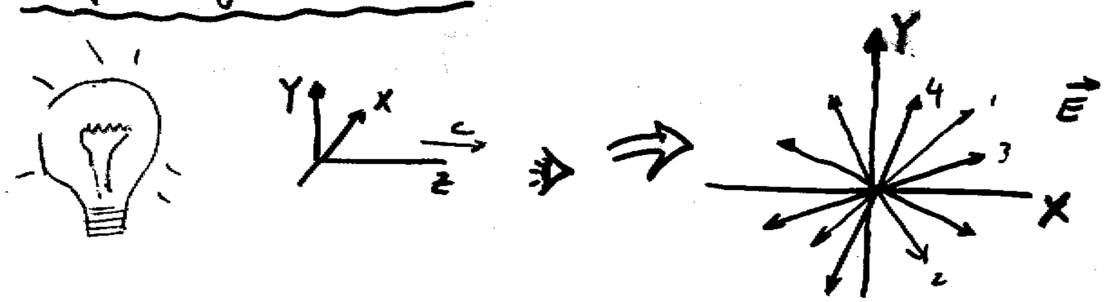
POLARIZED LIGHT

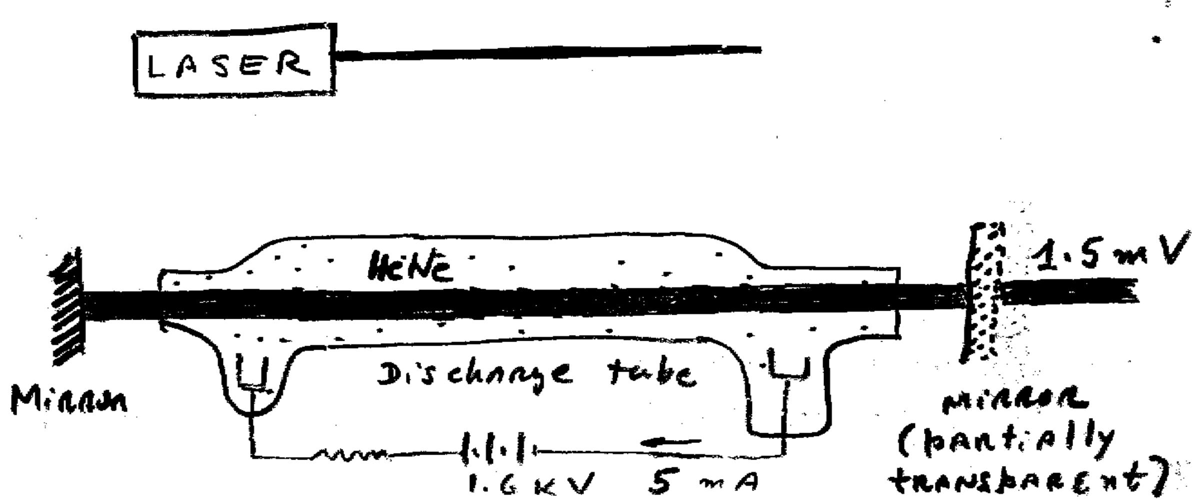
- Most common is to have
- Unpolarized light



orientation of the electric field has different directions over time.

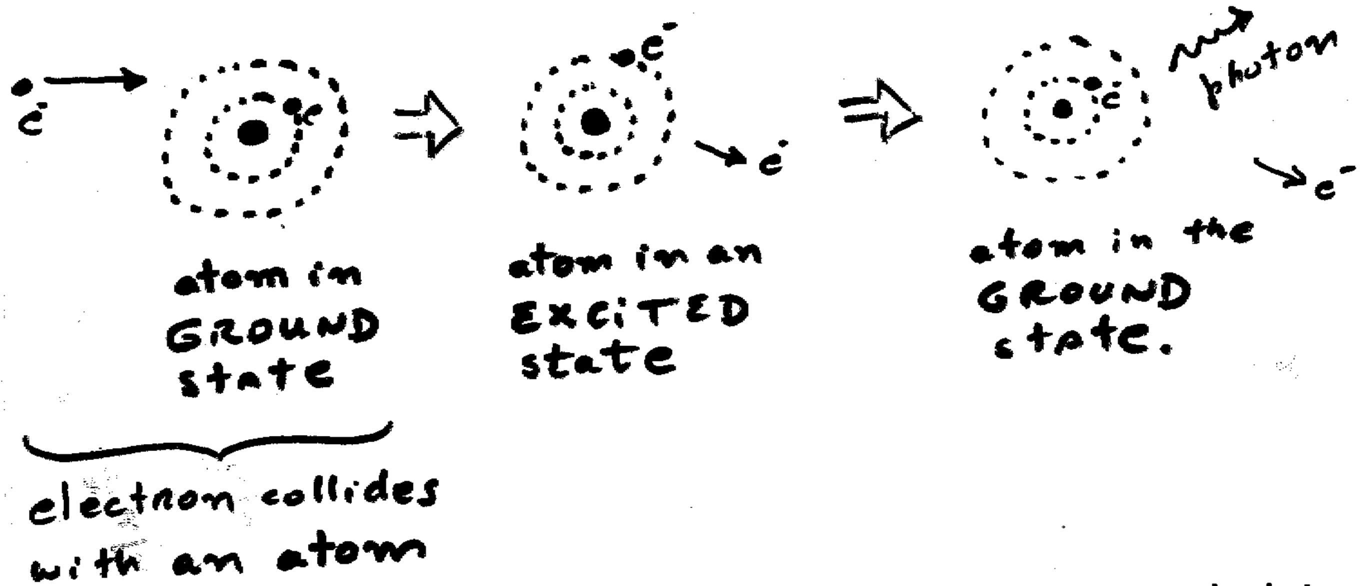
- What about LASER SOURCES?

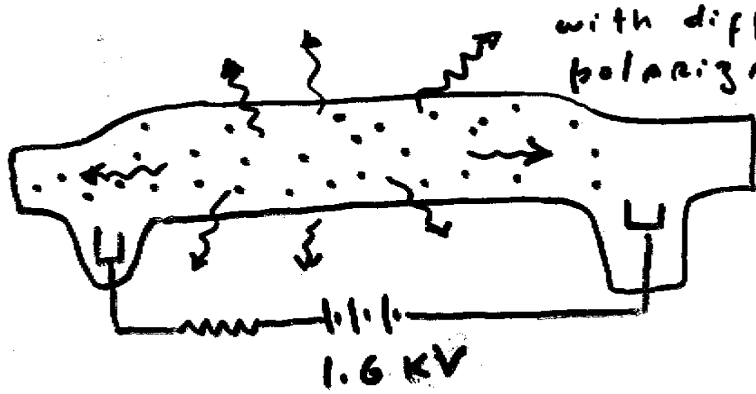
Is a laser beam a linearly polarized electromagnetic radiation?



No, a laser beam is not necessarily polarized

HOW A LASER BEAN is GENERATED ?

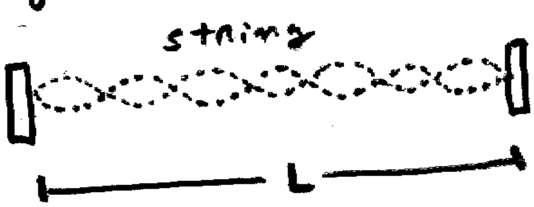




A set of parallel mirrors help to set up collimated beam.

But, still this collimated beam **does not** constitute a laser.
Resonance conditions have to be established

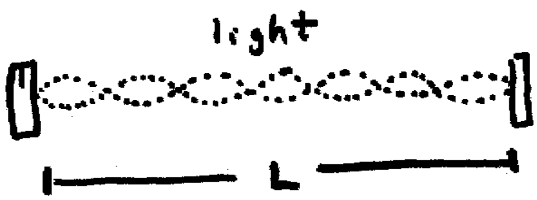
esonance conditions in the optical setup above is similar to the resonance conditions in a vibrating string



$$L = N \frac{\lambda}{2}$$

$N = 1, 2, 3, \ldots$

Similarly, since the electric field must be zero at the mirror surface (mirror is a metal), and the wavelength of light emmited by the atoms is λ (the type of atoms determine the values of λ available for lasing action), THEN, the conditions for optical resonance is



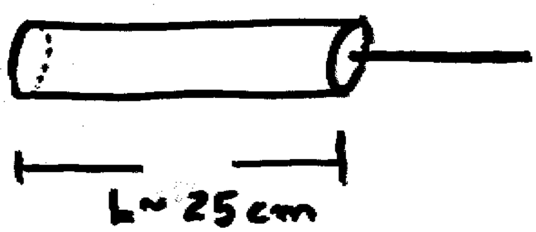
that L must be chosen such that

$$L = N\frac{\lambda}{2}$$

N = 1, or 2, or 3, or ....

condition for lasing action

Let's have an idea about the order of magnitude of the quantities involved in the expression above. If we have a laser system of dimension

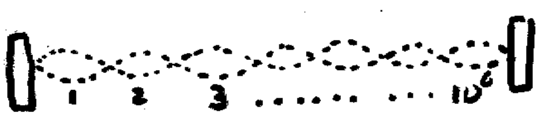


$L \sim 25\,cm$, and the emmited radiation is $\lambda \sim 500\,nm$,

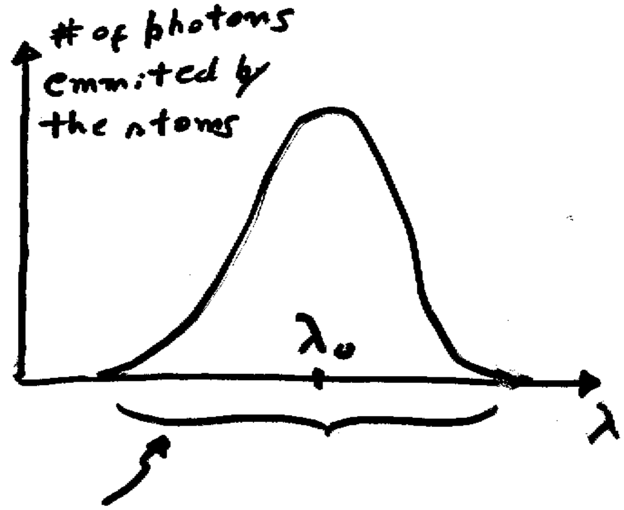
then,

$$25\times10^{-2}m = N\frac{0.5\times10^{-6}m}{2}$$

$$N = 10^{6}$$

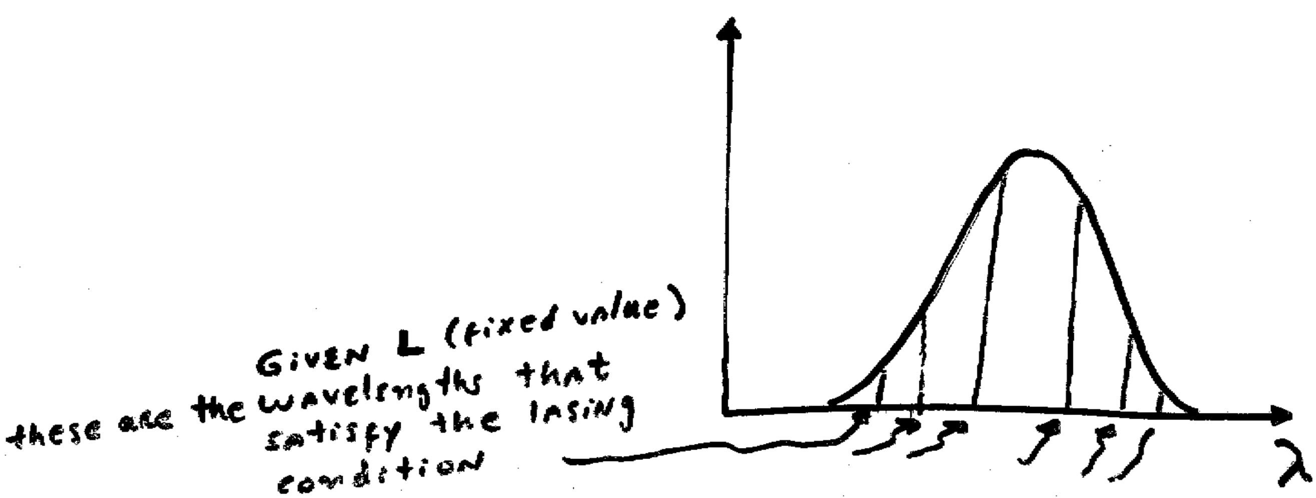


Typically, atoms emmit light of different wavelengths, all of them in the neighborhood of a given value λ_0



Given L not all the wavelengths comprised by the region satisfy the resonance condition $L = N\frac{\lambda}{2}$

But, a few of them will.



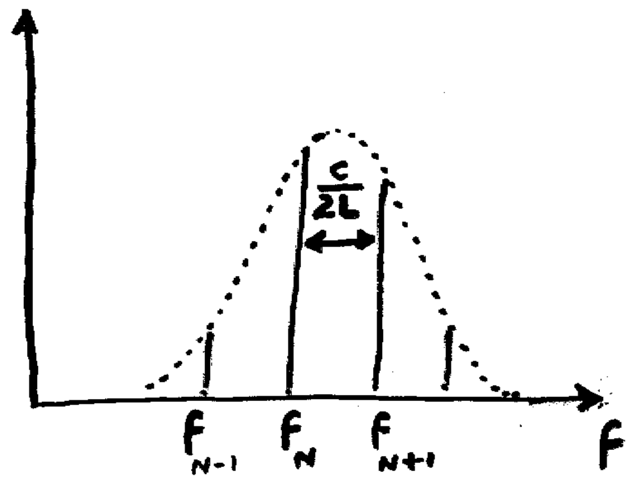
In terms of frequency $f = \frac{c}{\lambda}$, the lasing condition $L = N\frac{\lambda}{2}$ becomes

$$\boxed{f = N\frac{c}{2L}}$$

c : speed of light

L : distance between mirrors

N : integer number.

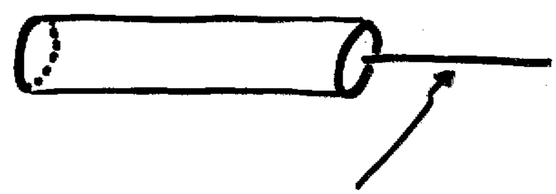


Notation:

$$\boxed{f_N = N\frac{c}{2L}}$$

notice:

$$(f_{N+1} - f_N) = \frac{c}{2L}$$



laser beam contains different discrete frequencies f_N

Order of magnitude:

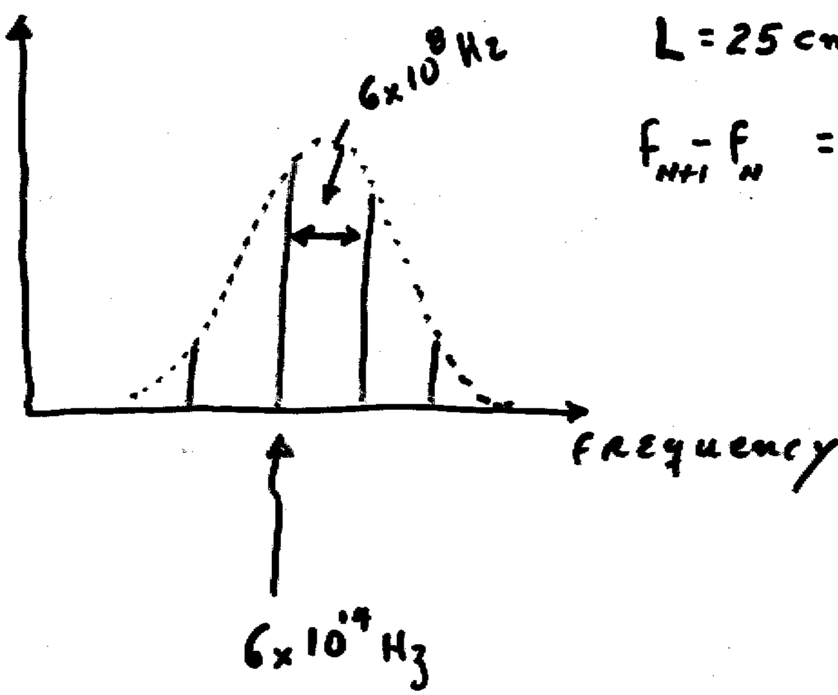
If $\lambda_N = 500\,nm$, then $f_N = \frac{c}{\lambda_N} = 6 \times 10^{14}\,Hz$

For a laser cavity of

$L = 25\,cm$

$f_{N+1} - f_N = \frac{c}{2L} = 6 \times 10^{8}\,Hz$

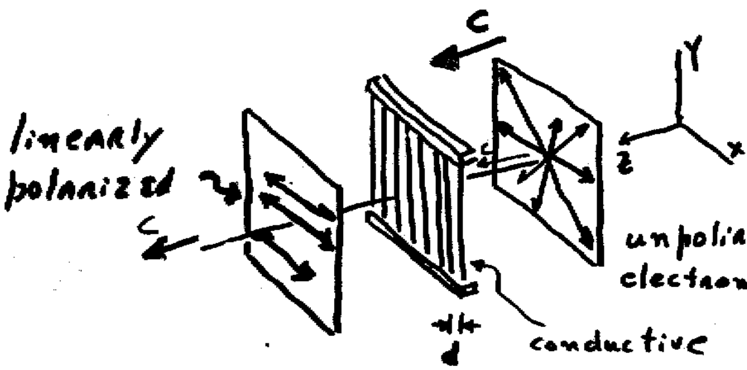
$= 600\,MHz$



How to produce linearly polarized light?

METHOD-1 USING POLARIZERS

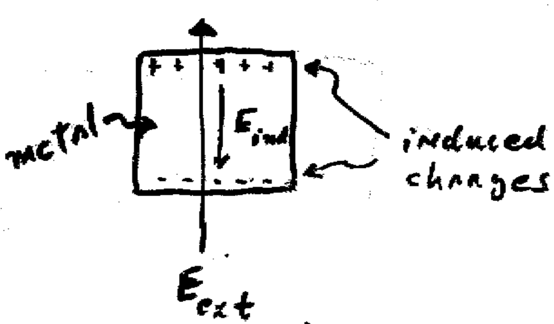
a) Wire-grid polarizer (for microwaves)



useful to polarize microwaves $\lambda \sim 1cm$

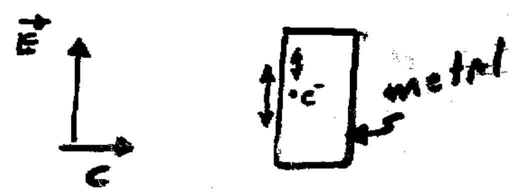
working principle

Electric field inside a metal tends to ZERO



$\vec{E}_{ext} + \vec{E}_{ind} = 0$

ELECTROSTATIC



electric field does NOT penetrate into the metal

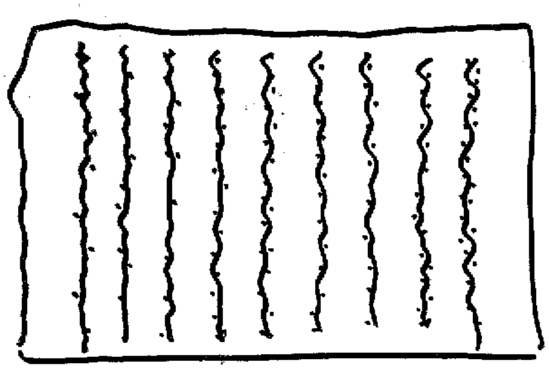
ELECTRODYNAMICS

b) "wire-grid" polarizer (for applications with radiation in the VISIBLE regime $\lambda \sim 500$ nm)

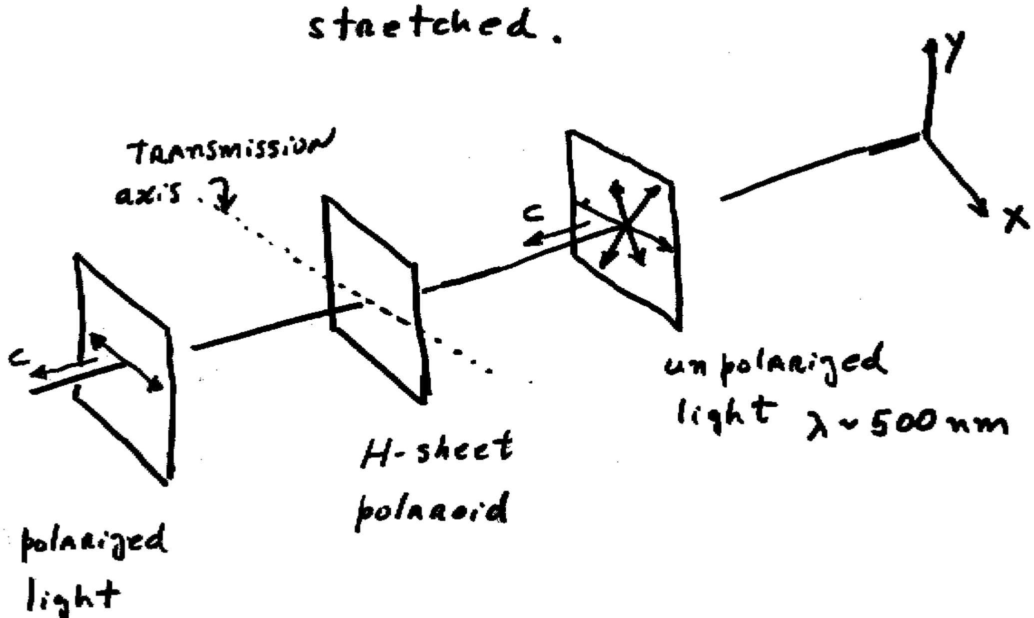
Polaroid

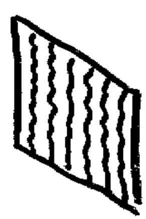
- Molecular analog of the wire-grid
- Sheet of polyvinyl alcohol is heated and stretched in a given direction.
  Its long hydrocarbon molecules become aligned parallel to the stretching direction
- Sheet is deeped into a solution reach in iodine.
  Iodine contains conduction electrons
- Iodine attaches to the long hydrocarbon

• RESULT: Free electrons (from the iodine) can move along the chain of hydrocarbons molecules as if thes polymeric molecules were long thin wires.

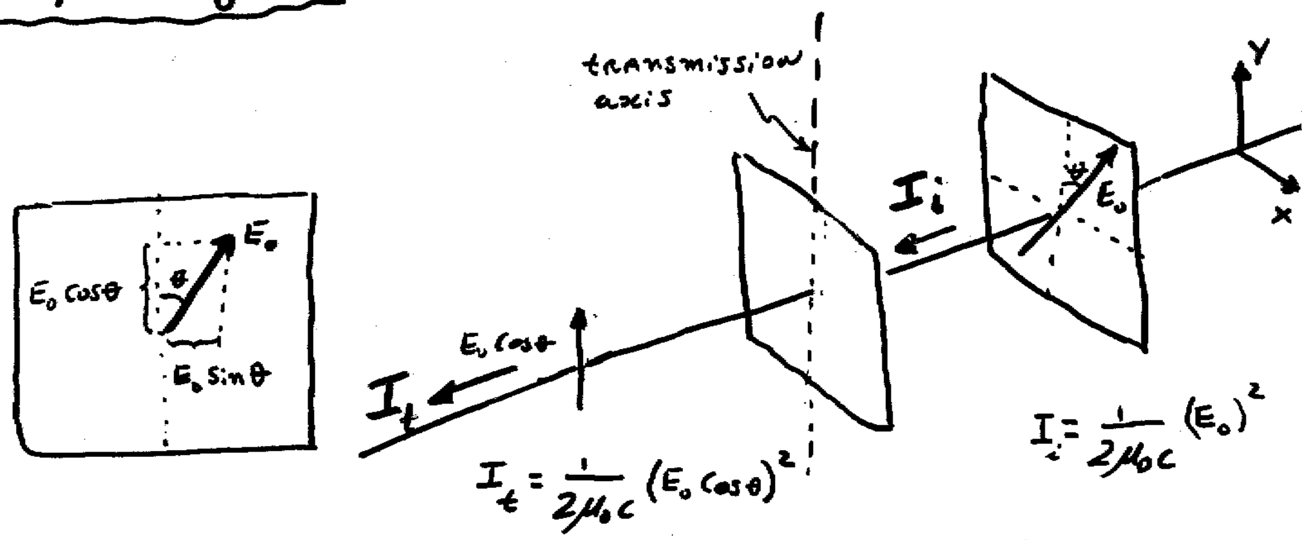


- Notice: the transmission axis of the polarizer is perpendicular to the direction in which the film was stretched.





Intensity of light passing through a polarizer.-



Notice : $\boxed{I_t = I_i \cos^2\theta}$

I_i: incident

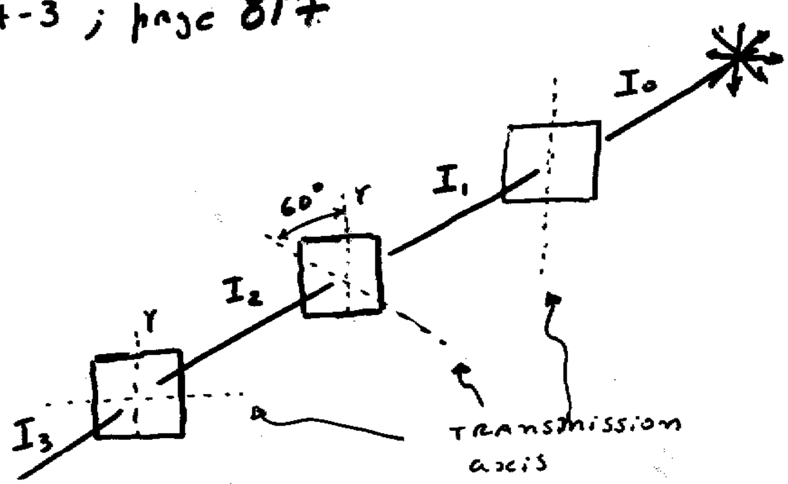
I_t: light intensity transmitted through the polarizer

Sample problem 34-3 ; page 817

$I_1 = \frac{1}{2} I_0$?

$I_2 = \cos^2 60\, I_1$

$I_3 = \cos^2 30\, I_2$

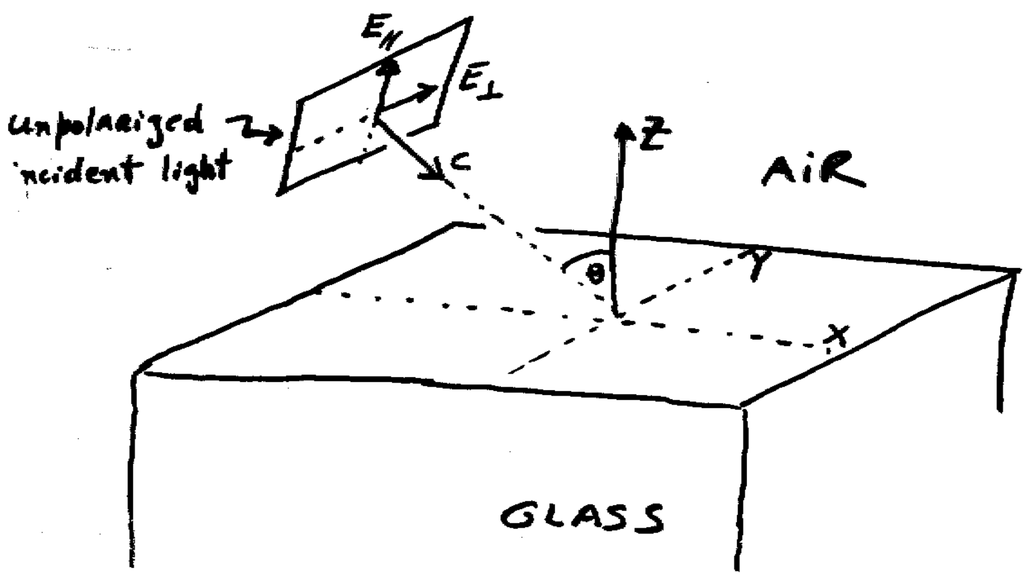


PRACTICE: checkpoint 4, page 818

Problems 32E, 34E, 35E; Chapter 34; page 830
36P, 38P, 39P

METHOD 2 Polarization of light without using a polaroid

POLARIZATION BY REFLECTION



Let's take a look, first, to the Huygens' principle (a geometrical description to explain how light propagates)

[see also section 36-2, textbook, page 862]