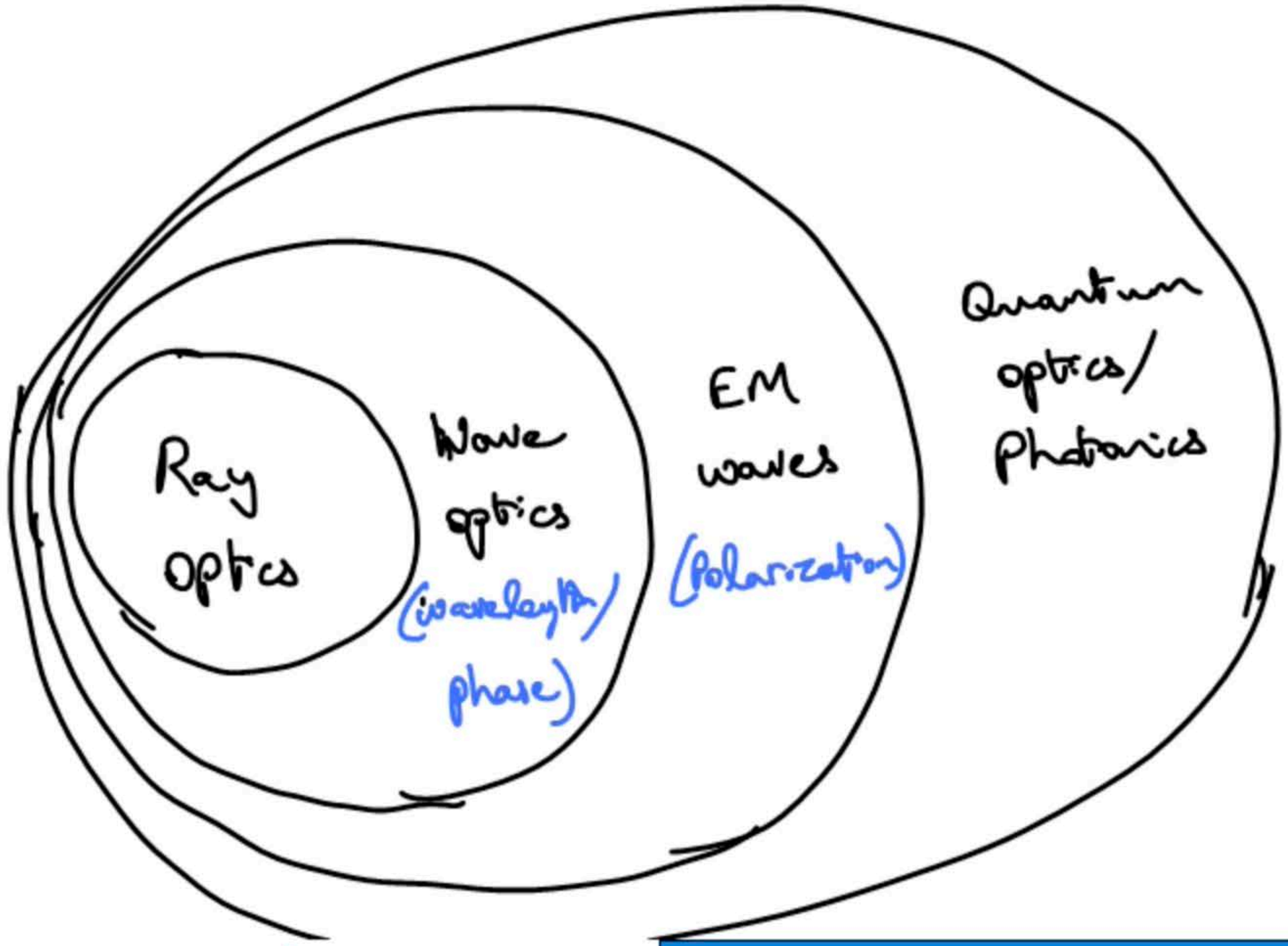
Photonics → Properties of photons/light
→ Generation/detection of photons
→ Manipulation of photons



Fermat, 1600s → light travels in straight lines

Huygens, mid-1600s → light travels as waves

Maxwell, mid-1800s → light travels as EM waves

Planck, 1900 → light emission/absorption is quantized

Einstein, 1905 → light comprises of quanta of energy (photons)

Note2 - Windows Journal

File Edit View Insert Actions Tools Help

Learning Outcome: Identify the limits of ray optics and the fundamental concepts of wave optics

8/2/2018

EE5500 - Introduction to Photonics

Identify the fundamental principles of photonics and light-matter interactions

Develop the ability to formulate problems related to photonic structures/processes and analyze them

Identify processes that help to manipulate the fundamental properties of light

I. Photonics - Fundamentals	**Schedule**	**Lab Session**	**Class TA**	**Lab TA**
1. Wave/particle duality	Week 1	Diffraction of light	Bagath	Nirjhar
2. Statistical properties of light, Coherence	Week 2	Michelson interferometer	Fredy	Srinivas
3. Photon properties - energy, flux, statistics	Week 3	Coupling laser light into optical fiber	Bagath	Fredy
4. Interaction of photons with atoms	Week 4	Light absorption & filtering	Srinivas	Bagath
5. Light amplification	Week 5	Optical amplifiers (EDFA)	Nirjhar	Srinivas
	Quiz I (20%)			
II. Semiconductor light sources & detectors				
1. Laser Fundamentals	Week 6		Srinivas	
2. Junction devices	Week 7	Fiber ring laser	Fredy	Bagath
3. Semiconductor light sources	Week 8	Optical sources	Nirjhar	Fredy
4. Semiconductor light detectors	Week 9	Optical detectors	Nirjhar	Fredy
	Quiz II (20%)			
III. Manipulation of photons				
1. Interaction with RF and acoustic waves	Week 10	Malus law	Bagath	Nirjhar
2. Nonlinear behavior of materials	Week 11	EOM characterization	Srinivas	Bagath
	Lab (30%)	Mini-Quiz (5)+Reports (10)+Viva (15)		
	Final (30%)			

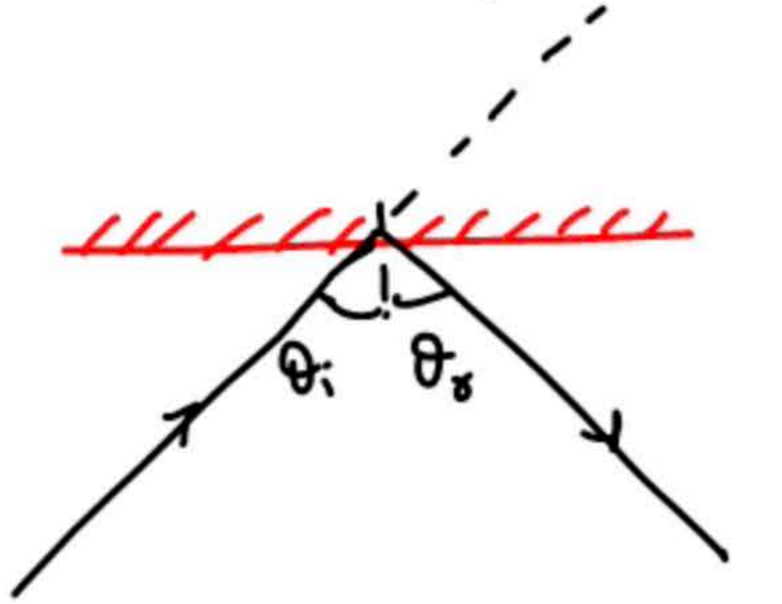
Text: Saleh & Teich, "Fundamentals of Photonics", Wiley Interscience, Second edition
Reference: Ben Streetman, "Solid State Electronic Devices", Prentice Hall, Sixth edition
Reference: Yariv & Yeh, "Photonics", Oxford Press, Sixth edition
Reference: Eugene Hect, "Optics", Addison Wesley, Second edition

Teaching Assistants

Bagath	ee16d033@smail.iitm.ac.in
Fredy	ee14d020@ee.iitm.ac.in
Nirjhar	ee15s076@ee.iitm.ac.in
Srinivas	ee14d209@ee.iitm.ac.in

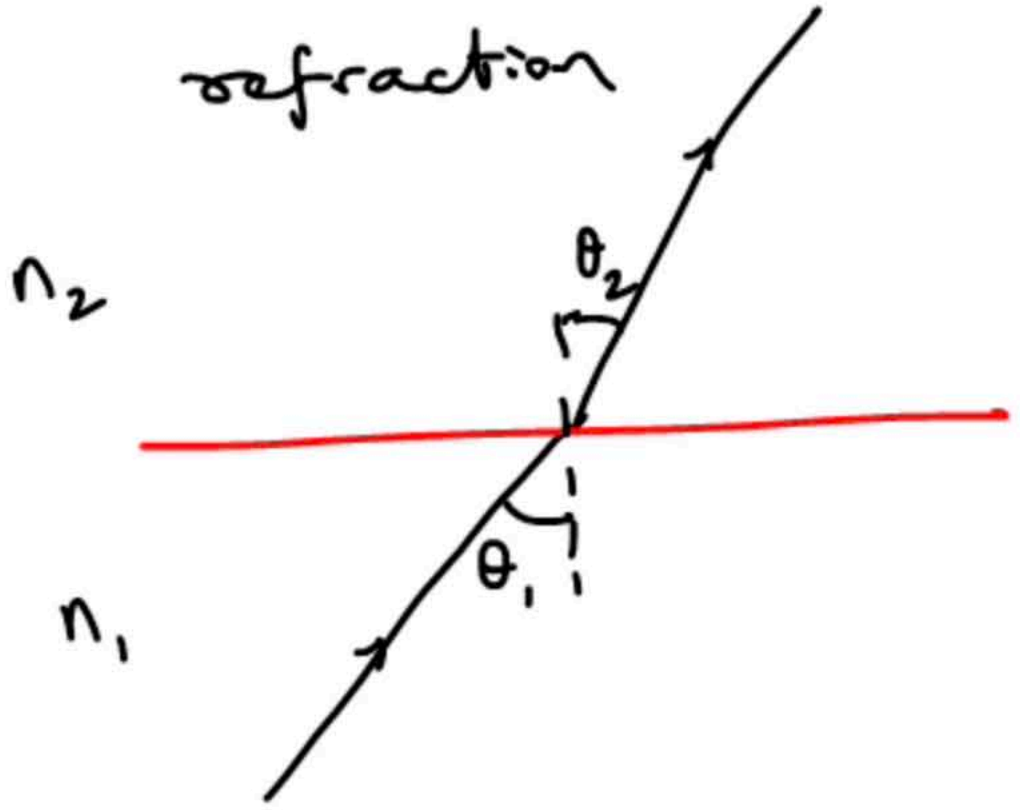
Endoscopy $\rightarrow$ optical probe

Law of reflection



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

Law of refraction



Snell's law

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

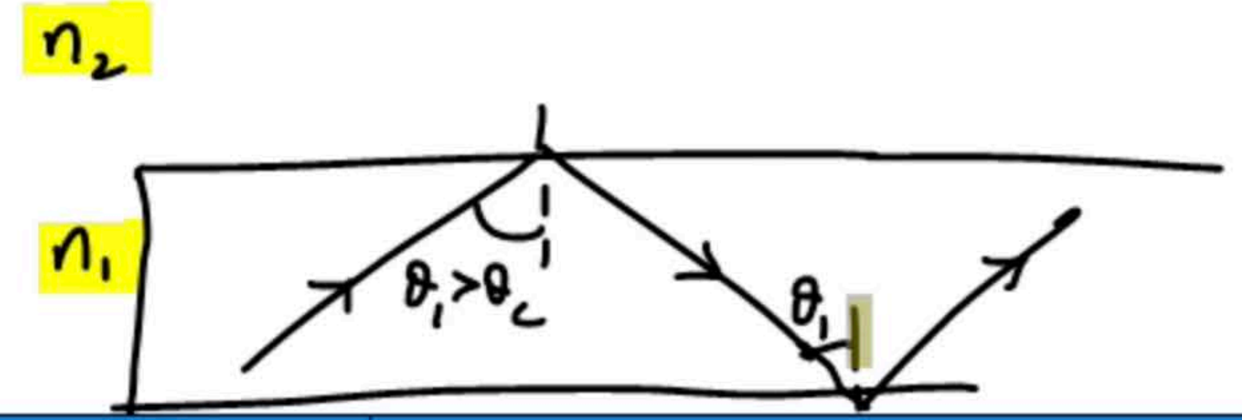
$n_1 > n_2 \implies \theta_2 > \theta_1$

$\theta_1 = \theta_c \rightarrow \theta_2 = \pi/2$

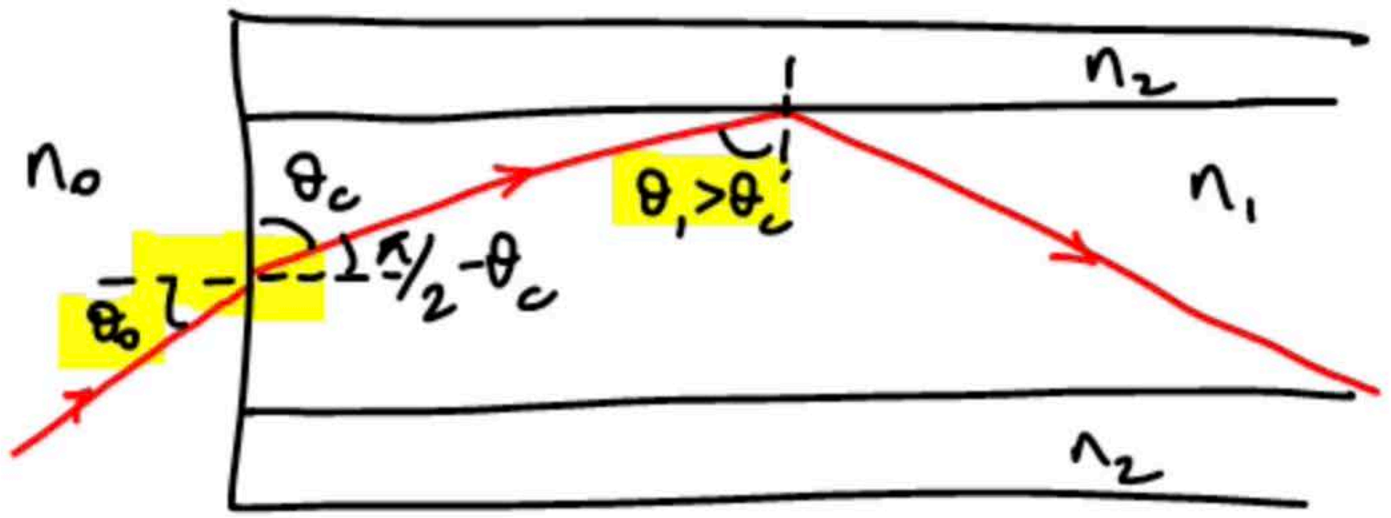
$$n_1 \sin\theta_c = n_2 \sin(\pi/2)$$
$$= n_2$$

$$\boxed{\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)}$$

If $\theta_1 > \theta_c \rightarrow$ Total Internal Reflection



Numerical Aperture



Ray optics

Dispersion in prism

Optical system design

Hubble Telescope

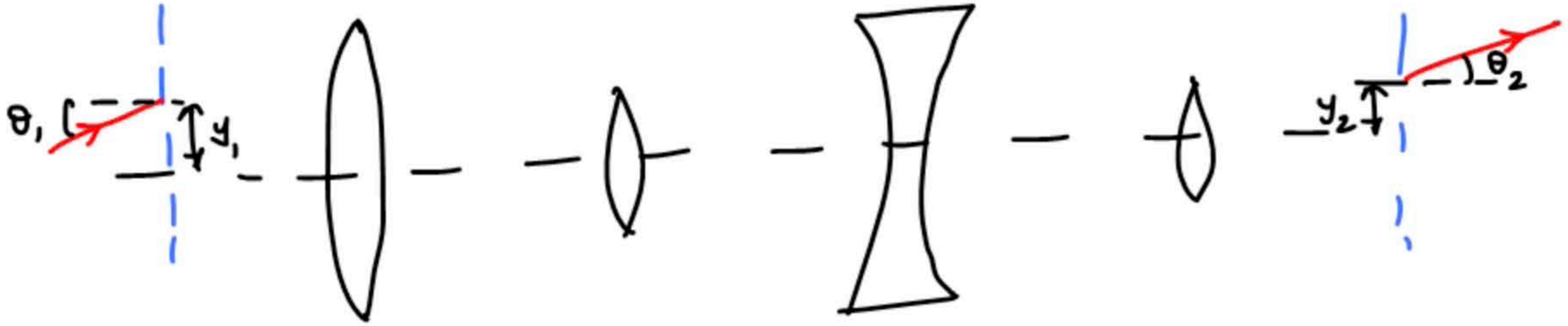
What is the largest value of θ_0 ?

$\rightarrow$ $\theta_1 = \theta_c$

$$n_0 \sin\theta_0 = n_1 \sin\left(\frac{\pi}{2} - \theta_c\right) = n_1 \cos\theta_c$$

$$= n_1\sqrt{1 - \sin^2\theta_c} = n_1\sqrt{1 - \left(\frac{n_2}{n_1}\right)^2}$$

If $n_0 = 1$, $\boxed{\sin\theta_0 = \sqrt{n_1^2 - n_2^2}}$



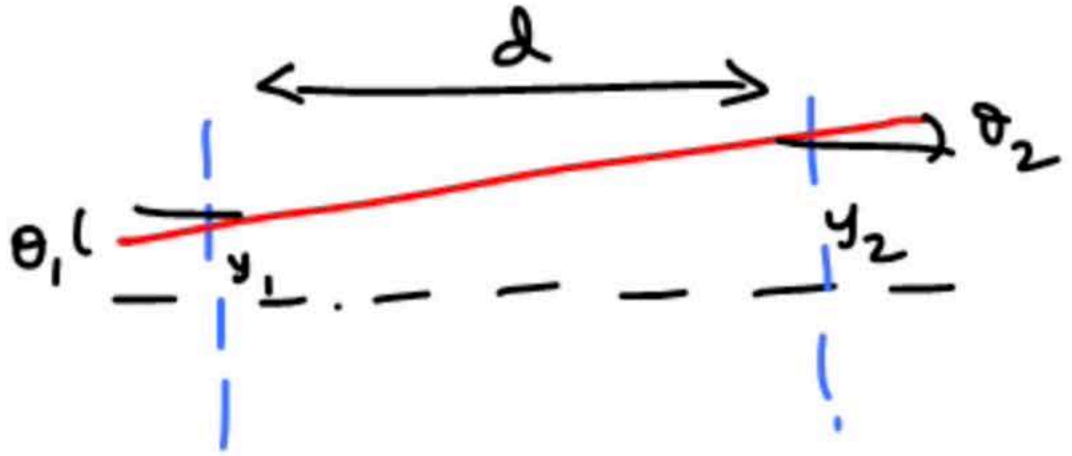
$$y_2 = A y_1 + B\theta_1$$

$$\theta_2 = C y_1 + D\theta_1$$

$$\Rightarrow \begin{pmatrix} y_2 \\ \theta_2 \end{pmatrix} = \begin{pmatrix} A & B \\ C & D \end{pmatrix} \begin{pmatrix} y_1 \\ \theta_1 \end{pmatrix}$$

$\downarrow$

Ray Matrix



$$\theta_2 = \theta_1$$

$$y_2 = y_1 + d\theta_1$$

$$\Rightarrow \begin{bmatrix} 1 & d \\ 0 & 1 \end{bmatrix}$$

$$M = M_N M_{N-1} \cdots M_1$$

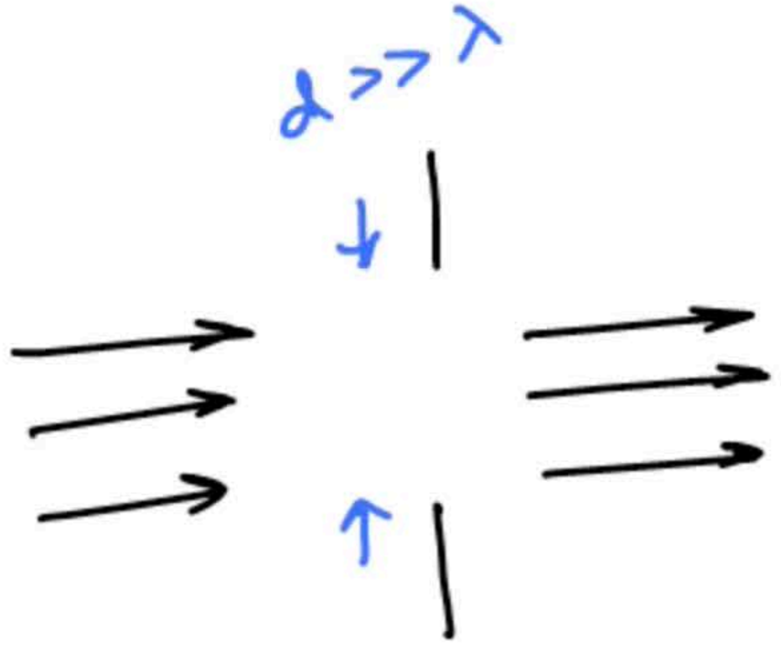
Paraxial approximation

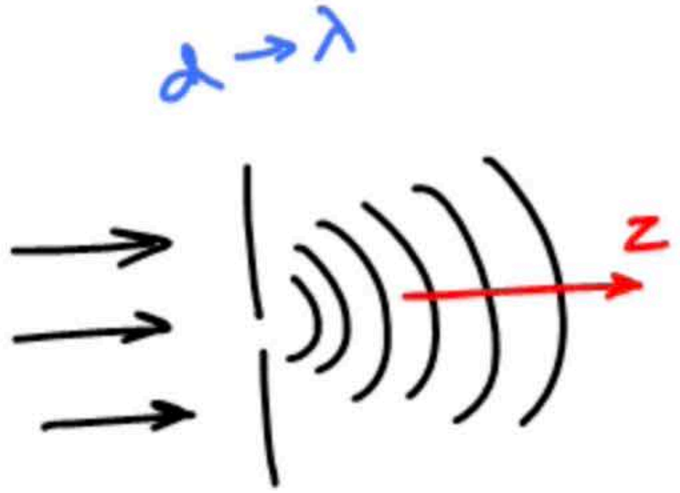
$$\sin\theta \simeq \theta \Rightarrow n_1\theta_1 = n_2\theta_2$$

Note Title 8/2/2018

Learning Outcome: Identify the limits of ray optics and the fundamental concepts of wave optics

Diffraction of light





Pebble dropped in water

Sound from a loudspeaker

Wave Equation $$\nabla^2 U - \frac{1}{c^2}\frac{\partial^2 U}{\partial t^2} = 0$$

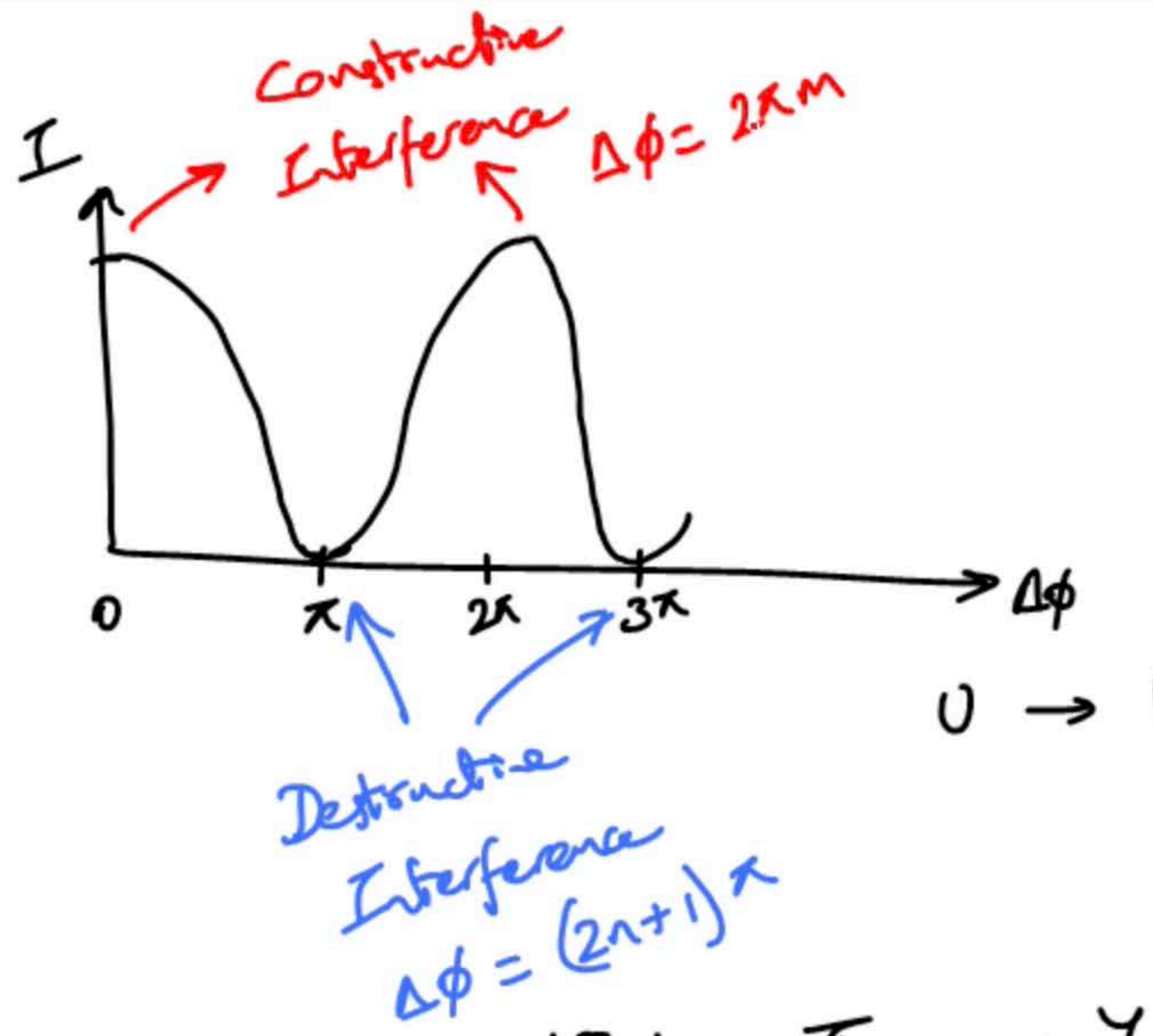
In EM
$U \to E/H$

Time-periodic signals.

$$U(x, y, z, t) = U(x, y, z)\, e^{j\omega t}$$

$$k = \frac{\omega}{c} = \frac{2\pi f}{c} = \frac{2\pi}{\lambda}$$

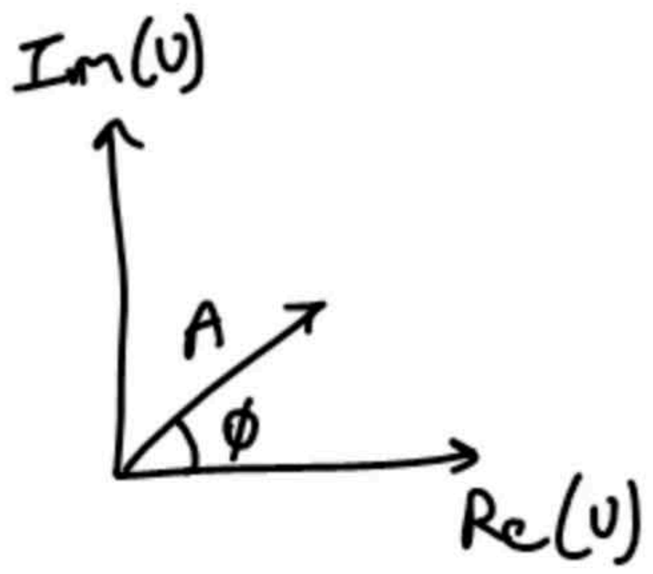
$$\frac{\partial}{\partial t} \to j\omega \qquad \frac{\partial^2}{\partial t^2} \to -\omega^2 \Rightarrow \boxed{\nabla^2 U + k^2 U = 0}$$

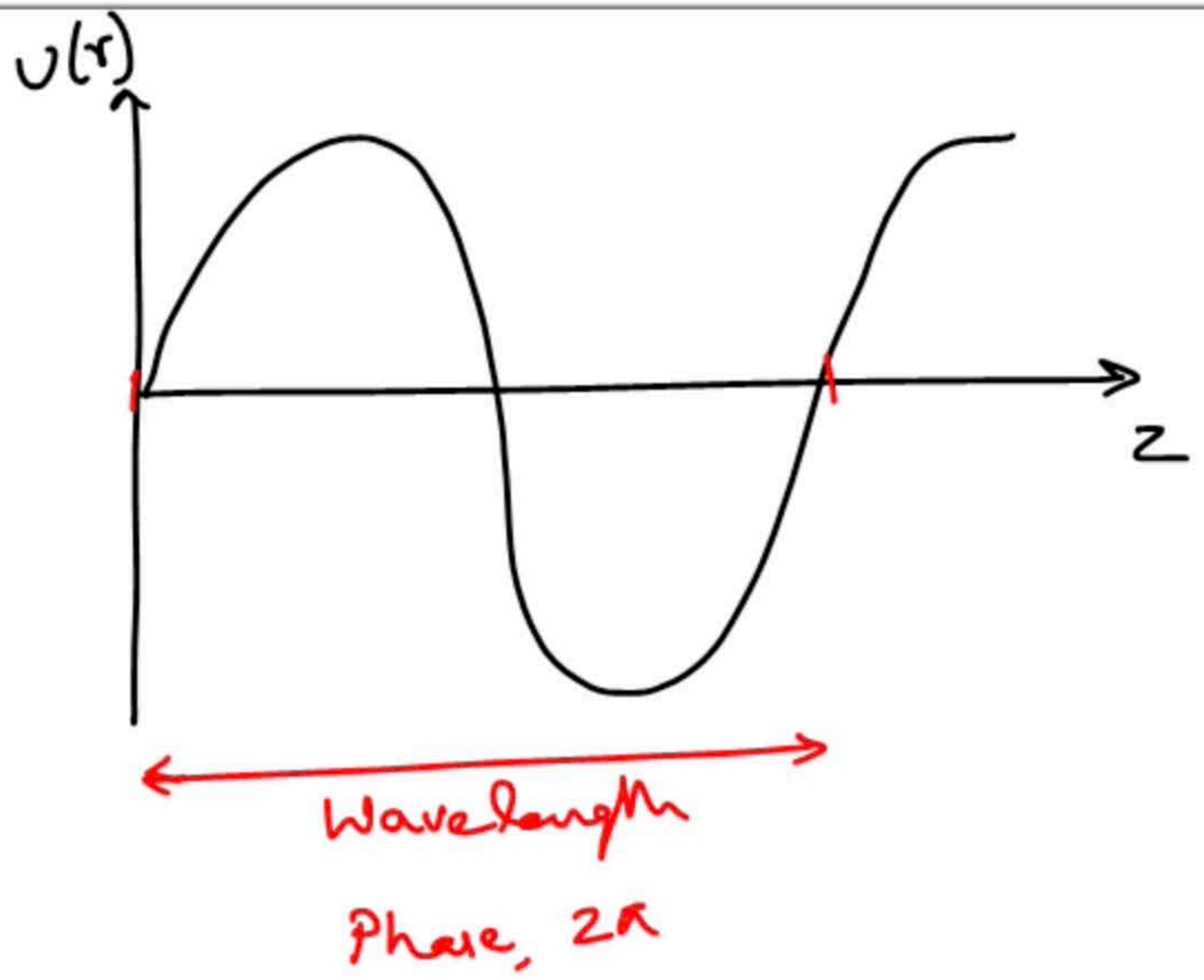


$$U(r) = A(r)\, e^{-jkz}\, e^{j\omega t}$$

Phase

$$U \rightarrow \text{Phasor} \rightarrow A e^{j\phi}$$



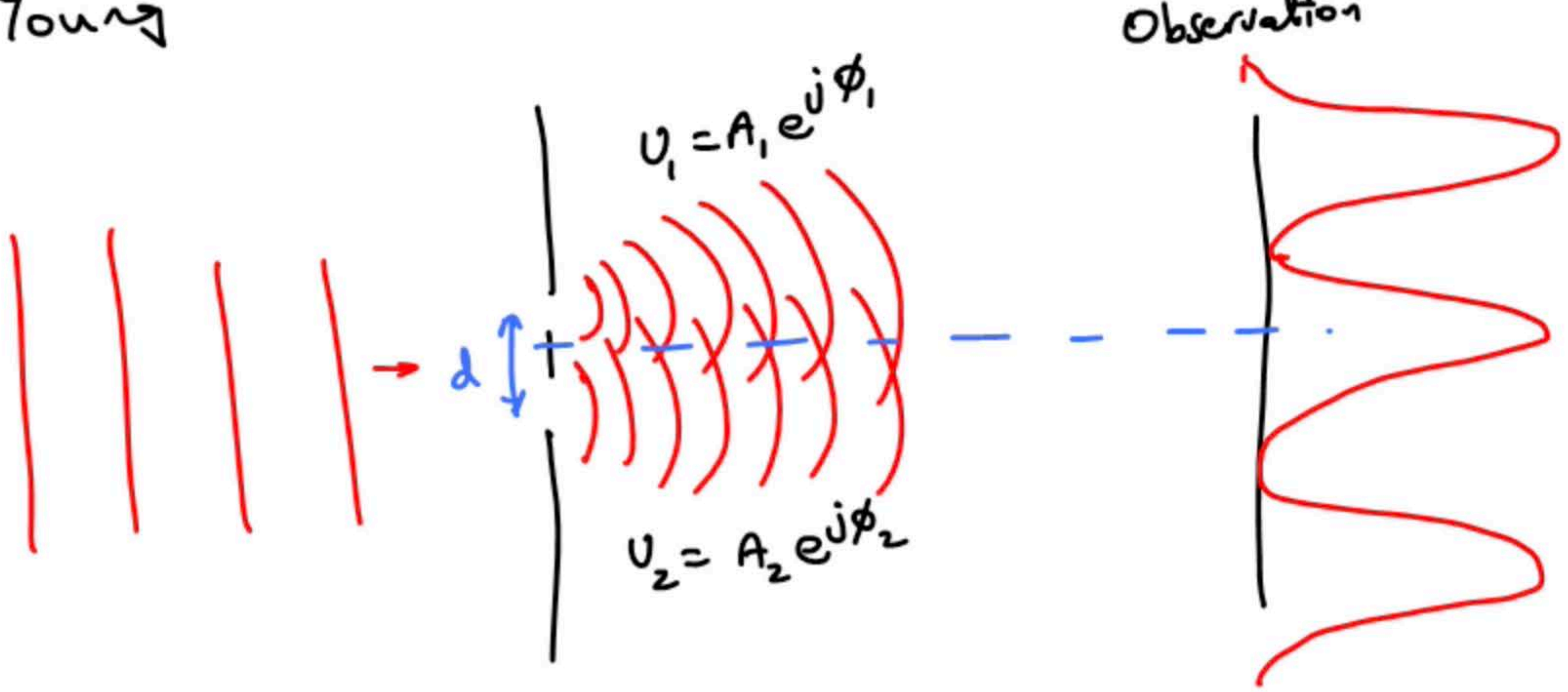


1801, Thomas Young

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos(\phi_1 - \phi_2)$$

If $I_1 = I_2 = I_0$

$$\boxed{I = 2I_0\,(1 + \cos\Delta\phi)}$$



$$I = |U|^2 = |U_1 + U_2|^2$$

$$= |U_1|^2 + |U_2|^2 + U_1 U_2^* + U_1^* U_2$$

$$= I_1 + I_2 + \sqrt{I_1 I_2}\, e^{j(\phi_1 - \phi_2)} + \sqrt{I_1 I_2}\, e^{-j(\phi_1 - \phi_2)}$$