OPTICAL INSTRUMENTS.

What is optical Instruments?

- Optical instruments are devices which are Used to help the human eye View Small or distant objects more clearly.
- Optical Instruments use a Combination of lenses and /or mirrors to produce an enhanced Image of an object.

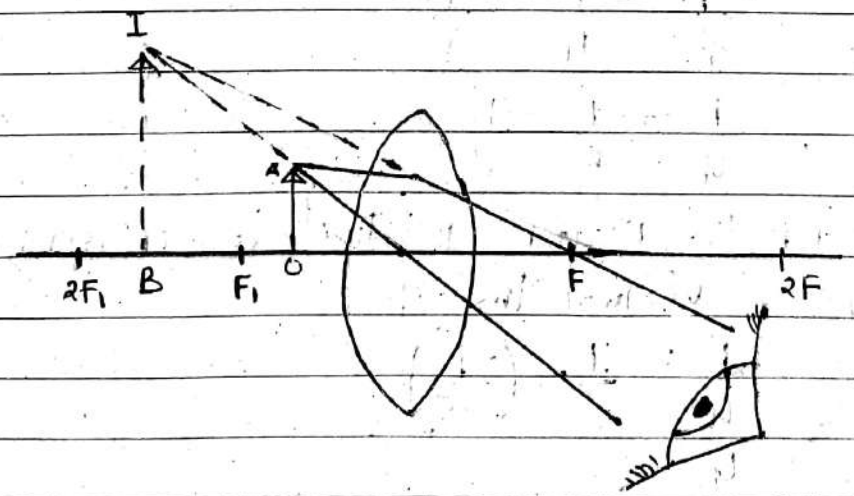
COMMON OPTICAL INSTRUMENTS

- The following are the Common optical Instruments
  1. Simple Microscope.
  2. Compound microscope.
  3. Astronomical Telescope.
  4. Projection lantern.
  5. Lens Camera.
  6. Human eye.

1. SIMPLE MICROSCOPE

What is Simple Microscope?

- Simple microscope is the one which forms magnified Image of an object placed in the focal plane of a Convex lens.



- When an object OA is placed within the focal length of a Convex lens ; A magnified, Virtual and erect image IB is formed.
- The Convex lens is then adjusted until the Image is at near point i.e 25 cm (V).
- The near point is the minimum distance in which a human eye Can see Clearly
- It is Sometimes Called least distance of distinct vision of the human eye.

MAGNIFICATION OF A SIMPLE MICROSCOPE

- What is magnification?

Magnification is the ration of image distance to the object distance.

Mathematically

$$\text{Magnification, } m = \frac{\text{Image distance, } v}{\text{Object distance, } u}$$

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

- from thin lens formula

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

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

- Consider the real-is-positive Convention, Then V is a Virtual Image

$$\frac{1}{u} = \frac{1}{f} - \left(\frac{-1}{25}\right)$$

$$\frac{1}{u} = \frac{1}{f} + \frac{1}{25}$$

$$\frac{1}{u} = \frac{25+f}{25f}$$

$$u(25+f) = 25f$$

$$u = \frac{25f}{25+f}$$

- From

$$m = \frac{v}{u} \quad (\text{but } v = 25)$$

$$m = \frac{25}{\frac{25f}{25+f}}$$

$$m = 25 \div \frac{25f}{25+f}$$

$$m = 25 \times \frac{25+f}{25f}$$

$$m = \frac{625}{25f} + \frac{25f}{25f}$$

$$m = \frac{25}{f} + 1$$

Where by
m = Magnification
f = Focal length (Always f is in cm).
v = Image distance
u = Object distance

Magnification of a Simple microscope is the ratio of the image size to the object size.

Mathematically

$$\text{Magnification, } m = \frac{\text{Image size}}{\text{Object size}} = \frac{h_i}{h_o}$$

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

Make hi the subject

$$h_i = m h_o$$

But

$$m = \frac{25}{f} + 1$$

then

$$h_i = \left(\frac{25}{f} + 1\right) h_o$$

$$\boxed{h_i = \left[\frac{25}{f} + 1\right] h_o}$$

thus:

the shorter focal length of a Simple microscope, the higher magnifying power and vice versa.

Note:

A Simple microscope is sometimes known as Magnifying glass or Hand lens

APPLICATIONS OF SIMPLE MICROSCOPE

- The following are the uses of Simple microscope
  i) To read Small prints.
  ii) To observe specimen in the laboratory which is not seen clearly by naked eye.

Example – 01

(a) What magnifying glass.

(b) What is the relationship between angular magnification and linear magnification

(c) A magnifying glass of focal length 5cm is Used to magnify a Small object held 4cm from the optical centre of the lens. Determine the position and magnification of the image formed.

Solution.

(a) Magnifying glass is a Convex lens that is Used to produce a magnified image of an object.

(b) The Angular magnification is alway equal to linear magnification.

(c) Data given.

Focal length, $f = 5cm$

Object distance, $u = 4cm$

Image distance, $v = ?$

Magnification, $m = ?$

From

$$M = \frac{25}{f} + 1$$

$$m = \frac{25}{5} + 1$$
$$= 5 + 1$$
$$= 6$$

$\therefore$ Magnification of the Image formed is 6

Recall

$$m = \frac{v}{u}$$
$$v = m \times u$$
$$= 6 \times 4cm$$
$$= \underline{24cm}$$

$\therefore$ Position of the Image formed is 24 cm and magnification is 6.

Example-02

(a) What is angular magnification

(b) Magnifying power (angular magnification) is relate to linear magnification? How

(c) A Simple microscope with focal length of 5cm is used to read division of scale 1.5mm in size. How large will be the size of the divisions seen through the simple microscope?

Solution

(a) Angular magnification is the ratio of the angle subtended at the eye by the object when viewed through the magnifying glass to the angle subtended at the eye by the object when viewed with naked eyes

(b)
Magnifying power is equal to linear magnification.

(c) Data given
Focal length, $f = 5cm$
Height of object, $h_o = 1.5mm$
Height of image, $h_i = ?$

From
$$h_i = Mh_o$$
But
$$m = \frac{25}{f} + 1$$
$$= \frac{25}{5} + 1$$
$$= 6$$
then
$$h_i = 6 \times 1.5mm$$
$$= 9mm$$
∴ Each division will appear to have to have a size of 9mm when viewed through the simple microscope.

Example-03

(a) Explain why when using a magnifying glass the image distance should be approximately 25cm from the eye for the object to be viewed clearly.
(b) Mention four uses of simple microscope.
(c) The magnifying power of a simple microscope is 8. What will be the focal length?

Solution

(a) Because you can not clearly see anything that is closer than 25cm to your eye.

(b) Four uses of Simple microscope

i) It is Used to View Specimen in the laboratory
ii) It is Used to View small Components of watch
iii) It is Used to read Small prints.
iv) It is Used to Concentrate light Rys.

(c) Data given

Magnifying Power, $m = 8$
Focal length, $f = ?$

From

$$m = \frac{25}{f} + 1$$

$$f = \frac{25}{m-1}$$

$$= \frac{25}{8-1}$$

$$= \frac{25}{7}$$

$$= 3.6\text{ cm}$$

$\therefore$ The focal length is 3.6 cm.

CONSTRUCTION OF SIMPLE MICRO SCOPE

- Using a Converging lens and pin, one can construct a Simpler microscope by placing the pin closer to the lens than its focal length. The Image obtained when you look through the lens is Much bigger than the Pin itself.

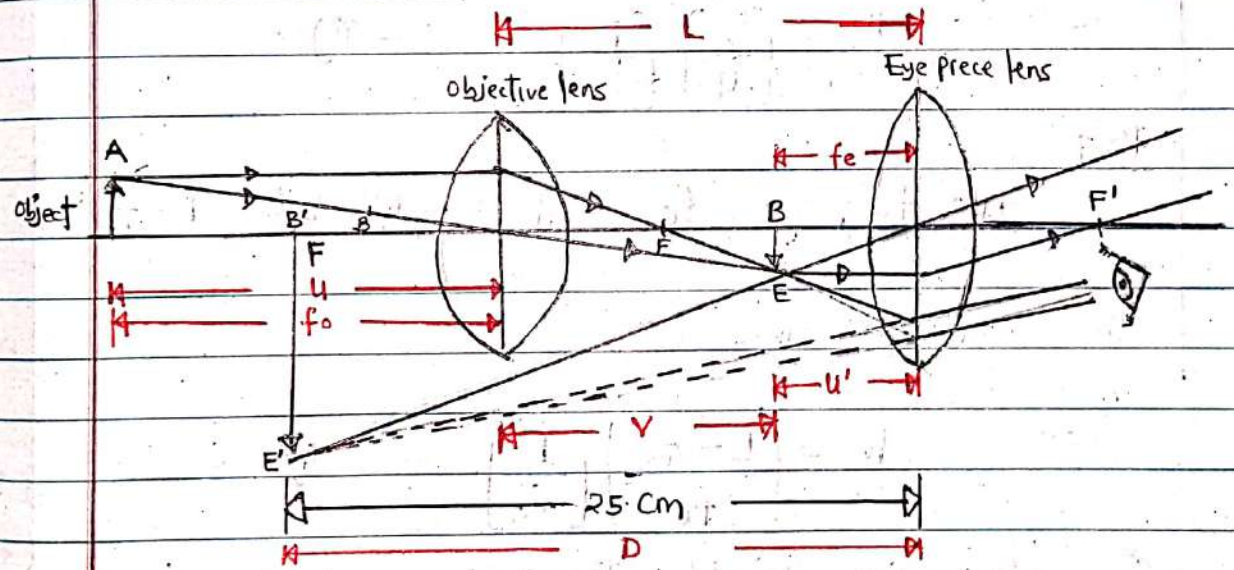
2. COMPOUND MICROSCOPE

What is Compound microscope?

- Compound microscope is an optical device uses two Convex lenses of short focal lengths to form a highly magnified image.
- A lens which is very close to an object is called objective lens while a lens which is very close to an observer's eye is called eye-piece lens
- The two Convex lenses are separated at a fixed distance in a tube.

DIAGRAM OF COMPOUND MICROSCOPE

- Below is a sketch of Compound microscope with two Convex lenses.



MECHANISM

- The object is placed at a distance greater than its focal length (F) of the objective lens so that the real image (BE) is formed inside the principal focus (Fe) of the eye piece. The eye piece treats the real image (BE) as an object and then forms its magnified virtual image (B'E').

MAGNIFICATION OF A COMPOUND MICROSCOPE

Definition :

Is the product of magnification of the Objective and eye piece lenses

Mathematically

$$M = M_o M_e \quad \text{---(i)}$$

But

$$M_o = \frac{V}{U} \quad \text{and} \quad M_e = \frac{D}{U'}$$

then —(i) becomes

$$M = \left(\frac{V}{U}\right)\left(\frac{D}{U'}\right) \quad \text{---(ii)}$$

But

$$U = f_o, \quad U' = f_e \quad \text{and} \quad \{V = L - U' = L - f_e\}$$

Then —(ii) becomes

$$M = \left(\frac{L - f_e}{f_o}\right)\left(\frac{D}{f_e}\right) \quad \text{---(iii)}$$

- To produce large magnification, f_e and f_o must be very Small Compared to L. There fore $L - f_e \approx L$

Thus: $M = \frac{DL}{f_o f_e}$

Since: $D = 25$

$$\boxed{M = \frac{25L}{f_o f_e}}$$

APPLICATIONS OF COMPOUND MICROSCOPE

- The following are the Uses of Compound microscope
  - (i) Observing Brownian motion in science
    - # Brownian movement - Is the random motion of tiny particles suspended in a fluid.
  - (ii) In studying microorganisms and cells in biology
  - (iii) To check Sample in the laboratory. Eg Blood if Infected

Example - 04

(a) What is Compound microscope

(b) State four uses of Compound microscope

(c) A Compound microscope consists of two lenses of focal length 12cm and 6cm for the objective lens and the eyepiece lens, respectively. The two lenses are separated by a distance of 30cm. The Microscope is focused so that the image is formed at infinity. Determine the position of the first image.

Solution

(a) Compound microscope is an optical device that uses two Convex lenses of short focal length to form a highly Magnified Image.

(b) Uses of Compound Microscope

i) Observing brownian motion

ii) Studying Microorganisms and cells in biology.

iii) Analysing laboratory Samples in hospitals

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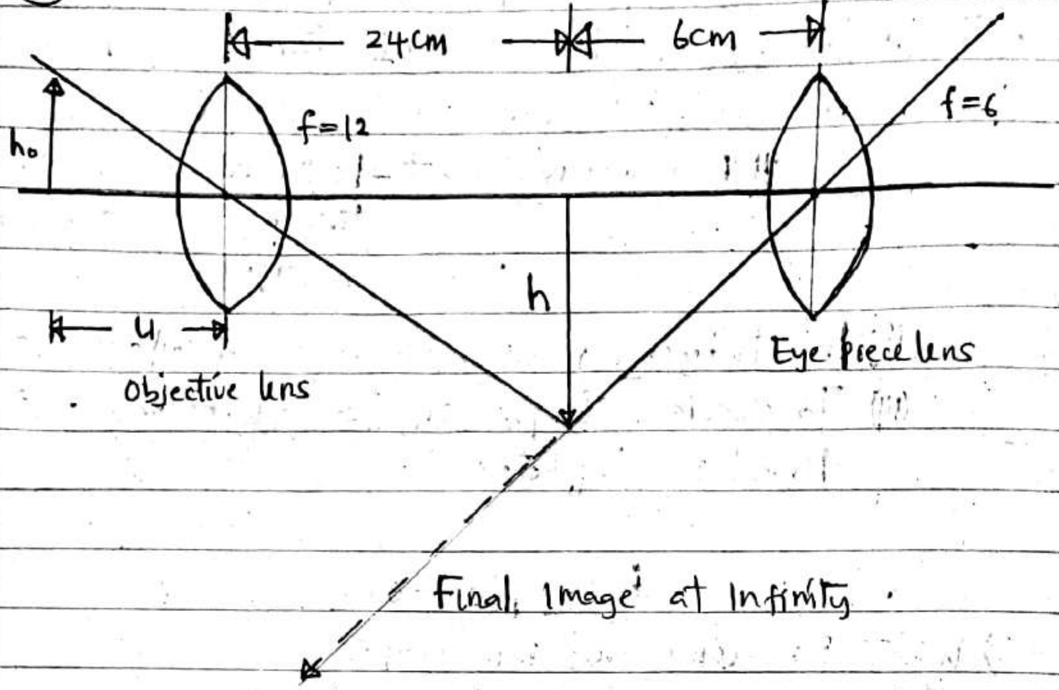
(c)



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

$$\frac{1}{12} = \frac{1}{24} + \frac{1}{u}$$

$$\frac{1}{u} = \frac{1}{12} - \frac{1}{24}$$

$$\frac{1}{u} = \frac{2-1}{24}$$

$$\frac{1}{u} = \frac{1}{24}$$

$$u = 24\ \text{Cm}.$$

∴ The position of the first Image is 24 cm.

N.B

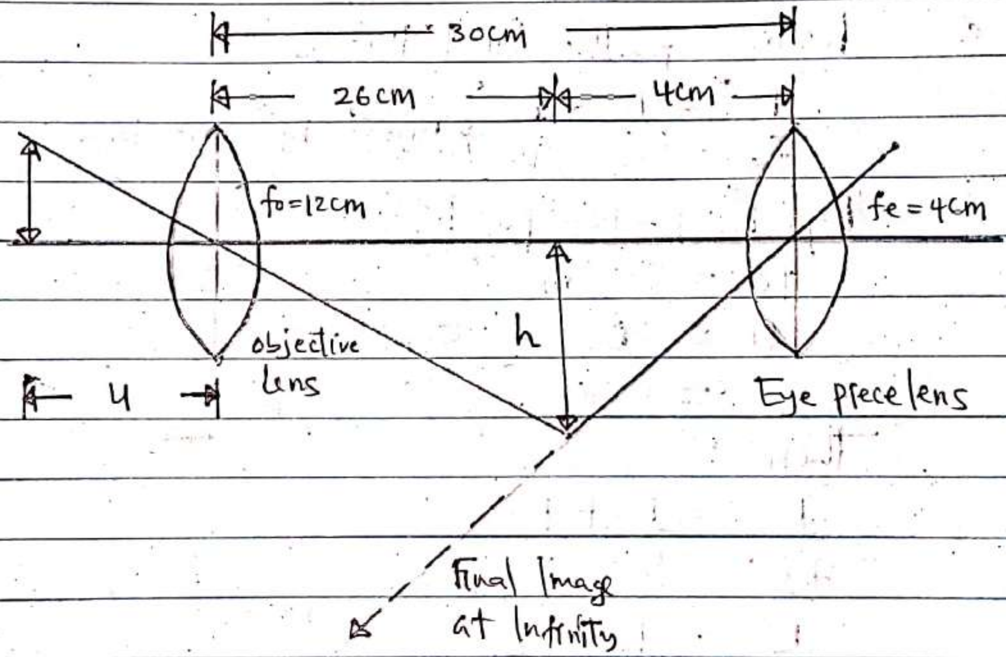
▸ Microscope.

- Is a device used to magnify very small objects which can not be seen by naked eye.

Example - 05

- A Compound microscope Consists of the objective lens and the eye piece lens of focal length 12cm and 4cm, respectively. The two lenses are separated by a distance of 30cm. The Microscope is focused So that the image is formed at infinity. Determine the position of the object.

Solution.



From

$V = L - fe$

$V = 30cm - 4cm$

$= 26cm$

- Using thin lens formula

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

$\frac{1}{12} = \frac{1}{u} + \frac{1}{26}$

$\frac{1}{u} = \frac{26cm - 12cm}{312\ cm^2}$

$\frac{1}{u} = \frac{14}{312cm}$

$u = 22.3\ cm$

$\therefore$ The object distance is 22.3 cm from the objective lens.

Example-06

A parallel beam of light falls on a converging lens arranged so that the axis lies along the direction of the light which is brought to focus 25cm from the lens. The light then passes through a second converging lens of focal length 7.5 cm placed at 30cm from the first lens. Calculate the position of the final image.

Solution

Position of the final image

$$\left.\frac{1}{fe} = \frac{1}{u} + \frac{1}{v}\right\}\text{ refraction by eye piece lens.}$$

By Real-is-positive

$fe = 7.5\text{cm}$

$u = 30\text{cm} - 25\text{cm}$

$= 5\text{cm}$

Then

$$\frac{1}{7.5} = \frac{1}{5} + \frac{1}{v}$$

$$\frac{1}{v} = \frac{1}{7.5} - \frac{1}{5}$$

$$\frac{1}{v} = \frac{2}{15} - \frac{1}{5}$$

$$\frac{1}{v} = \frac{4-6}{30}$$

$$v = -15$$

∴ The position of the final image is 15 cm

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N.B

Sometimes the formula below may be used in Calculations

$$M = \left[\frac{v}{f_o} - 1\right]\left[\frac{D}{f_e} - 1\right]$$

Example - 07

- A Compound microscope has an objective lens of focal length, 2cm and eye piece of focal length of 6cm. An object is placed 2.4 cm from the objective lens. If the distance between the objective lens and the eye piece is 17cm, find
  (a) The distance of the final image from the eye piece and
  (b) The linear magnification.

Solution.

(a) Data

$f_o = 2cm$

$f_e = 6cm$

$u = 2.4cm$

Refraction by the objective lens

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

$$\frac{1}{2} = \frac{1}{2.4} + \frac{1}{v}$$

$$\frac{1}{v} = \frac{1}{2} - \frac{1}{2.4}$$

$$\frac{1}{v} = \frac{1}{2} - \frac{5}{12}$$

$$\frac{1}{v} = \frac{6-5}{12}$$

$$\frac{1}{v} = \frac{1}{12}$$

$$v = 12\ cm$$

Refraction by eye piece lens

- By real-is-positive

$u = (17cm - 12cm)$
$= 5cm$
$f_e = 6cm$

By lens formula

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

$$\frac{1}{6} = \frac{1}{5} + \frac{1}{v}$$

$$\frac{1}{v} = \frac{1}{6} - \frac{1}{5}$$

$$v = -30cm$$

∴ The distance of the final image from the eye piece is 30 cm.

(b) Linear magnification, M

From

$$M = \left[\frac{v}{f_o} - 1\right]\left[\frac{D}{f_e} - 1\right]$$

$$= \left[\frac{12}{2} - 1\right]\left[\frac{30}{6} - 1\right]$$

$$= 5 \times 4$$
$$= 20$$

∴ The linear magnification is 20

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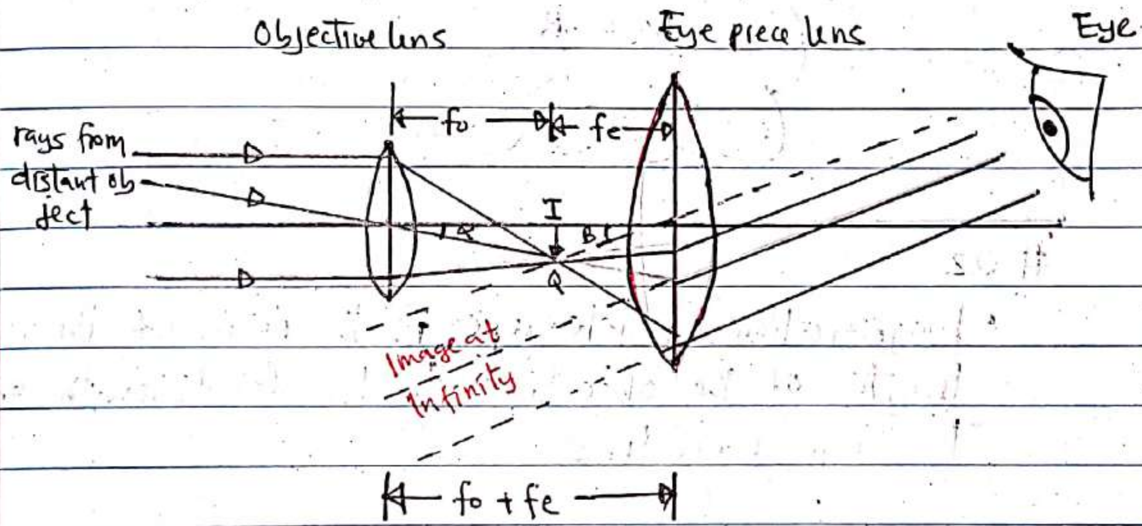
3. ASTRONOMICAL TELESCOPE

What is Astronomical Telescope?

- Astronomical telescope is an optical device which is Used to View distant object.
- It Consists of two Convex lenses namely Objective lens and eye piece lens
- Unlike the Compound microscope, the Astronomical Telescope has objective lens of long focal length and eye piece lens of short focal length.



MODE OF ACTION

- The objective lens of Astronomical telescope forms a real, Inverted and diminished Image of a distant object at its focal point, fo, this Image becomes the object for the eye piece lens. The position of eye piece lens is then adjusted until the object is at its focal point, fe, this adjustment makes the final Image to be formed at Infinity.

APPLICATION OF TELESCOPE

- It is Used to observe celestial objects Eg: moon, stars, planets etc.

MAGNIFICATION OF ASTRONOMICAL TELESCOPE

01

- Is the ratio of the angle in radians of final image subtended at the eye piece lens to the angle in radians a distant object subtended at the objective lens.

Mathematically

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

02

- Magnification of telescope is the ratio of the focal length of the objective to the focal length of the eye piece lens

Mathematically

$$M = \frac{f_o}{f_e}$$

Example - 08

- An astronomical telescope used in normal adjustment has an objective of focal length 60cm and an eye piece of focal length 5cm, what is
  (a) The distance between the lenses.
  (b) The magnifying power.

Solution

- Data given

Focal length of objective lens, $f_o = 60cm$

Focal length of eyepiece lens, $f_e = 5cm$.

(a) let, x = The distance between the lenses.

$$x = f_o + f_e$$
$$= 60cm + 5cm$$
$$= 65\ cm$$

(b) let, M = Magnifying Power

$$M = \frac{f_o}{f_e}$$
$$= \frac{60cm}{5cm}$$
$$= 12$$

Example-09

→ Find the magnification of a telescope with an objective lens whose focal length is 100cm and an eyepiece lens whose focal length is 2cm

Solution

Data

$f_o = 100cm$

$f_e = 2cm$

$M = ?$

From

$$M = \frac{f_o}{f_e}$$
$$= \frac{100cm}{2cm}$$

$M = 50$

∴ Magnification of telescope is 50

Example-10

A refracting telescope has an objective lens with a focal length of 5.0m and an eye piece lens with a short focal length of 0.02m. Calculate the magnifying power of such a telescope in its normal adjustment.

Solution

Data given

$f_o = 5.0m$

$f_e = 0.02m$

$m = ?$

From

$$m = \frac{f_o}{f_e}$$

$$= \frac{5.0m}{0.02m}$$

$$= 250$$

Example-11

An astronomical telescope in normal adjustment has a total length of 78cm and produces an angular magnification of 15. What is the focal length of the objective and eye piece lens?

Solution

Data given

Total length, $x = 78cm$

Magnification, $m = 15$

Focal length of the objective lens, $f_o = ?$

Since

$$x = f_o + f_e$$
$$x - f_o = f_e.$$

$$f_e = x - f_o \longrightarrow (i).$$
$$= \underline{78} - f_o$$

<u>Apply</u>

$$M = \frac{f_o}{f_e}.$$
$$15 = \frac{f_o}{78 - f_o}$$

$$15(78 - f_o) = f_o$$
$$1170 - f_o \times 15 = f_o.$$
$$1170 - 15f_o = f_o.$$
$$\frac{16f_o}{16} = \frac{1170}{16}$$
$$f_o = 73.1\ \text{cm}$$

From — eqn (i)

$$f_e = x - f_o$$
$$= 78 - 73.1\ \text{cm}$$
$$= \underline{4.9\ \text{cm}}$$

$\therefore$ Focal length of the objective is 73.1 cm and that of eye piece is 4.9 cm.

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Example -12

- An Home made telescope has an objective lens of focal length 140cm and an eye piece lens of focal length 4cm. What is the magnifying power of this telescope? Determine the separation distance between the eye piece lens and objective.

Solution:

$f_o = 140\,cm$

$f_e = 4\,cm$

$M = ?$

$X = ?$

From

$$M = \frac{f_o}{f_e}$$

$$= \frac{140\,cm}{4\,cm}$$

$$= 35$$

$\therefore$ The Magnifying power is 35

- let, X be the distance of separation.

$$X = f_o + f_e$$

$$= 140\,cm + 4\,cm$$

$$= 144\,cm$$

BINOCULARS

What are binoculars?

- Binoculars are a type of telescope that allows a user to view far away objects using both eyes

MAGNIFICATION OF BINOCULARS

- Is the ratio of the focal length of the objective lens to the focal length of the eye piece lens

Thus

$$M = \frac{fo}{fe}$$

Example-13

- A binoculars, acting as a telescope, produces an angular magnification of 7.5. What is the eye piece's focal length if the binoculars have an objective lens of focal length 75.0cm?

Solution.

Data given:

$M = 7.5$

$fo = 75\,cm$

$fe = ?$

From

$M = \frac{fo}{fe}$

$\frac{\cancel{M} fe}{\cancel{M}} = \frac{fo}{M}$

$fe = \frac{fo}{M}$

$= \frac{75\,cm}{7.5}$

$= 10\,cm$

$\therefore fe = 10\,cm$

USES OF BINOCULARS:

- The following are the Uses of binoculars
  (i) To View distant objects
  (ii) Used by soldiers to View the enermy Camp from a far point.
  (iii) Used by surveyors to observe land Scapes
  (iv) Used by tourists to View animals.

DIFFERENCES BETWEEN COMPOUND MICROSCOPE AND ASTRONOMICAL TELESCOPE

- The Following are the difference between Compound Microscope and Astronomical Telescope

COMPOUND MICROSCOPE	ASTRONOMICAL TELESCOPE
• Small in shape	• Large in size
• Uses Artificial light	• Uses natural light
• Used to see very small objects	• Used to see distant astronomical objects
• Objective lens has a smaller focal length than the eye piece lens	• Objective lens has a larger focal length than the eye piece lens

TEST YOUR CAPACITY

(14) An Astronomer wants to order a large Concave mirror for a telescope that is to produce high quality image. With explanation, advice whether the astronomer should order a spherical mirror or a parabolic mirror?

(15) Why a prism binoculars preffered over traditional ones?

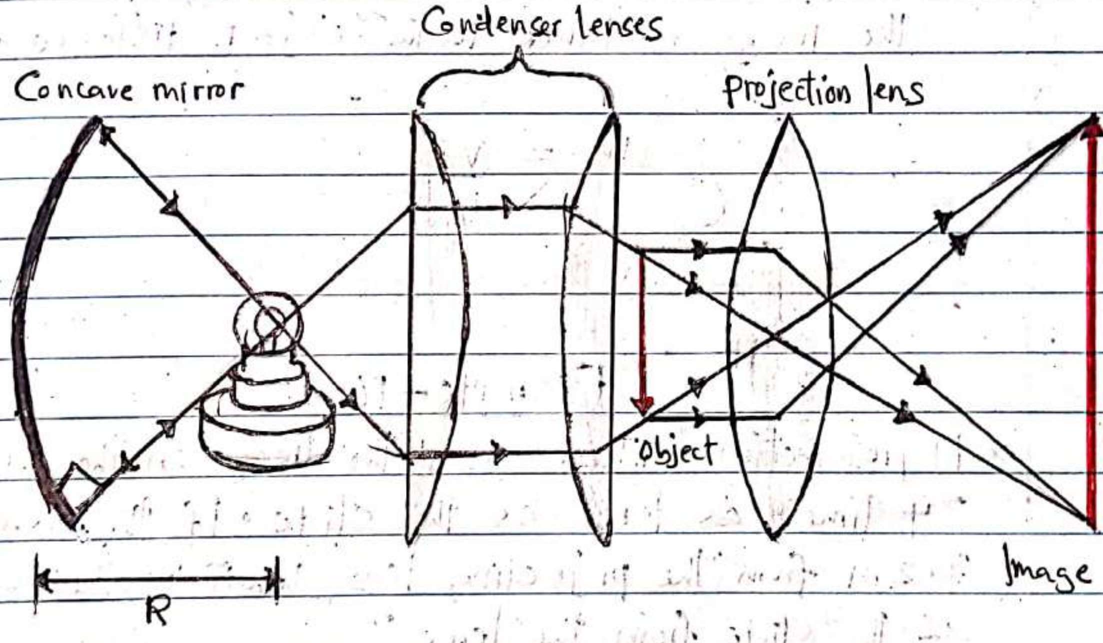
4. PROJECTION LANTERN

What is projenction lantern?

- Projenction lantern is an optical device used to display large image on a screen.
- The projenction lantern forms images of slides or camera film onto a distant screen. The film or slide to be projected is inverted and highly illuminated.

DIAGRAM

- The diagram below show the image formation by a projection lantern.



USES OF PROJECTION LANTERN

(i) Displaying notes and diagrams during class session.
(ii) Displaying pictures in art and entertainment hall.
(iii) Used to give the image of a slide on a screen.
(iv) When aided with some more accessories, movie can be projected to a large screen.

MAGNIFICATION OF A PROJENCTION LANTERN

#01

- Magnification of projenction lantern is given by the ratio of the image height to the object height

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

#02

- Magnification can also be given by the ratio of the image distance to the object distance.

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

Example – 16

A projenction lantern gives the image on the screen 24 times as large as the slide. If the screen is 7.2 m from the projecting lens, what is the position of the slide from the lens?

Solution

Data given:

Magnification, $m = 24$

Image distance, $v = 7.2\,m$

Object distance, $u = ?$

From

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

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

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

$$= \frac{7.2m}{24}$$

$$= 0.3$$

∴ The slide is at distance of 0.3 from the lens

Example-17

- A projenction lantern is used to project a slide measuring 3cm x 3cm onto a screen 12m from the projenction lens. If the size of the screen is 1.5m x 1.5m, how far from the lens must the slide be for the image to fill the entire screen?

Solution

$u = ?$

$v = 12m$

$h_o = 3cm$

$h_1 = 1.5m$

$= 150cm$

From

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

$$m = \frac{150cm}{3cm}$$

$$m = 50$$

Also

$$m = \frac{v}{u}, \quad 50 = \frac{12m}{u}$$

$$\frac{50u}{50} = \frac{12m}{50}$$

$$u = 0.24m$$

Example-18

- A lantern projector using a slide of 2cm x 2cm projects a picture 1m x 1m onto a screen 12m from the projection lens. How far from the lens must the slide be? Find the approximate focal length of the projection lens.

Solution:

Data given

$h_o = 2cm$

$h_i = 1m$, $= 100\ cm$

$v = 12\ m$, $= 1200cm$

$u = ?$

$f = ?$

From

$$M = \frac{v}{u} = \frac{h_i}{h_o}$$

$$\frac{v}{u} = \frac{h_i}{h_o}$$

$$\frac{1200}{u} = \frac{100}{2}$$

$$\frac{100u}{100} = \frac{1200 \times 2}{100}$$

$$u = 24\ cm$$

Also

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

$$\frac{1}{f} = \frac{1}{24} + \frac{1}{1200}$$

$$\frac{1}{f} = \frac{17}{400}$$

$$\frac{17f}{17} = \frac{400}{17}$$

$$f = 23.5\ cm$$

∴ the slide must be 24cm from the lens and the approximate focal length is 23.5cm

TEST YOUR CAPACITY

(19) A projector (projection lantern) is used to project a slide measuring 3cm x 3cm onto a screen 12m from the projection lens. If the size of the screen is 1.5m x 1.5m, how far from the lens must the slide be for the image to fill the entire screen?

(20) a) A projector is to be used to focus the image of an object 35cm high onto a screen measuring 3.5m by 2.4m. If the distance from the projector to the screen is 7m, determine the focal length of the projection lens that should be used so that the image fits exactly on the screen.

b) A slide projector has a projection lens of focal length 15cm. The projector is to be used to project an image of slide measuring 5cm x 5cm onto a screen measuring 1m x 1m. How far from the projection lens should the screen be placed:

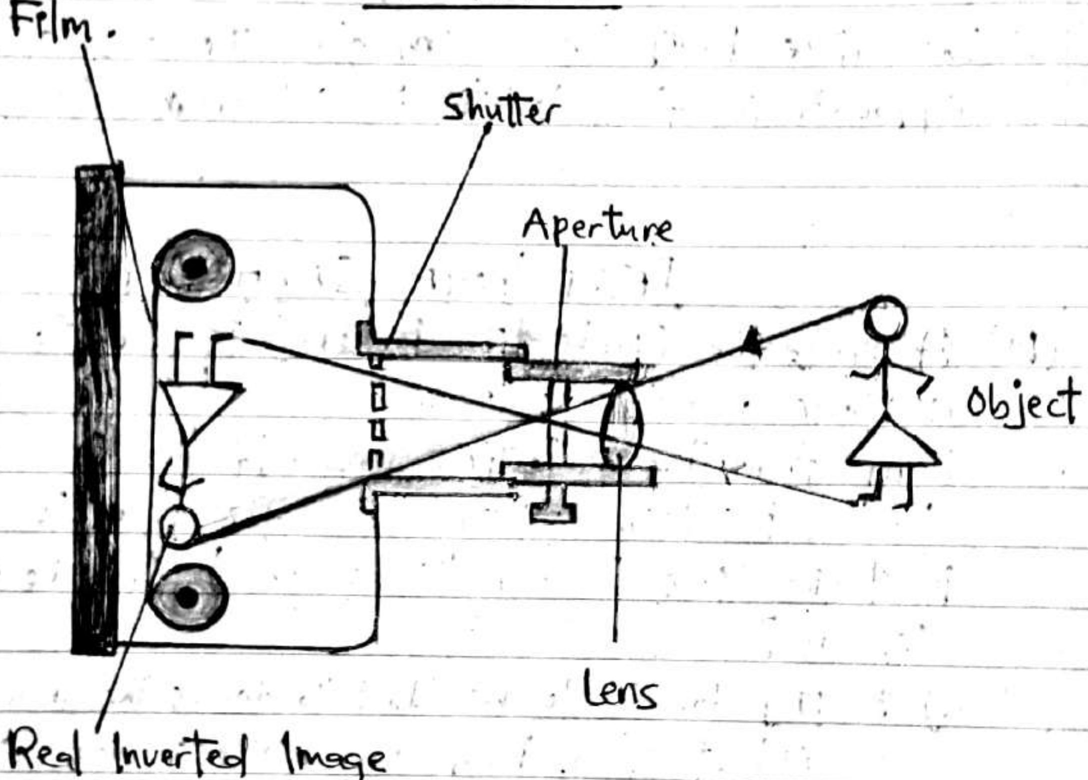
Answers

(19) $u = 24cm$ (20) a) $f = 6.9cm$ b) $7.5\ cm$

5. LENS CAMERA

- A Camera lens is an optical body that features a Single lens or an assembly of lenses that mounts to a Camera body.
- The lens is the Image forming device on a Camera.

DIAGRAM



TYPE OF LENSES IN A CAMERA

- There are four basic Categories of lenses exist in a Camera:
  - (a) Normal lens.
  - (b) Wide angle lens.
  - (c) Telephoto lens.
  - (d) Interchangeable lens.

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(A) NORMAL LENS

- Is the one which allows the viewing field of approx imately 50 degrees, giving a picture that is nor mal in size relative to the background and which looks natural to the viewer.

(B) WIDE ANGLE LENS

- Is the one which enables a view of 90 degrees and is used when smaller objects are to be photo graphed.

(C) TELEPHOTO LENS

- Is the one which has a wider field of view than the normal lens.
- It shows enlarged detail of the image over the same film area
- The Telephoto lens has a long reach, allowing you to capture an object that is far away.
- You have probably seen a photograph where an object is in focus but the background is **blurred**; this is often done by telephoto lens.
- Telephoto lens is also called long-focus-lens.

(D) INTERCHANGEABLE LENS

- Is the one which offers the photographer oppo rtunity to select the focal length that is best for a given situation

PARTS OF LENS CAMERA

- Lens camera has got the following parts:

(a) Diaphragm
(b) Shutter
(c) View finder
(d) Film.

(A) DIAPHRAGM

- The diaphragm determines the amount of light that passes through the lens by changing the size of the aperture.

APERTURE

What is Aperture?

- Aperture is an opening whose diameter is adjustable

(B) SHUTTER

- This is a mechanical device that acts as a gate, Controlling the duration of time that light is allowed to pass through the lens and fall on the film

(C) VIEW FINDER

- The Viewfinder defines the area Covered by the lens That is in Use on the Camera.

(D) FILM

- The film is a light-sensitive Surface of the Camera

MODE OF ACTION OF A LENS CAMERA

- To take a photograph of an object, the image of the object must be sharply focused on the film by adjusting the distance of the lens from the film. After focusing and correctly Setting the aperture size and shutter time, the click botTom is pressed. The Shutter opens to allow light to enter and expose the film to form an image of the object being photographed. The film is Then developed to produce a photograph of the object.

MAGNIFICATION

- Magnification produced by lens Camera is given as

$$m = \frac{v}{u} \quad \text{or} \quad m = \frac{h_i}{h_o}$$

- Recalling the lens formula

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

Make v the subject of the formula:

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

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

$$\frac{v(u-f)}{u-f} = \frac{fu}{u-f}$$

$$v = \frac{f}{u-f} \quad \text{—— (i)}$$

- From

$$m = \frac{v}{u} \quad \text{(Substitute eqn —(i) here)}$$

$$m = \frac{fu}{u-f} \div u$$

$$m = \frac{fu}{u-f} \times \frac{1}{u}$$

$$m = \frac{f\cancel{u}}{(u-f)\cancel{u}}$$

$$\therefore \quad m = \frac{f}{u-f}$$

Example-21

- A lens camera of focal length 10cm is used to take the picture of a girl 1.5m tall. Determine the magnification of the image if the girl 11m from the camera.

Solution

focal length, $f = 10cm$ $(0.1m)$
Object distance, $u = 11\ m$
Magnification, $m = ?$

From

$$M = \frac{f}{u-f}$$

$$= \frac{0.1}{11-0.1}$$

$$= 0.009$$

Example - 22

- A lens camera of focal length 15 cm is used to take a picture of a man of height 1.8m. If the man is standing 10m ahead of the camera. Determine the

(a) Magnification of the image
(b) Size of the image

Solution

Given

focal length, $f = 15cm$ $(0.15m)$
Height of object, $h_o = 1.8m$
Object distance, $u = 10m$

(a) Magnification of Image, $m = ?$

From

$$m = \frac{f}{u-f}$$

$$= \frac{0.15}{10-0.15}$$

$$= 0.0152$$

(b) Let Image height (size of Image) be, hi

Recall

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

$$h_i = m h_o$$

$$= 0.0152 \times 1.8\,m$$

$$= 0.027\,m$$

$$= 2.7\,cm$$

Example-23

- A lens Camera is used to take a picture of a boy whose height 200cm tall. The lens of the Camera has a focal length of 10cm. What should be the minimum size of the film frame required to photograph the boy if he is standing at a distance of 2010cm from the Camera?

Solution

Data given

Height of object, $h_o = 200\,cm$

Focal length, $f = 10cm$

Image height, $h_i = ?$

Object distance, $u = 2010\,cm$.

From

$$M = \frac{f}{u-f}$$

$$= \frac{10}{2010-10}$$

$$= \frac{10}{2000}$$

$$= \frac{1}{200}$$

Also

$$m = \frac{hi}{ho}$$

$$hi = m\,ho$$

$$= \frac{1}{200} \times 200\text{cm}$$

$$= \frac{200\text{cm}}{200}$$

$$= 1\text{cm}$$

$\therefore$ The size of the film frame should be 1cm square

$\therefore hi \times hi = 1\text{cm} \times 1\text{cm}$

YOU SHOULD NOTE THAT

i) Optometrists and ophthalmologists usually prescribe lenses measured in DIOPTERS

ii) Power of a lens in diopters is equal to the inverse of the focal length in metres

Thus

$$P = \frac{1}{f}$$

USES OF LENS CAMERA

(i) Video Cameras are Used to take motion pictures

(ii) High speed Cameras Used to record movement of particles.

(iii) Digital Cameras are Used to capture images

(iv) Closed – circuit television Cameras are Used for Surveillance in high- security.

Example – 24

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- Match the optical Instruments in List A with the Correct responses from List B, by writing its letter beside the item number in the answer sheet provided

LIST. A	LIST. B
i) It Consists of biconvex lens that may be placed in frame and Sometimes referred as magnifying glass.	A. Simple Microscope
ii) It Composes of two Convex lenses of short focal lengths placed in a tube.	B. Periscope
iii) It Composed of a long focal length of the objective lens and much shorter focal length of the eye piece lens.	C. The projection lantern
iv) A Complex Instrument which takes many forms like still and motion pictures.	D. The lens Camera
v) It is Used to display a large Image on a Screen.	E. Gold leaf electroscope.
	F. The Human eye
	G. The Compound Microscope
	H. The Astronomical Telescope.

ANSWER

LIST. A	I	II	III	IV	V
LIST. B	A	G	H	D	C

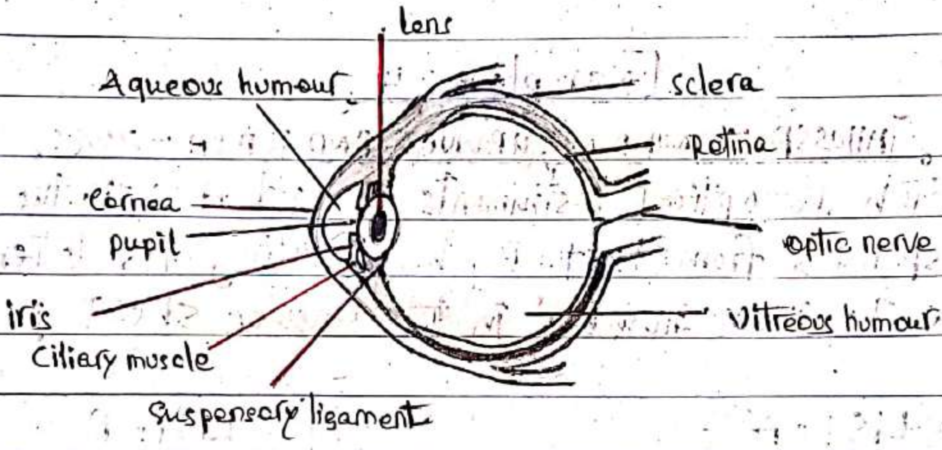
6. HUMAN EYE

What is human eye?

- Human eye is a natural optical instrument that is exceptionally important for human life.

OR

- Human eye is an optical device able to respond to an enormous range of light brightness.



PARTS OF THE HUMAN EYE

- The following are the parts of human eye
  - (a) Cornea
  - (b) Iris
  - (c) Pupil
  - (d) Lens
  - (e) Retina
  - (f) Optic nerve
  - (g) Sclera
  - (h) Vitreous humour

(A): CORNEA

- This is the transparent, outer part of the eye.
- It is the primary focusing tool of the eye
- The outer part of Cornea is known as epithelium

EPITHELIUM

What is epithelium?

- Epithelium is the outer layer of the cornea.

FUNCTION OF CORNEA

- The function of the cornea is to protect the eye

(B) IRIS

- Iris is the part of the eye which is responsible for one's eye colour.

FUNCTIOIN OF IRIS

- Iris acts like diaphragm of the Camera, dilating and constricting the pupil to allow more or less light into the eye

(C) PUPIL

- This is the dark opening in the centre of the coloured iris that controls the amount of light that enters the eye.

FUNCTION OF PUPIL

- The function of pupil is the same as that of aperture in a camera, the size of pupil determines the amount of light entering the eye.

(D) LENS

- The lens is the part of the eye immediately behind the iris..

FUNCTIOIN OF LENS

- To focus light rays on the retina.

- In person under 40 years, the lens is soft and flexible, allowing for fine focusing from a wide variety of distance.

(E) RETINA

- The retina is the membrane lining the back of the eye that contains photoreceptor cells it reacts to the presence and intensity of light by sending an impulse to the brain via the optic nerve.
- The retina compares to the film in a lens camera.

(F) OPTIC NERVE

What is optic nerve?

- Optic nerve is the structure which takes the information from the retina as electrical signals to the brain
- Optic nerve is referred as million nerve fibres.

(G). SCLERA

What is sclera?

- Sclera is the white, tough wall of the eye.

FUNCTION OF SCLERA

- The function of sclera is to protect the eye

(H) VITREOUS HUMOUR

What is virtreous humour?

- Vitreous humour is a jelly-like substance that fills the body of the eye. It is normally clear

FUNCTION OF VITREOUS HUMOUR

(i) To maintain the eye pressure.
(ii) Helps in focusing light rays.

SUMMARY

CAMERA	HUMAN EYE
• Film	• Retina
• Diaphragm	• Iris
• Aperture	• Pupil
• Lens	• Lens
• Black paint	• Choroid

SIMILARITY OF HUMAN EYE AND LENS CAMERA

- The following are the similarities between Human eye and lens Camera.
  (i) Both save images
  (ii) Both form a real, reduced and inverted image.
  (iii) Both have a Convex lens system to focus the Image.
  (iv) They both have surfaces on which the Image is formed.
  (v) The retina behaves like the photographic screen of a Camera.

Example-25

- The part of the human eye that corresponds to the film in a Camera is the
  (a) Iris (c) retina
  (b) Pupil (d) Cornea

$\boxed{C}$

DIFFERENCES BETWEEN LENS CAMERA AND HUMAN EYE

LENS CAMERA	HUMAN EYE
• Lens is hard	• Lens is soft and elastic
• Thickness of lens does not change	• Thickness of lens changes
• Image is focused by moving the lens	• Image is focused by changing the thickness of the lens
• Only the lens refracts the light	• Aqueous and vitreous humour refracts the light
• Diaphragm can be altered	• Iris alters itself.
• Cameras do not have blind spot	• Human eyes have blind spot.

ACCOMMODATION.

What is accommodation?

- Accommodation is the process where by an eye focal length adjusted to see distant objects.

EYE DEFECTS

What is eye defects?

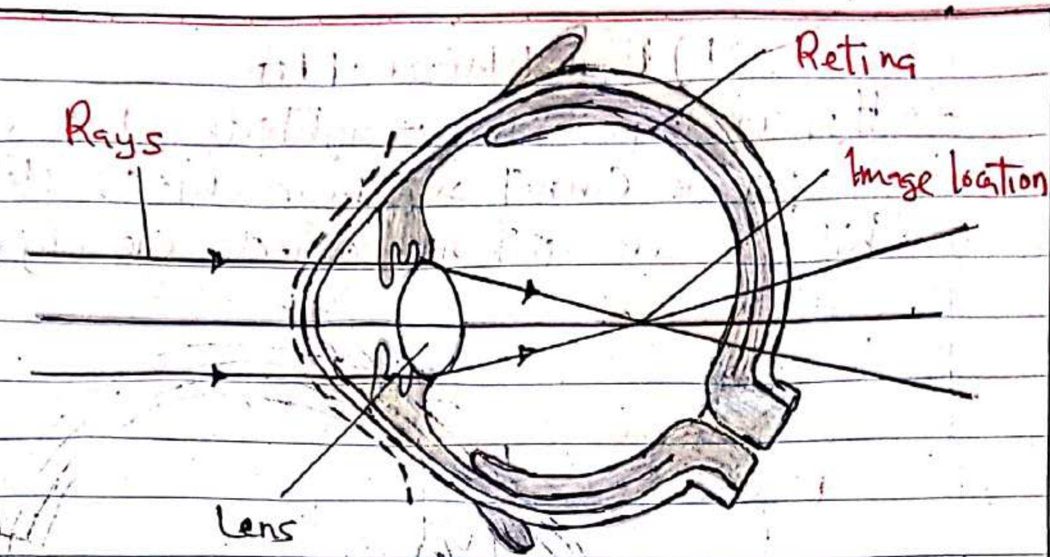
- Eye defects is the phenomenon where by eye defeat to see clearly.

COMMON EYE DEFECTS

- There are two common eye defects
  - (a) Myopia
  - (b) Hypermetropia.

(A) MYOPIA

- Myopia (short-sightedness defect) occurs when a person can see near objects clearly but can not see distant objects clearly.



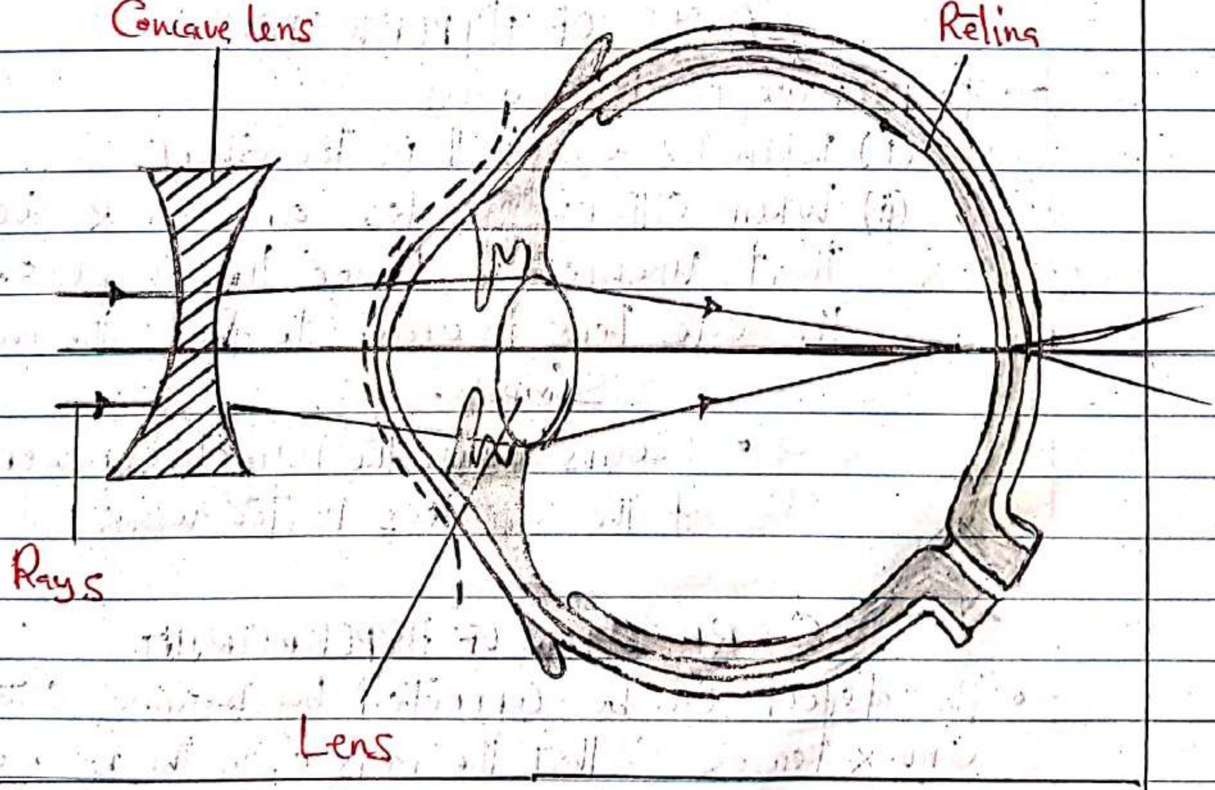
CAUSES OF MYOPIA

(i) When the eyeball is too long

(ii) When the refractive power of the lens is too strong

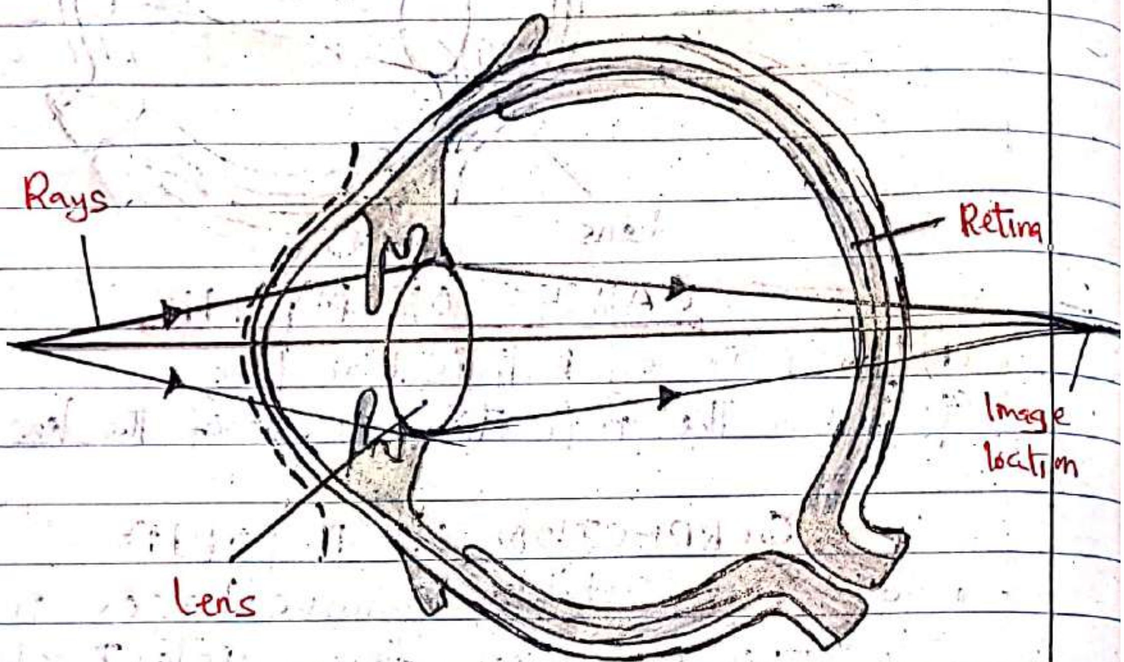
CORRECTION OF MYOPIA

- To wear suitable concave lenses in order to diverge the rays from distant objects before the reach the eye.



(B) HYPERMETROPIA

- Hypermetropia (long-sightedness) occurs when a person cannot see near objects clearly but can see distant objects clearly.

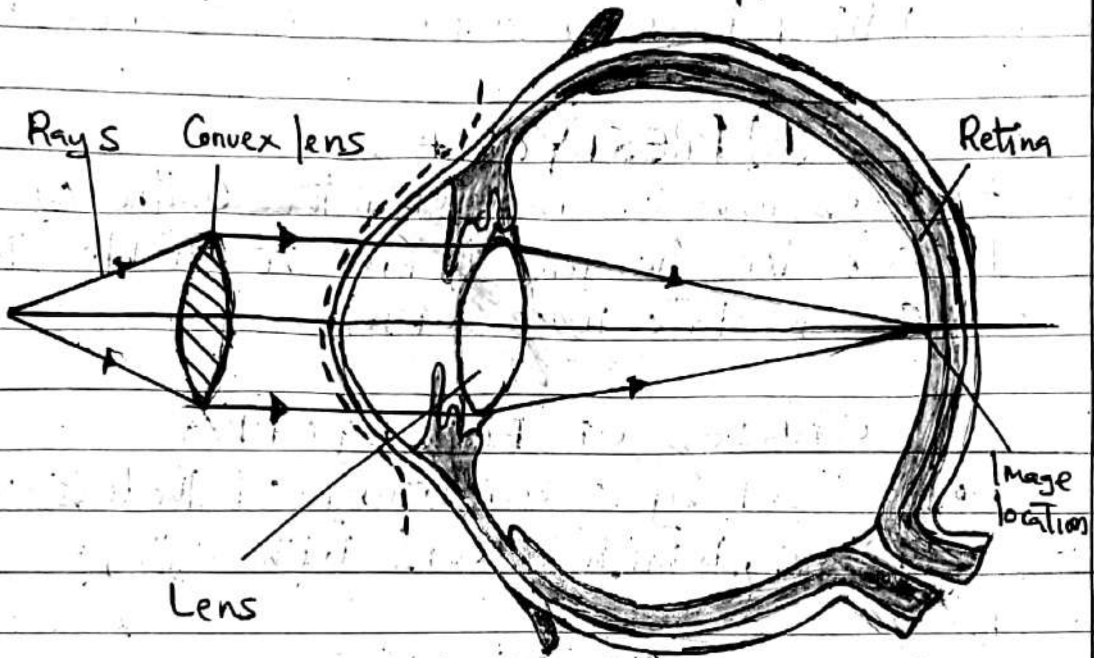


CAUSES OF HYPERMETROPIA

- Hypermetropia is caused
  (i) When the eye ball is too short
  (ii) When ciliary muscles are weak such that unable to change the shape of the eye lens in order to focus the image simply.
  - occurs when the refractive power of the eye lens is too weak.

CORRECTION OF HYPERMETROPIA

- The defect can be corrected by wearing suitable convex lenses so that the rays from the near object are made to converge and focus on the retina.



OTHER DEFECTS

- Other eye defects can be categorized into
  (a) Astigmatism
  (b) Presbyopia

(A) ASTIGMATISM

- This occurs when the Image is distorted beca use light rays are blocked from meeting at a Common focus

CAUSES OF ASTIGMATISM

- Astigmatism is caused when the Cornea shape is is like an oblong rugby ball and not spherical in shape as normal.

CORRECTION OF ASTIGMATISM

- Astigmatism Can be corrected by Using Cylindrical lenses or performing eye surgery.

(B) PRESBYOPIA

- Presbyopia occurs when the Centre of the eye lens hardens Making it Unable to accomodate near Vision.

CAUSES OF PRESBYOPIA

- Is Caused by a hardening of the lens of your eye, which occurs with aging.

CORRECTION

- Eye glasses with progressive lenses are prescribed to Correct or Improve the Condition.

Example-26

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- The term accomodation as applied to the eye refers to the ability of the organ in use. Predict which is the function of this case?
  - (a) To Vary focal length of the lens
  - (b) To Control the light Intensity falling on the retina
  - (c) To distinguish between different Colours
  - (d) To erect the Inverted Image formed on the retina
  - (e) To Transmit the Image to the brain.

Example-27

(a) How do people with short-sighted defect differ from those with long-sighted defect?

(b) Calculate the focal length of a lens when a projector is used to produce a sharp Image of an object being at a distance of 120cm from the Screen and image at 140cm from the screen.

Solution

(a)

SHORT SIGHTEDNESS	LONG SIGHTEDNESS
i) It is corrected by wearing biconcave glasses	i) It is corrected by wearing biconvex glasses
ii) Image of distant object is formed before the retina	ii) Image in the eye is formed behind retina.
iii) May be caused by either the lens being too thick or the eye ball bulging at the back	iii) May be caused by a thin eye lens or short eye ball.

(b) Data given:

Focal length, $f = ?$

Object distance, $u = 120cm$

Image distance, $v = 140cm$

From thin lens formula:

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

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

$$f = \frac{120cm \times 140cm}{140cm - 120cm} = \frac{16800\ cm^2}{20\ cm}$$

$$= 840cm$$

• This qn is not correct

Example-28

- Explain two ways in which lens cameras differ from human eye.

Answer

- Differences between a lens camera and a human eye

LENS CAMERA	HUMAN EYE
i) Image formed on a photographic plate	i) Image formed on the retina
ii) Focus is achieved by Movement of lens	ii) Focus is achieved by change in thickness of the lens

Example-29

(a) Explain two functions of the shutter in a camera.

(b) What is the effect of moving the pinhole camera closer to the object?

(c) State two ways in which the image formed in a plane mirror differs from that in a pinhole camera.

Answer

(a) Function of a shutter

i) To control the amount of light that goes through the photographic plate.

ii) To control the length of time during which the photographic plate is exposed to light.

(b) Moving pinhole camera closer to the object will increase the height of the image formed.

PREPARED BY ROBERT SILVESTER MSAKI
0624254757/0656078107

(c) Difference between an Image formed in a plane mirror to that formed in a pinhole Camera.

PLANE MIRROR IMAGE	PIN HOLE CAMERA IMAGE
• Virtual	• Real
• Upright	• Inverted
• Behind the mirror	• On a screen
• It is the same size as the object	• It is diminished relative to the object

Example-30

(a) State briefly the cause for blurred image in a concave mirror or convex lenses.

(b) Explain two principles in physics used to make telescopes.

(c) A telescope of 5.0 m diameter with a reflector of focal length 18.0 m is used to focus the image of the Sun. Using the distance of the Sun from the earth and diameter of the Sun as 1.5×10^{11} m and 1.4×10^{9} m respectively, calculate the:

i) Position of the Image of the Sun.

ii) diameter of the Image of the Sun.

Solution

(a) A blurred image occurs when light rays passing through the lens are not brought to the same focus.

(b) Two principles of Physics used to make telescope

i) Reflection.

ii) Refraction.

(c) Given

$u = 1.5 \times 10^{11}\,m$

$d = 1.4 \times 10^{9}$

$v = f = 18.0\,cm$

From

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

$$= \frac{18.0m}{1.5 \times 10^{11} m}$$

$$= 1.2 \times 10^{-10}$$

Also

$$m = \frac{d'}{d}$$

$$d' = m \times d$$

$$= 1.2 \times 10^{-10} \times 1.4 \times 10^{9}$$

$$= 0.168\,m$$

$\therefore$ The Image is 16.8 cm wide

Example – 31

- The distance between the film and the lens Camera is 6.25 cm When it is focused on an object 1.5M from the lens. How far Must the lens be moved, and in what direction, in order to focus the Camera on the distant object?

Solution

Initial Image distance, $v_o = 6.25\,cm$

Initial object distance, $u_o = 1.5\,m$

$= 150\,cm$

- By Using Real is positive

$$\frac{1}{f} = \frac{1}{u_0} + \frac{1}{v_0}$$

$$\frac{1}{f} = \frac{1}{150cm} + \frac{1}{6.25 cm}$$

$$\frac{1}{f} = \frac{1}{6cm}$$

$$f = 6cm$$

Now the object is at Infinity ($u = \infty$)

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

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

$$\frac{1}{f} = \frac{1}{6cm}$$

$$v = 6cm$$

Change in Image distance $= v - v_0$

$$= 6cm - 6.25 cm$$

$$= -0.25 cm$$

$\therefore$ The lens should be moved 0.25 cm backwards

TEST YOUR CAPACITY

(32) A far-sighted eye can only focus on objects beyond 100cm. What are the focal length and power of the contact lens needed to correct this problem?.

(33) An astronomer wants to order a large concave mirror for a telescope that is to produce high quality images. With explanations, advise whether the astronomer should order a spherical mirror or a parabolic mirror?

(34) Explain the meaning of the following terms as used in optical Instruments:
(a) Magnifying power.
(b) Accomodation.

(35) Explain how the image of an object is formed in the human eye.

(36) Give two defects of human eye and explain how they can be corrected.

(37) Describe two ways in which a lens camera and the human eye are similar.

(38) Describe two ways in which a lens camera and the human eye are different.

(39) Two students complain that they can not see objects that are closer than 1m from their eyes.
(a) What problem do they have? Describe it using a neat diagram.
(b) How can their problem be solved?
(c) Determine the power of the device that can be used to solve their problem.

Example-40

(a) Distinguish between Hyperopia and presbyopic
(b) The far point of a myopic eye person is 50cm in front of the eye. What is the nature and power of the lens required to correct the problem?

Solution

(a) Hyperopia is a condition in which images of nearby objects are blurry while presbyopic is the gradual loss of the eye's ability to focus on nearby objects, and occurs because of old age.

(b)

The Concave lens should make the objects at Infinity appear at the far point,

- For object at Infinity, $u\ \infty$, Far point of the defected eye, $v = -50cm$

By Lens formula:

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

$$\frac{1}{f} = \frac{1}{\infty} + \frac{1}{-50cm}$$

$$\frac{1}{f} = \frac{1}{-50cm}$$

$$f = 1 \times -50cm$$

$$f = -50cm$$

$$= -0.5m$$

Hence

$$P = \frac{1}{f}$$

$$= \frac{1}{-0.5m}$$

$$= -2.0\ D$$

$\therefore$ Power of the lens is $-2.0\ D$

— xx END OF TOPIC — xx —

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