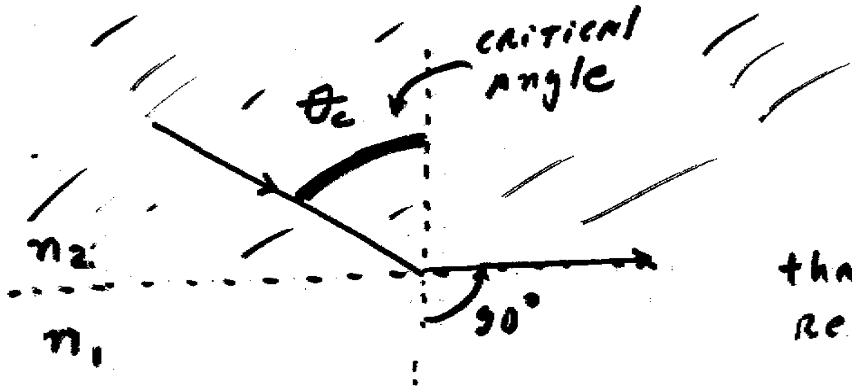
CASE 3



$n_2 \sin(\theta_2) = n_1 \sin(\theta_1)$

$n_2 > n_1 \Rightarrow \theta_2 < \theta_1$

what happens if we keep increasing the incidence angle θ_2 ?



that is refracted angle $\theta_1 = 90$ in this case

Given n_2 and n_1 the critical angle θ_c can be obtained from the Snell's law

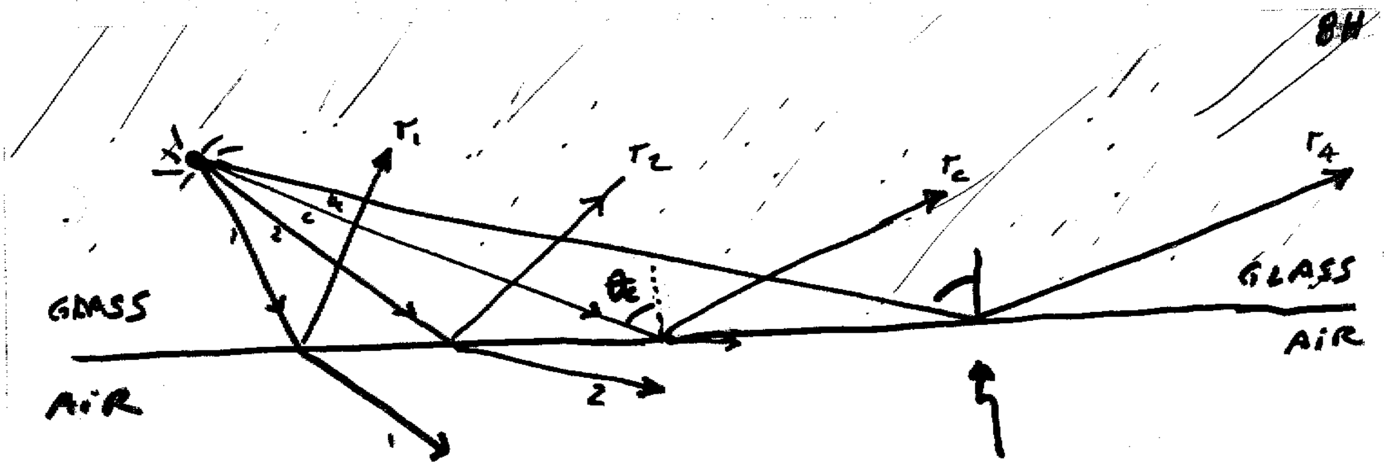
$$n_2 \sin(\theta_c) = n_1 \underbrace{\sin(90°)}$$

$$\boxed{\theta_c = \sin^{-1}\left(\frac{n_1}{n_2}\right)}$$

Notice this result requires $n_1 < n_2$

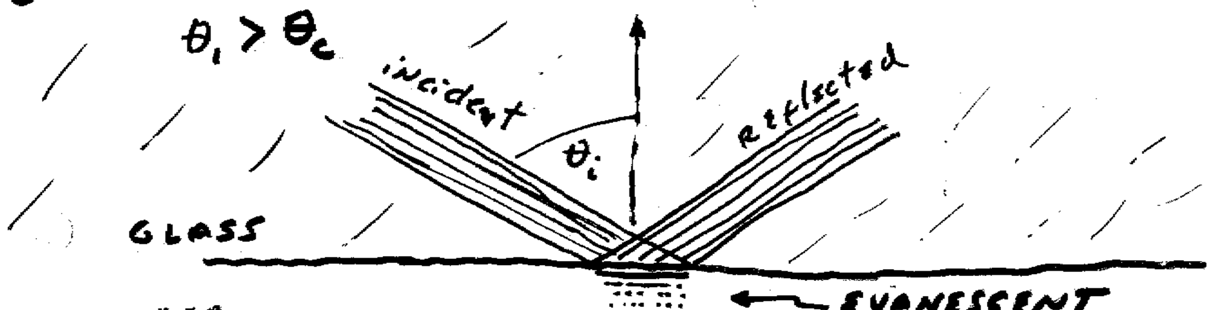
What happens if we make the incidence angle greater than θ_c?

8H



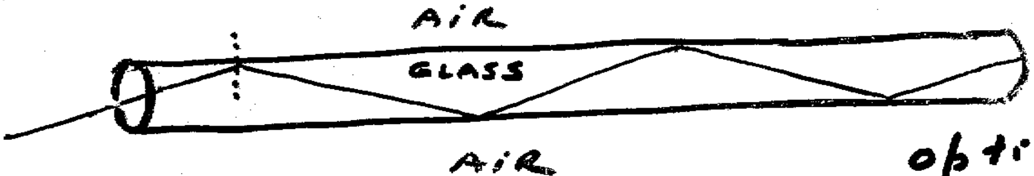
"TOTAL INTERNAL REFLECTION"

- $\theta_1 > \theta_c$



EVANESCENT ELECTRIC field (the further away from the interface, the weaker the field. It decreases exponentially

- WAVEGUIDE



optical fiber

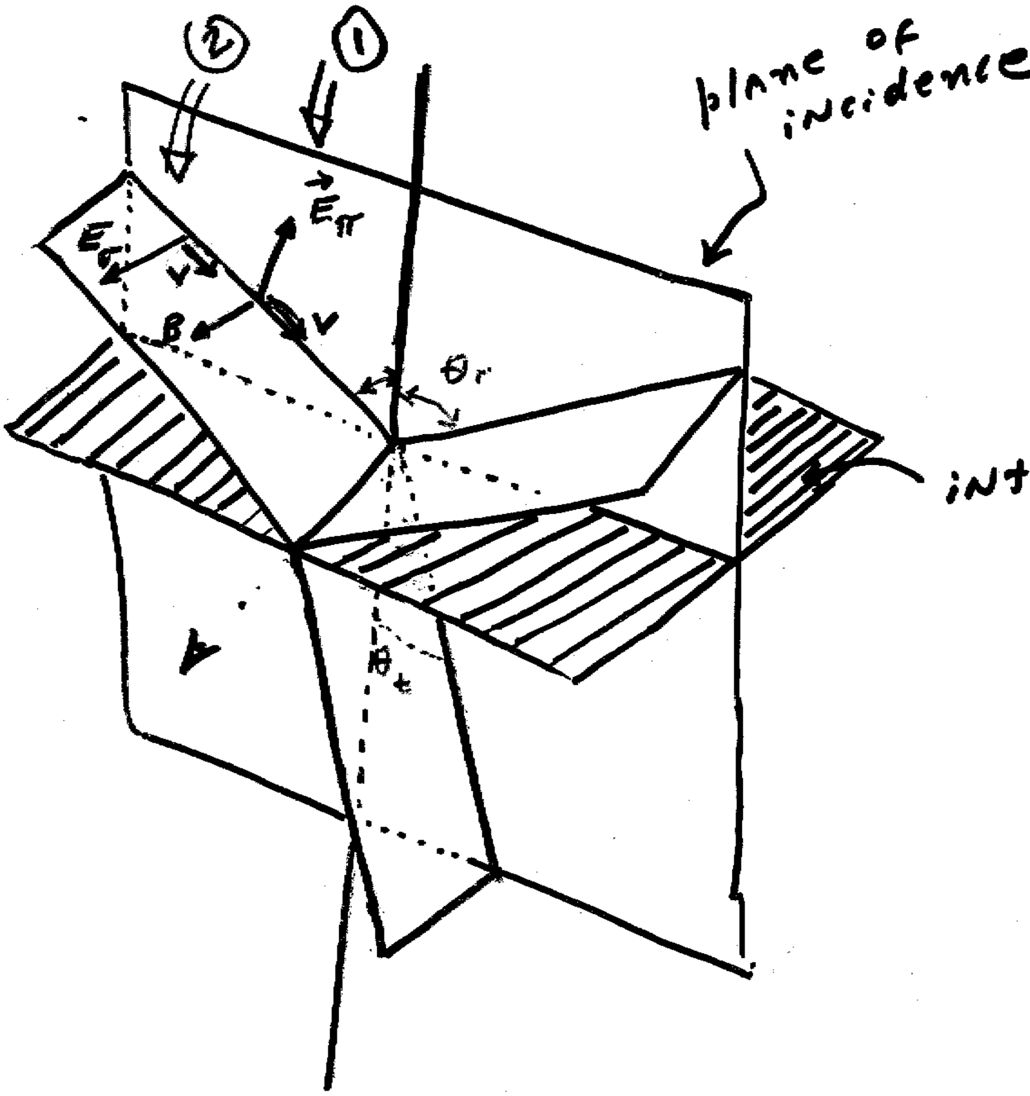
Practice:

- sample problem 34-3 p. 817
  checkpoint 4 p. 818; checkpoint #5
  sample problem 34-5; checkpoint #6 p. 824
- Questions 5*, 7, 8, 9 CH-34, p. 826
- Problems 32E, 34E, 35E CH-34
- Problems 42E, 44E, 46P*, 47P, 49P
  51P* CHAPTER-34
- Problems 52E, 53E*, 54E*, 58P*

Snell's law: $n_A \sin(\theta_A) = n_B \sin(\theta_B)$

is the equivalent of the kinematic equations ($y = y_0 + v_0 t + \frac{1}{2} g t^2$) studied in mechanics. Remember, these equations do not care what causes the motion of a particle (forces). They deal only with position, velocity, acceleration.

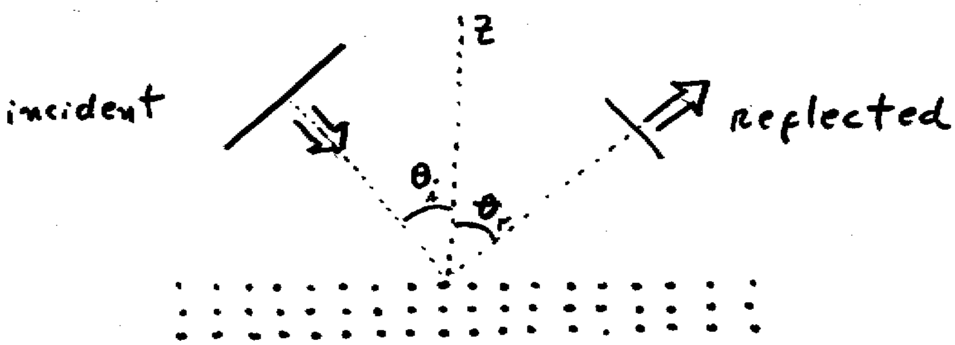
Simillarly, Snell's law does not deal with the vectorial character of the electromagnetic waves



Notice: there can be 2 types of incident polarized light

1. $\vec{E}_\pi$ lies in the plane of incidence

2. $\vec{E}_\sigma$ perpendicular to the plane of incidence

- 

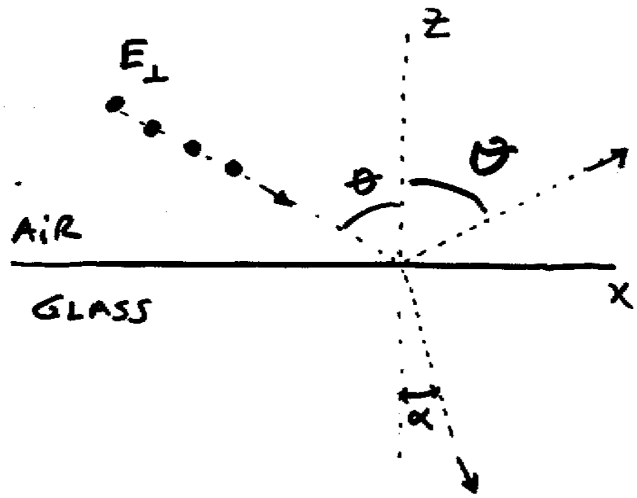
$\boxed{\text{reflection angle = incident angle}}$

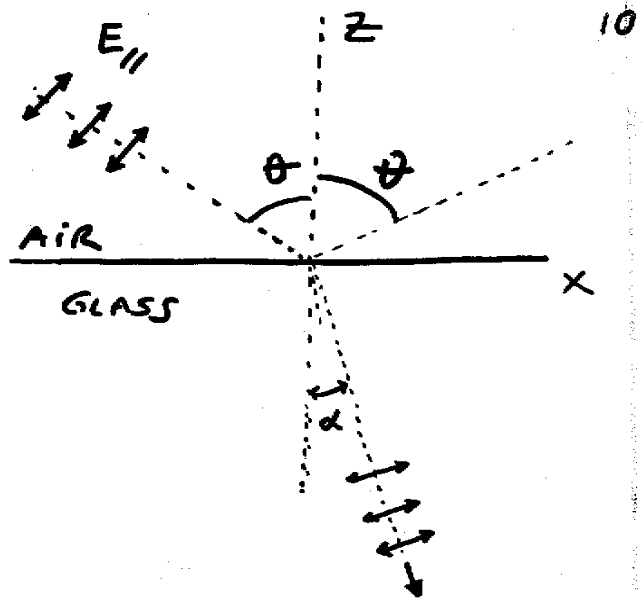
We have this result $\theta_i = \theta_r$ somewhat <u>independent</u> of the type of <u>polarization</u> of the incident wave.

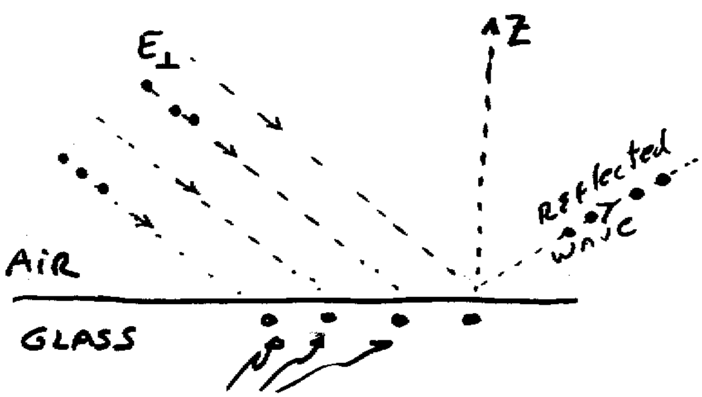
What is the effect of the POLARIZATION characteristic of light?

- When we take into account the <u>polarization</u>, we realize that it rather affects the <u>intensity</u> (power) of the reflected and transmitted light.

There exists cases in which even the reflected wave is completely supressed! Let's see, qualitatively, how this may happen.

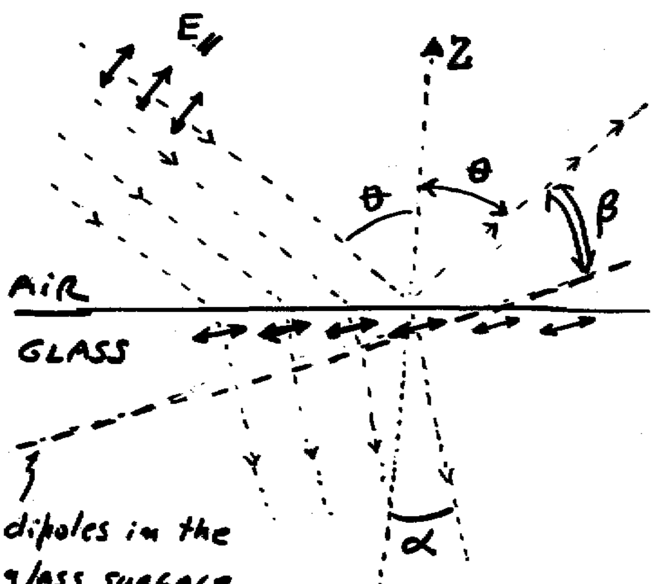






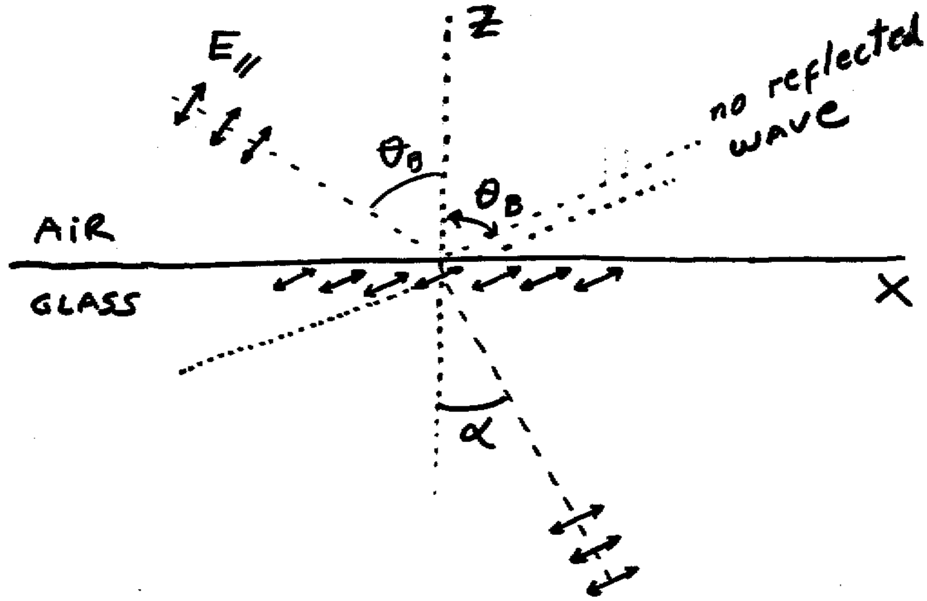
dipoles in the glass surface, vibrating $\perp$ to the Z-AXIS.

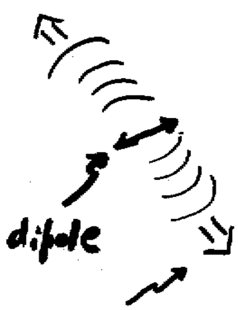
NOTICE: there will always be a reflected wave



dipoles in the glass surface vibrate along this direction.

What happens in the particular" case that $\beta = 0$?





power predominantly radiated in directions perpendicular to the direction in which the dipole vibrates

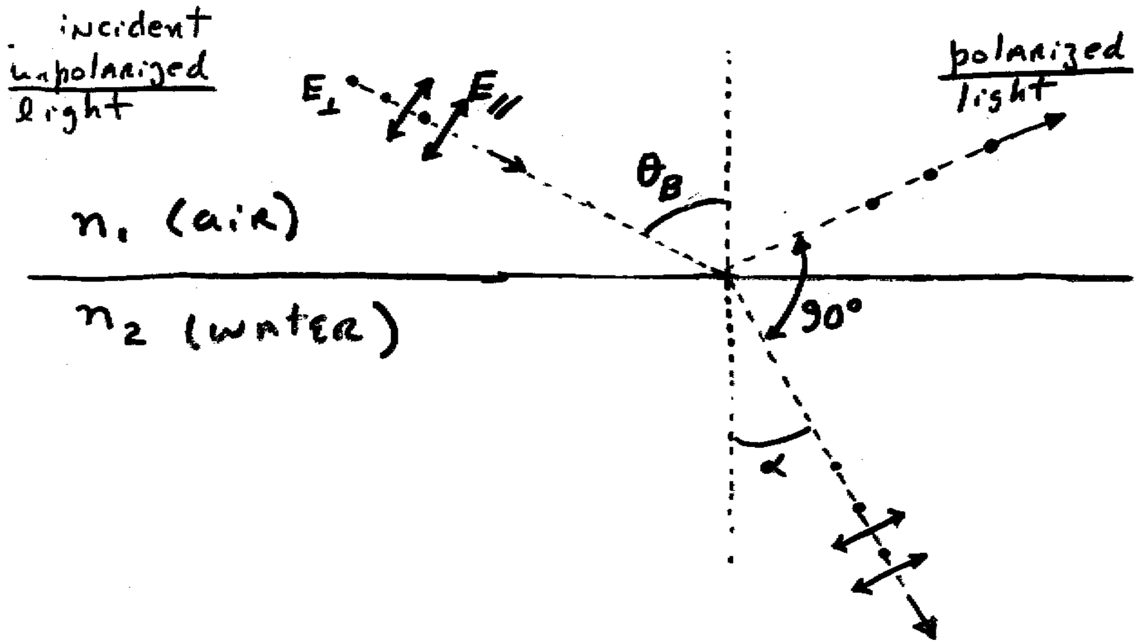
This situation happens when the incident angle $\theta = \theta_B$ is such that

$$\theta_B + \alpha = 90^\circ$$

$$\text{incident angle} + \text{refracted angle} = 90^\circ$$

θ_B : is called the Brewster angle

In conclusion: If $\theta_{incident} = \theta_B$ (Brewster angle)



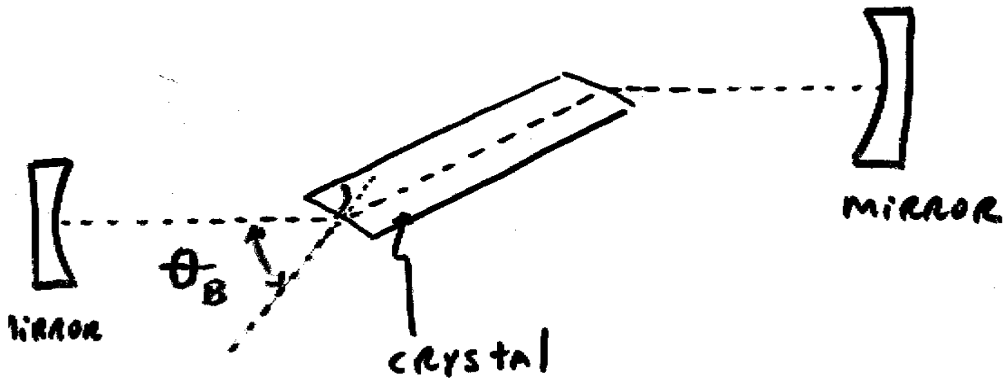
$$\theta_B + \alpha = 90° \Big\} \text{ condition to obtain polarized reflected light.}$$

How to find θ_B? → If we apply Snell's law, we obtain

$$n_1 \sin\theta_B = n_2 \sin\alpha$$
$$= n_2 \sin(90 - \theta_B)$$
$$= n_2 \cos\theta_B$$

$$\Rightarrow \boxed{\tan\theta_B = \frac{n_2}{n_1}}$$

Application



Example: Problem 60E, CH-34, p. 832

a) At what angle of incidence will the light reflected from water be completely polarized?

b) Does this angle depend on the WAVELENGTH of the light?

Solution: a) From Table 34-1 (p. 819)

WATER (20°C) $n = 1.33$

$$\tan(\theta_B) = \frac{n_{water}}{n_{AIR}}$$

b) ?