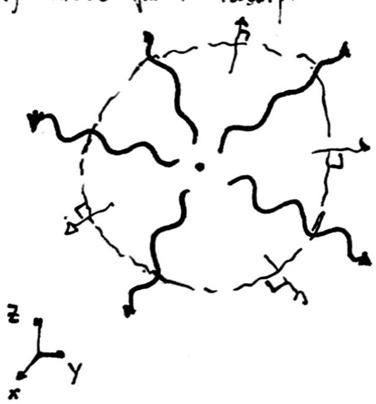
Experimental Mechanics : 24 Sept 2018

Notes on Optics

- Of the $\vec{E}$-$\vec{H}$ fields, we're going to mostly neglect magnetic field
- By wave theory of light by Maxwell, $\vec{E}$ & $\vec{H}$ fields are in phase & orthogonal with waves being transverse to travel
- Parameters
  - → λ : wavelength
  - → f : frequency

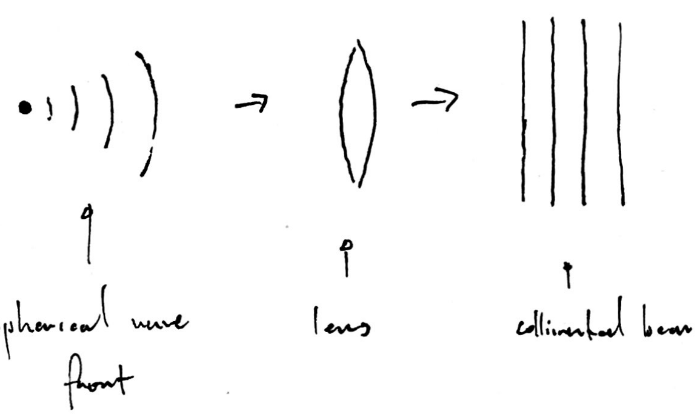
  } $\lambda f = c$; note that only monochromatic light associated to a singular λ - most a spread
- Wave Theory of light
  1) Wave front description



- The region of same phase expands as a sphere, given an optically homogenous medium
- Spherical Region is the wavefront
- Rays pass though wave front orthogonal to surface which indicates direction of energy travel

→ with travel, the wavefront surface can be approximated as planar

→ a lens can change the shape of the wave front



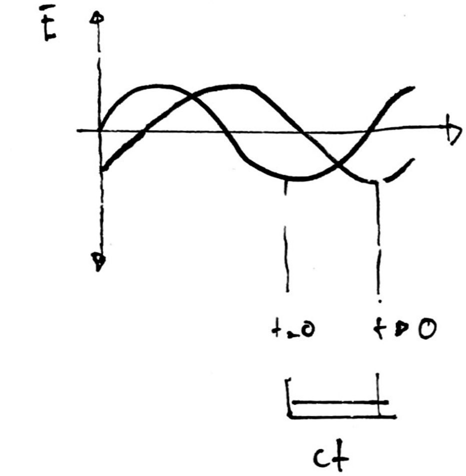
· Wave Equation

→ $E = f(z - ct) + g(z + ct)$: general as not necessarily sinusoidal

positive z $\quad$ z^-

magnitude of light as function of distance traveled & t: time

→ Optical Effects



Amplitude: A

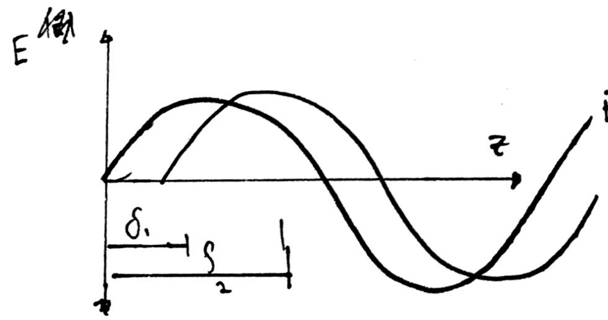
$$E = f(z - ct)$$
$$= A\cos\left(\frac{2\pi}{\lambda}(z - ct)\right)$$

↳ $T = \lambda / c = 1/f \; ; \; f = \frac{\omega}{2\pi}$

↳ Wave Number $\xi = 2\pi/\lambda$

ξ should be "xi"

· Wave Interaction



$$\left.\begin{aligned} E_1 &= a_1 \cos\left(\frac{2\pi}{\lambda}(z - ct)\right) \\ E_2 &= a_2 \cos\left(\frac{2\pi}{\lambda}(z - ct)\right) \end{aligned}\right\} \text{for } a_1 = a_2$$

$$\left.\begin{aligned} &\delta_1 : \text{initial phase of } E_1 \\ &\delta_2 : \text{initial phase of } E_2 \end{aligned}\right\} \delta \text{ is the linear phase difference} : \delta = \delta_2 - \delta_1$$

Use of superposition to measure is basis of Moiré, photoelasticity, and interferometry

$$\left.\begin{aligned} E_1 &= a_1 \cos\left(\frac{2\pi}{\lambda}(z_0 + \delta_1 + ct)\right) = a_1 \cos(\phi_1 - \omega t) \\ E_2 &= a_2 \cos\left(\frac{2\pi}{\lambda}(z_0 + \delta_2 + ct)\right) = a_2 \cos(\phi_2 - \omega t) \end{aligned}\right\} \phi_i = \frac{2\pi}{\lambda}(z_0 - \delta_i)$$

→ if in same plane, we can write

$$E = E_1 + E_2 = a\cos(\phi - \omega t)$$

- $a^2 = a_1^2 + a_2^2 + 2a_1a_2\cos(\phi_2 - \phi_1)$
- $\phi = \tan^{-1}\left(\dfrac{a_1\sin\phi_1 + a_2\sin\phi_2}{a_1\cos\phi_1 + a_2\cos\phi_2}\right)$

Resultant "E" has the same frequency but $a(a_1, a_2, \phi_1, \phi_2)$ and $\phi(a_1, a_2, \phi_1, \phi_2)$

→ Special Case of $a_1 = a_2$: $a^n = \sqrt{4a_0^2\cos^2\frac{\pi\delta}{\lambda}}$; $a \propto \sqrt{I}$; I : intensity

$I \propto a^2$

$\propto 4a^2\cos^2\left(\frac{\pi\delta}{\lambda}\right)$ so that as intensity changes its a function of the phase difference only

I_{max} is when $\{\delta = n\lambda,\ n \in \mathbb{I}\} \rightarrow I_{max} = 4a^2$

I_{min} $\{\delta = \frac{2n+1}{2}\lambda,\ n \in \mathbb{I}\} \rightarrow \frac{1}{2}, \frac{3}{2}, \frac{5}{2} \ldots = 0$

+ these equations are the basis of interference methods