$\boxed{\text{PH 2502}}$

Introduction To Lasers

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About the Course

- format
- level
- HW
-
- textbook
- other resources (reserve books, web links)

Outline of Course

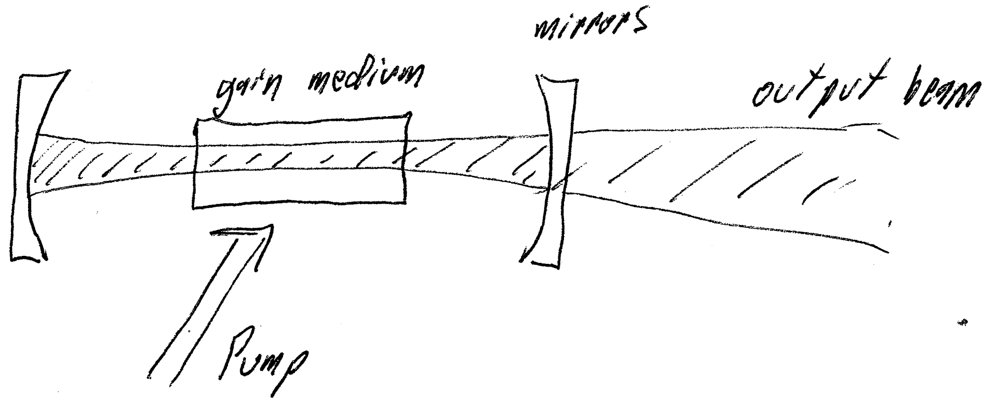
I Optics — ray optics, waves
- Beam propagation
- Resonators

II Light-Matter Interaction — semiclassical
- absorption
- emission

III Laser Characteristics
- threshold
- efficiency
- output spectrum
- tunable lasers
- pulsed lasers

IV Specific Laser Systems

LASER



oscillator: gain, feedback, power source

Consider:
1) what gain medium to use
2) how to pump
3) what type of cavity, mirrors
4) what kind of beam do we get out?
5) what is special about laser light?

Start with #5: laser light is highly coherent

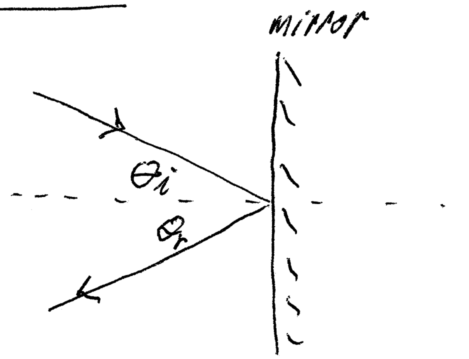
First, what is light?

optics →
- Ray optics – propagation, $D \gg \lambda$
- Wave optics – propagation, $D \sim \lambda$
- Quantum optics – light-matter interaction

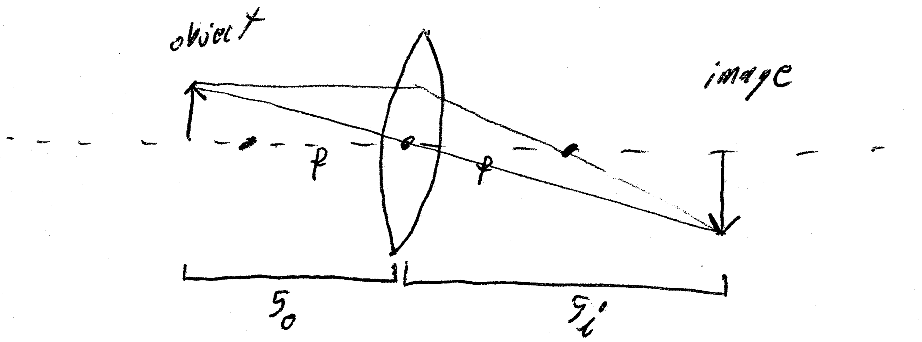
Newton: light as particle
Huygens: light as wave

} wave when propagating
particle (photon) when emitted or absorbed
$E = h\nu$

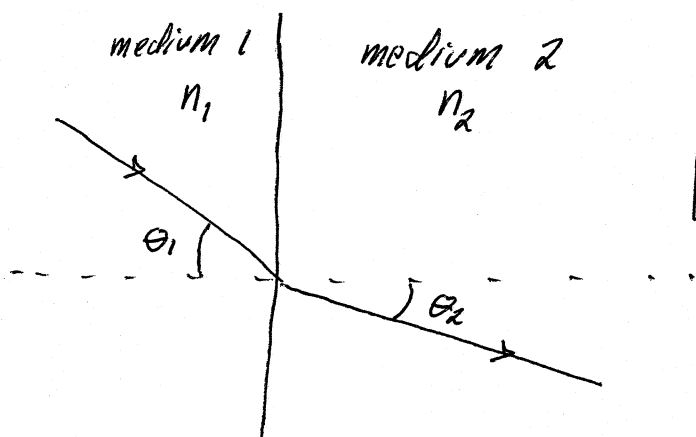
Ray Optics



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



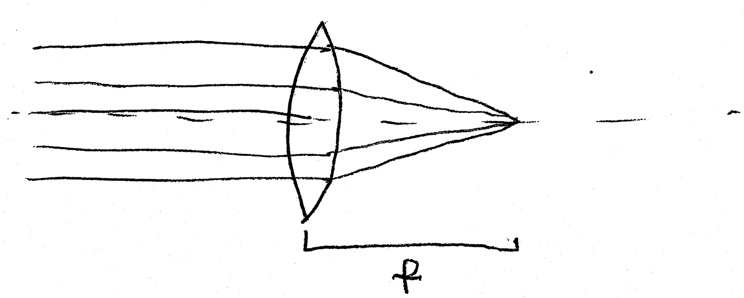
$$\boxed{\frac{1}{s_o} + \frac{1}{s_i} = \frac{1}{f}}$$



Snell's Law

$$\boxed{n_1 \sin\theta_1 = n_2 \sin\theta_2}$$

here $n_2 > n_1$

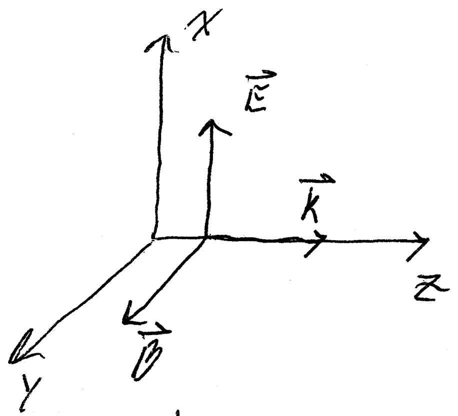


how small is focused spot?

Need wave picture to answer

Wave Optics

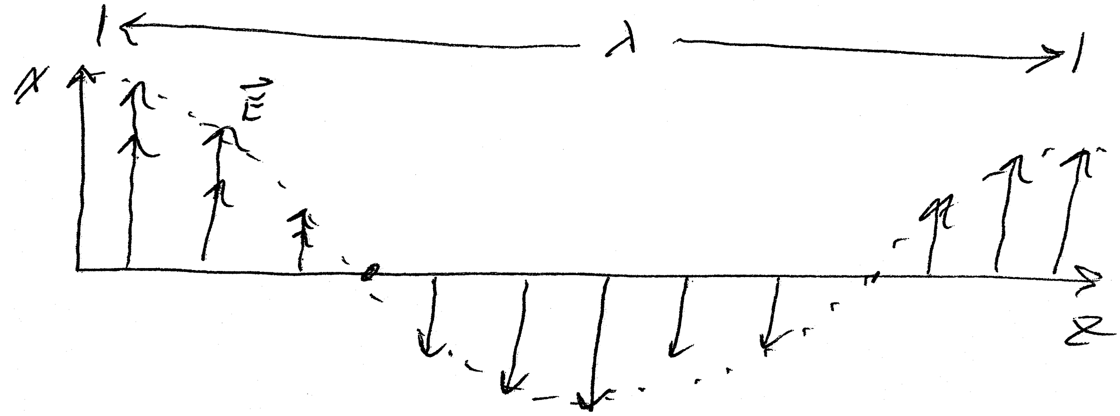
Light is propagating EM wave



$\vec{k}$: direction wave moves

polarization : direction of E

Transverse wave



$$\vec{E} = E_0 \hat{i} \cos(kz - \omega t)$$

$$k \equiv \frac{2\pi}{\lambda}$$

$$\omega \equiv 2\pi f$$

Speed of wave

$v_p = \frac{\omega}{k}$ since $z = \frac{\omega}{k} t$ for constant phase

$v_p = f\lambda$

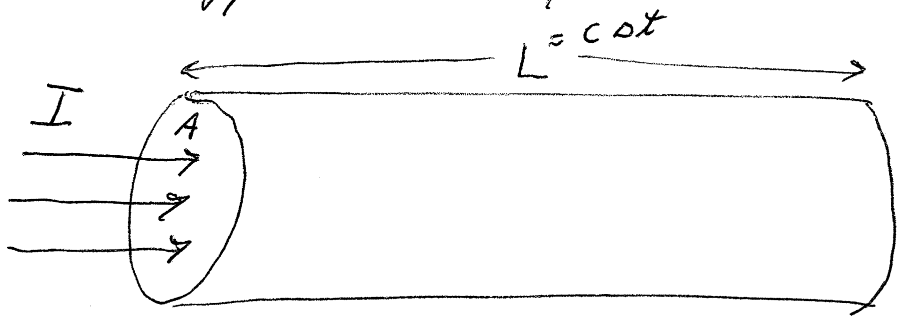
Free space : $v_p = c$

in medium : $v_p = c/n$ f stays same

$$\lambda = \frac{c}{nf}$$

Wave goes slower, has shorter λ in medium

Energy carried by EM wave



$$\rho A c \Delta t = I A \Delta t$$

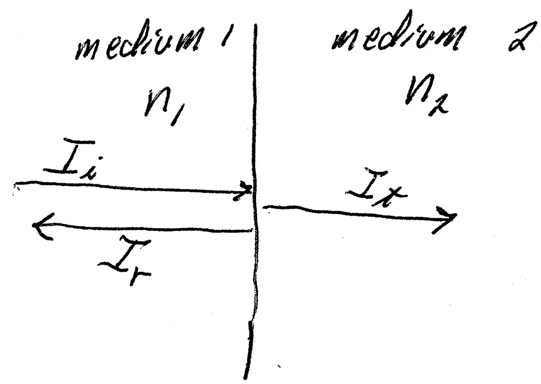
$$\therefore \; I = c\rho$$

$$\rho = \frac{\text{energy}}{\text{Vol}} = \underbrace{\frac{1}{2}}_{\langle \cos^2 \rangle}\left[\frac{1}{2}\epsilon_0 E^2 + \frac{1}{2\mu_0}B^2\right] = \frac{1}{2}\epsilon_0 E^2$$

equal

$$\boxed{I = \frac{1}{2} c \epsilon_0 E^2}$$

Reflection of Light from dielectrics



Normal incidence: $R \equiv \dfrac{I_r}{I_i} = \dfrac{(n_2 - n_1)^2}{(n_2 + n_1)^2}$

ex. $n_1 \simeq 1$, $n_2 \simeq 1.5$ (glass)

$$R \simeq 0.04$$