Lecture 1: Optics - basics

Reference Book: **Optics by Ajoy Ghatak, 6E**

Chapter 1, History of Optics

Chapter 2, What is light, A Brief history

2.1 Introduction
2.2 The corpuscular Model of light
2.3 The wave model
2.4 Maxwell’s Electromagnetic Waves

Optics is the branch of physics that deals with the behaviour and properties of **light**.

What is light ?

Properties?

Sources?

Parameters to describe?

Mathematical representation?

Usages?

Light is an electromagnetic radiation that can be perceived by the human eye.

History of optics

Ancient Indian Theories	Euclid	Galileo	Grimaldi	Robert Hooke
Speed of light, Reflections etc	~ 300 BC Geometry of vision	~ 1609 Use of telescope for astronomy	~ 1660 Discovered diffraction of light	~ 1664 Studied interference patterns

One of the great debates in physics

1690 - 1924

Light is particle or wave?

Christiaan Huygens	Isaac Newton	Thomas Young	James Clerk Maxwell	Albert Einstein	Louis de Broglie
1690 Light as waves	1704 Light as corpuscles (little particles)	1801 Demonstrated wave nature of light	1864 Light as electromagnetic waves	1905 Light consists of quanta of energy	1924 All matter have wave properties

Corpuscular model of light

Newton believed light as corpuscular (little particles). He wrote:

Are not the rays of light very small bodies emitted from shining substance?

Why?

- Formation of sharp shadows
- Light could propagate in vacuum
- Snell's law can be derived from conservation of energy and momentum

Wave model of light

Huygens proposed wave theory of light & **Thomas Young** confirmed it.

What is wave?

Propagation of disturbances (without any translation of the medium in the direction of medium) is terms as wave

A sine wave can be represented as: $y(x,t) = A\sin(kx - \omega t + \varphi)$

Thomas Young's interference experiment confirmed wave nature of light in 1801

Waves follow principle of superposition

Light also follow principle of superposition

Light added to light can produce darkness

Water waves

Sound waves

Maxwell's Electromagnetic (EM) waves

Faraday's law: A time varying magnetic field induces an electromotive force

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

Ampere's law: A time varying electric field can also create a magnetic field

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{j} + \frac{1}{c^2}\frac{\partial \mathbf{E}}{\partial t}$$

Maxwells predicted the existence of EM waves

Plane wave solution of maxwell's equation:

$$E(z,t) = \hat{x}E_o \cos(kz - \omega t)$$
$$H(z,t) = \hat{y}H_o \cos(kz - \omega t)$$

where $H_o = \sqrt{\frac{\epsilon_o}{\mu_o}}E_o$ and $c = \frac{\omega}{k} = \frac{1}{\sqrt{\mu_o \varepsilon_o}} \approx 3 \times 10^8 m/s$

Electromagnetic waves

- Radio waves,
- microwaves,
- infrared radiation,
- visible light,
- ultraviolet radiation,
- X-rays,
- gamma rays

What is photon?

As quanta of light, photons are the smallest possible packets of electromagnetic energy.

A photon is defined as an elementary excitation of a single mode of the quantized electromagnetic field.