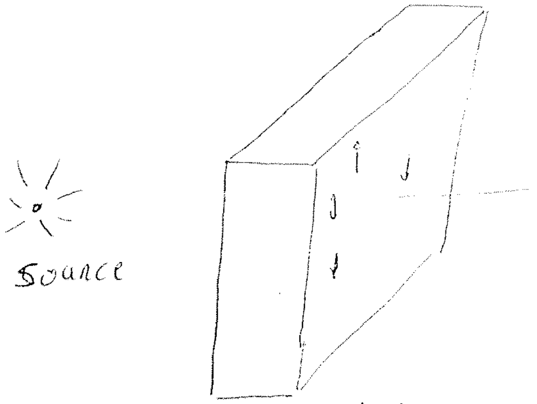
C. INDEX OF REFRACTION



changes put in motion by the radiation from the source

P

$$\vec{E} = \vec{E}_s + \underbrace{\sum_n \vec{E}_n}$$

due to the source

due to changes in the glass plate

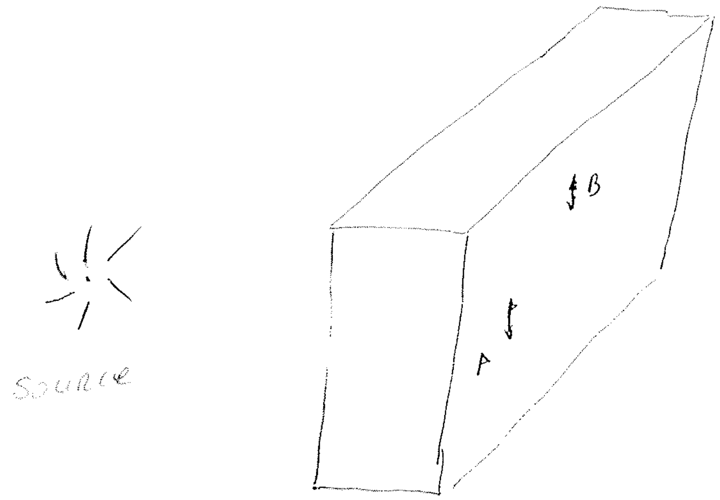
The field at P.

- Is not the same as the one which was there before the glass was introduced.
- It is different than $\vec{E}_s$.

It turns out that the modification is such that it appears as if the fields inside the glass were traveling at a speed different than c.

We want to understand this quantitatively

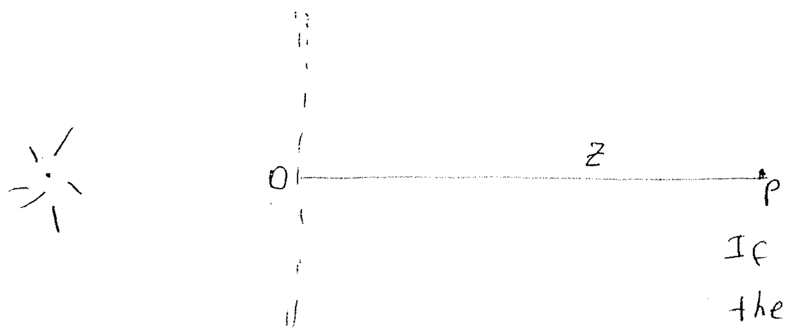
Approximation: We are assuming that the motion of the charge at A does not modify the motion of the charge at B.



In fact, this assumption allows to write $\vec{E}$ at P the way is written in (7)

$$\bar{E}_P = \bar{E}_S + \underbrace{\sum_n \bar{E}_n}_{\text{let's call it } \bar{E}_a}$$

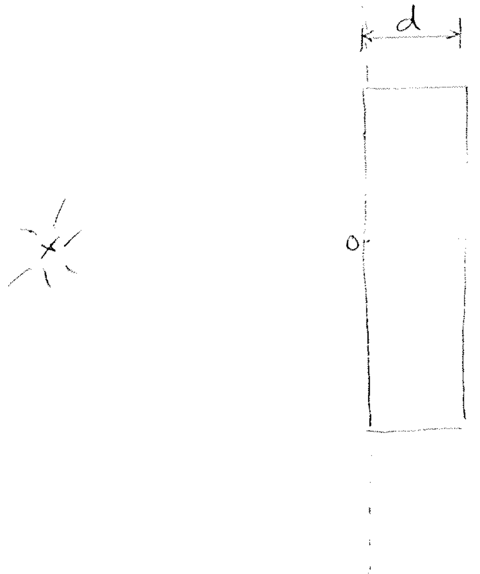
FIRST APPROACH "Let's find out what the field E_a would have to be if the total field E_P is going to look like radiation from the source that is slowed down while passing through the thin plate"



No plate

If the plate is not present, the field at P is the field

$$E_s = E_0 e^{i\omega(t - \frac{z}{c})}$$



what would happen if the wave travelled more slowly in going through the plate?

↳ when there is no plate the wave travels "d" in the time $\frac{d}{c}$

↳ ~~w~~when the plate is there, if the wave traveled at speed $\frac{c}{n}$ it would take a time $n\frac{d}{c}$ to cross the plate

n is the index of refraction

So, there is a delay $\Delta\cancel{t}$ equal to

$$\Delta\cancel{t} = (n-1)\frac{d}{c} \qquad (8)$$

$$E_p = E_0 e^{i\omega\left(t - \frac{z}{c} - \Delta\right)}$$

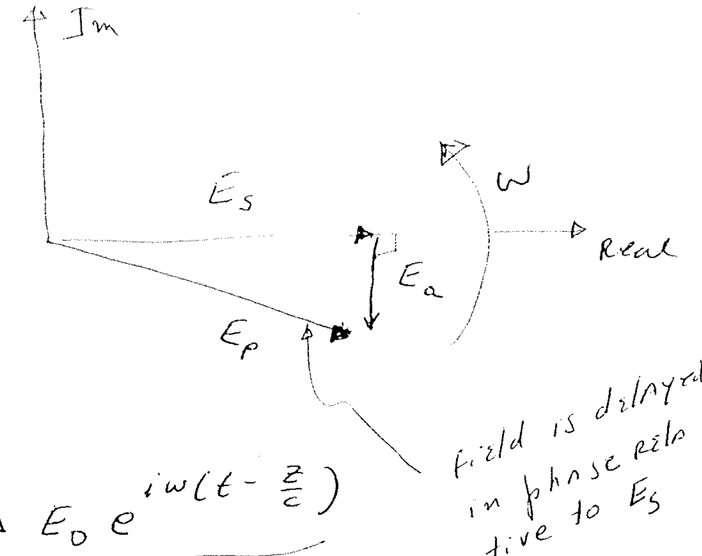
$$= E_0 e^{-i\omega\Delta} e^{i\omega\left(t - \frac{z}{c}\right)}$$

$$= \cancel{E_0} e^{-i\omega\Delta} E_s$$

But $e^{-i\omega\Delta} \approx 1 - i\omega\Delta$

$$E_p = (1 - i\omega\Delta)\, E_s$$

$$= E_s - \underbrace{i\omega\Delta E_s}_{\equiv E_a}$$



$$E_p = E_0 e^{i\omega(t - \frac{z}{c})} - \underbrace{i\omega\Delta E_0 e^{i\omega(t - \frac{z}{c})}}_{E_a}$$

$$\boxed{E_p = E_0 e^{i\omega(t - \frac{z}{c})} + \underbrace{\omega\Delta E_0 e^{i\omega(t - \frac{z}{c}) - i\frac{\pi}{2}}}_{E_a}} \qquad (9)$$

where $\Delta = \dfrac{(n-1)\,d}{c}$

n is the index of refraction

Notice: the delay due to the slowing down in the plate causes a delay in the phase of E_p relative to E_s