CHAPTER I
NATURE OF LIGHT

• The Personality of Light
• Reflection and Refraction
• Total Internal Reflection
• Dispersion
THE FIELD OF OPTICS

• Deals with the behavior of light and other electromagnetic waves.

• We can reach a deeper appreciation of the visible world.

THE FIELD OF OPTICS

• Allows us to understand the blue color of the sky
• The design of optical devices such as telescopes, microscopes, cameras, eyeglasses, and the human eye.
• Modern developments such as the laser, optical fibers, holograms, optical computers, and new techniques in medical imaging.
Section I

THE DIFFERENT PERSONALITIES OF LIGHT

DUAL NATURE OF LIGHT

Isaac Newton

• Thought that light consisted of streams of particles emitted by light sources.
• Several effects associated with emission and absorption of light reveal a particle aspect.

Clerk Maxwell

• Predicted the existence of electromagnetic waves and calculated their speed of propagation
**DUAL NATURE OF LIGHT**

- A comprehensive theory that includes both wave and particle properties was introduced.
- The energy carried by light waves is packaged in discrete bundles called photons.
- No matter what its source, electromagnetic radiation travels in vacuum at the same speed:
  \[ C = 3 \times 10^8 \text{ m/s} \]

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**Section 2**

**REFLECTION AND REFRACTION**
Definition of Reflection

- The change in direction of a wavefront at an interface between two different media so that the wavefront returns into the medium from which it originated.
**Reflection Laws**

**Incidence Angle**
- The angle which the *incident* ray makes with the normal.

**Reflection Angle**
- The angle which the *reflected* ray makes with the normal.

**Refraction Angle**
- The angle which the *refracted* ray makes with the normal.

If the reflecting surface is very smooth:
1. The *incident ray*, the *reflected ray* and the *normal* to the reflection surface at the point of the incidence lie in the same plane.
2. The angle which the incident ray makes with the normal is *equal* to the angle which the reflected ray makes to the same normal.
Reflection

Specular Reflection:
Reflection at a definite angle from a very smooth surface

Diffuse Reflection
If the interface is rough, the light is reflected in various directions, and there is no single angle of reflection.

Refraction

Definition of Refraction
• The bending of a wave when it enters a medium where its speed is different.
REFRACTION

Refractive Index:
• The ratio of the speed of light in vacuum (c) to its speed in the material (v):

\[ n = \frac{c}{v} \]

• The wave speed is inversely proportional to the index of refraction.

• The greater the index of refraction in a material, the slower the wave speed in that material.
Snell’s Law

• A formula used to describe the relationship between the angles of incidence and refraction:

\[ n_1 \sin \theta_1 = n_2 \sin \theta_2 \]

• If \( n_1 > n_2 \) the beam bends away from the normal
• If \( n_1 < n_2 \) the beam bends towards the normal
• If the beam is incident perpendicularly, it goes unrefracted
TOTAL INTERNAL REFLECTION

Critical Angle

• The angle of incidence within a more dense medium (large $n$) for which the light is refracted parallel to the interface.

![Critical Angle Diagram]

APPLICATIONS OF TOTAL INTERNAL REFLECTION

Optical Fibres

• When a beam of light enters at one end of a transparent rod, the light can be totally reflected internally if the index of refraction of the rod is greater than that of the surrounding material.

The light is trapped in the rod if all the angles of incidence (such as $\alpha$, $\beta$, and $\gamma$) exceed the critical angle.

![Optical Fibres Diagram]
**Applications of Total Internal Reflection**

**Endoscopes**
- Devices that can be inserted directly into the bronchial tubes, the bladder, the colon, and other organs for direct visual examination.

![Types of Endoscopy](image)

**Applications of Total Internal Reflection**

![Endoscope Example](image)
APPLICATIONS OF TOTAL INTERNAL REFLECTION

Endoscopic Images of a Drilling Site
Section 3

DISPERSION

- Ordinary white light is a superposition of waves with wavelengths extending throughout the visible spectrum.
- The speed of light in vacuum is the same for all wavelengths.
- The speed in a material substance is different for different wavelengths.
- The index of refraction, $n$, of a material depends on wavelength, $\lambda$. 
**DISPERSION**

**Definition of Dispersion**

- The dependence of the index of refraction on wavelength is called dispersion.

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**RAINBOWS**

- Combined effects of dispersion, refraction, and reflection

  - A primary rainbow is formed by rays that undergo two refractions and one internal reflection. The angle $\Delta$ is larger for red light than for violet.

  - A secondary rainbow is formed by rays that undergo two refractions and two internal reflections. The angle $\Delta$ is larger for violet light than for red.
**PRISM**

**What is a Prism?**

• A transparent optical element with flat, polished surfaces that refract light.
• At least two of the flat surfaces must have an angle between them.
• The exact angles between the surfaces depend on the application.

The traditional geometrical shape is that of a triangular prism with a triangular base and rectangular sides.
**PRISM IN DENTISTRY**

- Dental Colorimeter

  ![Dental Colorimeter](image)

**PRISM IN DENTISTRY**

**Dental Colorimeter**

- A colorimeter is a device used for measuring colours. It measures the reflectance or absorbance of different wavelengths of light.

  **Traditional Colorimeter Consists of:**
  - White light source
  - Monochromator
  - Intensity Sensor (Photocell)
**PRISM IN DENTISTRY**

Dental Colorimeter