$$\frac{1}{v} = \frac{1}{25} - \frac{1}{40}$$

$$= \frac{40 - 25}{1000}$$

$$\frac{1}{v} = \frac{15}{1000}$$

$$15v = 1000$$

$$v = \frac{1000}{15} = \frac{200}{3}\text{ cm}$$

$$\frac{\text{height of image}}{\text{height of object}} = \frac{\text{image distance}}{\text{object distance}}$$

$$\frac{5}{\text{height of object}} = \frac{200/3}{40}$$

$$\frac{5}{\text{height of object}} = \frac{200}{3 \times 40} = \frac{200}{120}$$

$$\therefore \text{height of object} = \frac{5 \times 120}{200} = \frac{600}{200}$$

$$= 3\text{cm}$$

Worked example 32.3

An object is placed 30m in front of a converging lens of focal length 10m. What is the magnification of the image formed?

Solution

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

$$\frac{1}{10} = \frac{1}{30} + \frac{1}{v}$$

$$\frac{1}{10} - \frac{1}{30} = \frac{1}{v}$$

$$\frac{1}{v} = \frac{3 - 1}{30} = \frac{2}{30}$$

$$30 = 2v$$

$$v = \frac{30}{2}$$

$$v = 15\text{m}$$

$$\text{magnification} = \frac{v}{u} = \frac{15}{30} = \frac{1}{2} = 0.5$$

$$= 0.5$$

Worked example 32.4

A lens of focal length 12.0cm forms an upright image three times the size of a real object. What is the distance between the object and the image?

Solution

$F = 12\text{cm}, V = -3x, u = x$

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

$$\frac{1}{x} - \frac{1}{3x} = \frac{1}{12}$$

$$\frac{12 - 4 = x}{12x}$$

$$\therefore u = x = 8\text{cm}$$

Worked example 32.5

An object is placed in front of a converging lens of focal length 20cm. The image is virtual and has a magnification of 2. What is the distance of the object from the lens?

Solution: $F = 20\text{cm}, m = 2, \Rightarrow V = -2x, u = x,$

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

$$\frac{1}{x} - \frac{1}{2x} = \frac{1}{10}$$

$$\frac{10 - 5 = x}{10x}$$

$$\therefore u = x = 5\text{cm}$$

32.9 Power of Lens

Power of a lens is the ratio of one to the focal length or the ratio of a focal length.

Mathematically,

$$\text{Power of a lens} = \frac{1}{F}$$

Power of diverging lenses is negative, while the power of converging lenses is positive: Diverging = - power lens

Converging = + power lens

Worked example 32.6

A concave lens has a focal length of 5cm. Find the power of the lens.

Solution

$$\text{Power of lens} = \frac{1}{f}$$

$f = -5cm - 0.050m$

$\therefore$ Power of lens $= \frac{1}{f} = \frac{V}{-0.05} = -20D$

Power lens $= -20D$

Worked example 32.7

Find the image distance of the object whose distance is 10cm and the power of a lens is 5 diopters.

Solution

Power of a lens $= \frac{1}{f}$, $u = 10cm$

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

$$5 = \frac{1}{f} = p$$

$$\therefore 5 = \frac{1}{u} + \frac{1}{v}$$

$$5 = \frac{1}{10} + \frac{1}{v}$$

$$\frac{1}{v} = 5 - \frac{1}{10} = \frac{49}{10}$$

$$49v = 10$$

$$v = \frac{10}{49}$$

$$\therefore V \simeq 0.20cm$$

Revision exercise

1. Name the two major types of lenses and mention three classifications of each.
2. Explain with the aid of a diagram, the focus of a converging lens and diverging lens.
3. Define the following terms: (i) The pole (ii) Principal axis (iii) Focal length (iv) The radius of curvature.
4. Draw a ray diagram to show the image formed by a convex lens when the object is: (i) at infinity (ii) behind the double focus (iii) on the focus (iv) between the pole and the focus.
5. Give an account of an experiment to show the focal length of a converging lens.
6. If the power of a converging lens is 6 diopters, find the distance of the object from the lens to produce an image of height 3m, if the height of object is 5m.
7. Find the focal length of a concave lens, if the distance of the object to the lens is 7.8m and on the other side of the lens an image is formed at a distance of 6m.
8. Two different lenses of power 3.5 and 2.5 diopters are in contact. Find the focal length of the lenses.
9. Give five applications of concave and convex lenses.
10. Explain with the aid of a diagram how a converging lens could be used to: (i) ignite a piece of carbon paper (ii) produce an enlarged picture on a screen (iii) correct eye defect. [SSCE, June 1988]
11. An object is placed 36cm from a converging lens of focal length 24cm. If a real image which is 4cm high is formed, calculate the height of the object. [SSCE, June 1991]
12. An illuminated object is placed on the axis of a converging lens and a magnified image is obtained on the screen. If the distance of the image from the lens is 45cm and the magnification is 2, calculate the focal length of the lens. [SSCE, Aug. 1991]
13. An object placed 50cm away from the focus of a converging lens of focal length 15cm produces a focused image on a screen. Calculate the distance between the object and the screen. [SSCE, Nov. 1990]
14. A simple microscope forms an image twice the size of the object. If the focal length of the lens of the microscope is 20cm, how far is the object from the lens ? [SSCE, Nov. 1990]
15. A converging lens of focal length 5cm forms a vertical image, which is 10cm from the lens. How far from the lens is the object ? [SSCE, June 1996]
16. The image of a pin formed by a diverging lens of focal length 10cm is 5cm from the lens. Calculate the distance of the pin from the lens. [SSCE, June 1992]
17. A real image of an object formed by a converging lens of focal length 15cm is three times

33. APPLICATION OF LIGHT WAVES

33.1 Optics

Optics is the act of using lens or mirror in the eyes for observation purposes. Lens is mostly used in optical instrument than mirrors, because of certain factors.

Lens has various applications, some of which are: (i) film projector (ii) telescope (iii) prism (iv) binoculars.

The optical instrument uses the aid of image formed by the lens—either concave or convex in their operations and in accordance with the position of the object.

33.2 Light Waves

Simple camera

The camera is a device used for producing an image of an object with the aid of a light-sensitive film. The camera is sometimes referred to as "man-made resemblance of the eye", because all its features are more or less of the same functions as those of the eye, but for the absence of cells.

The camera is made up of a light sensitive film, convex lens and focusing arrangement. There is an adjustment aperture known as *diaphragm*, which helps to regulate the in-coming stream of rays. The lens in the camera is an achromatic doublet and the use of two lenses diminishes the spherical alteration of the camera. It is made up of a light-proof, but the shutter works on the process of stimulation. It opens and closes rapidly when the photograph is taken.

A real inverted image of an object is focused on the film by adjusting the lens. The amount of light entering the lens is controlled by the diaphragm and speed of the shutter.

The major factors controlling the brightness of a camera are:

(i) the exposure time (t)
(ii) the focal length of the lens
(iii) the diameter of the aperture.

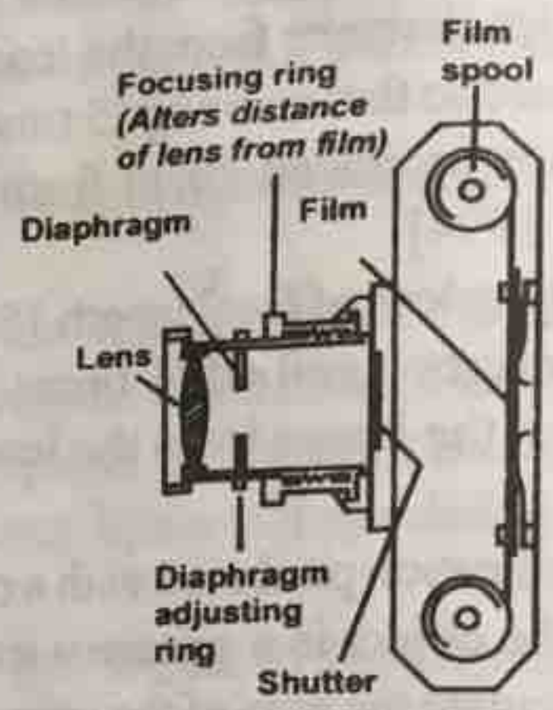

Fig. 33.1 Simple camera

33.3 Film Projector

Film projector is a projection lantern used in cinema or theatre for showing slides on a screen. The apparatus used is a condenser which consists of two plano convex lens. There is powerful source of light slide and a projection lens which is positioned at the front of the slide, to produce a large and inverted image of the film on the slide. To prevent the image from being inverted, the film on the slide can be turned upside down so that the image produced on the screen is erect. The procedures are as follows:

(i) The power source of light incidented its ray on the condenser which helps in the production of parallel rays from the concave reflector.

(ii) The reflector mirror is placed behind the source of light and the condenser now focuses the rays on the projecting lens which helps to produce a diverge image on the screen with greater magnification.

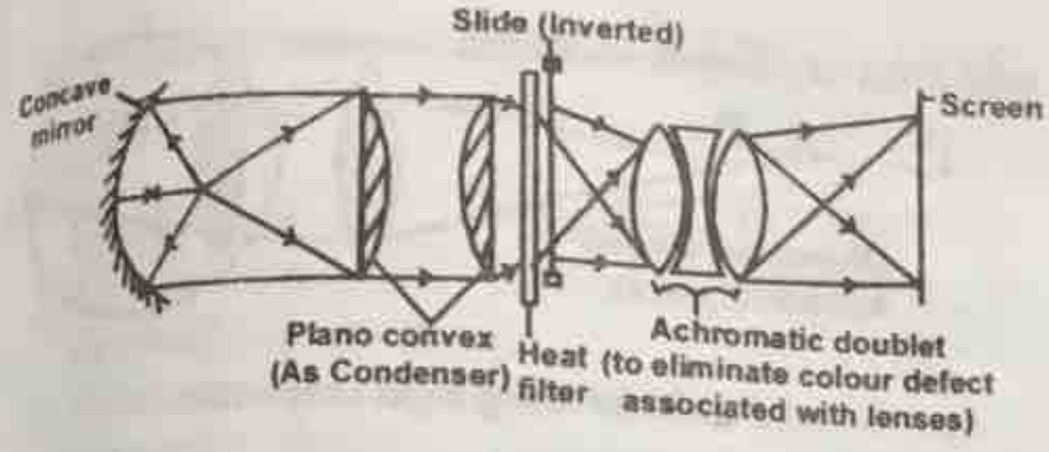

Fig. 33.2 Film projector

33.4 Human Eye

The human eye is a pair located in the eye sockets of the brain which is held in position by some muscles that connect the blood vessels with nerve cells.

The eye is made of three layers: (i) schleroid layer (ii) choroids layer (iii) rectina layer. The scheroid and choroids layers are the outer and sub-inner layers respectively, while the rectina layer is the innermost layer, the most sensitive part of the eye being fovea. The rectina darkens the focus of the image so that any ray of object focused on it can be interpreted quickly in the brain.

Some parts of the eye and their functions

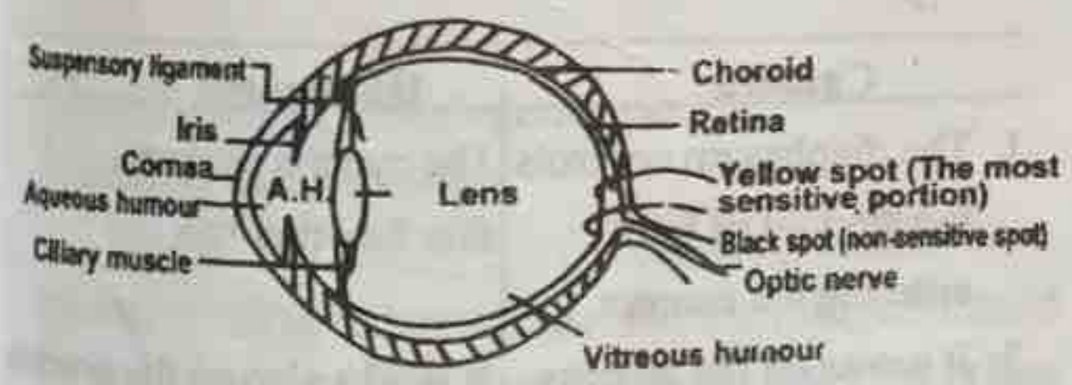

Fig. 33.3 Human eye

(i) Cornea: This is a tough white transparent skin which helps in the projection of the eye and in the refraction of light rays.

(ii) Fovea: The fovea is a point on the rectina layer that serves as the focus of all the light rays which forms the image on it. Since it is the most sensitive part, the nerve cells are stimulated and the messages are sent to the brain.

(iii) Ciliary muscle: It is muscle fibres which are attached to the eye lens for varying its focal length for proper focus of the image.

(v) Eye lens: This is a smooth, tough white skin which serves as a converging lens. It converges any ray passing through it at its focus.

(vi) Iris: Iris is a white fibrous skin attached to the choroids layer of the eye. It helps to regulate the amount of rays passing through the pupil, to the lens by either contracting or dilating in light or dark environment respectively.

33.5 Eye Defect and Correction

Eye defect is a disease of the eye which is experienced when light refraction coming from the object through the lens is not properly focused on the rectina. It may be before or beyond the rectina, wrong image, untrue colour image or blurred image.

Some of the eye defects are:

(i) Myopia
(ii) Hypermetropia
(iii) Presbyopia
(iv) Astigmatism
(v) Colour blindness

(i) Myopia: Short sightedness is an eye defect in which one can only see short distance object very clearly but can not see long distance object. This arises when the eye-ball is too long.

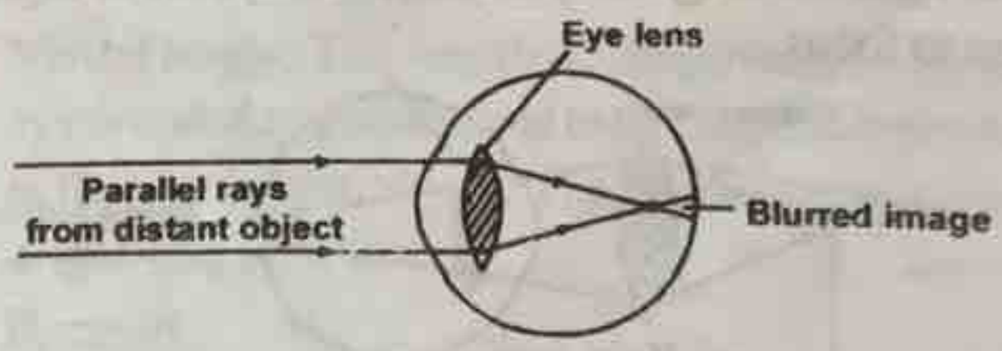

Fig. 33.4 Myopia

Correction: Myopia (Short sightedness) is corrected by using concave spectacle lens or diverging spectacle lens which diverges the ray of light entering the eye, so that the ray is brought in to focus.

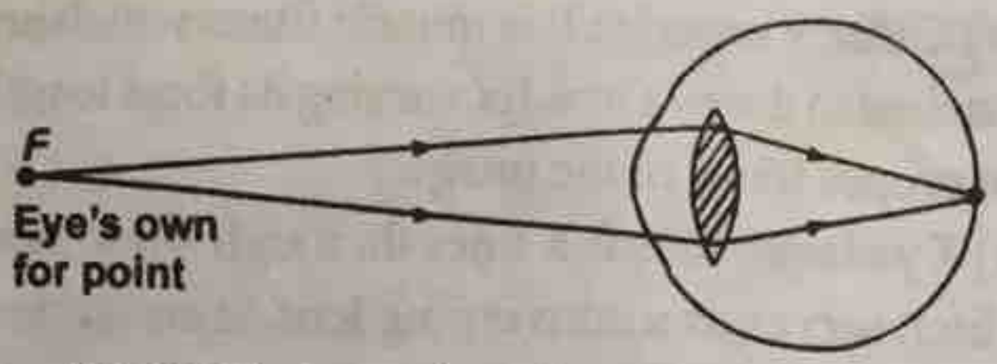

Fig. 33.5 Eye's own far point nearer than infinity

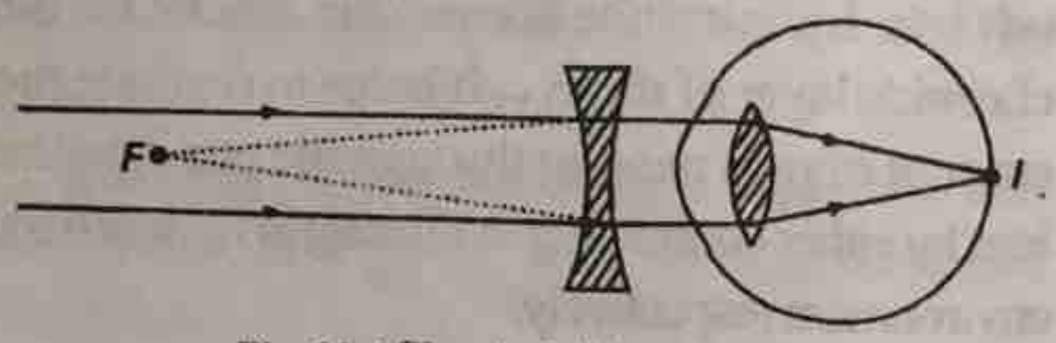

Fig. 33.6 Short-sight correction

NB: Diverging lens causes rays to diverge as though coming from F

(ii) Hypermetropia: This is a long sight defect in which one can only see long distance objects very clearly, and not short distance objects. This is caused by the eye-ball being too short.

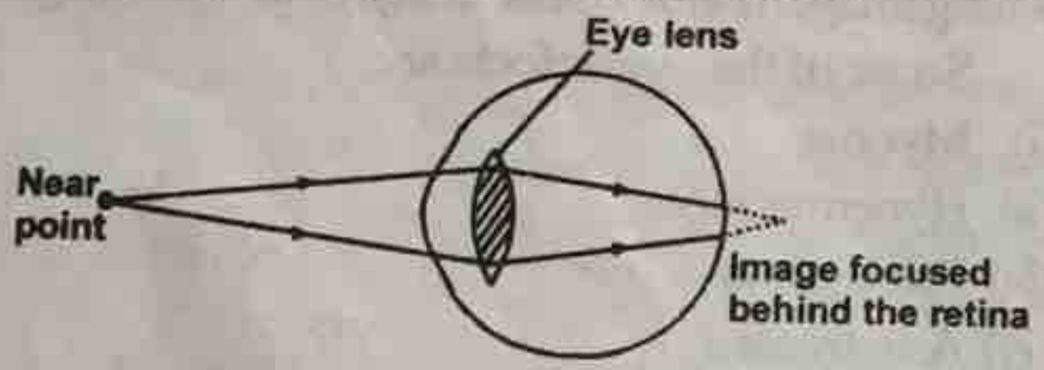

Fig. 33.7 Hypermetropia

Hypermetropia (Long sightedness) can be corrected by using convex spectacle lens or converging spectacle lens which converges the rays of light entering the eye so that the rays are brought in to focus.

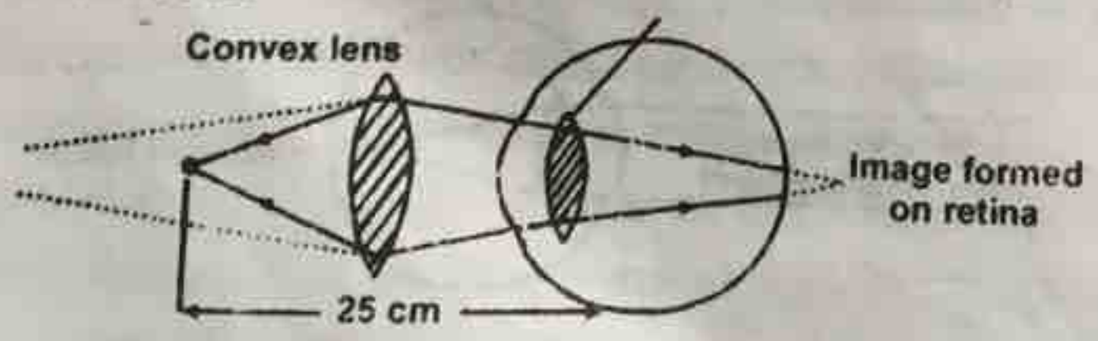

Fig. 33.8 Long sight and its correction

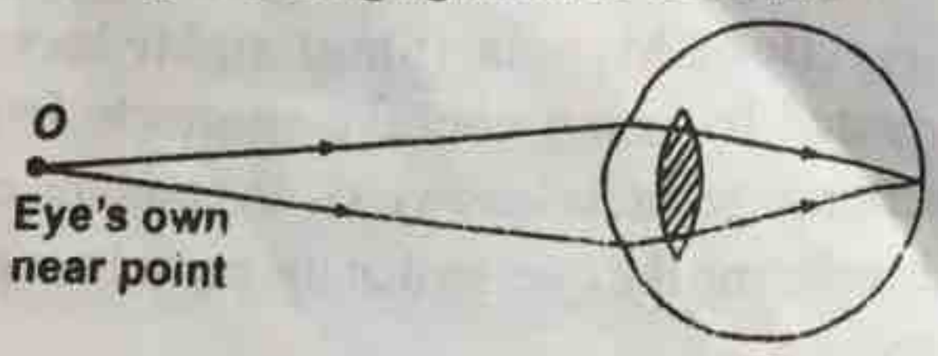

Fig. 33.9 Eye's own near point farther than 25cm

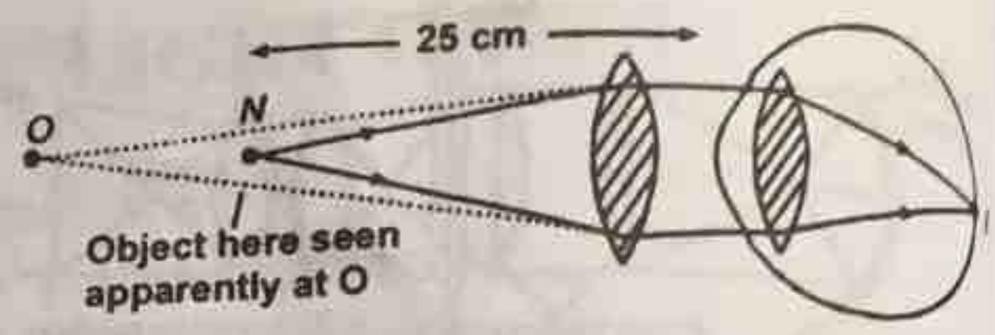

Fig. 33.10 Long-sight correction

NB: Converging lens reduces divergence of rays so that they appear to come from O.

(iii) Astigmatism: This defect is mostly caused by the cornea. When the rays of object reach the cornea, they are reflected at different rates because of the roughness, muteness and thickness of the cornea and the lens. It is the inability to see things more clearly in one direction than in other directions. To correct this eye defect, cylindrical lenses are used.

(iv) Presbyopia: This is an eye defect in which the eye is unable to accommodate. It is caused by the inelasticity of eye lens due to old age. Bifocal lens is used to correct presbyopia

33.6 Similarities between the Eye and the Camera

Camera	Human eye
1. The diaphragm controls the amount of light entering the camera.	The eye iris performs this function too.
2. It works on the process of refraction.	It works also on the process of refraction.
3. The aperture serves as the passage for light unto camera	The pupil serves as the passage for light into the eye
4. The photographic film is the most sensitive part.	The yellow spot in the eye is most sensitive part.
5. The interior is black and light proof to prevent reflection of stray rays of light	The interior is also black and light proof to prevent reflection of stray rays of light.