APPLIED PHYSICS -II

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UNIT-II OPTICS

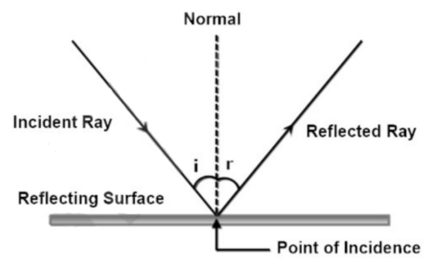
1) Define reflection of light

The phenomenon due to which a ray of light, travelling from one optical medium to another optical medium, bounces off from its surface with a change of angle, is called reflection of light.

2) Explain Laws of reflection.

According to two laws of reflection:

When a light ray is reflected from a plane smooth surface
a) The incident ray, the reflected ray, and the normal to the surface lie in the same plane at the point of incidence.
b) The angle of incidence is always equal to the angle of reflection.



3) What are spherical mirrors, list some uses of it

A mirror which is made from a part of a hollow sphere is called a spherical mirror. Spherical mirrors are mainly classified into convex mirrors and concave mirrors. If the inner surface of the spherical surface reflects light, then it is called a **concave mirror**. If the outer surface of the spherical surface reflects light, then it is called a **convex mirror**.

Uses of spherical mirrors:

a) Concave mirror is used as shaving mirrors. b) Parabolic mirrors are used in astronomical telescopes and search lights. c) Convex mirrors are used in vehicles to see the rear side.

4) Define the various parameters related to spherical mirror

The various parameters related to spherical mirrors are:

Centre of curvature (C) :- It is the center of the sphere of which the mirror is a part.

Radius of curvature (R):- It is the radius of the sphere of which the mirror is a part.

Pole (P) :- It is the geometrical center of the mirror

Principal axis (PA) :- It is the straight line passing through the pole and the center of curvature of the mirror.

Principal focus (F) :- A narrow beam of light parallel to the principal axis after reflection converges to a point on the principal axis in the case of a concave mirror and appears to diverge from a point on the principal axis in the case of a concave mirror. This point is called the principal focus.

Focal length(f) :- It is the distance between the pole and the principal focus.

5) Give the relation between focal length and radius of curvature for a spherical mirror

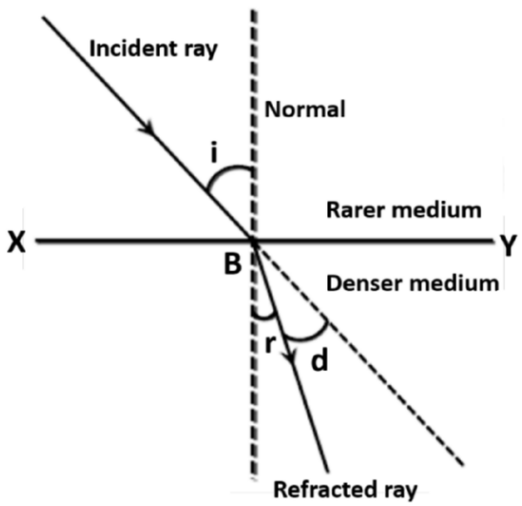
focal length (f) of the spherical mirror is exactly half its radius of curvature (R).

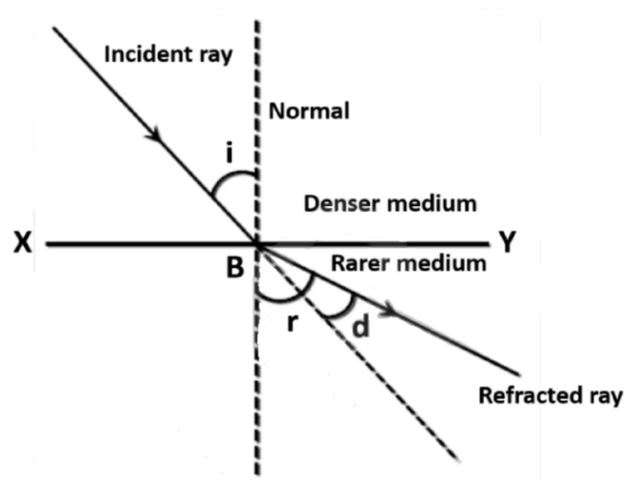
$$f = \frac{R}{2}$$

6) What is refraction of light, Give some practical examples of refraction

The phenomenon of bending of light when it travels from one medium to another is known as refraction.

When light travels from a rarer medium to a denser medium, light bends towards the normal at the point of incidence. When light travels from a denser medium to a rarer medium, light bends away from the normal





some practical examples of refraction are:

a) Twinkling of stars: The twinkling of stars is due to the refraction of light from the star at different layers of the atmosphere.

b) Apparent depth and real depth: When an object inside a denser medium is viewed from a rarer medium (air) apparent depth (d) seems to be less than the actual depth (D)

c) Apparent shift in the position of the sun at sunrise and sunset: Sun is visible before sunrise and after sunset because of the bending of light rays due to atmospheric refraction.

7) Explain Laws of refraction

The two laws of refraction are:

a) The incident ray, the refracted ray, and the normal at the point of incidence, all lie in the same plane.

b) The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant for a given pair of media. it is mathematically expressed as

$$\frac{sin(i)}{sin(r)} = constant$$

8) Define Snells law.

According to Snell's law, The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant for a given pair of media. it is mathematically expressed as

$$\frac{sin(i)}{sin(r)} = constant$$

where i is the angle of incidence in the first medium and r the angle of refraction in the second medium and the constant is known as the refractive index of the second medium with respect to the first medium denoted as n_{21} . Then by Snells law,

$$\frac{sin(i)}{sin(r)} = n_{21}$$

9) What is refractive index

Refractive index is a physical quantity related to the speed of propagation of light in different media. Refractive index of a medium is defined as the ratio of the speed of the light in vacuum (c) to the speed of the light in the medium (v).The refractive index of the medium (n) is given by

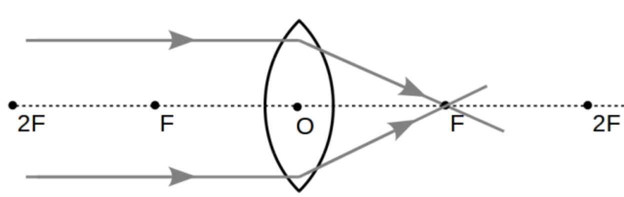
$$\text{Refractive index of the medium} = \frac{\text{Speed of the light in vaccum}}{\text{Speed of light in the medium}}$$

$$\boldsymbol{n = \frac{c}{v}}$$

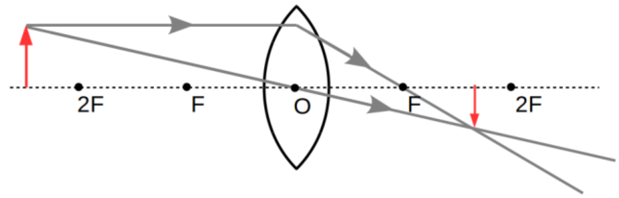
10) Sketch the image formation of a convex lens when objects are placed at different distances from the lens.

1) Object at infinity:

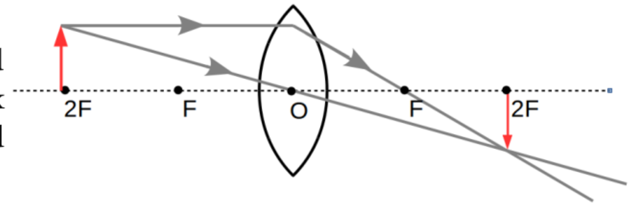
When the object is at infinity, the parallel rays from the object, after refraction, converge to the principal focus on the other side of the lens and produce a real, inverted and highly diminished image at F.



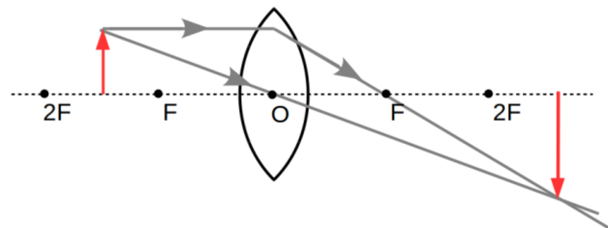
2) Object beyond 2F:
When the object is just beyond 2F, the image is formed between F and 2F on the other side of the lens. The image is real, inverted, and smaller than the object.



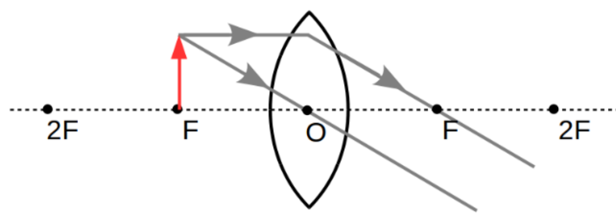
3) Object at 2F:
When the object is at 2F, the image is formed exactly at 2F on the other side of the convex lens. The image formed is real, inverted, and exactly the same size as that of the object.



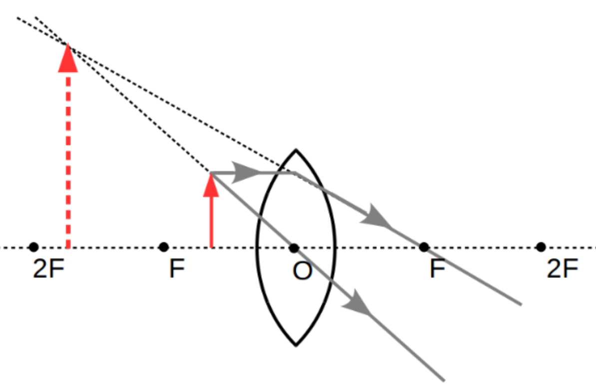
4) Object between 2F and F:
When the object is between 2F and F, the image is formed beyond 2F on the other side of the convex lens. The image formed is real, inverted, and larger than the object.



5) Object at F:
When the object is at F, the refracted rays travel parallel to each other, and the image is formed at infinity.



6) Object is between F and O:
When the object is between F and O, the image is formed on the same side of the convex lens. The image is virtual, erect, and larger than the object.



11) Distinguish between real image and virtual image

A convex lens can form two types of images namely real image and virtual image.

Real image:- Real image is formed when the refracted rays intersect on the other side of the lens. Real images are inverted and can be captured on a screen

Virtual image:- A virtual image is formed when the refracted rays appear to diverge from a point on the same side of the lens. Virtual images are erect and cannot be captured on a screen

12) What is magnification

Magnification (m) of a lens is defined as the ratio of the height of the image to the height of the object. If h_o is the height of the object and h_i is the height of the image, then magnification is given by

$$m = \frac{h_i}{h_o}$$

Magnification can also be defined as the ratio of image distance to object distance. If u is the object distance and v is the image distance, then magnification is given by

$$m = \frac{v}{u}$$

Magnification is negative for real images and positive for virtual images.

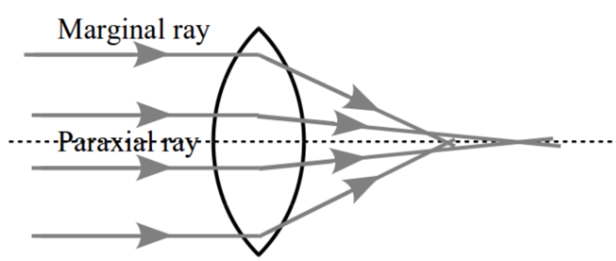
13) What will be the focal length of a plane mirror?

The focal length of a plane mirror is infinity. Since the radius of curvature (R) of a plane mirror is infinity, from the relation $f = \frac{R}{2}$ we get $f=$ infinity for a plane mirror

14) What are the defects of a lens? How can we rectify it?

Spherical aberrations and chromatic aberrations are the two most common defects of the lens.

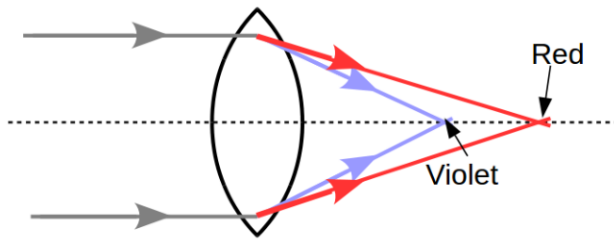
1) Spherical aberration:- When beam of monochromatic light, parallel to the principal axis, is incident on a convex lens, the marginal rays will converge at one point and the paraxial rays converge at another point on the principal axis. So, the focus will not be sharp.
Spherical aberration can be minimized by using stops, crossed lenses, and plano-convex lenses.



2) Chromatic aberration:-

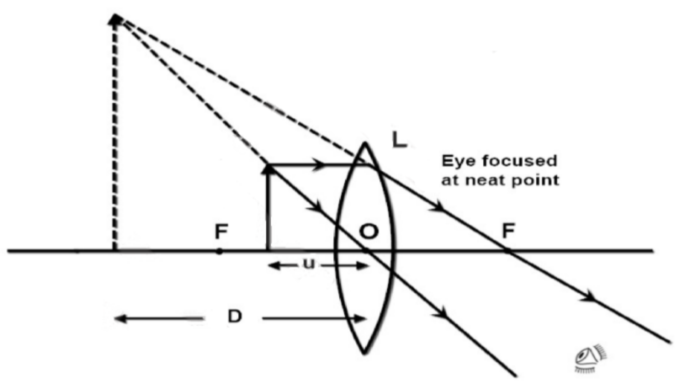
When a beam of white light, parallel to the principal axis, is incident on a convex lens, dispersion takes place and it is splitup into its constituent colours. and different colours are focused at differenet point.

The inability of a lens to focus all the colours to a single point is called chromatic aberration. Chromatic aberration can be eliminated by combining a convex lens and concave lens of suitable focal length and material. Such a combination is called an achromatic doublet or **achromat**.



15) With the help of a diagram explain the working of a Simple microscope

A simple microscope or magnifier is an optical instrument to see the magnified image of an object. A simple microscope consists of a convex lens of a short focal length. The principle behind the simple microscope is that when a tiny object is placed between the principal focus (F) and optic center (O) of a convex lens, a virtual, erect, and magnified image of the object is formed on the same side of the lens. The lens is held near the object and the eye is positioned close to the lens on the other side



The linear magnification m, for the image formed at the least distance of distinct vision D, for a simple microscope can be obtained as follows:

$$m = \frac{v}{u}$$

From the lens formula,

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$
$$\frac{1}{u} = \frac{1}{v} - \frac{1}{f}$$
$$\therefore m = v(\frac{1}{v} - \frac{1}{f})$$
$$m = 1 - \frac{v}{f}$$

since $v = -D$ for clear vision of image with eye

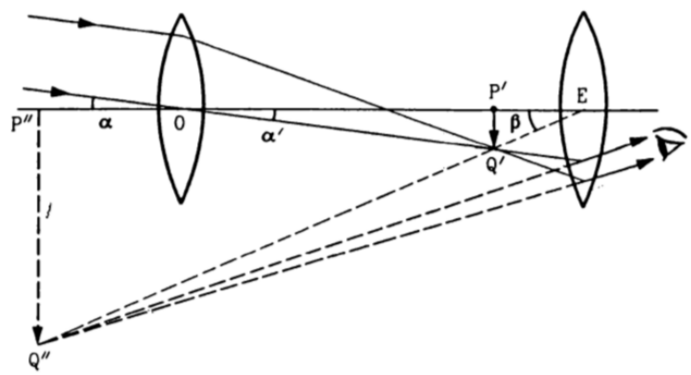
$$m = 1 + \frac{D}{f}$$

Hence the magnification of a simple microscope is given by

$$m = 1 + \frac{D}{f}$$

16) With the help of a diagram explain the working of a Astronomical telescope

An astronomical telescope is an optical instrument used to see a magnified image of distant objects like planets, satellites, stars, galaxies, etc. The telescope provides angular magnification of distant objects. It consists of an objective and an eyepiece. The objective has a large focal length and aperture. The objective lens forms a real image of the object at the focal point of the objective lens. this real image is magnified by the eyepiece and a inverted image is formed.



Magnification of the telescope m is given by,

$$m = \frac{\beta}{\alpha}$$

Or

$$m = \frac{f_o}{f_e}(1 + \frac{f_e}{D})$$

where β is the angle subtended at the eye by the image,α is the angle subtended at the eye by the object, f_o and f_e are the focal length of the objective and eyepiece and D is the least distance of distinct vision.

17) Write a note on the resolving power and magnifying power of optical instruments.

Resolving power:-

The ability of an instrument to show two very closed objects as separate is called its resolving power. An optical instrument with high resolving power can reveal fine details of the object. The resolving power of a telescope is defined as the reciprocal of the smallest angular separation $d\theta$ between two distant objects whose images are distinctly separated by the telescope.

$$\begin{aligned}\text{Resolving power} &= \frac{1}{d\theta}\\ &= \frac{d}{1.22\lambda}\end{aligned}$$

where $\lambda$is the wavelength of the light used and d is the diameter (aperture) of the telescope. Hence the resolving power a telescope can be increased by increasing the aperature of the objective

magnifying power:-

Magnification of a optical instrument is defined in two ways, linear magnification and angular magnification. In case of a lens or a microscope magnification is expressed in terms of linear magnification. The magnification of telescope is expressed in terms of angular magnification

The linear magnification (m) is defined as the ratio of the height of the image (h_i) to the height of the object (h_o).

$$m = \frac{h_i}{h_o}$$

Magnification can also be defined as the ratio of image distance v to object distance u.

$$m = \frac{v}{u}$$

In case of a simple microscope the magnification is givne by

$$m = 1 + \frac{D}{f}$$

where f is the focal length of the lens and D is the least distance of distinct vision of eye.

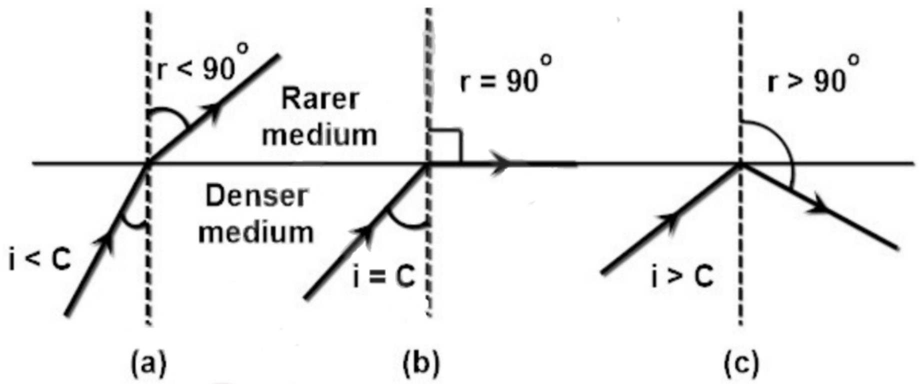
Angular magnification is defined as the ratio of the angle subtended by the image at the eye (β) and the angle subtended by the object at the eye (α).

$$m = \frac{\beta}{\alpha}$$

for a telescope magnification increases with the focal length of the objective lens.

18) Define total internal reflection. What are the conditions of total internal reflection?

Total internal reflection is defined as the complete reflection of light back into a medium when light travels from a denser medium to a rarer medium and the angle of incidence in the denser medium is greater than the critical angle.



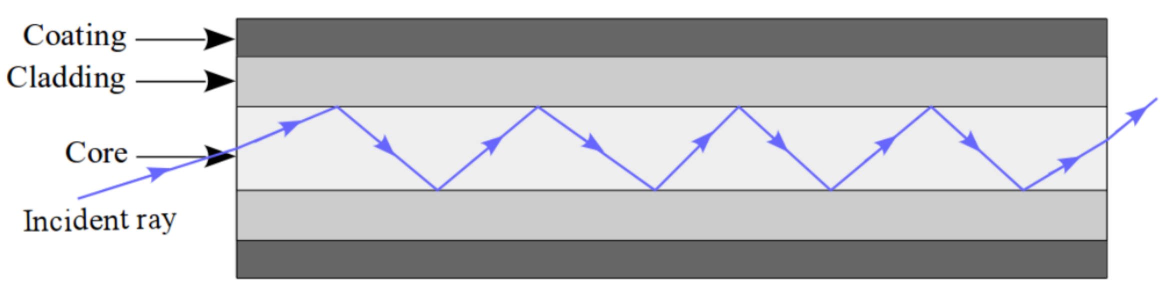
The two conditions for total internal reflection are:

1) The light should travel from a denser medium to a rarer medium.

2) The angle of incidence in the denser medium should be greater than the critical angle.

19)Explain the working of optical fibers.

Optical fiber is a device which works on the principle of total internal reflection and transmits light signals from one place to another without much loss of energy. An optical fiber consists of basically three parts core, cladding, and coating. Core is the innermost part of the optical fiber. Cladding is the layer just outside the core. The outer layer of the optical fiber is called coating or buffer which protects the fiber from external stresses. The core has a high refractive index compared to that of the cladding. Light travels along the core of the fiber undergo repeated total internal reflections at the the core-cladding interface of the fiber and finally emerges out as shown in the figure.



20) Write the uses of optical fibers.

The applications of optical fibers are:-

1) Optical fibers are used to transmit light from one place to another

2) Optical fiber cables are used to transmit communication signals (telephone,internet)

3) Optical fibers are used for decoration purposes

4) Optical fibers are used in the medical field to examine the interior parts of the human body like the stomach, intestine, etc.(Endoscopy)

21) What is the principle behind the glittering of diamonds

Since the refractive index of diamond is high ($n = 2.42$) and the critical angle is small ($C = 24.4^0$). The light entering into the face undergoes total internal reflection many times inside the crystal and comes out through one or two faces. So these faces appear glittering.

22) Explain why an air bubble in a jar of water shines brightly

Air bubble in a jar of water shines brightly because of total internal reflection of light at the water air buble interface. Since the refractive index of water is higher than air.

23) An air bubble inside the glass slab appears to be brighter than glass. Why?

Since the refractive index of glass is higher than air, light rays travelling through a glass slab undergoes total internal reflection when it reaches the air bubble inerface. Because of this total internal reflection of light at the glass air interface, air bubble inside the glass slab appears to be brighter

Important formula for doing problems

Lens formula

The relation connecting the focal length (f), image distance (v) and object diatance (u) is givne by the lens formula

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Magnification, (m) is given by

$$m = \frac{v}{u}$$

$$m = \frac{h_i}{h_o}$$