Physics 142 – November 29, 2005

EM Waves, Polarization

Project Scheduling: Dec. 6 + 8

Last Time –

EM wave Energy flow

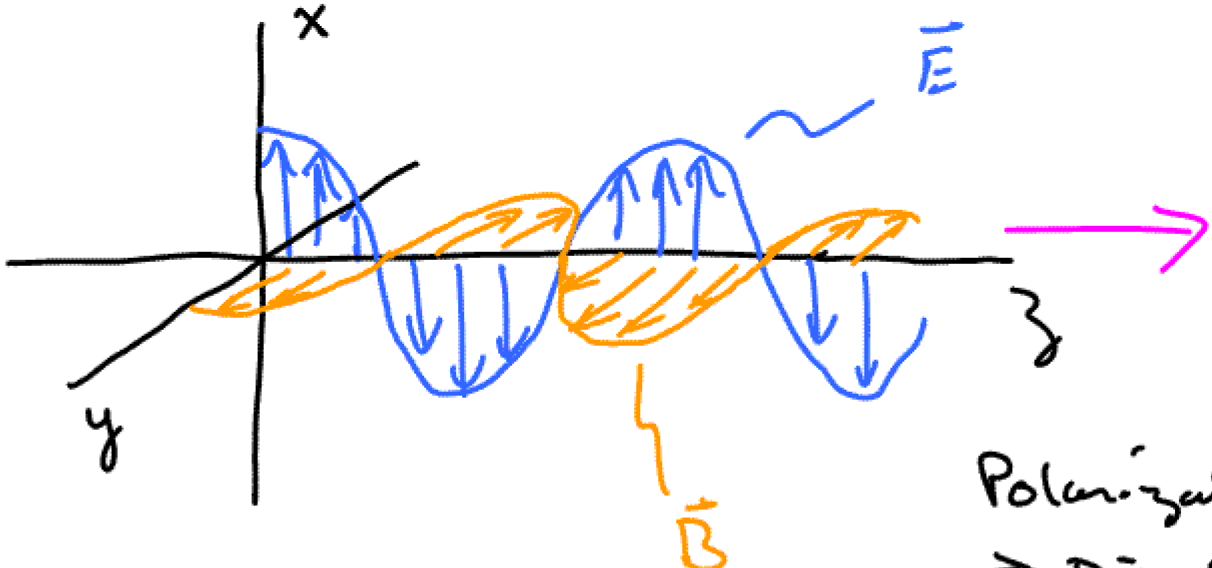
Poynting Vector $\vec{S} = \dfrac{\vec{E} \times \vec{B}}{\mu_0}$ $\qquad \dfrac{\text{Energy}}{\text{Time}} / \text{Area}$

$$\langle S \rangle = \frac{E_0^2}{2\mu_0 c} = \frac{c B_0^2}{2\mu_0} \qquad \text{Intensity}$$

Momentum in EM wave $\qquad p = \dfrac{U}{c}$ ← Energy

Radiation pressure $= \frac{S}{c}$ total absorption

Polarization



Polarization
$\rightarrow$ Dir. of $\vec{E}$ vector

$\vec{E}$ oriented along x axis

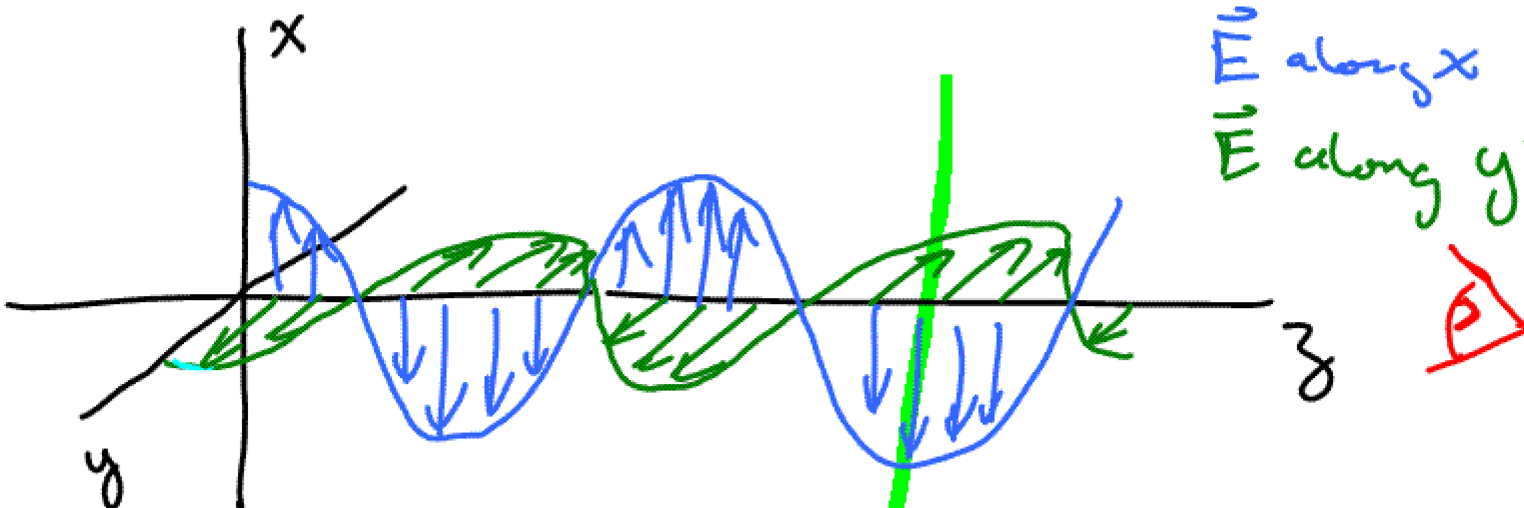
wave is polarized along x-axis

MOST general Soln

Superposition of two orthogonal waves
(basis in Mathematics)

1 – plane polarized along x-axis

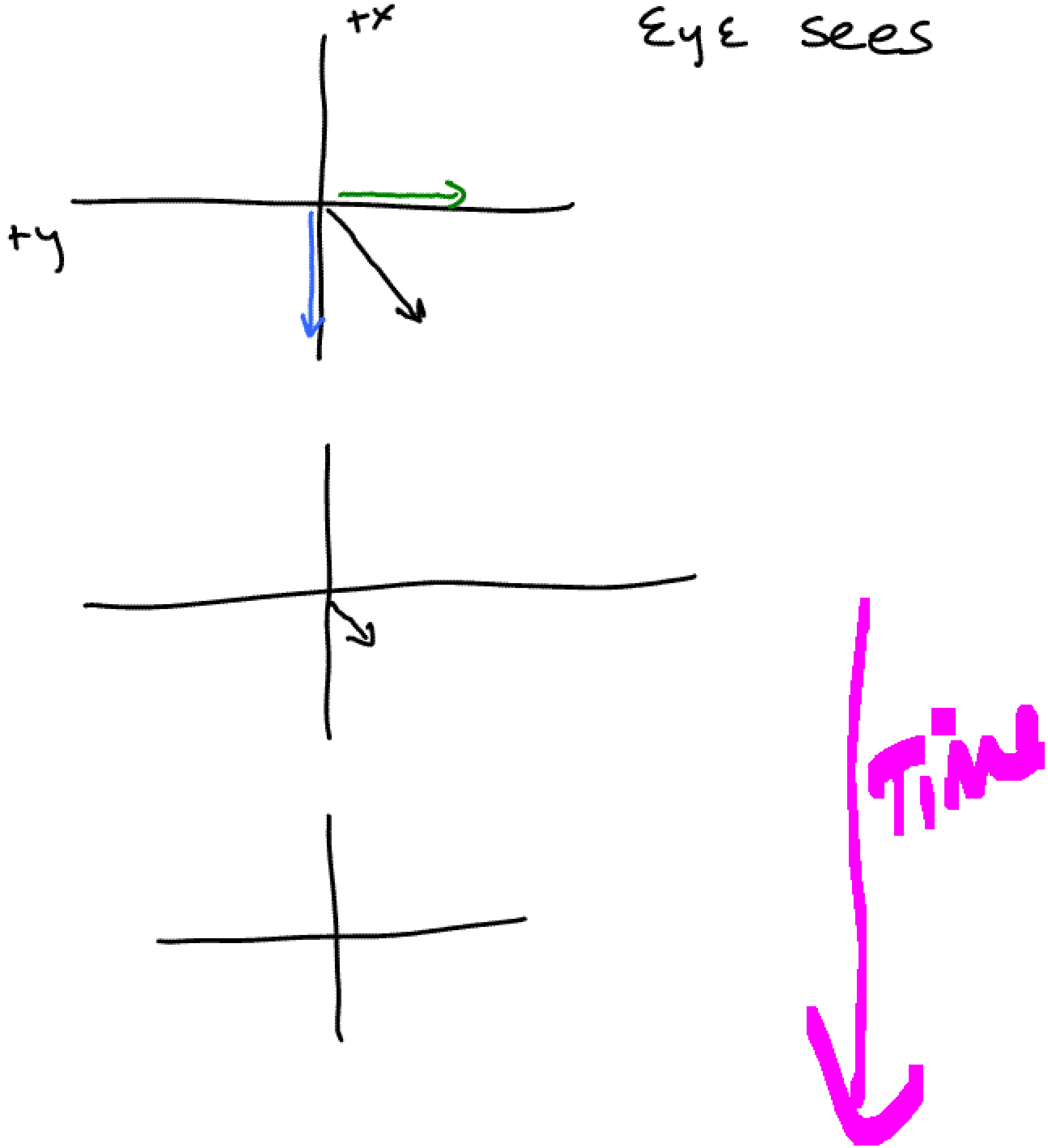
1 – " " " y-axis

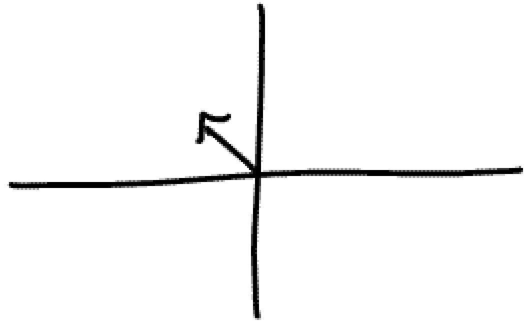


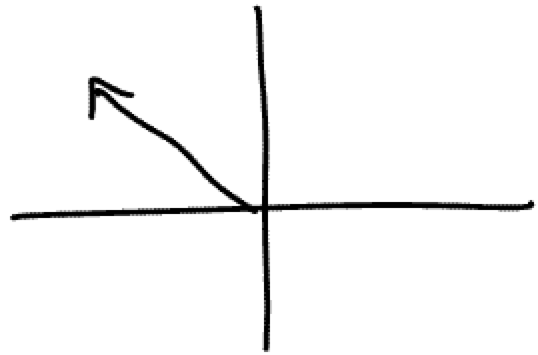
$$\vec{E}_x = E_{0x}\cos(kz-\omega t)\,\hat{i}$$

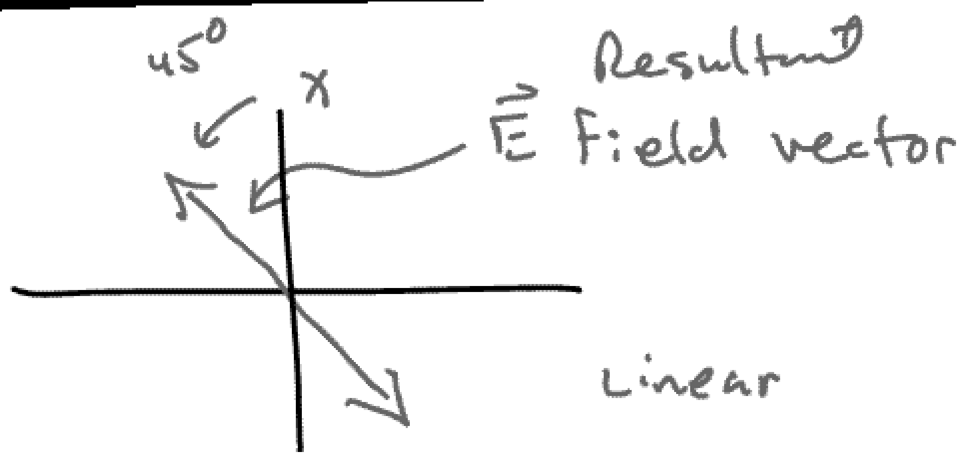
$$\vec{E}_y = E_{0y}\cos(kz-\omega t)\,\hat{j}$$

Eye sees

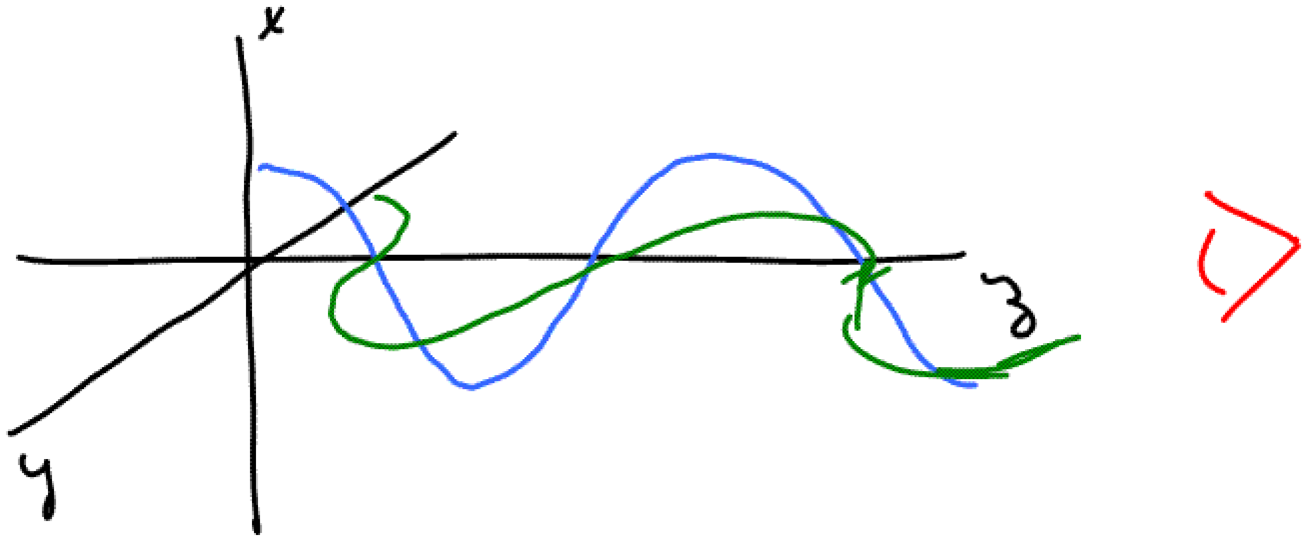






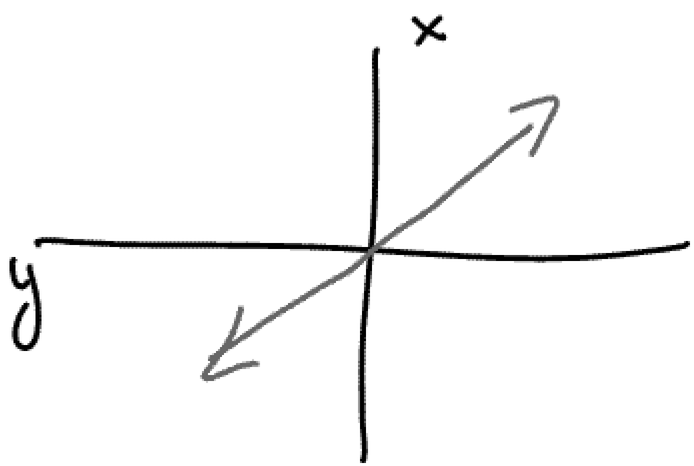


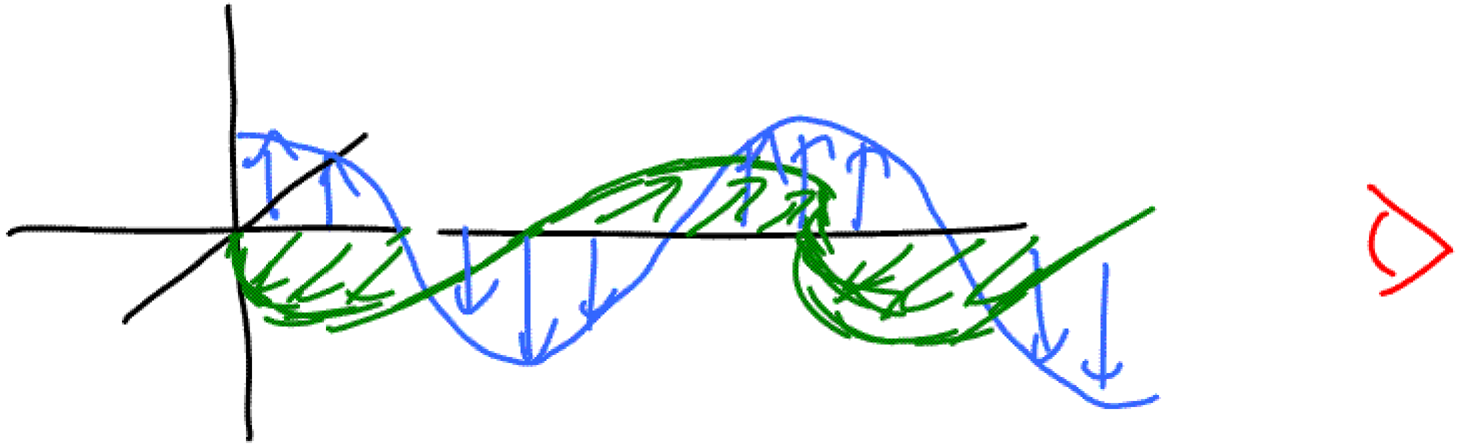
45°
x
Resultant
$\vec{E}$ Field vector
Linear



$$E_x = E_{0x} \cos(kz - \omega t)\,\hat{i}$$

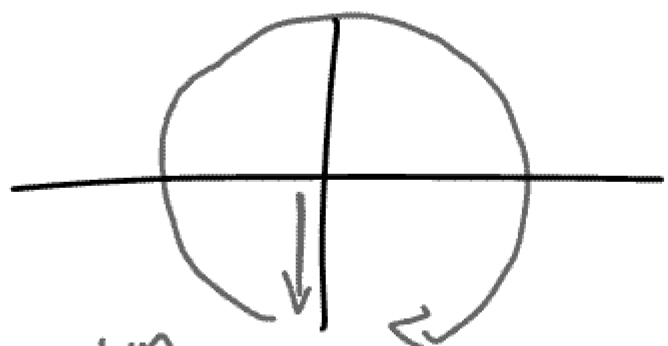
$$E_y = E_{0x} \cos(kz - \omega t + \pi)\,\hat{j}$$





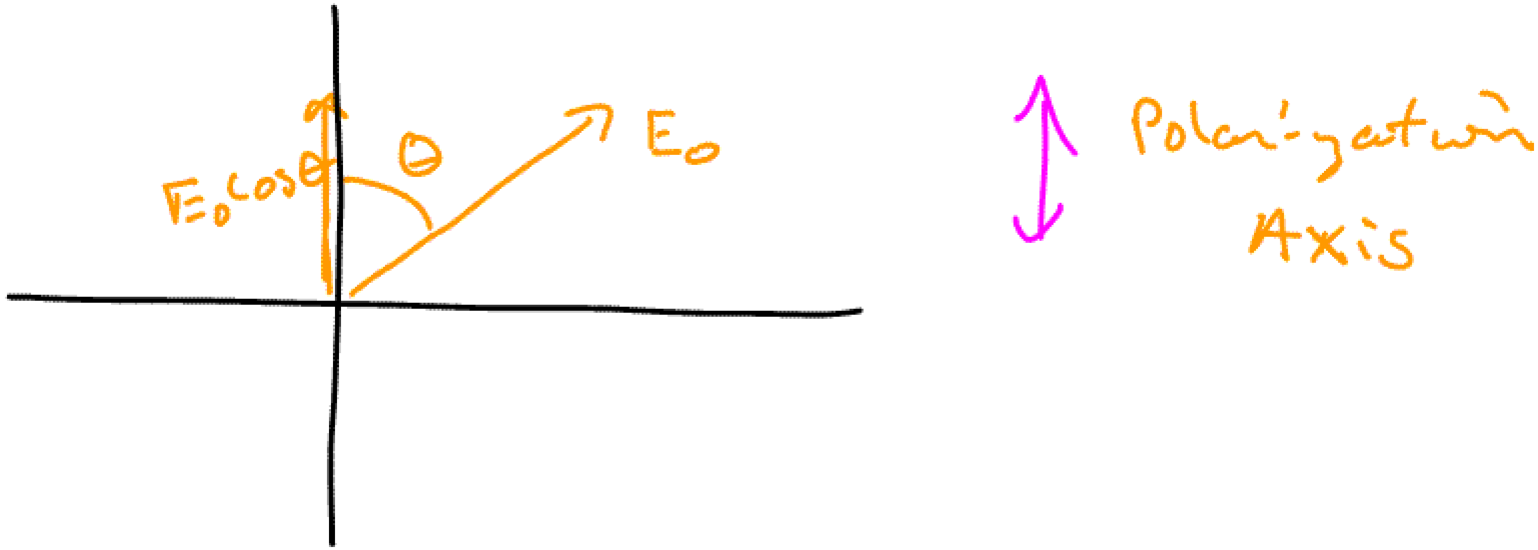
$$E_x = E_{0x} \cos(kz - \omega t)\ \hat{i}$$

$$E_y = E_{0x} \cos(kz - \omega t + \pi/2)\ \hat{j}$$

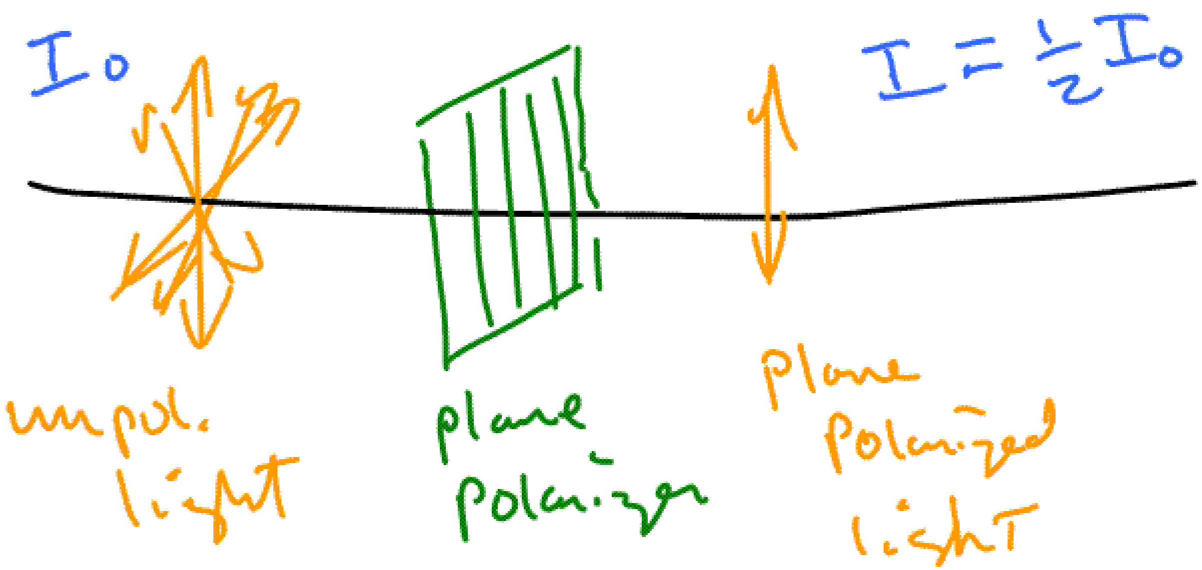


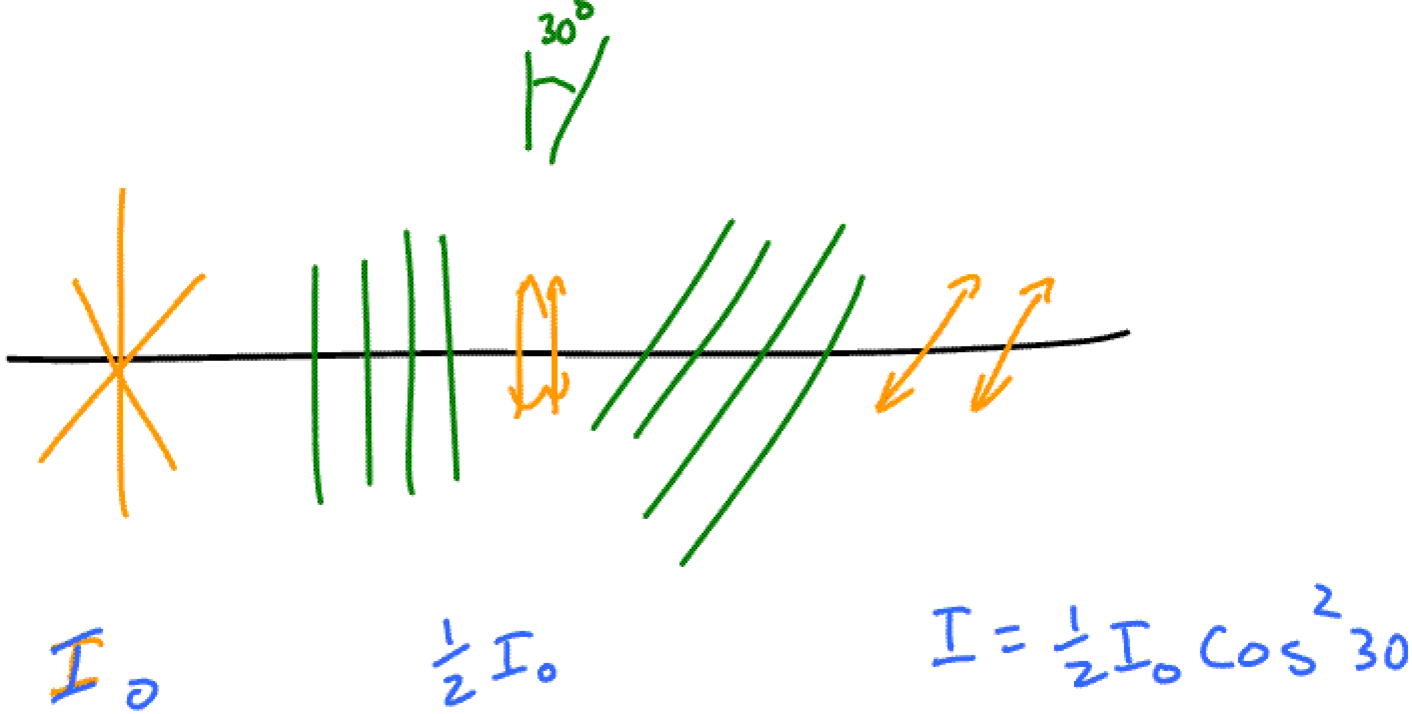
Resultant vector Rotates W/ Time

Clockwise Right circular Polarization



$$I_{new} \sim E_0^2 \cos^2\theta \sim I_{init} \cos^2\theta$$





EM waves + Laws of optics

Light in a Material

$$c = \frac{1}{\sqrt{\epsilon_0 \mu_0}} \longrightarrow v = \frac{1}{\sqrt{\epsilon \mu}}$$

$v < c$

$$\frac{c}{v} \equiv n \equiv \text{index of refraction}$$

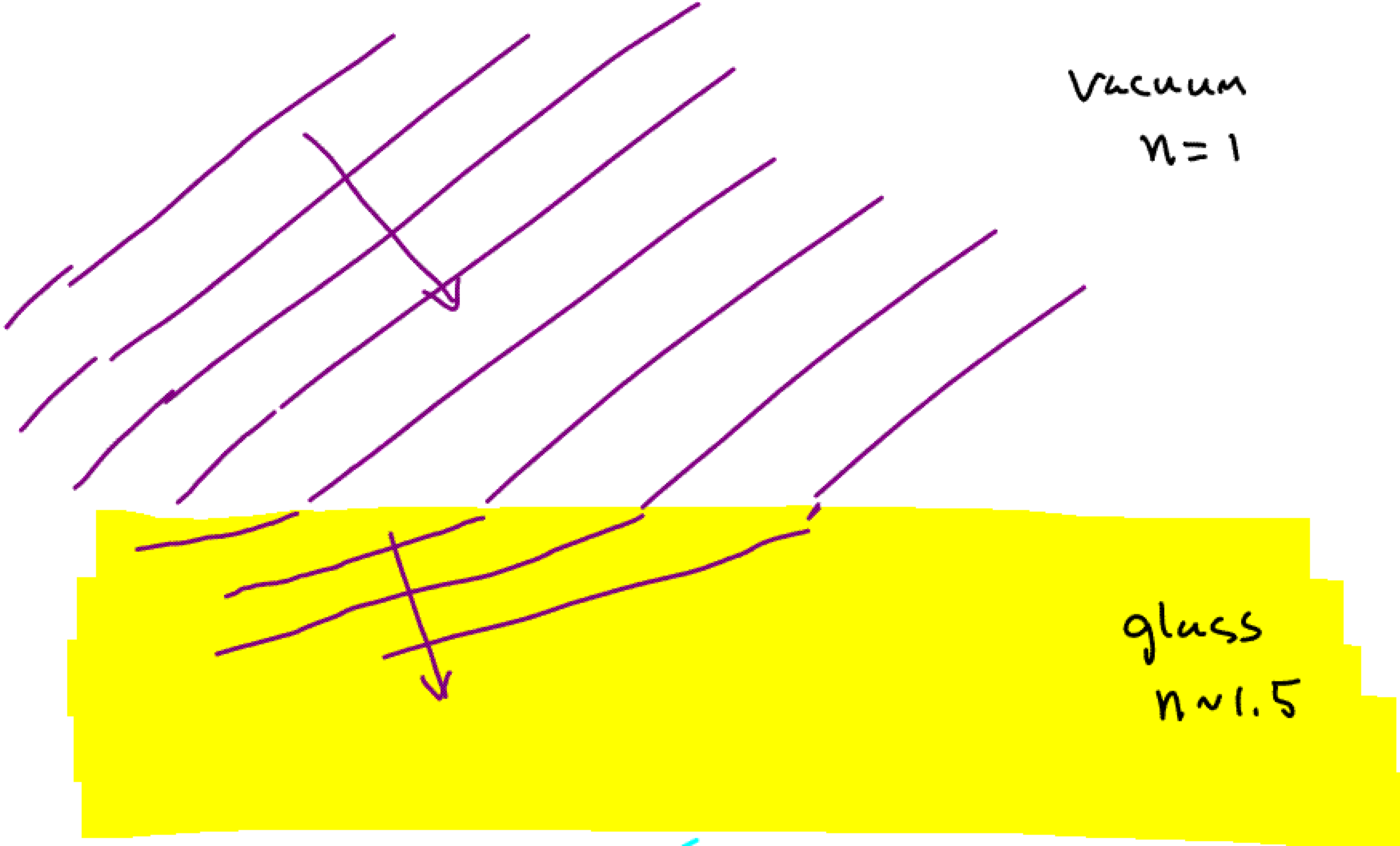
vacuum

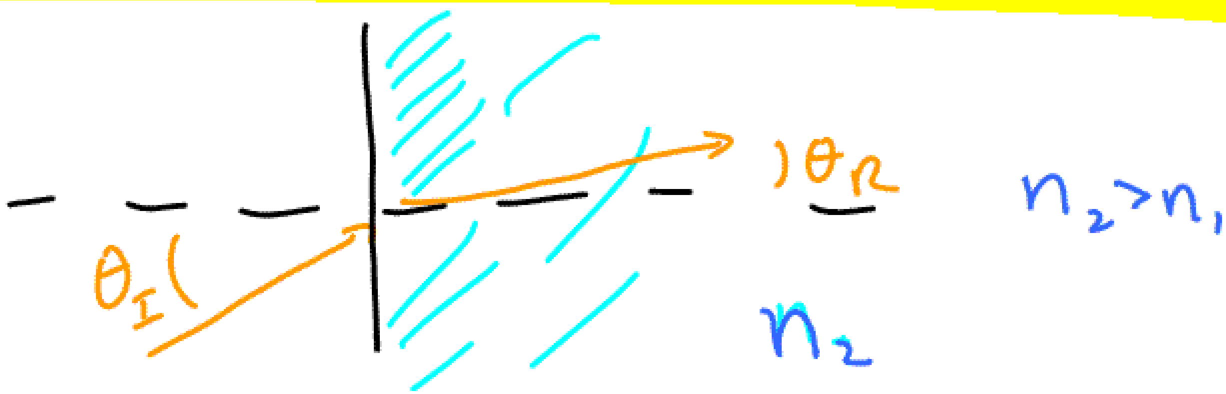
$$\lambda_0 \nu = c$$

$$\lambda \nu = v$$

$$\lambda \nu = \frac{c}{n}$$

$$\underbrace{\lambda}_{\text{in Material}} n = \frac{c}{\nu} = \underbrace{\lambda_0}_{\text{in vacuum}}$$

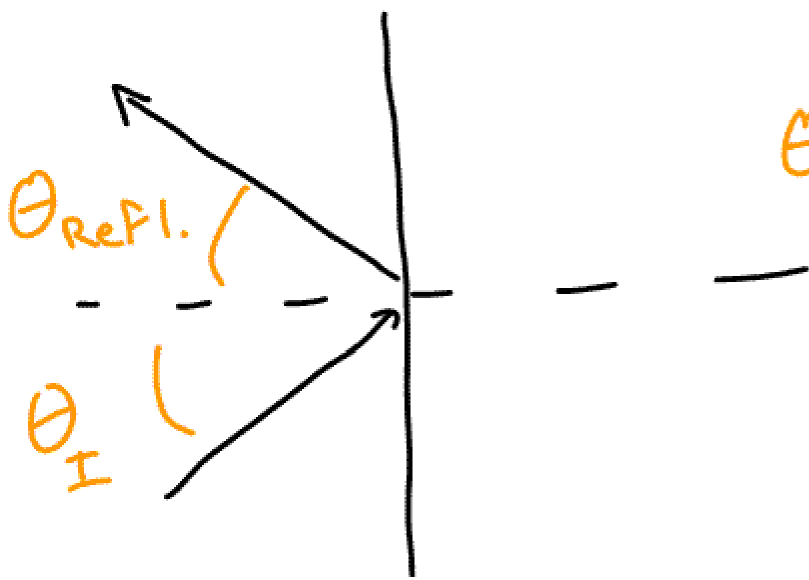

vacuum
n=1
glass
n~1.5


θ_R
$n_2 > n_1$
θ_I
n_1
n_2

Snell's law

$$n_1 \sin\theta_I = n_2 \sin\theta_R$$

Refraction



$$\theta_I = \theta_{Refl}$$