Bhartiya Vidya Bhavan's Shri Ishvarlal L. P. Arts-Science and J. Shah Commerce College, Dakor
Dakor - 388225, Dist. – Kheda, Gujarat

B.Sc. (semester -3)

Subject : Physics

Course : USO3CPHY21 OPTICS

UNIT 1: Geometrical Optics/ Part-1

By

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Unit:1 Geometrical Optics

- Introduction to optics
  - Reflection
  - Refraction
  - Total internal reflection
- Lens system :
- Introduction to lenses
  - simple lens and compound lens
- Cardinal points and planes of lens system :
  - Two Principal points and principal planes
  - Two focal points and focal planes
  - Two nodal points and nodal planes

Text Book:

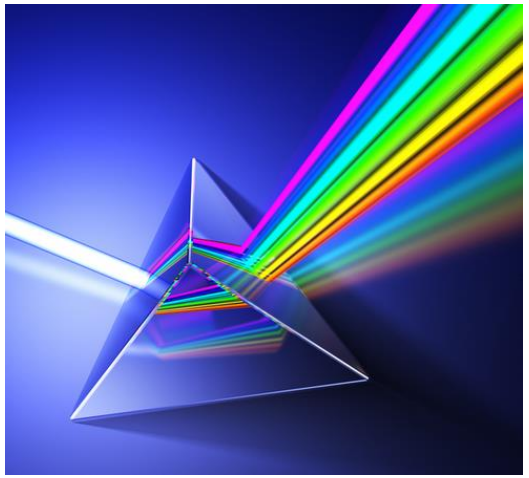
1. A Textbook of Optics
   Subrahmanyam, Brij lal and Avadhnulu
   S Chand Publication (24th Revised addition 2010)

Reference Books:

1. Optics
   Ajoy Ghatak,
   McGraw-Hill Publishing Co. Ltd.
2. Textbook of light
   D N Vasudev
   Atma Ram and Sons, New Delhi
3. Fundamental of Optics
   F A Jenkine and H E White
   Tata McGraw Hill Book Co. Ltd.

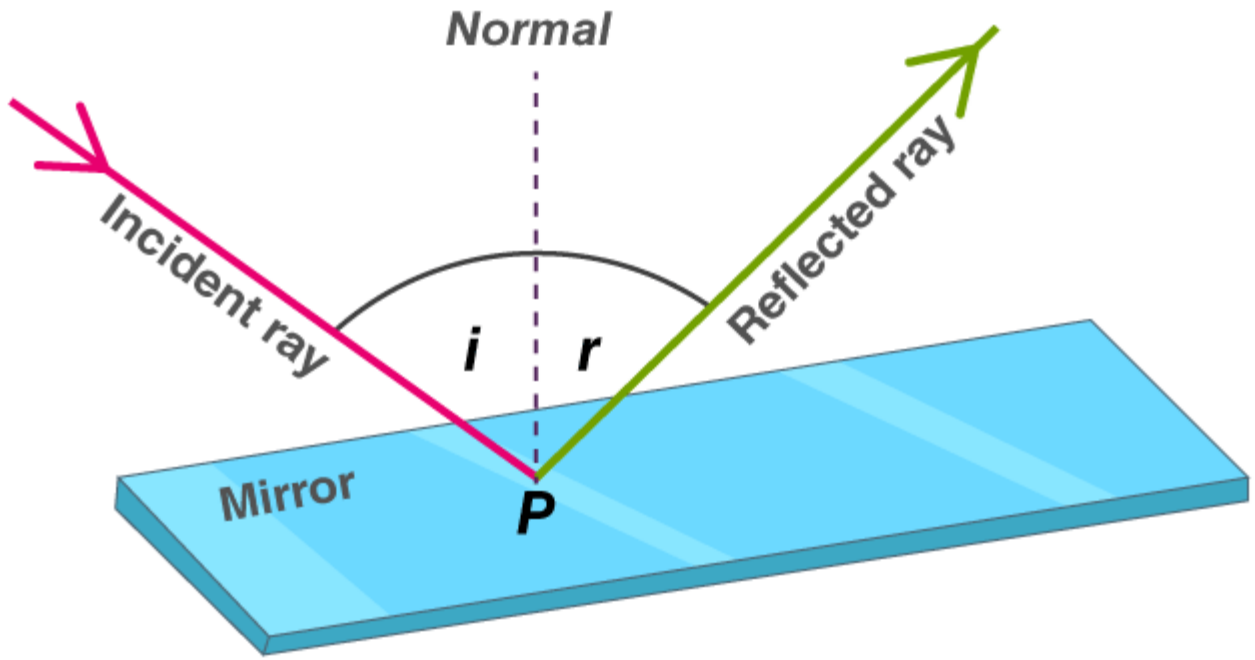
What is Optics ?

- **Optics** is the branch of **physics** that studies the behavior and properties of light, including its interactions with matter and the construction of instruments that use or detect it.
- **Optics** usually describes the behavior of visible, ultraviolet, and infrared light.



What is Reflection of Light?

- When a ray of light falls on highly smooth polished surface like a mirror most of the light is sent back into the same medium. This process is called reflection of light. If a perpendicular were to be drawn on reflecting surface, it would be called normal. The figure shows the reflection of an incident beam on a plane mirror.

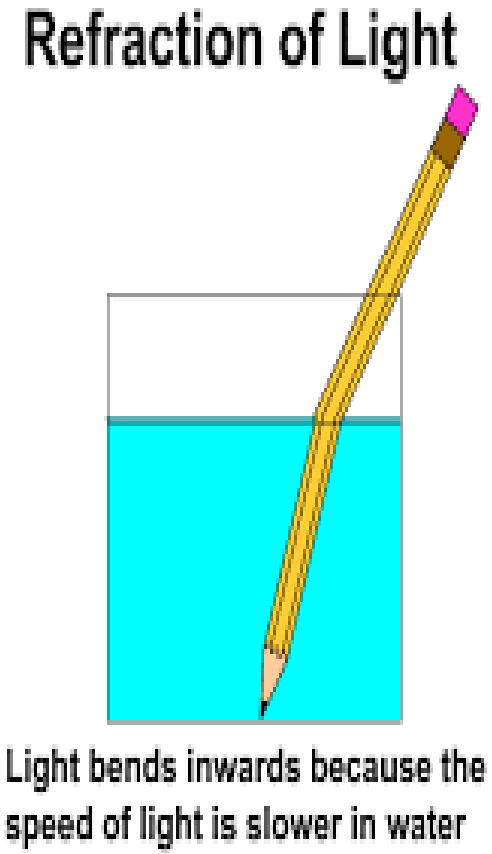


Laws of Reflection

The law of reflection states that

1. The incident ray, the reflected ray and the normal all lie in the same plane
2. The angle of incidence = Angle of reflection

What is Refraction ?

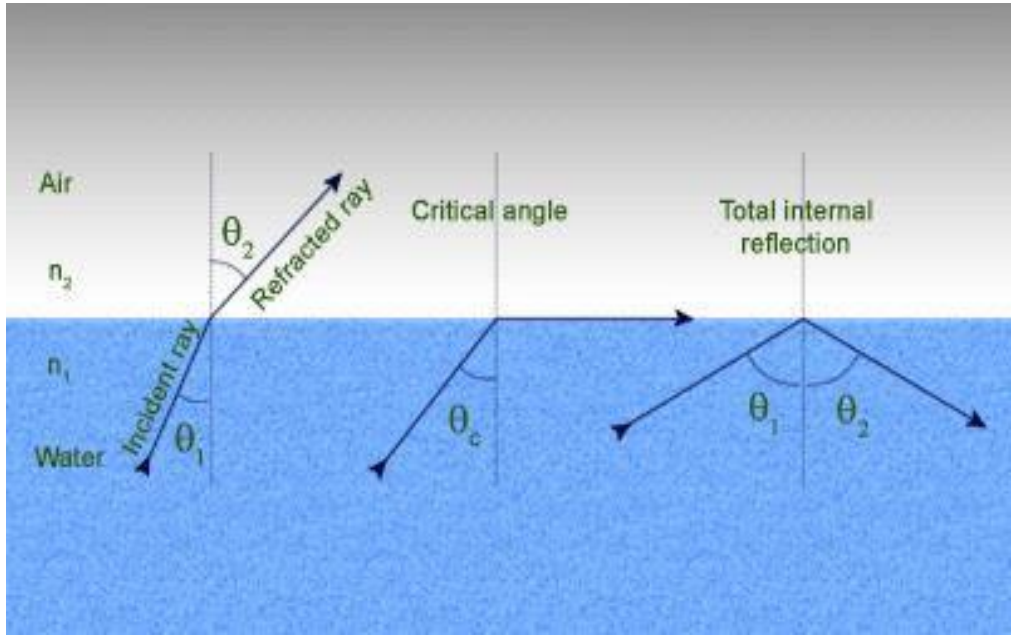


- The bending of light when it passes from one medium to another is called refraction.
- This property of refraction is used in a number of devices like microscopes, magnifying lenses, corrective lenses, and so on.
- In this property, when the light is transmitted through a medium, polarization of electrons takes place which in-turn reduces the speed of light, thus changing the direction of light.

What is Total internal reflection ?

- When a beam of light strikes the water, a part of the light is reflected, and some part of the light is refracted. This phenomenon is called as Total internal reflection.

- Consider the following situation. A ray of light passes from a medium of water to that of air. Obviously, the light ray will be refracted at the junction separating the two media.
- Since it passes from a medium of a higher refractive index to that having a lower refractive index, the refracted light ray bends away from the normal. At a specific angle of incidence, the incident ray of light is refracted in such a way that it passes along the surface of the water.
- This particular angle of incidence is called the critical angle. Here the angle of refraction is 90 degrees.



Snell's law

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{n_2}{n_1}$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

- θ_2 is the angle of refraction
- θ_1 is the angle of incidence
- n_1 is the refractive index in medium 1(Water)
- n_2 is the refractive index in medium 2 (Air)
- θ_c is the critical angle

What are Lenses?

- A lens is a transmissive optical device that focuses or disperses light beams by means of refraction.
- A simple lens consists of a single piece of transparent material while compound lenses consist of several simple lenses arranged along with a common axis.

Types of Lenses

The classification of a lens depends on how the light rays bend when they pass through the lens.

There are mainly two types of two lenses :

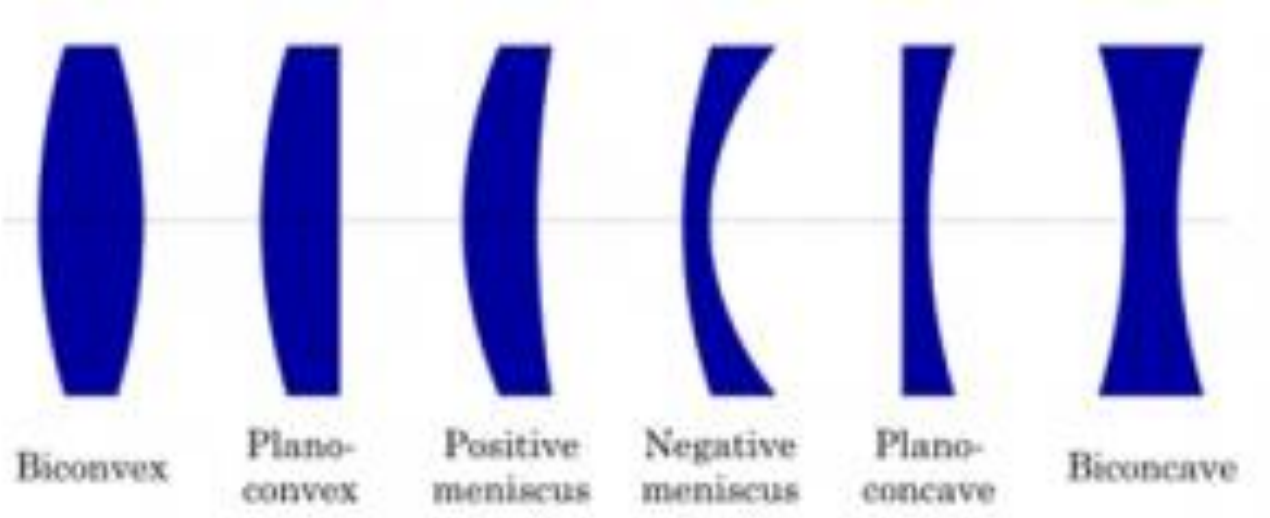
1. Convex Lens (Converging): Convex lenses are thick in the middle and thinner at the edges.

2. Concave Lens (Diverging) : A concave lens is flat in the middle and thicker at the edges.

- A convex lens is also known as the converging lens as the light rays bend inwards and converge at a point which is known as focal length.
- On the other hand, the concave lens is also known as a diverging lens because it bends the parallel light rays outward and diverges them at the focal point.

Classifications of lenses :

- Simple lens and compound lens are the two classifications of lenses.
- **Simple lenses** are different from compound lenses based on their surface of curvature. Different types of simple lenses are given below :



- **Compound lenses** are those constructed out of a combination of different simple lenses.
- The lens types used to build a compound lens may have different refractive indices and other properties.
- The placement of lenses are such that they lie on a single axis, and properties like focal length are calculated again for the new compound lens.

Cardinal Points of lens system (6 marks)

Single lenses are rarely used for image formation, as they suffer from various defects.

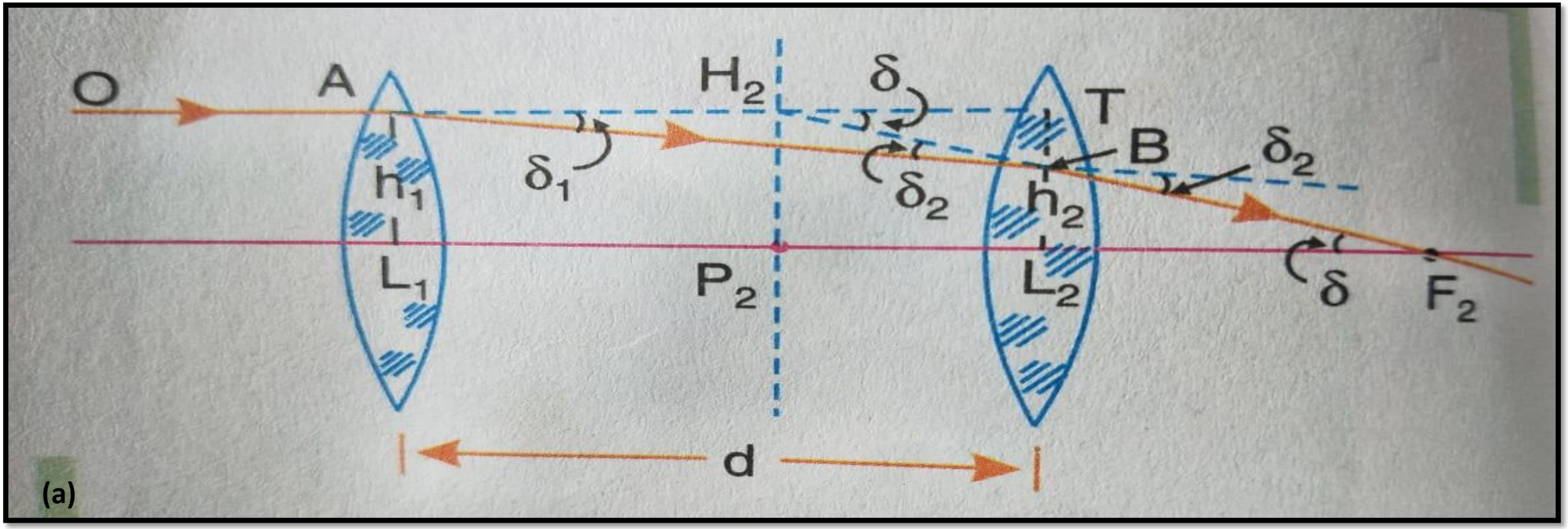
- In optical instruments such as camera, microscope, telescopes etc., a collection of lenses are employed for forming images of objects.
- An optical system consist of a number of lenses placed apart and having a common principal axis.

- The points of interaction of these planes with the axes are called the principle points or Gauss points. , there are six points in all, which characterize on optical system.

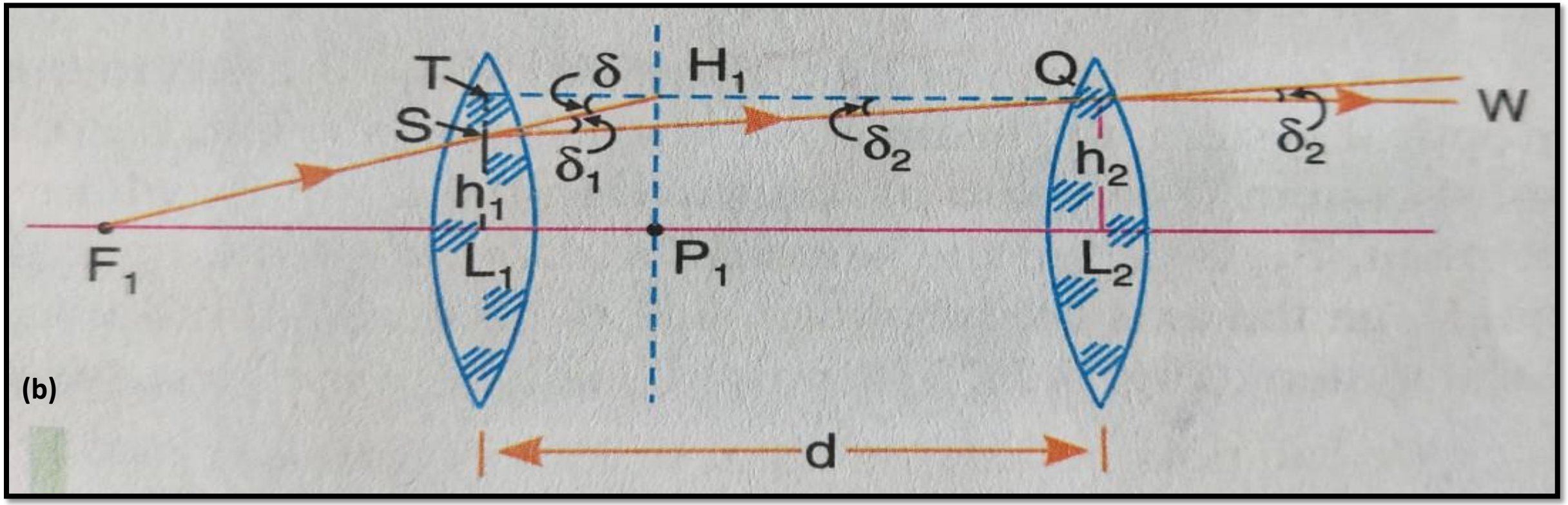
There are six points

1. Two focal points:
2. Two principal points:
3. Two nodal points:

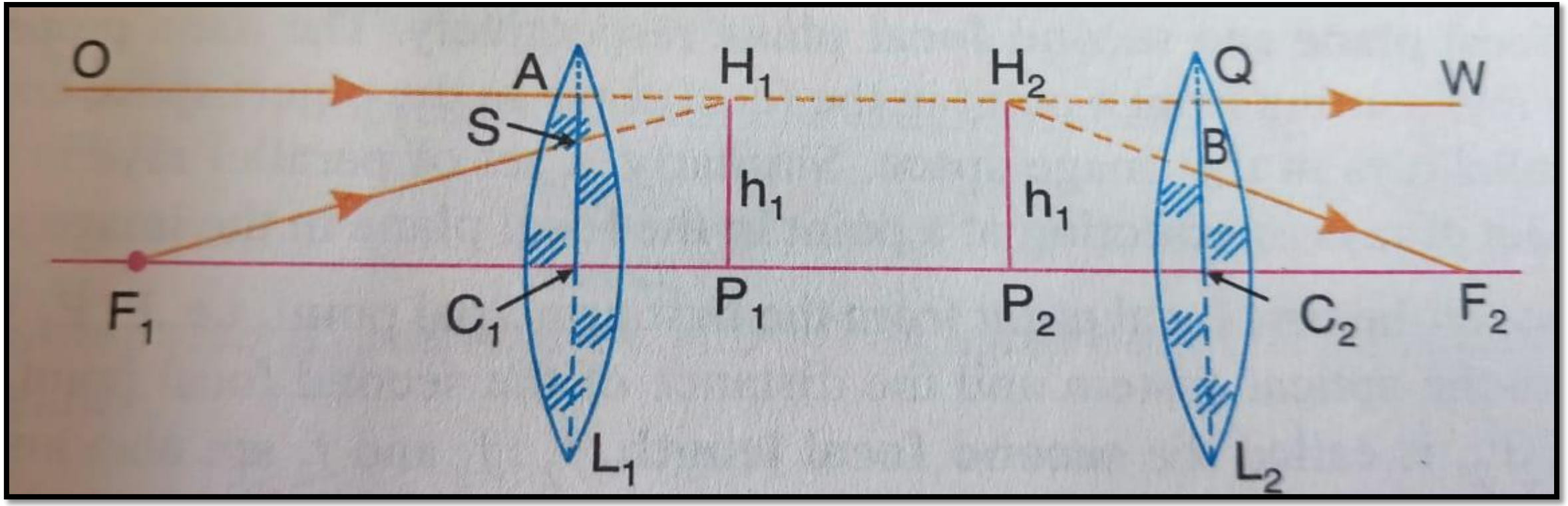
1. Principal points and principal planes



- A ray OA travelling parallel to the principle axis and incident at A is brought to focus at F2 in the image space of the optical system as shown in above Figure.
- A plane drawn through the point H_2 and perpendicular to the axis may be regarded as the surface at which refraction take place. This plane is called the principal plane of the optical system.
- H_2P_2 is the principal plane in the image space and is called the second principal plane.
- The point P_2 at which the second principal plane intersects the axis is called the second principal point.



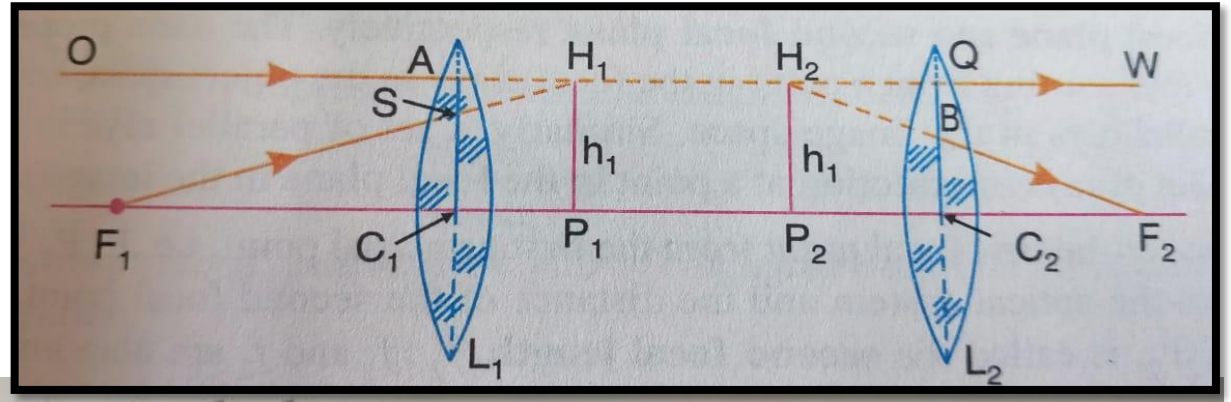
- We can locate the principal plane H1P1 and principal point P1 in the **object space**.
- A plane perpendicular to the axis and passing through H1 is called the first principal plane.
- The point of interaction, P_1 of the first principal plane with the axis is called the first principal point.



- It seen from above figure, that two incidents ray are directed towards H_1 and after refraction seem to come from H_2.
- Therefore H_2 is image of H_1 Thus H_1 and H_2 are the conjugate points and the planes H_1P_1 and H2P2 are a pair of conjugate planes . It is also seen that

$$H_2P_2 = H_1P_1$$

Some remarkable feature of Principal planes (2 marks)



1. Even a complex optical system has *only two principal planes.*
2. Between H_1 and H_2 all rays are *parallel* to the principal axis.
3. The location of the principal planes is characteristic of a given optical system. Their positions do not change with the object and image distance used.
4. The principal planes are conjugate to each other. An object in the first principal plane is imaged in the second principal plane with *unit magnification.* Any ray directed towards a point on the first principal plane emerge from the lens as if it originated at the corresponding point (at the same distance above or below the axis) on the second principal plane. Hence, the name *unit planes.*
5. The principal points H_1 and H_2 provide a set of references from which several system parameters are measured.

Do you have Any Questions

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Thank you

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