Chapter = 10

Geometrical Optics

THEORY NOTES

GEOMETRICAL OPTICS:-

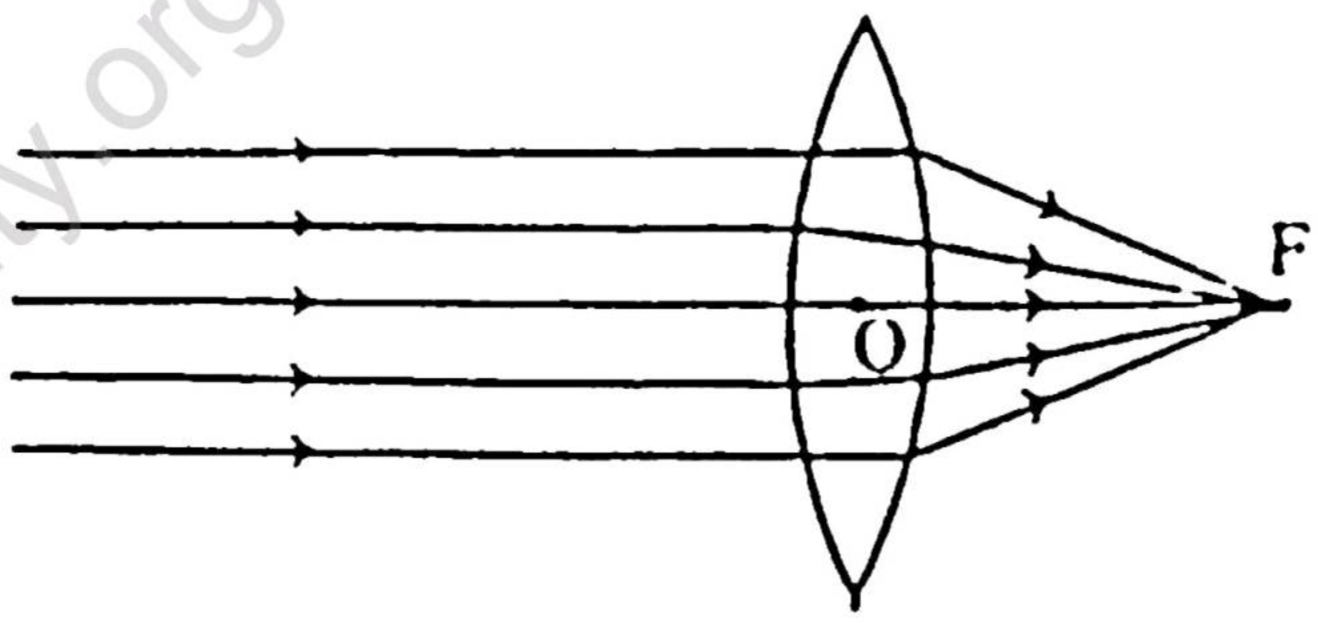
The study of nature and behavior of light is called optics which is a branch of physics., where the wave nature of radiation need not be considered, but situation can be discussed in terms of rays, such study is traditionally called Geometrical optics.

LENSES

A lens is a piece of transparent material that can focus a transmitted beam of light. This is usually bounded by two spherical surfaces. or a spherical and a plane surface. Basically lenses fall into two categories.
1. Converging or Convex lenses
2. Diverging or Concave lenses.

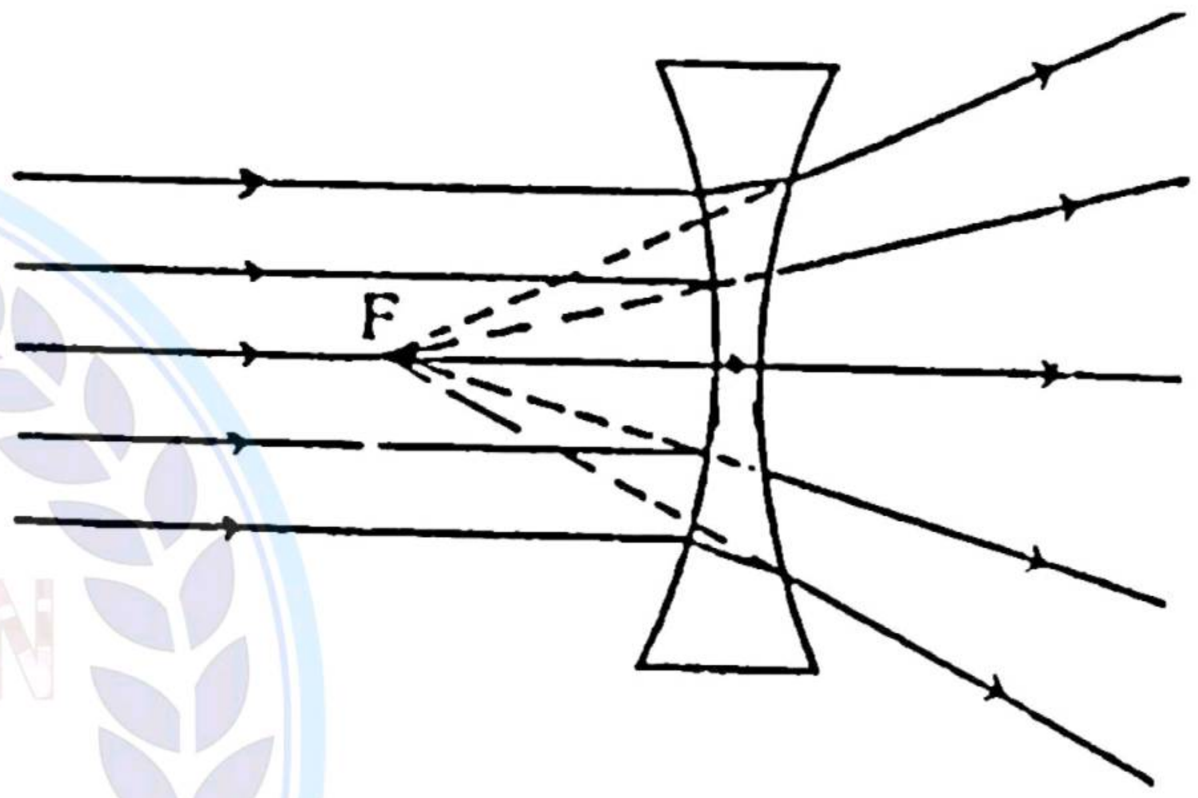
1. CONVERGING OR CONVEX LENSES:

A convex lens is thicker in the middle and thinner at the edges light rays towards its optical axis. (the line through its centre of curvature) ,so that a beam of parallel rays converges at a point F.For example in bright sunlight , a convex lens can produce bright spot of light intense enough to ignite paper.



2. DIVERGING OR CONCAVE LENSES:

A concave lens is thinner in the middle and thicker at the edges light rays towards its optical axis. (the line through its centre of curvature) ,so that a beam of parallel rays diverges in different direction.



PRINCIPAL FOCUS OR THE FOCAL POINT:

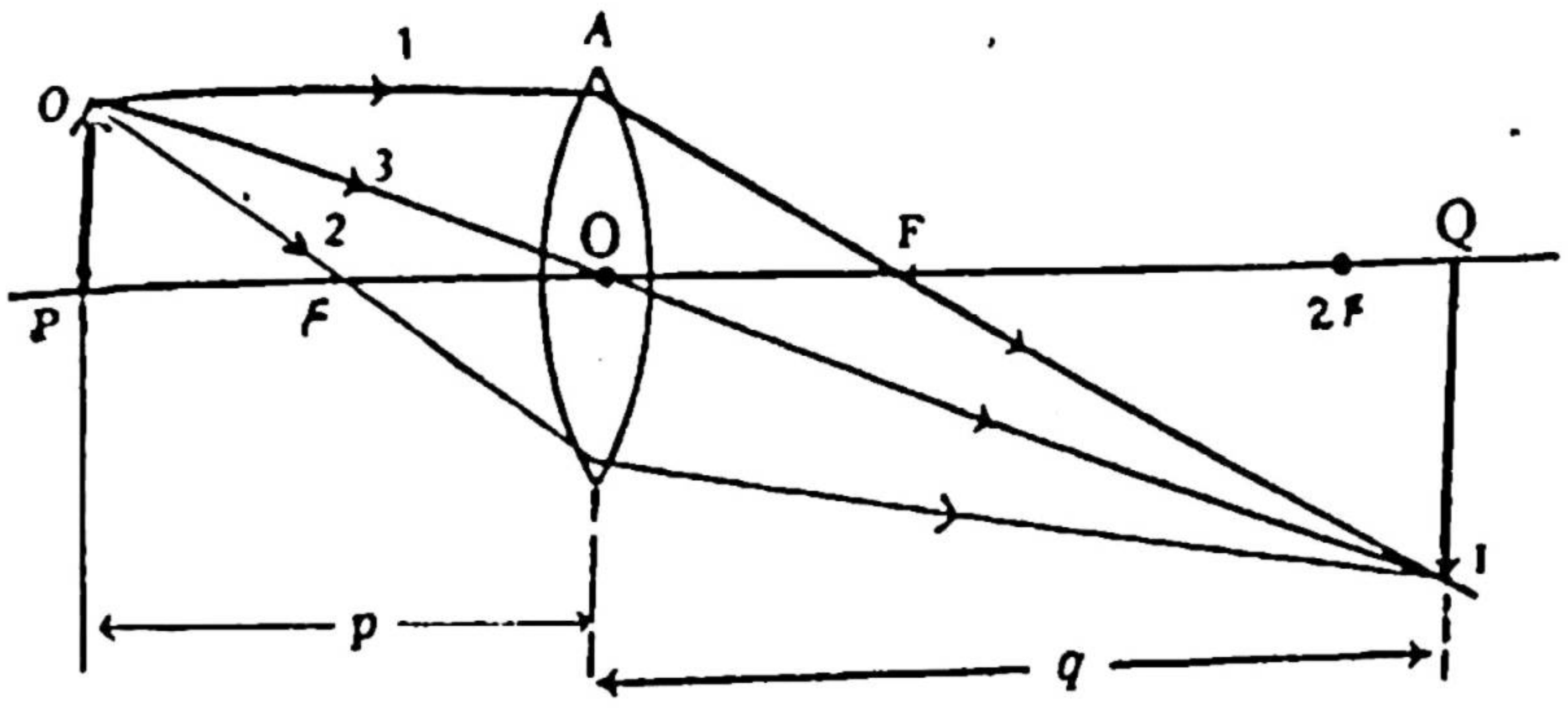
The point F to which the rays are brought to focus is called the principal focus or the focal point.

FOCAL LENGTH:

The distance between the optical centre of the lens and its principal focus is called focal length. For Concave lens it is taken negative and for convex lens it is positive.

PROPERTIES OF RAYS:

(1) A ray comes parallel to principal axis after serving refraction passes through focus.
(2) A ray comes through focus after refraction becomes parallel to principal axis.
(3) A ray strikes at center of lens refract without any deviation.



THIN LENS FORMULA

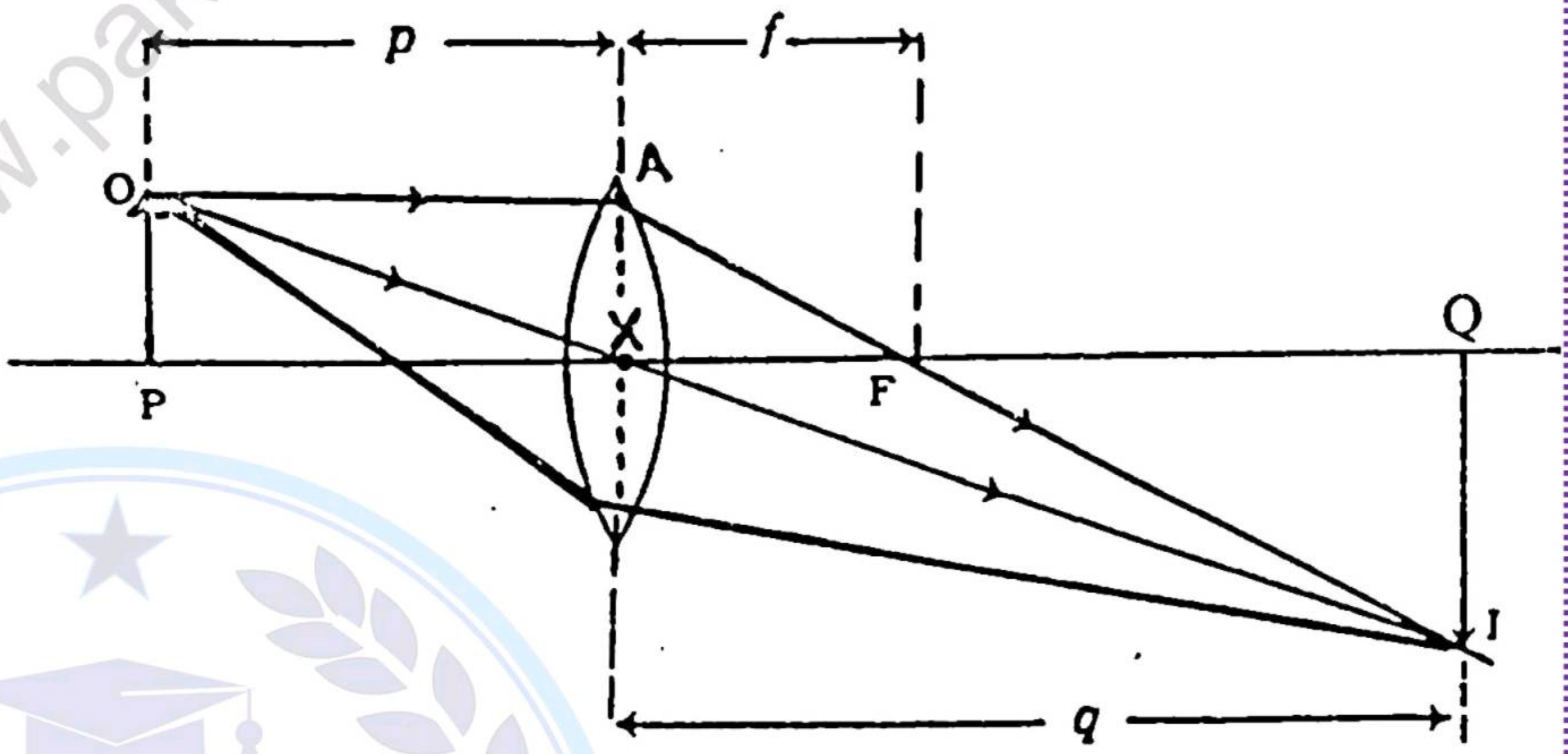
Let us consider an object whose real and inverted image is formed by a thin convex lens as shown in figure.

As shown in the figure the right angled triangle OPX and IQX are similar, therefore we can write as,

$$\frac{OP}{IQ} = \frac{PX}{QX} = \frac{p}{q}$$

Again right angled triangles AXF and IQF are also similar, Therefore,

$$\frac{AX}{IQ} = \frac{XF}{QF} = \frac{f}{q-f}$$



Since AX=OP, Therefore,

$$\frac{OP}{IQ} = \frac{XF}{QF}$$

or $$\frac{p}{q} = \frac{f}{q-f}$$

$$p(q-f) = qf$$

$$pq - pf = qf$$

Dividing by "pqf" on both sides we get,

$$\frac{pq}{pqf} - \frac{pf}{pqf} = \frac{qf}{pqf}$$

$$\frac{1}{f} - \frac{1}{q} = \frac{1}{p}$$

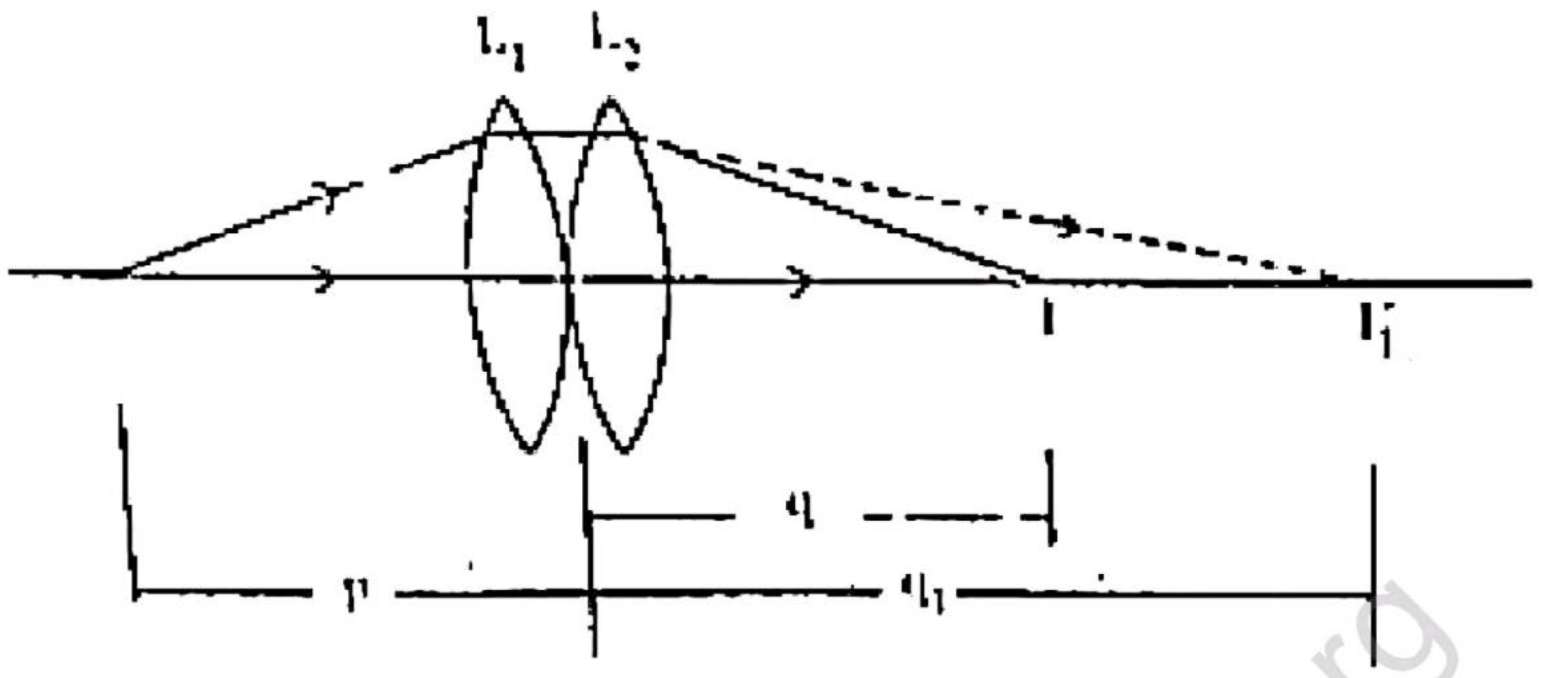
or

$$\boxed{\frac{1}{f} = \frac{1}{p} + \frac{1}{q}}$$ This is known as lens equation of lens formula.

COMBINATION OF LENSES

Lens are also used in combination as desired this combination may be of some type lens are in different lens continuation may be in styles. i.e. (1) lenses are separated sufficiently or (2) may be in contact or closer. Whenever parallel rays are desired to make again parallel the lenses are places such that their separation is sum of their focal lengths are shown above i.e. focus of both lenses lies at a some point.

Consider two lenses of focal length f_1 and f_2 placed in contact. First lens form the image at I_1 of object O at a distance q_1 the lens equation for first be.



$$\frac{1}{f_1} = \frac{1}{p} + \frac{1}{q_1} \text{------(i)}$$

This image now serves as the virtual object for the second lens of focal length f_2. It forms the image at I of object O at a distance q ,For second lens formula is

$$\frac{1}{f_2} = -\frac{1}{q_1} + \frac{1}{q} \text{ ------(ii)}$$

By adding equation (1) and (2)

$$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{p} + \frac{1}{q_1} - \frac{1}{q_1} + \frac{1}{q}$$

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

or $$\boxed{\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}}$$

This close combination behaves as a single lens whose focal length is given by the above relation.The power of combination is given by,

$$\boxed{P = P_1 + P_2} \qquad \because P = \frac{1}{f}$$

MAGNIFYING GLASS(SIMPLE MICROSCOPE)

Sometimes tiny objects are desired view in fine detail of which brought closer to eye for getting greater visual angle but object becomes within least distance of distinct vision consequently being closer could not viewed distinctly . For removing this difficulty converging lens (convex) is used in between object and eye to view virtual image at least distance 25cm at greater visual angle as shown in figure such used convex lens is called magnifying glass.

ANGULAR MAGNIFICATION:

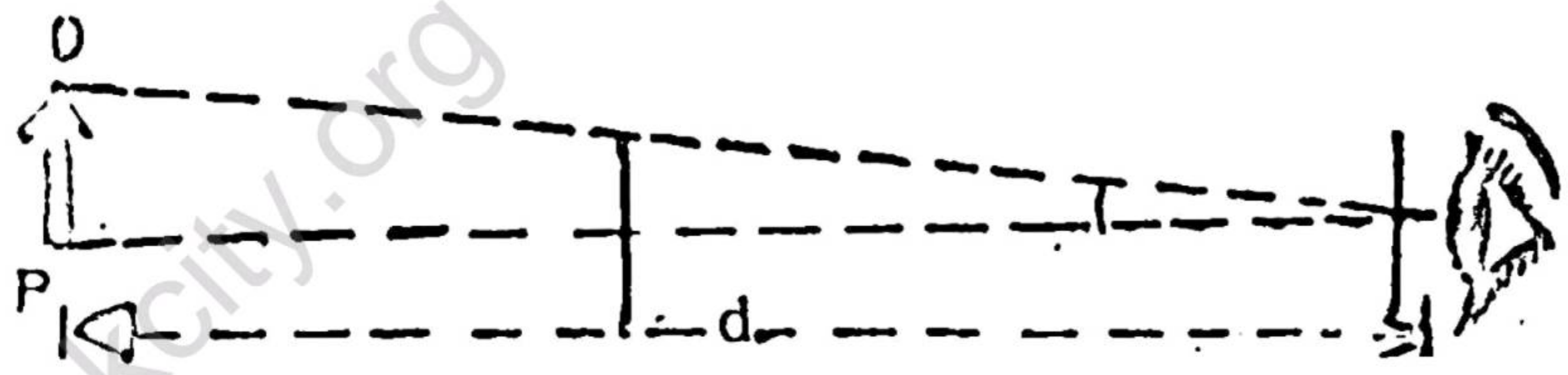
Let us consider a small object OP which is placed at a distance p within the focal length of magnifying glass "L" such that its erect and virtual magnified image IQ is formed at least distance of distinct vision "d" as shown in figure. The magnifying power of magnifying glass is given by

$$M = \frac{\beta}{\alpha} \text{ ------------(i)}$$

where α is the visual angle subtended by object when placed at least distance of distinct vision. β is the visual angle subtended by the image seen through the magnifying glass.

$$\tan \propto = \frac{OP}{d}, \text{ since } \propto \text{ is small}$$

$$\therefore \tan \propto = \alpha$$

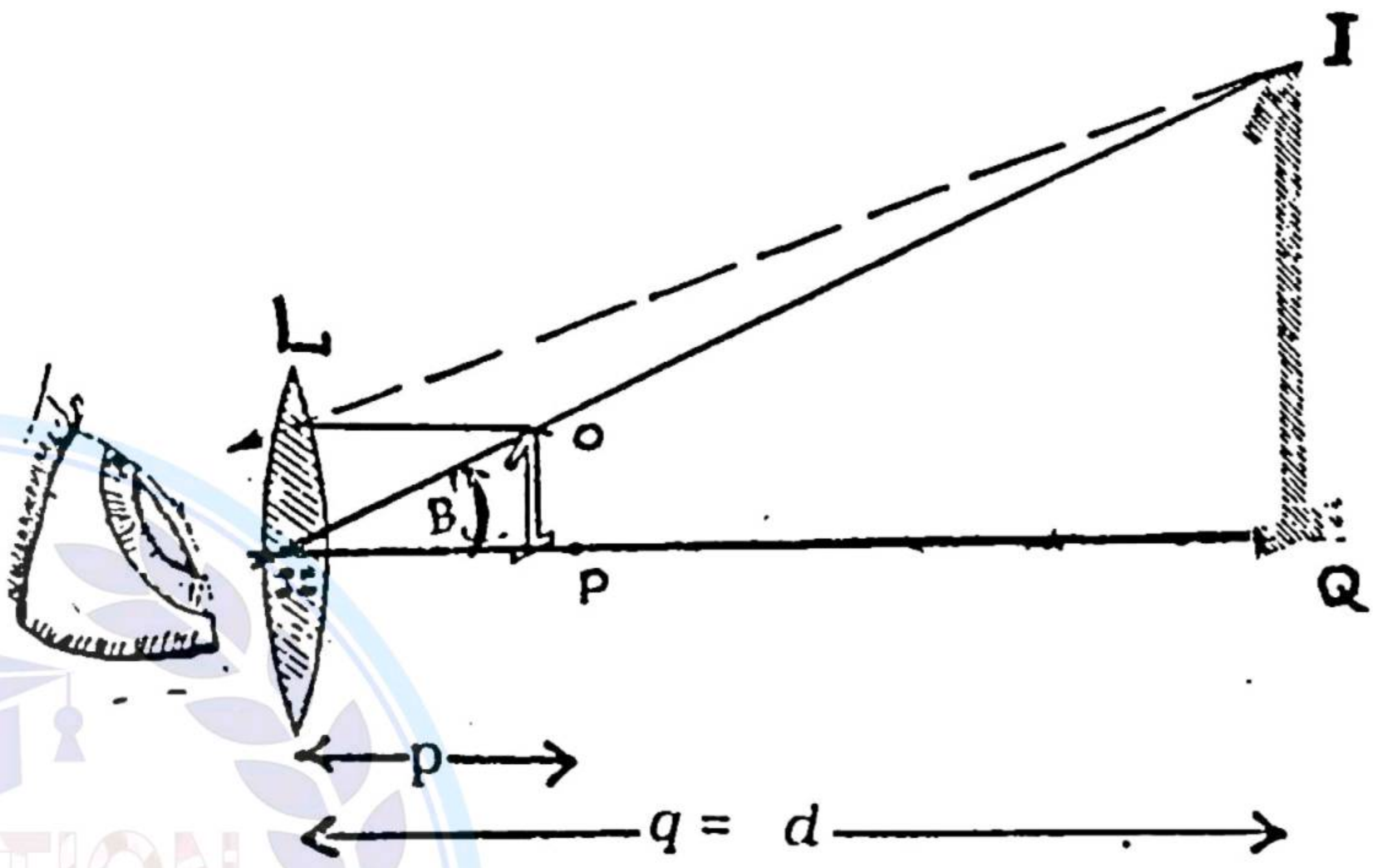


$$\therefore \alpha = \frac{OP}{d}$$

In right angled triangle OPX, we have

$$\tan \beta = \beta$$

$$\therefore \beta = \frac{OP}{p}$$



putting values of α and β in eq(i), we get

$$M = \left(\frac{OP}{p}\right) / \left(\frac{OP}{d}\right)$$

or

$$M = \left(\frac{\cancel{OP}}{p}\right) / \left(\frac{d}{\cancel{OP}}\right)$$

$$\boxed{M = \frac{d}{p}} \text{ --------(ii)}$$

From the lens formula ,we have

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

For Magnifying Glass we have p=+p , q=-d and f= +f

$$\therefore \frac{1}{f} = \frac{1}{p} - \frac{1}{d}$$

Multiply by "d" on both sides, we get

$$\frac{d}{f} = \frac{d}{p} - \frac{d}{d}$$
$$\frac{d}{f} = \frac{d}{p} - 1$$

From eq(ii), we get

$$\frac{d}{f} = M - 1$$

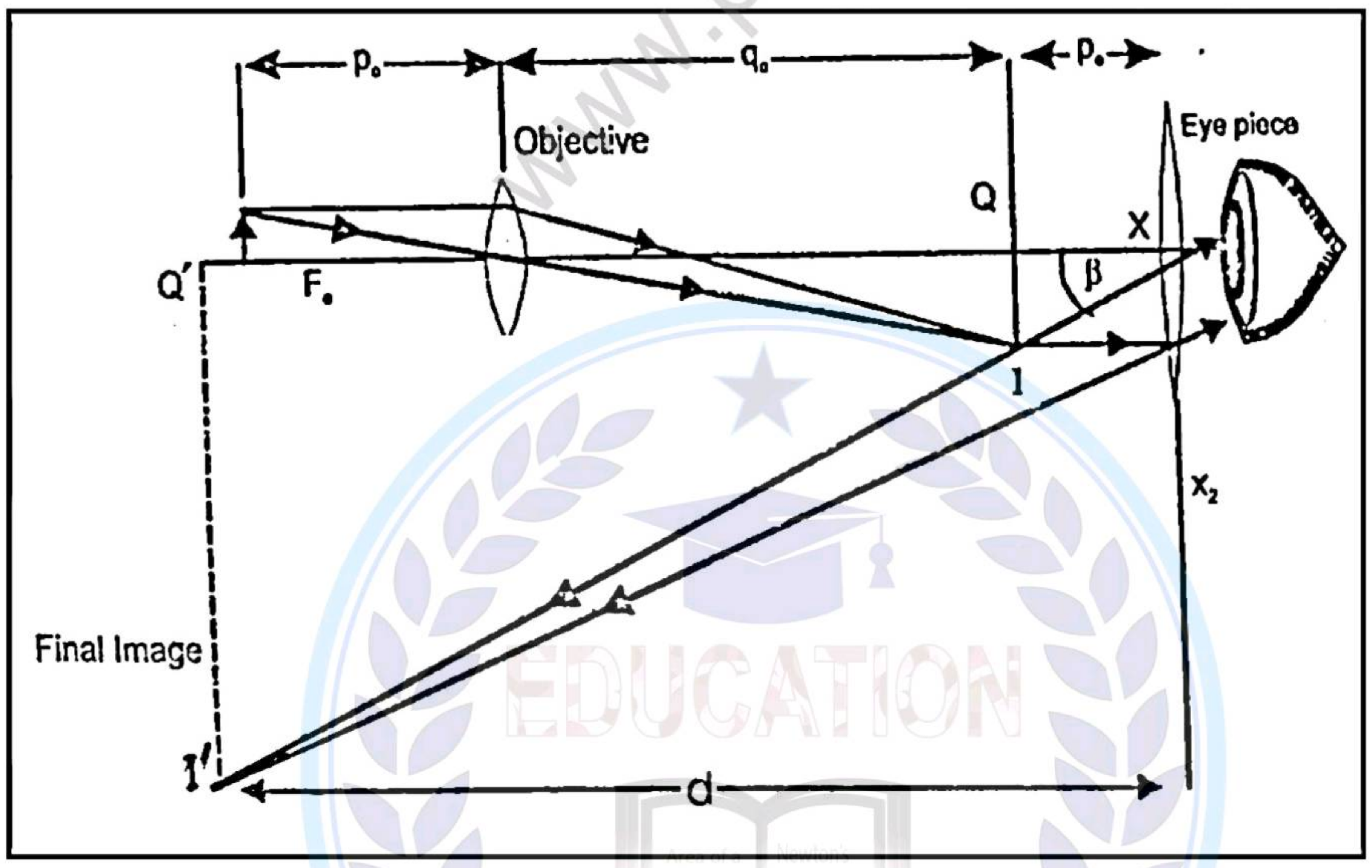
$$\boxed{M = 1 + \frac{d}{f}}$$ This gives magnifying power of magnifying glass.

COMPOUND MICROSCOPE

Microscope is used extensively in biological researches and in sum researches physic by microscope small objects as bacteria and other carriers of disease are magnifications sufficiently for detail examination.

CONSTRUCTION:

It consists of two converging lenses. One called objective of shorter focal length 'f_o' and other eye piece of relatively longer length 'f_e' ($f_o > f_e$) object is placed very close to objective lens just beyond the focus in order to get magnified real image which is then viewed through eye piece used as magnificent glass as shown in figure.



ANGULAR MAGNIFICATION:

The magnification power of microscope could as calculated. The magnification of objective is

$$M_o = \frac{q_o}{p_o}$$

Where q_o image distance from objective and p_o object distance from objective. Magnification of eye piece uses as magnifying glass is

$$M_e = 1 + \frac{d}{f_e}$$

Where d = least distance of distinct Vision = 25cm

Net magnification of combination in microscope is

$$M = M_o \times M_e$$

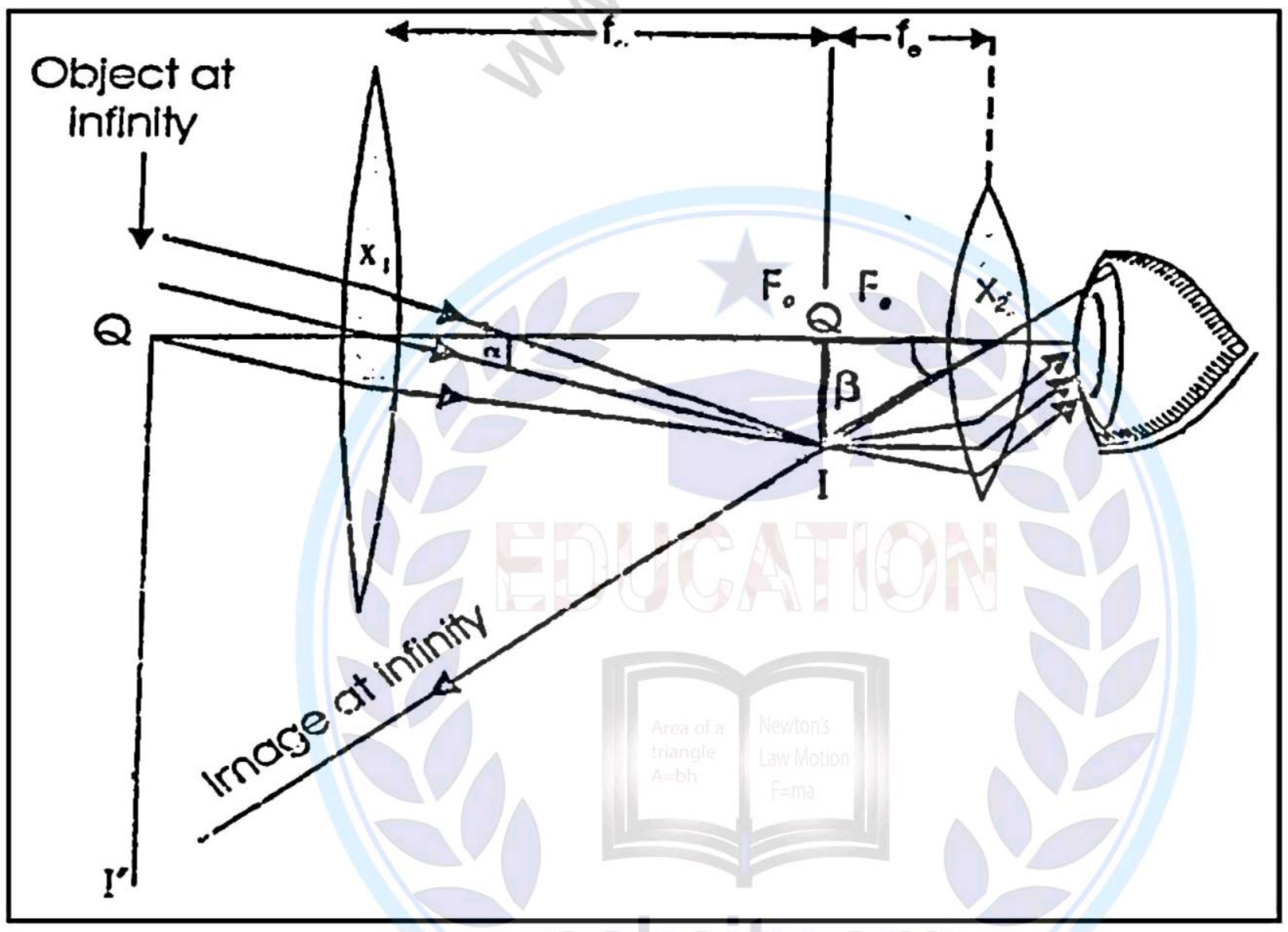
Putting values of M_o *and* M_e ,we get

$$\boxed{M = \frac{q_o}{p_o}\left(1 + \frac{d}{f_e}\right)}$$ This gives magnifying power of compound microscope.

ASTRONOMICAL TELESCOPE

CONSTRUCTION:

The telescope is used to view the distant objects like stars, planets the image form by telescope is not greater one but near to eye. Telescope is consists of two converging lens, one objective of longer focal length 'f_o' and eye-piece of some shorter focal length 'f_e' ($f_o > f_e$) the image formation shown in figure,final image is virtual and inverted. Hence use to view heavenly object having spherical shape. That is why called Astronomical telescope.



ANGULAR MAGNIFICATION:

The magnifying power of telescope is given by

$M = \frac{\beta}{\alpha}$ ------------(i)

where α is the visual angle subtended by object and image respectively.

in right angled triangle IX_1Q

$\tan \propto = \frac{IQ}{QX_1}$, since $\propto$ is small

$\therefore \tan \propto = \alpha$

$\therefore \alpha = \frac{IQ}{QX_1}$

or $\alpha = \frac{IQ}{f_o}$

in right angled triangle IX_2Q

$\tan \beta = \frac{IQ}{QX_2}$, since $\propto$ is small

$\therefore \tan \beta = \beta$

$\therefore \beta = \frac{IQ}{QX_2}$

or $\beta = \frac{IQ}{f_e}$

putting values of α and β in eq(i), we get

$$M = \left(\frac{IQ}{f_e}\right) / \left(\frac{IQ}{f_o}\right)$$

or $$M = \left(\frac{\cancel{IQ}}{f_e}\right) / \left(\frac{f_o}{\cancel{IQ}}\right)$$

$\boxed{M = \frac{f_o}{f_e}}$ This gives magnifying power of astronomical telescope.

and $\boxed{L = f_o + f_e}$,is the length of astronomical telescope.

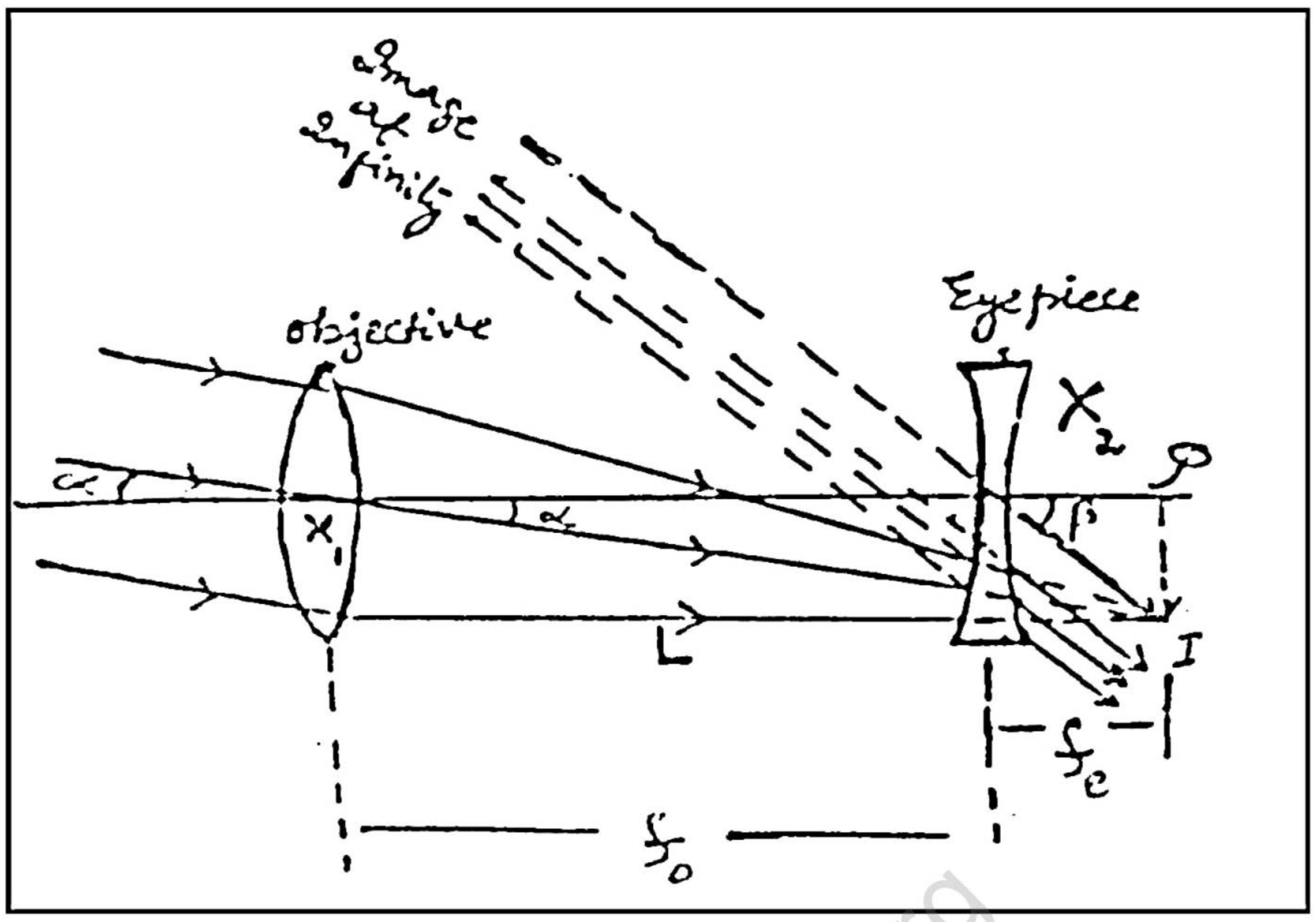
TERRESTRIAL TELESCOPE:

As astronomical telescope forms inverted final images of heavenly bodies like moon and stars which are acceptable. But when terrestrial objects are to be viewed, it is necessary to have an erect final image. The erection of image can be made by introducing a third lens between objective and eye piece of telescope. This modified telescope is known as terrestrial telescope whose magnifying power is just equal to the magnification of astronomical telescope but it just gives erect image.

GALILEAN TELESCOPE

Galilean telescope is a convenient reduced length terrestrial telescope developed by Galileo. He replaced two convex lenses erecting and eye-piece by single concave lens which does two jobs erection and magnification simultaneously as shown in diagram.

Magnification of Galilean telescope is computed maximum magnification i.e. when parallel rays, coming from object at infinite are again made parallel by concave lens for getting such focusing of telescope, focus of both converging and lenses lies at a single point a shown below diagram.



ANGULAR MAGNIFICATION:

The magnifying power of telescope is given by

$$M = \frac{\beta}{\alpha} \text{ ------------(i)}$$

where α is the visual angle subtended by object and image respectively.

in right angled triangle IX_1Q

$\tan \propto = \frac{IQ}{QX_1}$, since $\propto$ is small

$\therefore \tan \propto = \alpha$

$\therefore \alpha = \frac{IQ}{QX_1}$

or $\alpha = \frac{IQ}{f_o}$

in right angled triangle IX_2Q

$\tan \beta = \frac{IQ}{QX_2}$, since $\propto$ is small

$\therefore \tan \beta = \beta$

$\therefore \beta = \frac{IQ}{QX_2}$

or $\beta = \frac{IQ}{f_e}$

putting values of α and β in eq(i), we get

$$M = \left(\frac{IQ}{f_e}\right) / \left(\frac{IQ}{f_o}\right)$$

or $$M = \left(\frac{IQ}{f_e}\right) / \left(\frac{f_o}{IQ}\right)$$

$$\boxed{M = \frac{f_o}{f_e}}$$ This gives magnifying power of astronomical telescope.

and $$\boxed{L = f_o + f_e}$$,is the length of astronomical telescope.

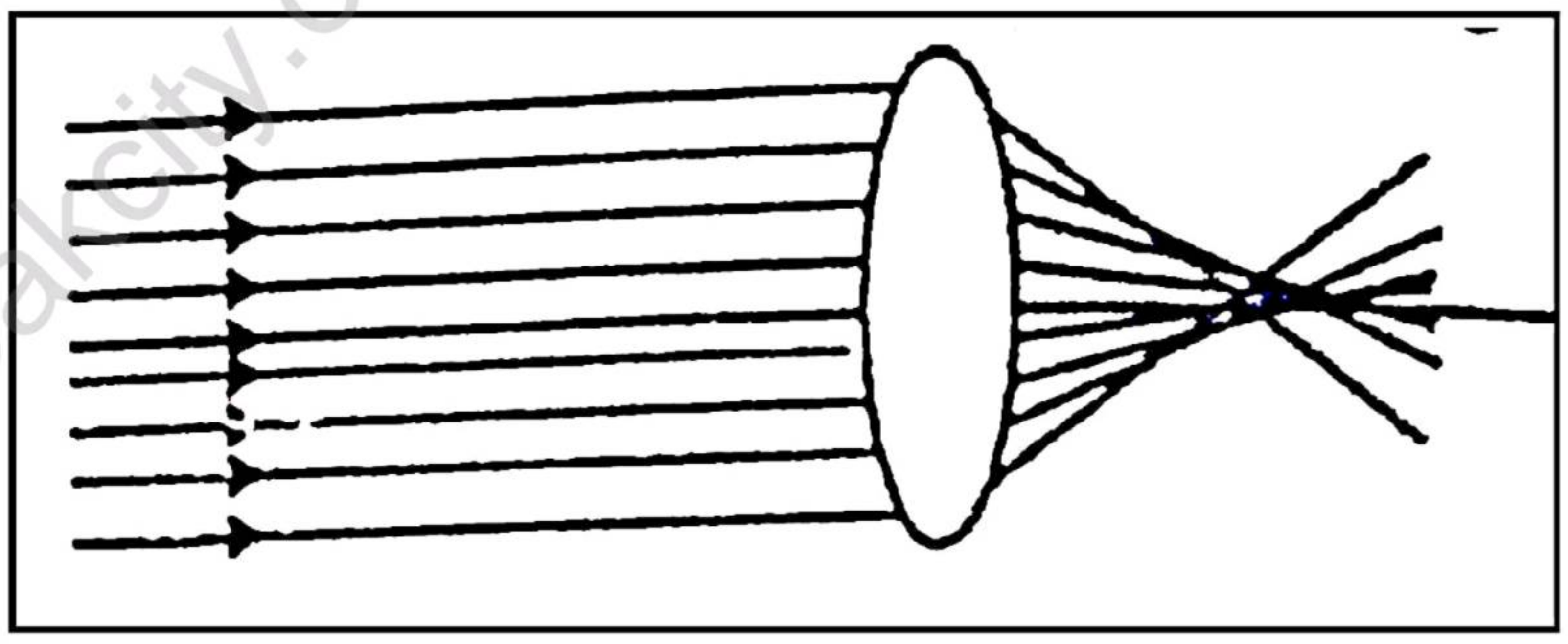
DEFECTS IN LENSES OR LENS ABERRATION

The defect in the image formation by the lenses are due to two common reasons.

1. Spherical Aberration
2. Chromatic Aberration

1.SPHERICAL ABERRATION:

When rays of light parallel to the principal axis of a lens pass through zones near its edges, these are brought to focus nearer the lens than those rays which pass through the region nearer to its center. Therefore, the focus is not a sharp point but is contained in a region called 'focal region' This produces blurred images. This problem is knows as spherical aberration as shown in fig.



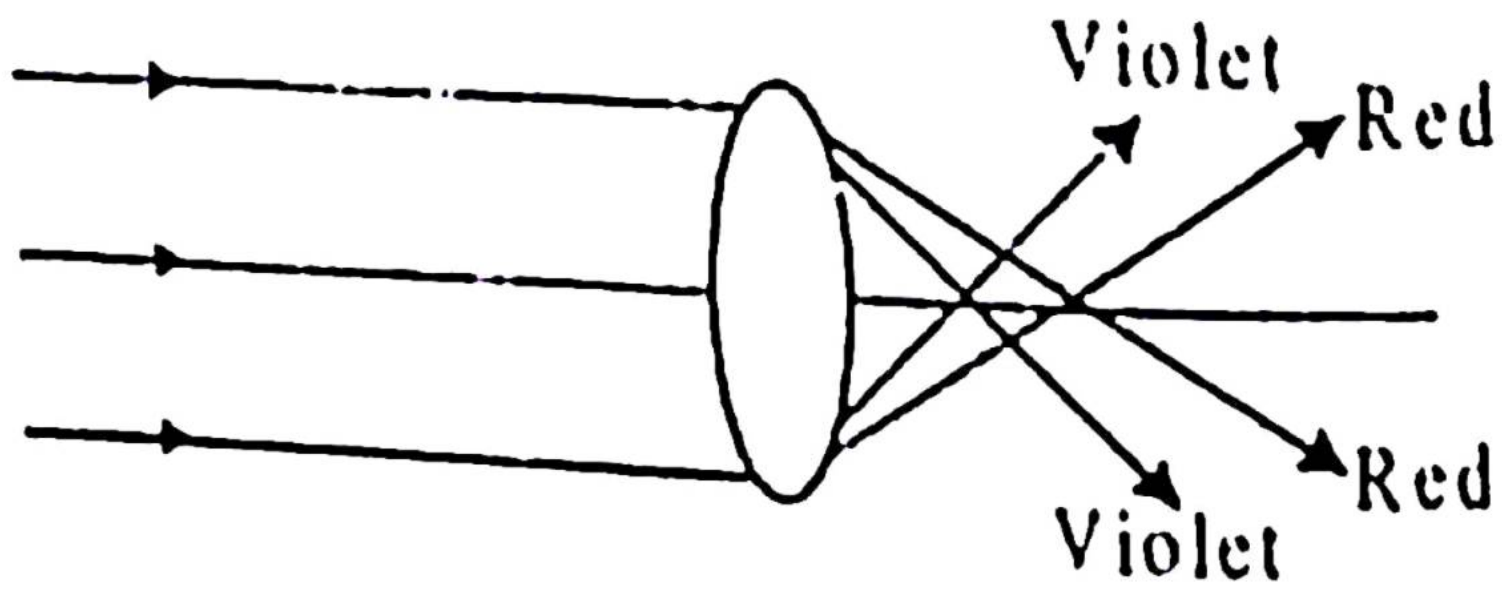
This defect can be minimized by following ways:

i. By using only the central portion of the lens. This can be achieved by using a stop on the lens which makes effective aperture of the lens small.
ii. By making opposite surfaces of the lens of different curvatures.
iii.By combining a strongly convergent lens of producing little spherical aberration with a weaker diverging lens producing equal amount of aberration in the opposite direction.

CHROMATIC ABERRATION:

The fact that different wavelengths of light refracted by lens focus at different points give rise to chromatic aberration as shown in fig. Actually a thick lens may be regarded as made up of two prism placed one above the other and due to dispersion of the refracting medium of the lens different wave length of light focus at different points. Hence image formed by lens consists of small linear spectrum. Chromatic aberration for a diverging lens is opposite to that for a converging lens.
This defect can be reduced to a large extent by combining Converging lens of crown glass with a

diverging lens of flint glass. These lenses are so chosen that dispersion of one is equal and opposite to that of the other. Lenses which are free from dispersion are called "achromatic lenses"



M.C.Qs.

1. Power of a lens is equal to
(a) Focal length in meters
(b) Reciprocal of focal length
(c) Double of focal length
(d) Half of focal length

2. A terrestrial telescope can be made by adding an erecting lens to a:
(a) Prism spectroscope (b) Reflecting telescope
(c) Field telescope (d) Astronomical telescope

3. In an astronomical telescope objective is a:
(a) Concave lens of large focal length
(b) Convex lens of large focal length
(c) Concave lens of small focal length.
(d) Convex lens of small focal length.

4. The focal length of magnifying glass is equal to the least distance of the distinct vision. Its angular magnification will be :
(a) 6 (b) 5 (c) 2 (d) 1

5. A lens of linear magnification 2 is placed between as object and a fixed screen. If size of image is 6cm, the size of the object will be:
(a) 0.5cm (b) 2 cm
(c) 3 cm (d) 18 cm

6. The length of a simple astronomical telescope is:
(a) The difference of the focal length of two lenses.
(b) The sum of the focal length of two lenses.
(c) Half the sum of the focal length
(d) Equal to the focal length of the objective lens

7. The magnifying power of a lens of focal length 1/2m is:
(a) 1 dioptre (b) 2 dioptres
(c) 50 dioptres (d) 100 dioptres

8. In a convex lens of large aperture fails to converge the light rays incident on it to a single point, it is said to suffer from?
(a) Chromatic aberration (b) Spherical aberration
(c) Both spherical and chromatic (d) Distortion

9. The distance between the principal focus and the optical center is called:

(a) Aperture (b) Focal length
(c) Principal axis (d) Radius of curvature

10. If the length of the telescope is 96cm the focal lengths of its lenses is:
(a) 100cm, -4cm (b) -80cm, -6cm
(c) 90cm, -6cm (d) 90cm, 6cm

11. Two convex lenses of same focal length 'f' are combined together. The focal length of the combines lens is:
(a) 2f (b) f/2
(c) 2 + f (d) 2 – f

12. The magnifying power of a simple microscope:
(a) Increase with increase in focal length
(b) Increase with decrease in focal length
(c) No effect with decrease or increase with the focal length
(d) Equals to distinct vision

13. If an object is placed at principle focus 'F' of a converging lens, the image will be formed:
(a) at F (b) at 2F
(c) at infinity (d) between focus & optical center

14. Least distance of distinct vision of normal and healthy people:
(a) Increases with increase in age
(b) Decreases with increase in age
(c) Neither increases nor decreases
(d) Becomes infinite after 60 years

15. The length of a Galilean telescope when focused for infinity is:
(a) fo/fe (b) fe /fo
(c) fo + fe (d) fo – fe

16. Final image produced by a compound microscope with respect to the object is?
(a) Real and inverted (b) Real and erect
(c) Virtual and erect (d) Virtual and inverted

17. By using adjustable aperture of a lens we can reduce the defect of the lens which is called:
(a) astigmatism (b) spherical aberration
(c) chromatic aberration (d) none of them

18. A lens, which is thicker at the center and thinner at the edges, is called?
(a) Concave lens (b) Convex lens
(c) Plano-convex lens (d) Plano concave lens

19. If magnifying power of simple microscope is 6, the focal length of lens used is:
(a) 6 cm (b) 5 cm (c) 25 cm (d) -5 cm

20. A spectrometer is used to find?
(a) Wavelength flight
(b) Refractive index of the prism
(c) The wavelength of different colors
(d) All of the above

21. A convex and concave lens of focal length 'f' are in contact. The focal length of the combination will be?
(a) Zero (b) f/2 (c) 2f (d) Infinite

22. Magnification of the astronomical telescope is?
(a) fo + fe (b) fo / fe
(c) fe / fo (d) (1 + fo/fe) L/fo

23. The function of collimator in spectrometer is?
(a) To produce parallel beam of light
(b) To filter the light rays
(c) To make them mutually perpendicular
(d) No function

24. Chromatic aberration can be removed by combining:

(a) A convex lens and concave lens of same type of glass.
(b) Two convex lenses of different types of glass
(c) Two concave lenses of different types of glass.
(d) A concave lens of one type of glass and a convex lens of another types of glass

25 .The final image of Astronomical telescope is:
(a) Real erect enlarged (b) Virtual erect enlarged (c) Real inverted enlarged (d) Virtual inverted enlarged

PAST PAPER M.C.Qs.

2022

21.If Mo and Me are magnifying powers of objective and eye piece of a compound microscope respectively, then total magnification will be
*** Mo x Me** * Mo - Me * Mo + Me * Mo/Me

25.In a spectrometer, parallel beam of light is obtained by
* Beam Splitter ***Collimater** * Diffraction grating *Prism

30.2nd condition of equilibrium is:
* $\sum F = 0$ * $\sum P = 0$ * $\boldsymbol{\sum \tau = 0}$ * $\sum a = 0$

2021

(xii) In compound microscope, the image formed by objective is:
*Virtual and magnified ***Real and magnified** *Real and diminished *Virtual and diminished

(xiii) The point in the lens through which the light rays pass without any deviation is called:
*** Optical centre** *Principle axis * Optical axis *Pole

(xvi) An astronomical telescope when focused for infinity with focal length of objective is 60cm and a focal length of eye piece is 3cm, the length of telescope is:
***63cm** *20cm * 57cm * 180cm

(xvii) In convex lens when an object is placed beyond 2F then its image will be formed:
*at 2F on the other side ***between F and 2F on the other side**
* beyond 2F on the other side * at infinity

(xxxix) The magnifying power of Astronomical telescope is:
* fo+fo *fofe *** fo+fe** * f-fe

2019

8. In a spectrometer, the focal length of convex lens is equal to length of its:

*telescope *obstacles **<u>*collimator</u>** *turntable

<u>2018</u>

8. The focal length of magnifying glass is equal to the least distance of the distinct vision. Its angular magnification will be :

* 6 * 5 **<u>* 2</u>** * 1

12. A lens of linear magnification 2 is placed between as object and a fixed screen. If size of image is 6cm, the size of the object will be:

*0.5cm *2 cm **<u>* 3 cm</u>** * 18 cm

<u>2017</u>

13. An astronomical telescope is focused at infinity. The focal length of objective is 0.2 cm and that of the eye piece is 5cm, the length of telescope is:

*2.5 cm *4 cm **<u>*5.2 cm</u>** *25 cm

<u>2016</u>

7.The magnifying power of a lens of focal length 1/2m is:

*1 dioptre **<u>*2 dioptres</u>** *50 dioptres *100 dioptres

9.The distance between the principal focus and the optical center is called:

*Aperture **<u>*Focal length</u>** *Principal axis *Radius of curvature

<u>2015</u>

10. The final image formed by a compound microscope is:

*virtual and diminished *real and diminished

* real and magnified **<u>*virtual and magnified</u>**

16. Two convex lenses of same focal length 'f' are combined together. The focal length of the combines lens is:

*2f **<u>*f/2</u>** * 2 + f * 2 – f

<u>2014</u>

6. If an object is placed at principle focus 'F' of a converging lens, the image will be formed:

*at F * at 2F **<u>*at infinity</u>** * between focus & optical center

10. The length of a Galilean telescope when focused for infinity is:

*fo/fe *fe /fo *fo + fe **<u>*fo – fe</u>**

<u>2013</u>

4. In the terrestrial telescope, the central lens is used to:

<u>*erect the image</u> *increase magnifying power

*both of these *none of these

12. Power of magnifying glass having focal length 5cm is:

*5 dioptre *10 dioptre **<u>*20 dioptre</u>** *50 dioptre

<u>2012</u>

1. The length of Galilean telescope is equal to:

*f_o/f_e *** f_o- f_e** * f_e- f_o * f_e+f_o

4. If magnifying power of simple microscope is 6, the focal length of lens used is:

*6 cm *** 5 cm** * 25 cm * -5 cm

2011

3. The magnifying power of a lens of focal length 25 cm is:

*1/2 * 1 * zero *** 2**

2010

3. By using adjustable aperture of a lens we can reduce the defect of the lens which is called:

*astigmatism *** spherical aberration**
* chromatic aberration * none of them

9. If the power of converging lens is 4 diopter, what is the focal length of the lens:

*20 cm ***25 cm**
*10 cm *50 cm

TEXTBOOK NUMERICALS

Q.1: An object 4 cm tall is placed near the axis of a thin converging lens. If the focal length of the lens is 25 cm, where will the image be formed and what will be the size of the image? Sketch the principal ray diagram.

Data:

Height of Object $= h_o = 4\ cm$

Focal length of lens $= f = 25\ cm$

Image distance $= q = ?$

Height of Image $= h_i = ?$

Object distance $= p = 33.33\ cm$

Solution:

Using Thin Lens Formula

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

$$\frac{1}{25} = \frac{1}{33.33} + \frac{1}{q}$$

$$\frac{1}{25} - \frac{1}{33.33} = \frac{1}{q}$$

$$0.04 - 0.03 = \frac{1}{q}$$

$$0.01 = \frac{1}{q}$$

$$\boxed{q = 100\ cm}$$

As We know that

$\frac{h_i}{h_o} = \frac{q}{p}$

$\frac{h_i}{4} = \frac{100}{33.33}$

$\boxed{h_i = 12\ cm}$

Result: The image will be formed at 100 cm from lens and the size of the image will be 12 cm.

Q.2: A convex lens has a focal length of 10 cm. Determine the image distances when an object is placed at the following distances from the lens. 50 cm, 20 cm, 15 cm, 10 cm and 5 cm

Data:

Focal length of lens $= f = 10\ cm$

Image distance $= q = ?$

(i) Object distance $= p = 50\ cm$

(ii) Object distance $= p = 20\ cm$

(iii) Object distance $= p = 15\ cm$

(iv) Object distance $= p = 10\ cm$

(v) Object distance $= p = 5\ cm$

Solution:

Using Thin Lens Formula

$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$

(i) Object distance $= p = 50\ cm$

$\frac{1}{10} = \frac{1}{50} + \frac{1}{q}$

$\frac{1}{10} - \frac{1}{50} = \frac{1}{q}$

$\frac{4}{50} = \frac{1}{q}$

$\boxed{q = \frac{50}{4} = 12.5\ cm}$

(ii) Object distance $= p = 20\ cm$

$\frac{1}{10} = \frac{1}{20} + \frac{1}{q}$

$\frac{1}{10} - \frac{1}{20} = \frac{1}{q}$

$\frac{1}{20} = \frac{1}{q}$

$\boxed{q = 20\ cm}$

(iii) Object distance $= p = 15\ cm$

$\frac{1}{10} = \frac{1}{15} + \frac{1}{q}$

$\frac{1}{10} - \frac{1}{15} = \frac{1}{q}$

$\frac{5}{150} = \frac{1}{q}$

$\boxed{q = 30\ cm}$

(iv) Object distance $= p = 10\ cm$

$\frac{1}{10} = \frac{1}{10} + \frac{1}{q}$

$\frac{1}{10} - \frac{1}{10} = \frac{1}{q}$

$0 = \frac{1}{q}$

$\boxed{q = \infty}$

(v) Object distance $= p = 5\ cm$

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

$\frac{1}{10} - \frac{1}{5} = \frac{1}{q}$

$-\frac{1}{10} = \frac{1}{q}$

$\boxed{q = -10\ cm}$

Result: The image will be formed at 12.5 cm , 20 cm ,30 cm,Infinity and -10 cm.

Q.3: Two converging lenses of focal lengths 40 cm and 50 cm are placed in contact. What is the focal length of this lens combination? What is the power of the combination in diopters?

Data:

$focal\ length\ of\ first\ lens = f_1 = 40\ cm$

$focal\ length\ of\ second\ lens = f_2 = 50\ cm$

$focal\ length\ of\ combination = f = ?$

$Power\ of\ combination = P = ?$

Solution:

The power of combination of lenses is given by

$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$

$\frac{1}{f} = \frac{1}{40} + \frac{1}{50}$

$\frac{1}{f} = \frac{9}{200}$

$$\boxed{f = 22.2\ cm}$$

or $f = 0.22\ m$

According to the definition of power of lens

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

$$\boxed{P = \frac{1}{0.22} = 4.5\ diopters}$$

Result: The power of combination is 4.5 diopters and focal length is 22.2 cm.

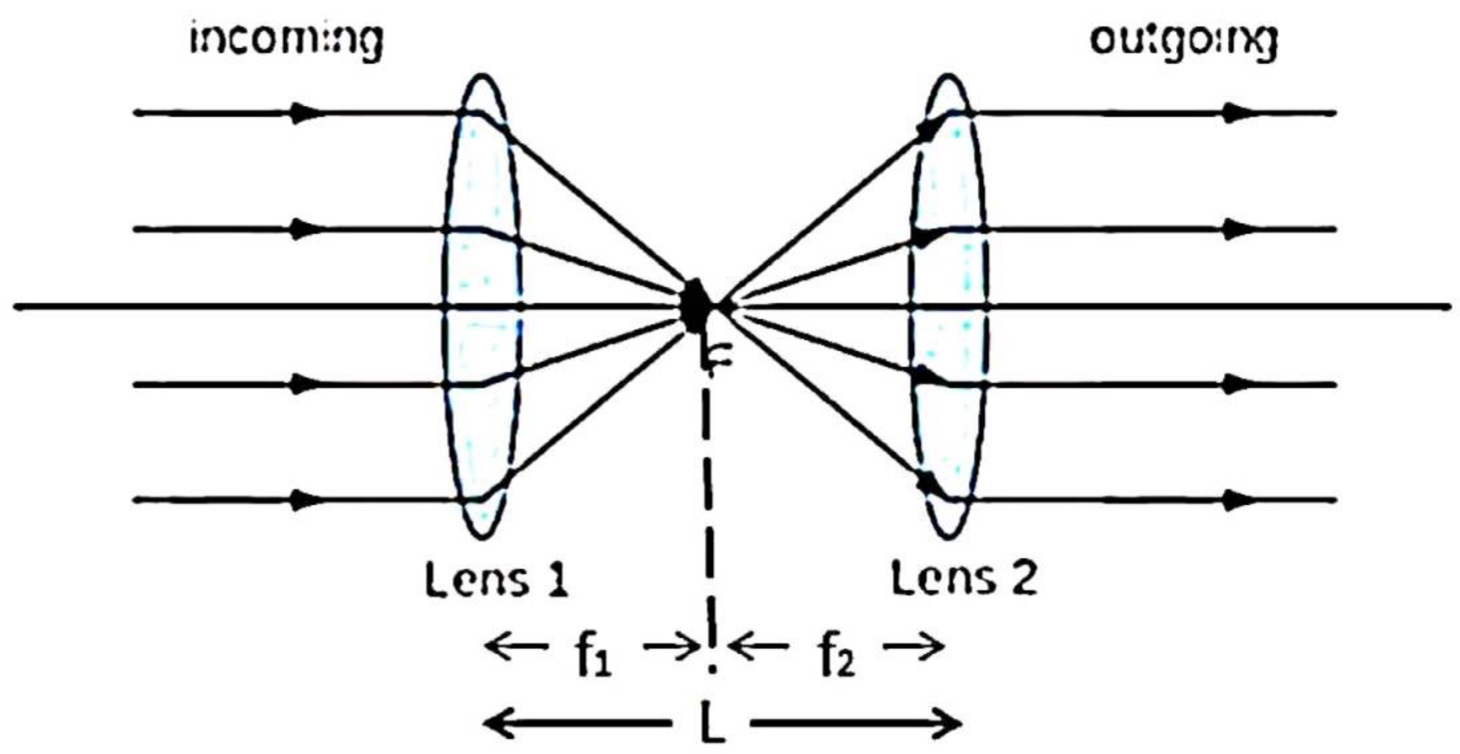
Q.4: A converging lens of focal length 20 cm is placed in front of a converging lens of focal length 4 cm. What is the distance between the lenses if parallel rays entering the first lens leave the second lens as parallel rays?

Data:

Distance between lenses= L = ?

Focal length of 1st lens = f_1 = 20 cm

Focal length of 2nd lens = f_2 = 4 cm



Solution:

According to the figure

$$L = f_1 + f_2$$

$$L = 20 + 4$$

$$\boxed{L = 24\ cm}$$

Result: The distance between lenses is 24 cm

Q.5: A parallel light beam is diverged by a concave lens of focal length -12.5 cm and then made parallel once more by a convex lens of focal length 50 cm. How far are the two lenses apart.

Data:

Distance between lenses= L = ?

Focal length of 1st lens = f_1 = -12.5 cm

Focal length of 2nd lens = f_2 = 50 cm

Solution:

As explained in Q.4

$$L = f_1 + f_2$$

$$L = -12.5 + 50$$

$$\boxed{L = 37.5\ cm}$$

Result: The distance between lenses is 37.5 cm

Q.6: Two lenses are in contact, a converging one of focal length 30 cm and a diverging one of focal length -10cm. What is the focal length and power of the combination?

Data:

$focal\ length\ of\ first\ lens = f_1 = 30\ cm$

$focal\ length\ of\ second\ lens = f_2 = -10\ cm$

$focal\ length\ of\ combination = f = ?$

$Power\ of\ combination = P = ?$

Solution:

The power of combination of lenses is given by

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\frac{1}{f} = \frac{1}{30} + \frac{1}{(-10)}$$

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

$$\frac{1}{f} = -\frac{2}{30}$$

$$\boxed{f = -15\ cm}$$

or $f = -0.15\ m$

According to the definition of power of lens

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

Or $\boxed{P = \frac{1}{(-0.15)} = -6.67\ diopters}$

Result: The power of combination is -6.67 diopters and focal length is 15 cm.

Q.7: Moon light passes through a converging lens of focal length 19 cm, which is 20.5 cm from a second converging lens of focal length 2 cm. Where is the image of the moon produced by the lens combination?

Focal length of Objective $= f_o = 19\ cm$

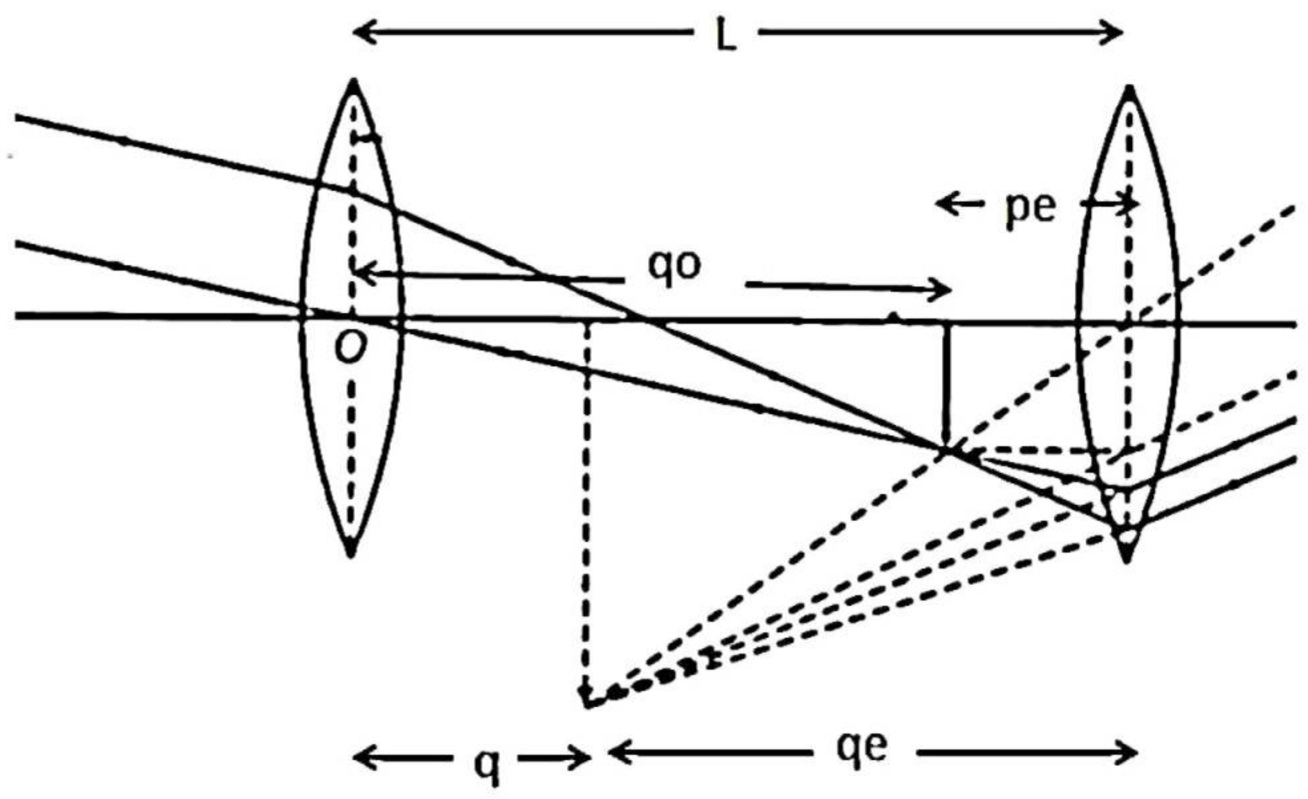
Focal length of Eye Piece $= f_e = 2\ cm$

Distance between Lenses $= L = 20.5\ cm$

Object distance from objective $= p_0 = \infty$

Image distance from Objective $= q = ?$

Image distance from Eye piece $= q_e = ?$



Solution:

For Objective:

$\frac{1}{19} = \frac{1}{\infty} + \frac{1}{q_0}$

$\frac{1}{19} = 0 + \frac{1}{q_0}$

$\frac{1}{19} = \frac{1}{q_0}$

$\boxed{q_0 = 19\ cm}$

Now , Distance between lenses

$L = p_e + q_0$

$20.5 = p_e + 19$

$\boxed{p_e = 1.5\ cm}$

For Eye Piece:

$\frac{1}{f_e} = \frac{1}{p_e} + \frac{1}{q_e}$

$\frac{1}{2} = \frac{1}{1.5} + \frac{1}{q_e}$

$\frac{1}{2} - \frac{1}{1.5} = \frac{1}{q_e}$

$-0.16 = \frac{1}{q_e}$

$\boxed{q_e = \frac{1}{-0.16} = -6\ cm}$

Final Image distance from Objective

$q = L + q_e$

$q = 20.5 - 6$

$\boxed{q = 14.5\ cm}$

Result: The image distance from Eye Piece is 6cm and from objective is 14.5 cm.

Q.8: Find the distance at which an object should be placed in front of a convex lens of focal length 10 cm to obtain an image of double its size?

Data:

Object distance $= p = ?$

Focal length of lens $= f = 10\ cm$

Linear Magnification $= M = 2$

Solution:

Magnification is given by

$M = \frac{q}{p}$

$2 = \frac{q}{p}$

$\boxed{q = 2p}$

For Real Image:

Using Thin Lens Formula

$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$

$\frac{1}{10} = \frac{1}{p} + \frac{1}{2p}$

$\frac{1}{10} = \frac{2p + p}{2p^2}$

$\frac{1}{10} = \frac{3p}{2p^2}$

$\frac{1}{10} = \frac{3}{2p}$

$\boxed{p = 15\ cm}$

For Virtual Image:

Using Thin Lens Formula

$$\frac{1}{f}=\frac{1}{p}+\frac{1}{q}$$

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

$$\frac{1}{10}=\frac{2p-p}{2p^2}$$

$$\frac{1}{10}=\frac{p}{2p^2}$$

$$\frac{1}{10}=\frac{1}{2p}$$

$$\boxed{p=5\ cm}$$

Result: For real image the object should be placed at 15 cm and for virtual image object should be placed at 5 cm.

Q.9: A compound microscope has a 12 mm focal length objective and a 75 mm focal length eye piece, and the two lenses are mounted 200 mm apart. If the final image is 225 mm from the eye piece, what is the magnification produced?

Data:

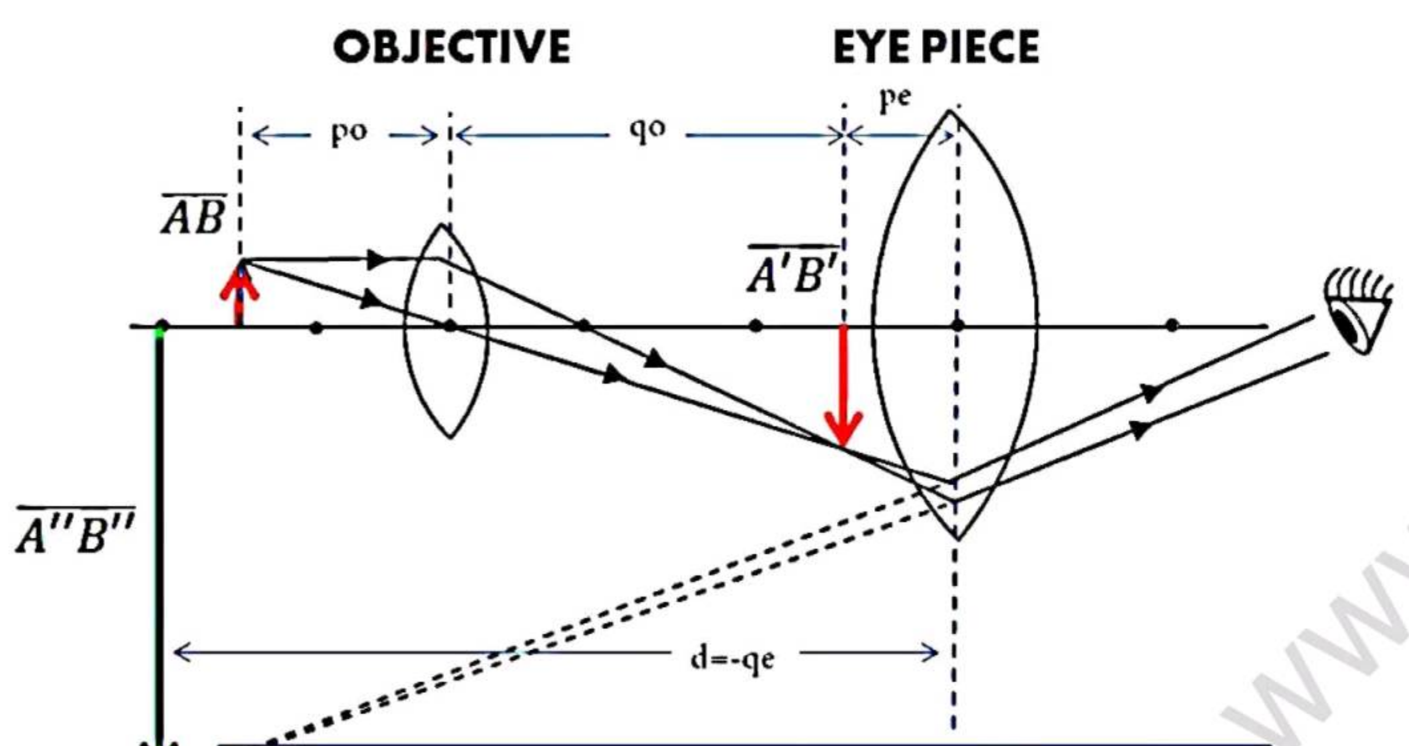
Focal length of Objective $= f_0 = 12\ mm$

Focal length of Eye Piece $= f_e = 75\ mm$

Distance between lenses $= L = 200\ mm$

Magnifying Power $= M = ?$

Image distance from eye piece $= q_e = -225\ mm$



RAY DIAGRAM OF COMPOUND MICROSCOPE

Solution:

For Eye Piece:

$$\frac{1}{f_e}=\frac{1}{p_e}+\frac{1}{q_e}$$

$$\frac{1}{75}=\frac{1}{p_e}+\frac{1}{(-225)}$$

$$\frac{1}{75}+\frac{1}{225}=\frac{1}{p_e}$$

$$\frac{4}{225}=\frac{1}{p_e}$$

$$\boxed{p_e=\frac{225}{4}=56.25\ mm}$$

Now , Distance between lenses

$$L=p_e+q_0$$

$$200=56.25+q_0$$

$$\boxed{q_0=143.75\ mm}$$

For Objective:

$$\frac{1}{f_0}=\frac{1}{p_0}+\frac{1}{q_0}$$

$$\frac{1}{12}=\frac{1}{p_0}+\frac{1}{143.75}$$

$$\frac{1}{12}-\frac{1}{143.75}=\frac{1}{p_0}$$

$$0.0763=\frac{1}{p_0}$$

$$\boxed{p_0=\frac{1}{0.0763}=13\ mm}$$

And Magnification of micro scope is given by

$$M=\left(\frac{q_0}{p_0}\right)\left(1+\frac{d}{f_e}\right)$$

$$M=\left(\frac{143.75}{13}\right)\left(1+\frac{225}{75}\right)$$

$$M=(11.05)(4)$$

$$\boxed{M=44}$$

Result: The magnification of compound microscope is 44.

Q.10: An astronomical telescope of angular magnification 1000 has an objective of 15 m focal length. What is the focal length of the eye piece?

Data:

Angular Magnication $= M = 1000$

Focal Length of Objective $= f_0 = 15\ m$

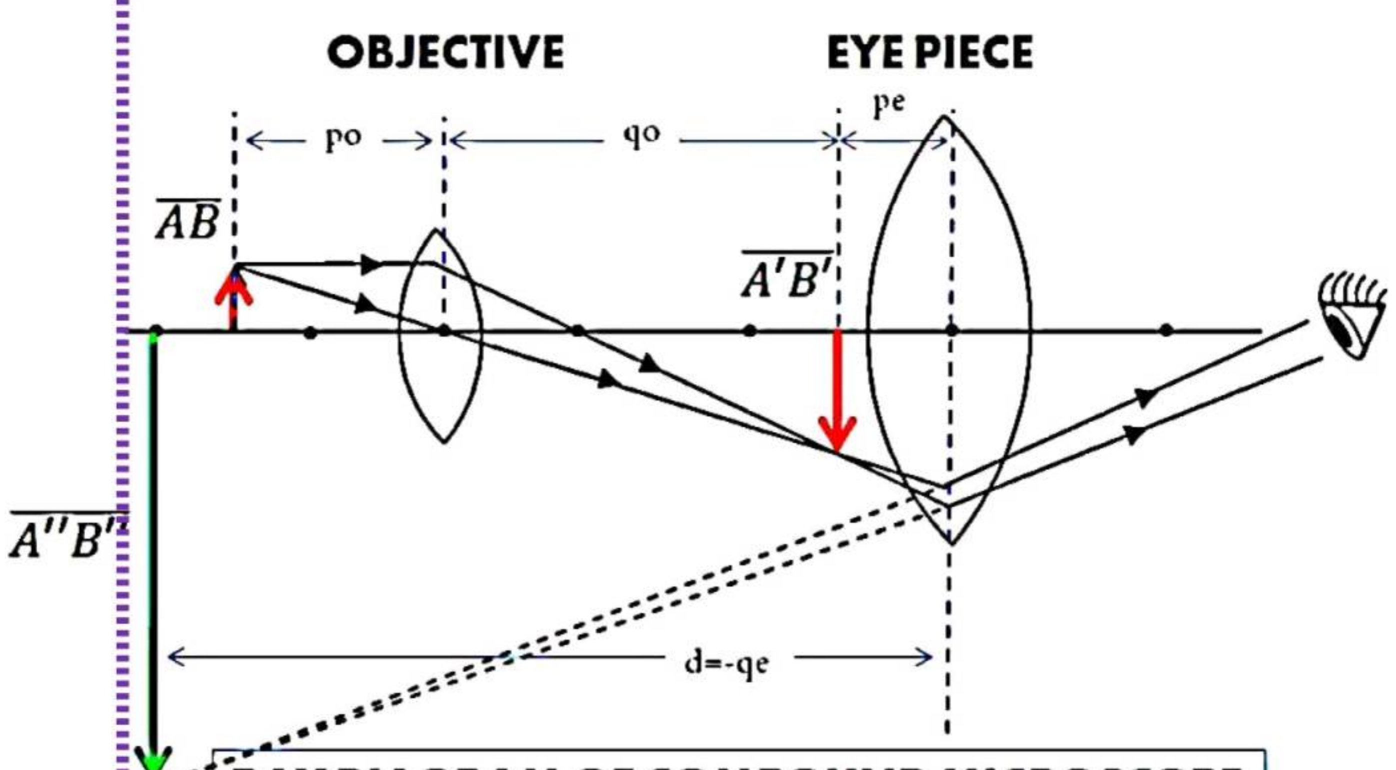
Focal Length of Eye Piece $= f_e = ?$

Solution:

Angular Magnification of Astronomical telescope

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

$$1000=\frac{15}{f_e}$$

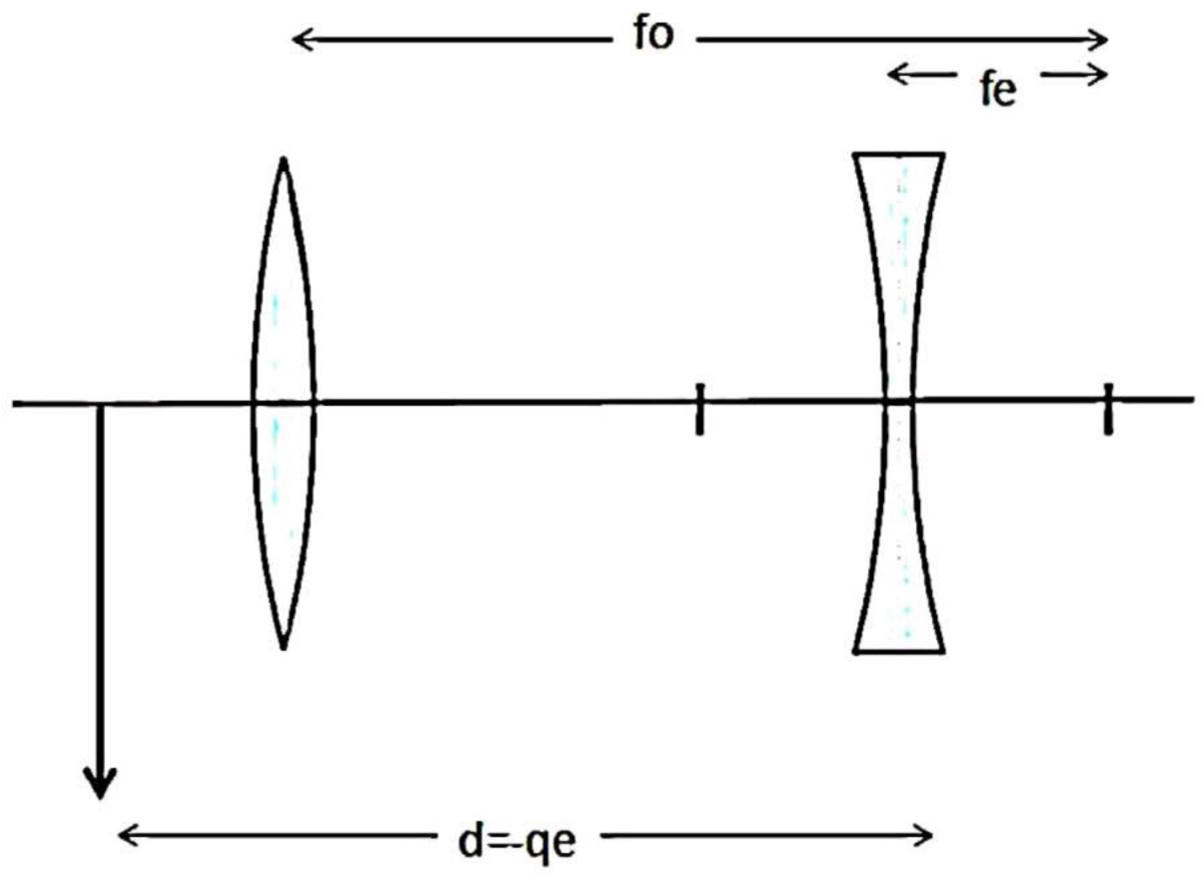


RAY DIAGRAM OF COMPOUND MICROSCOPE

$$f_e = \frac{15}{1000}$$
$$f_e = 0.015\ m$$
or $$f_e = 15\ mm$$

Result: The Focal Length of Eye Piece is 15 mm.

Q.11: A Galilean telescope has an objective of 120 mm focal length and an eye piece of 50 mm focal length. If the image seen by the eye is 300 mm from the eye piece, what is angular magnification?



Data:

Angular Magnication $= M = ?$

Focal Length of Objective $= f_0 = 120\ mm$

Image distance from Eye Piece $= q_e = -300\ mm$

Focal Length of Eye Piece $= f_e = 50\ mm$

Solution:

Angular Magnification of Galelean Telescope is given by

$$M = \frac{f_o}{p_e} \text{ ---(i)}$$

For Eye Piece:

$$\frac{1}{f_e} = \frac{1}{p_e} + \frac{1}{q_e}$$
$$\frac{1}{50} = \frac{1}{p_e} + \frac{1}{(-300)}$$
$$\frac{1}{50} + \frac{1}{300} = \frac{1}{p_e}$$
$$\frac{7}{300} = \frac{1}{p_e}$$
$$\boxed{p_e = \frac{300}{7} = 42.8\ mm}$$

Putting in eq(i)

$$M = \frac{120}{42.8}$$
$$\boxed{M = 2.8}$$

Result: The magnification of telescope is 2.8

Q.12: A compound microscope has an objective with a focal length of 10 mm and a tube 100 mm long. An image is produced 250 mm from the eye piece when the object is 12 mm from the objective. What is the angular magnification?

Data:

Focal length of Objective $= f_0 = 10\ mm$

Distance between lenses $= L = 100\ mm$

Magnifying Power $= M = ?$

Image distance from eye piece $= q_e = -250\ mm$

Object distance from objective $= p_0 = 12\ mm$

Solution:

For Objective:

$$\frac{1}{f_0} = \frac{1}{p_0} + \frac{1}{q_0}$$
$$\frac{1}{10} = \frac{1}{12} + \frac{1}{q_0}$$
$$\frac{1}{10} - \frac{1}{12} = \frac{1}{q_0}$$
$$\frac{1}{60} = \frac{1}{q_0}$$

$$\boxed{q_0 = 60\ mm}$$

Now , Distance between lenses

$$L = p_e + q_0$$
$$100 = p_e + 60$$
$$\boxed{p_e = 40\ mm}$$

For Eye Piece:

$$\frac{1}{f_e} = \frac{1}{p_e} + \frac{1}{q_e}$$
$$\frac{1}{f_e} = \frac{1}{40} + \frac{1}{(-250)}$$
$$\frac{1}{f_e} = \frac{1}{40} - \frac{1}{250}$$
$$\frac{1}{f_e} = \frac{21}{1000}$$

$$\boxed{f_e = \frac{1000}{21} = 47.6\ mm}$$

And Magnification of microscope is given by

$$M = \left(\frac{q_0}{p_0}\right)\left(1 + \frac{d}{f_e}\right)$$

$$M = \left(\frac{60}{12}\right)\left(1 + \frac{250}{47.6}\right)$$

$$M = (5)(6.25)$$

$$\boxed{M = 31}$$

Result: The magnification of compound microscope is 31.

Q.13: A converging lens of 4 dioptres is combined with a diverging lens of -2 dioptres. Find the power and focal length of the combination?

Data:

$Power\ of\ first\ lens = P_1 = 4\ diopters$

$Power\ of\ second\ lens = P_2 = -2\ diopters$

$Power\ of\ combination = P = ?$

$focal\ length\ of\ combination = f = ?$

Solution:

The power of combination of lenses is given by

$$P = P_1 + P_2$$

$$P = 4 + (-2)$$

$$\boxed{P = 2\ diopters}$$

According to the definition of power of lens

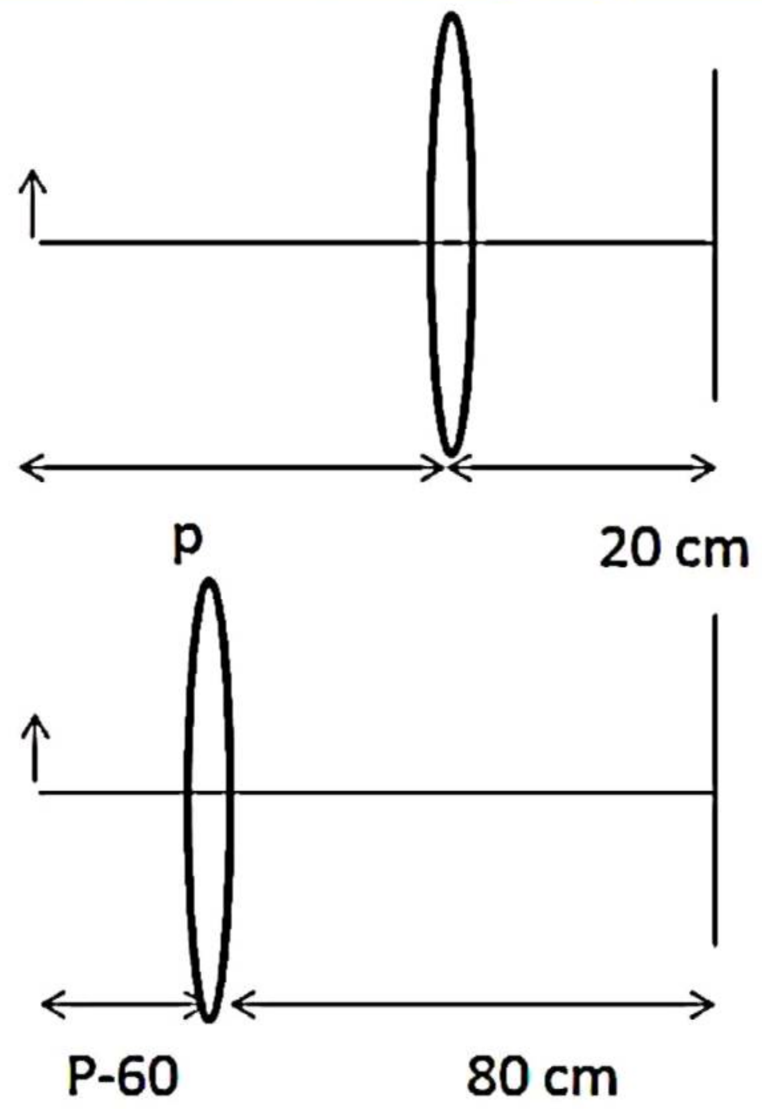
$$P = \frac{1}{f}$$

Or $$f = \frac{1}{P} = \frac{1}{2} = 0.5\ m$$

$$\boxed{f = 50\ cm}$$

Result: The power of combination is 2 diopters and focal length is 50 cm.

Q.14: A convex lens forms image of an object on a fixed screen 20 cm from the lens. On moving the lens 60 cm towards the object, the image is again formed on the screen. What is the focal length of the lens?



Data:

Initial Image distance $= q = 20cm$

Initial Oject distance $= p$

Final Image distance $= q' = 80cm$

Final Object distance $= p' = p - 60$

Focal length of lens $= f = ?$

Solution:

For 1st Case:

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

$$\boxed{\frac{1}{f} = \frac{1}{p} + \frac{1}{20}} \text{ ---- (i)}$$

For 2nd Case:

$$\frac{1}{f} = \frac{1}{p'} + \frac{1}{q'}$$

$$\boxed{\frac{1}{f} = \frac{1}{p-60} + \frac{1}{80}} \text{ ---- (ii)}$$

Comparing eq(i) and eq(ii)

$$\frac{1}{p} + \frac{1}{20} = \frac{1}{p-60} + \frac{1}{80}$$

$$\frac{20+p}{20p} = \frac{80+p-60}{80(p-60)}$$

$$\frac{20+p}{20p} = \frac{20+p}{80p-4800}$$

$$\frac{1}{20p} = \frac{1}{80p-4800}$$

$$80p - 4800 = 20p$$

$$60p = 4800$$

$$\boxed{p = 80\ cm}$$

To find focal length putting in eq(i)

$$\frac{1}{f} = \frac{1}{80} + \frac{1}{20}$$

$$\frac{1}{f} = \frac{5}{80}$$

$$\boxed{f = \frac{80}{5} = 16\ cm}$$

Result: The focal length of the lens is $16\ cm$.

Q.15: Two converging lenses are 25 cm part. Focal length of each is 10 cm. An object is placed in front of one lens at 50 cm. Find the distance between the object and the final image?

Data:

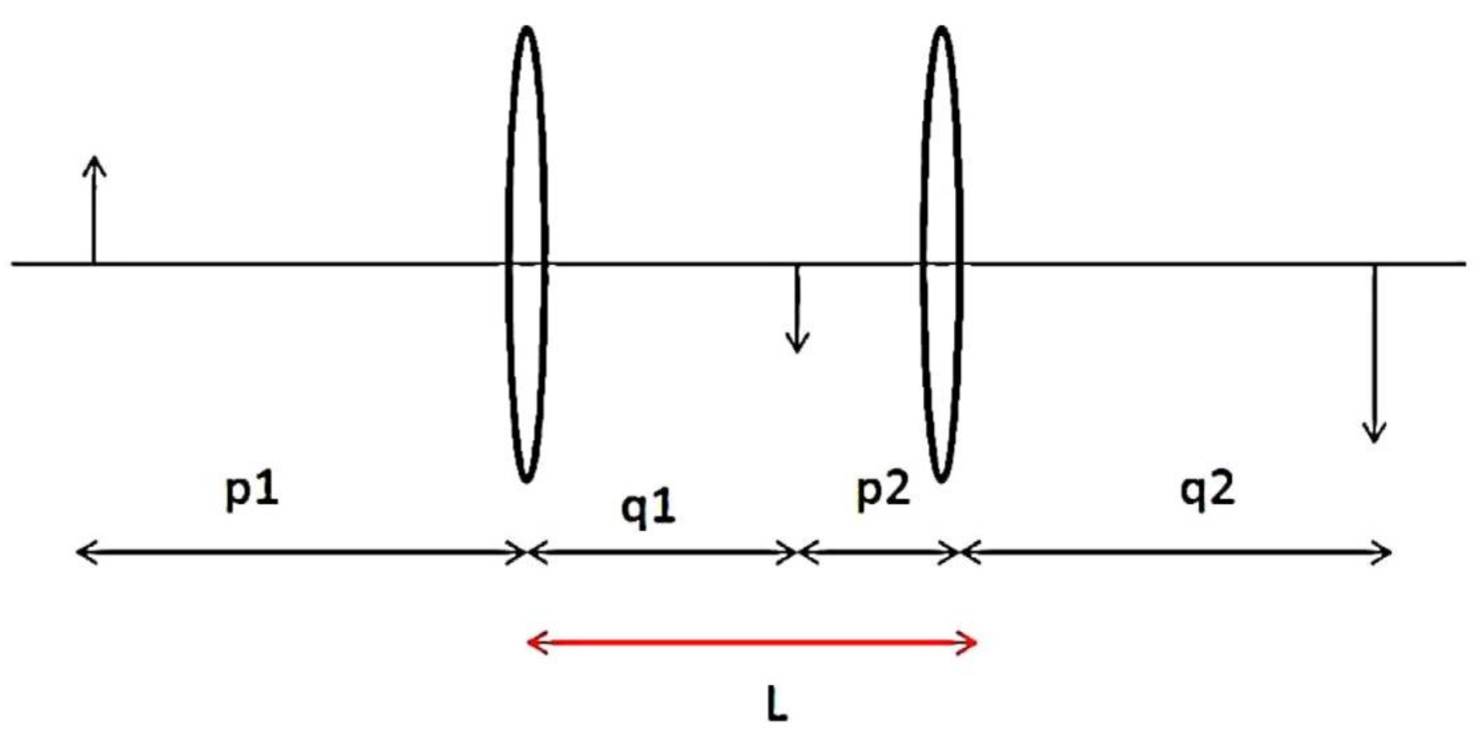
Focal length of 1st lens $= f_1 = 10\ cm$

Focal length of 2nd lens $= f_2 = 10\ cm$

Distance between lenses $= L = 25\ cm$

Distance between the object and the final image $= p_1 + L + q_2 = ?$

Object distance from 1st lens $= p_1 = 50\ cm$



Solution:

For 1st lens:

$$\frac{1}{f_1} = \frac{1}{p_1} + \frac{1}{q_1}$$

$$\frac{1}{10} = \frac{1}{50} + \frac{1}{q_1}$$

$$\frac{1}{10} - \frac{1}{50} = \frac{1}{q_1}$$

$$\frac{4}{50} = \frac{1}{q_1}$$

$$\boxed{q_1 = 12.5\ cm}$$

Now, Distance between lenses

$$L = p_2 + q_1$$

$$25 = p_2 + 12.5$$

$$\boxed{p_2 = 12.5\ cm}$$

For 2nd lens:

$$\frac{1}{f_2} = \frac{1}{p_2} + \frac{1}{q_2}$$

$$\frac{1}{10} = \frac{1}{12.5} + \frac{1}{q_2}$$

$$\frac{1}{q_2} = \frac{1}{10} - \frac{1}{12.5}$$

$$\frac{1}{q_2} = \frac{2.5}{125}$$

$$\boxed{q_2 = \frac{125}{2.5} = 50\ cm}$$

According to the figure

Distance between the object and the final image $= p_1 + L + q_2$

$$p_1 + L + q_2 = 50 + 25 + 50$$

$$\boxed{p_1 + L + q_2 = 125\ cm}$$

Result: Distance between the object and the final image is $125\ cm$.

PAST PAPER NUMERICALS

2022

iii) Two converging lenses of focal length 40 cm and 50 cm are placed in contact. What is the focal length of this tens combination?

Data:

$focal\ length\ of\ first\ lens = f_1 = 40\ cm$

$focal\ length\ of\ second\ lens = f_2 = 50\ cm$

$focal\ length\ of\ combination = f = ?$

$Power\ of\ combination = P = ?$

Solution:

The power of combination of lenses is given by

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\frac{1}{f} = \frac{1}{40} + \frac{1}{50}$$

$$\frac{1}{f} = \frac{9}{200}$$

$\boxed{f = 22.2\ cm}$

Q.2 (vi) An astronomical telescope with small amplitude has an objective whose power is 2 diopters. The lens is placed 60cm from the eye piece, when the telescope is adjusted for minimum eye strain. Calculate the angular magnification of the telescope.

Data:

Power of Objective= Po =2 diopters

Distance between lenses = L = 60 cm=0.6 m

Angular magnification = M=?

Solution:

The angular magnification of telescope is given by

$$M = \frac{P_e}{P_o} \text{-------(i)}$$

And the length of telescope is given by

$$L = \frac{1}{P_o} + \frac{1}{P_e}$$

$$0.6 = \frac{1}{2} + \frac{1}{P_e}$$

$$0.6 = 0.5 + \frac{1}{P_e}$$

$$\frac{1}{P_e} = 0.6 - 0.5 = 0.1$$

So, $P_e = \frac{1}{0.1} = 10\ diopter$

Putting values in equation (i)

$$M = \frac{10}{2}$$

$$\boxed{M = 5}$$

Result: The magnification of telescope is 5.

2019

Q.2(ii) An astronomical telescope having angular magnification 5 consists of two thin lenses 24 cm apart. Find the power of its lenses.

Data:

Magnification= M = 5

Length of Telescope= L = 24 m

Power of Objective = P_o=?

Power of Eye Piece = P_e=?

Solution:

$$L = f_0 + f_e$$

$$24 = f_0 + f_e \text{ ----(i)}$$

$$\because\ M = \frac{f_0}{f_e}$$

$$5 = \frac{f_0}{f_e}$$

$$\boxed{f_0 = 5\,fe}$$

Putting in equation (i)

$$24 = 5\,fe + f_e$$

$$24 = 6\,fe$$

$\boxed{fe = 4\ cm}$ Or $\boxed{fe = 0.04\ m}$

Then

$\boxed{f_0 = 5 \times 4 = 20\ cm}$ Or $\boxed{f_0 = 0.2\ m}$

Now,

$$\boxed{P_0 = \frac{1}{fo} = \frac{1}{0.2} = 5\ Dioptre}$$

And

$$\boxed{P_e = \frac{1}{fe} = \frac{1}{0.04} = 25\ Dioptre}$$

Result: The powers of lenses are 5 dioptre and 25 dioptre.

2018

Q.2(vi) An astronomical telescope has a length of 105 cm and its magnification is 6. Determine the power of objective and eye piece?

Data:

Magnification= M = 6

Length of Telescope= L = 105 cm

Power of Objective = P_o=?

Power of Eye Piece = P_e=?

Solution:

$$L = f_0 + f_e$$

$$105 = f_0 + f_e \text{ ----(i)}$$

$\because\ M = \frac{f_0}{f_e}$

$6 = \frac{f_0}{f_e}$

$\boxed{f_0 = 6\,fe}$

Putting in equation (i)

$105 = 6\,fe + f_e$

$105 = 7\,fe$

$\boxed{fe = 15\ cm}$ Or $\boxed{fe = 0.15\ m}$

Then

$\boxed{f_0 = 6 \times 15 = 90\ cm}$ Or $\boxed{f_0 = 0.9\ m}$

Now,

$\boxed{P_0 = \frac{1}{fo} = \frac{1}{0.15} = 6.66\ Dioptre}$

And

$\boxed{P_e = \frac{1}{fe} = \frac{1}{0.9} = 1.11\ Dioptre}$

Result: The powers of lenses are 6.66 dioptre and1.11 dioptre.

2(xv) A microscope has an objective of 12mm focal length and eye piece of 25 mm focal length. What is the distance between the lenses? What is the magnifying power if the object is in sharp focus when it is 15 mm from the objective?

Data:

Focal length of Objective $= f_0 = 12\ mm$

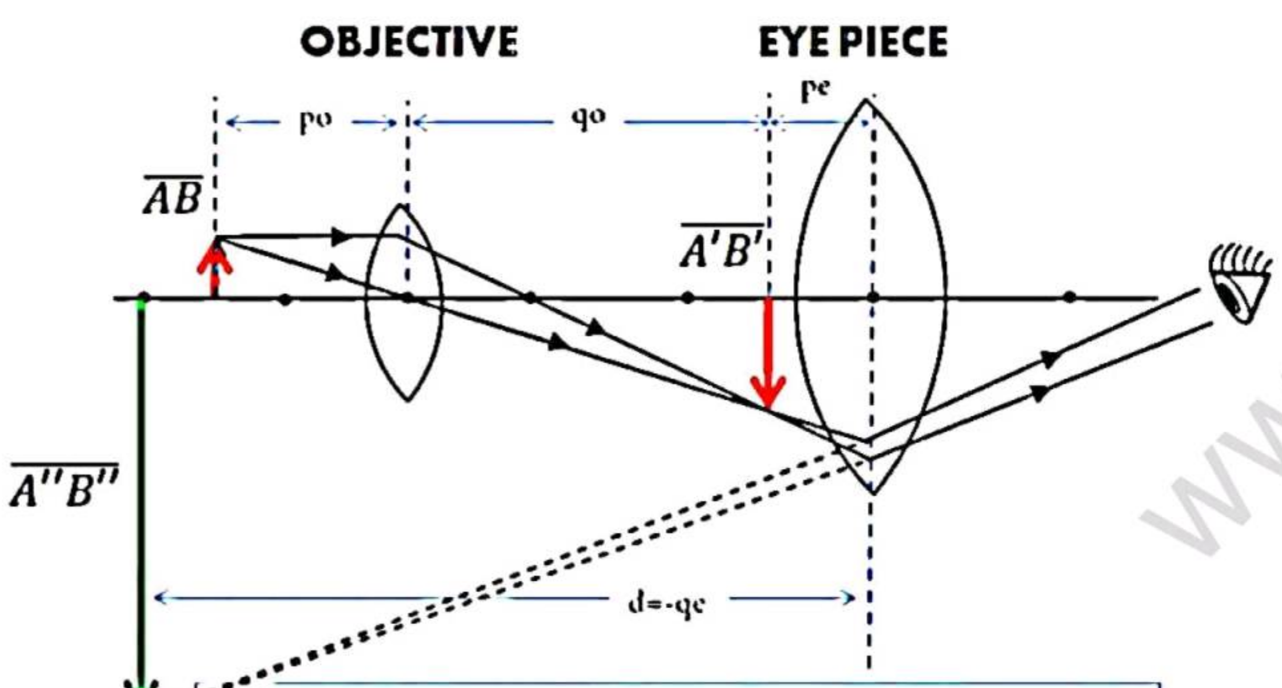
Focal length of Eye Piece $= f_e = 25\ mm$

Distance between lenses $= L = ?$

Magnifying Power $= M = ?$

Object distance from objective $= p_o = 15\ mm$

Image distance from eye piece $= q_e = -250\ mm$



RAY DIAGRAM OF COMPOUND MICROSCOPE

Solution:

For Objective:

$\frac{1}{f_0} = \frac{1}{p_0} + \frac{1}{q_0}$

$\frac{1}{12} = \frac{1}{15} + \frac{1}{q_0}$

$\frac{1}{12} - \frac{1}{15} = \frac{1}{q_0}$

$\frac{3}{180} = \frac{1}{q_0}$

$\boxed{q_0 = \frac{180}{3} = 60\ mm}$

For Eye Piece:

$\frac{1}{f_e} = \frac{1}{p_e} + \frac{1}{q_e}$

$\frac{1}{25} = \frac{1}{p_e} + \frac{1}{(-250)}$

$\frac{1}{25} + \frac{1}{250} = \frac{1}{p_e}$

$\frac{11}{250} = \frac{1}{p_e}$

$\boxed{p_e = \frac{250}{11} = 22.72\ mm}$

Now , Distance between lenses

$L = p_e + q_0$

$L = 22.72 + 60$

$\boxed{L = 82.72\ mm}$

And Magnification of micro scope is given by

$M = \left(\frac{q_0}{p_0}\right)\left(1 + \frac{d}{f_e}\right)$

$M = \left(\frac{60}{15}\right)\left(1 + \frac{250}{25}\right)$

$M = (4)(11)$

$\boxed{M = 44}$

Result: The distance between lenses is 82.72 mm and the magnification is 44

2017

Q.2(xii) A lens 2 cm focal length is to be used as a magnifying glass. How far from the lens should the object be placed? What is its magnifying power?

Data:

Focal Length = f = 2cm

Image distance = q = -d = -25cm

Object distance = p = ?

Magnifying Power = M = ?

Solution:

As we know that

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$
$$\frac{1}{2} = \frac{1}{p} + \frac{1}{(-25)}$$
$$\frac{1}{2} + \frac{1}{25} = \frac{1}{p}$$
$$\frac{27}{50} = \frac{1}{p}$$

Or $\boxed{P = \frac{50}{27} = 1.85\ cm}$

Now, Magnification of Magnifying Glass is given by

$$M = 1 + \frac{d}{f} = 1 + \frac{25}{2}$$
$$\boxed{M = 13.5}$$

Result: The object should be placed at 1.85 cm and the magnification is 13.5.

2016

Q.2 (x) Textbook Numerical 13

2015

No Numerical

2014

Q.2(xv) A watch maker uses a magnifying glass of local length 5cm to see the damaged spring of a watch. If he holds the glass close to the eye what is the best position of the object? What is the linear magnification?

Data:

Focal length of lens = 5 cm

Position of object = p = ?

Linear magnification = M = ?

Solution:

The magnification of Magnifying Glass

$$M = 1 + \frac{d}{f}$$
$$M = 1 + \frac{25}{5}$$
$$\boxed{M = 6}$$

As we know that

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

For best view the minimum distance is 25 cm

$$\frac{1}{5} = \frac{1}{p} + \frac{1}{(-25)}$$
$$\frac{1}{5} = \frac{1}{p} - \frac{1}{25}$$
$$\frac{1}{5} + \frac{1}{25} = \frac{1}{p}$$
$$\frac{1}{p} = \frac{6}{25}$$
$$\boxed{p = 4.16\ cm}$$

Result: The magnification is 6 and object distance should be 4.16 cm.

2013

Q.2 (vii) A magnifying glass of focal length 6 cm is used to see a small specimen. The least distance of distinct vision of the observer is 25 cm. What is the magnifying power of the lens?

Data:

Focal length of Magnifying Glass = f = 6 cm

Least distance of distinct vision = d = 25 cm

Magnifying Power = M = ?

Solution:

The magnification of magnifying glass is

$$M = 1 + \frac{d}{f}$$
$$M = 1 + \frac{25}{6}$$
$$\boxed{M = 5.16}$$

Result: The magnifying power of the lens is 5.16.

2012

Q.2 (xii) Same as 2018 Q.2 (vi)

2011

2(xv) Two converging lenses of focal lengths 30 cm and 60 cm are placed in contact. What is the focal length of this combination? Calculate the power of the combination in dioptres.

Data:

$focal\ length\ of\ first\ lens = f_1 = 30\ cm$

$focal\ length\ of\ second\ lens = f_2 = 60\ cm$

$focal\ length\ of\ combination = f = ?$

$Power\ of\ combination = P = ?$

Solution:

The power of combination of lenses is given by

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$\frac{1}{f} = \frac{1}{30} + \frac{1}{60}$$

$$\frac{1}{f} = \frac{3}{60}$$

$$\boxed{f = 20\ cm}$$

or $f = 0.2\ m$

According to the definition of power of lens

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

Or $\boxed{P = \frac{1}{0.2} = 5\ diopters}$

Result: The power of combination is 5 diopters and focal length is 20 cm.

2010

Q.2 (xiii) A magnifying glass produces an image of magnifying 6. What is the power of the lens? What is the best position of the object if a watch maker holds the same lens close to his eye to see the damaged spring of the watch?

Data:

Power of lens = ?

Position of object = p = ?

Linear magnification = M = 6

Solution:

The magnification of Magnifying Glass

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

$$6 = 1 + \frac{25}{f}$$

$$5 = \frac{25}{f}$$

$$\boxed{f = 5\ cm}$$

Power of lens is given by

$$\boxed{P = \frac{1}{f} = \frac{1}{0.05} = 20\ diopter}$$

As we know that

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

For best view the minimum distance is 25 cm

$$\frac{1}{5} = \frac{1}{p} + \frac{1}{(-25)}$$

$$\frac{1}{5} = \frac{1}{p} - \frac{1}{25}$$

$$\frac{1}{5} + \frac{1}{25} = \frac{1}{p}$$

$$\frac{1}{p} = \frac{6}{25}$$

$$\boxed{p = 4.16\ cm}$$

Result: The magnification is 6 and object distance should be 4.16 cm.