CHAPTER / 13

Optical Instruments

Topics Covered

Microscope
- Microscope (Magnifying Glass/Reading Glass/Magnifier)
- Compound Microscope

Telescope
- Refracting (Astronomical) Telescope
- Reflecting Telescope
- Characteristics of a Good Telescope

A number of optical devices and instruments have been designed utilising reflecting and refracting properties of mirror, lens and prism. Periscope, telescope and microscope are some examples of optical devices and instruments that are in common use.

Microscope

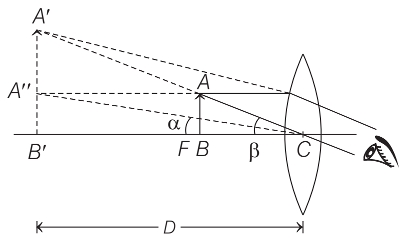
It is an optical instrument which forms a magnified image of a small nearby object and thus increases the visual angle subtended by the image at the eye, so that the object is seen to be bigger and distinct. Here, we discuss two types of microscope:

(i) Simple microscope (ii) Compound microscope

(i) Simple Microscope (Magnifying Glass/Reading Glass/Magnifier)

It is a converging lens of small focal length which forms large image of close and minute objects. When an object is at a distance less than the focal length of the lens, the image obtained is virtual, erect and magnified. When the object is at a distance equal to focal length of lens, image is formed at infinity.

***Case* I** **When image is formed at the near point** The angular magnification of a simple microscope is the ratio of the angle β subtended at the eye by image at the near point to the angle α subtended at the unaided eye by the object at the near point.



Magnifying power, $M = \frac{\beta}{\alpha} = 1 + \frac{D}{f}$

[$\because$ $v = -D$, because image is formed at near point]

If the eye is placed behind the lens at a distance a, then

$$M = 1 + \frac{D - a}{f}$$

***Case* II When the image is formed at infinity**

The magnification at near point is larger than that at infinity,

$$M = M_{\text{near point}} = \frac{D}{f}$$

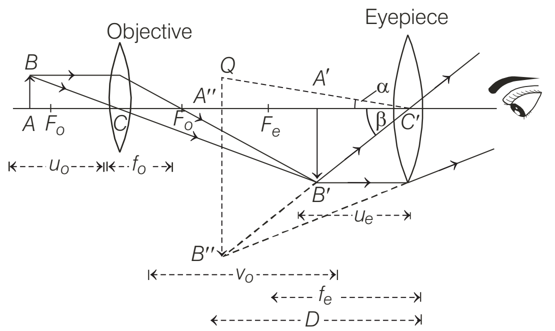
(ii) Compound Microscope

A compound microscope consists of two convex lenses coaxially separated by some distance. The lens nearer to the object is called objective and the lens through which final image is viewed is called eyepiece.

Working

The objective of compound microscope forms the real, inverted and magnified image of the object. This image serves as the object for the second lens, i.e. eyepiece, which produces the final image that is large and virtual.

The first inverted image is thus near the focal plane of the eyepiece, at a distance appropriate for final image formation at infinity or a little closer for image formation at near point. The final image is inverted with respect to the original object.



Angular magnification or **magnifying power** of a compound microscope is defined as the ratio of the angle β subtended by the final image at the eye to the angle α subtended by the object seen directly, when both are placed at the least distance of distinct vision.

The magnification produced by the compound microscope is the product of the magnification produced by the eyepiece and objective.

$\therefore$ $M = M_e \times M_o$

***Case* I When final image is formed at near point**

Linear magnification of eyepiece is given by

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

where, f_e is focal length of the eyepiece.

The linear magnification of the object produced by the objective,

$$M_o = \left(1 - \frac{v_o}{f_o}\right)$$

So, the magnification is given as

$$M = \left(1 - \frac{v_o}{f_o}\right)\left(1 + \frac{D}{f_e}\right)$$

and length between objective and eyepiece,

$$L = v_o + \frac{Df_e}{D + f_e}$$

***Case* II When final image is at infinity**

If u_o is the distance of the object from the objective and v_o is the distance of the image from the objective, then the magnifying power of the objective is $M_o = \frac{v_o}{u_o}$.

When the final image is at infinity, then angular magnification of eyepiece is given by

$$M_e = \frac{D}{f_e}$$

The total magnification when image is at infinity is given by

$$M = M_o \times M_e = \left(\frac{v_o}{u_o} \times \frac{D}{f_e}\right)$$

If the object is very close to the principal focus of the objective and the image formed by the objective is very close to the eyepiece, then

$$M = \frac{-L}{f_o} \cdot \frac{D}{f_e}$$

where, L = length of the microscope = $v_o + f_e$.

In this case, the microscope is said to be in normal adjustment.

Telescope

It is an optical instrument which increases, the visual angle at the eye by forming the image of a distant object at the least distance of distinct vision, so that the object is seen distinct and bigger. In our syllabus, two types of telescope are discussed, namely

(i) refracting (astronomical) telescope and

(ii) reflecting telescope.

(i) Refracting (Astronomical) Telescope

It has two convex lenses coaxially separated by some distance. The lens towards the object is called objective and has much larger aperture than the eyepiece towards the eye. Astronomical telescope is of refracting type.

Working

Light from the distant object enters the objective and real image is formed at second focal point of objective. The eyepiece magnifies this image producing a final inverted image.

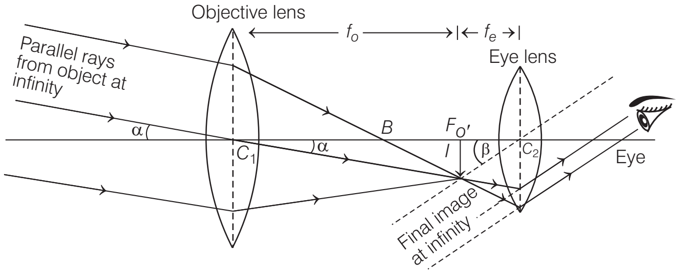
***Case* I When the final image is formed at infinity**

Angular magnification is given by

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

However, β and α are very small.

$\therefore \quad \beta \approx \tan\beta \quad \text{or} \quad \alpha \approx \tan\alpha \Rightarrow M = \dfrac{\tan\beta}{\tan\alpha}$



I is the image formed by the objective, f_o and f_e are the focal lengths of objective and eyepiece, respectively.

$$\tan\alpha = \frac{I}{f_o} \quad \text{or} \quad \tan\beta = -\frac{I}{f_e}$$

$$\therefore \qquad M = \frac{-\dfrac{I}{f_e}}{\dfrac{I}{f_o}} \Rightarrow M = -\frac{f_o}{f_e}$$

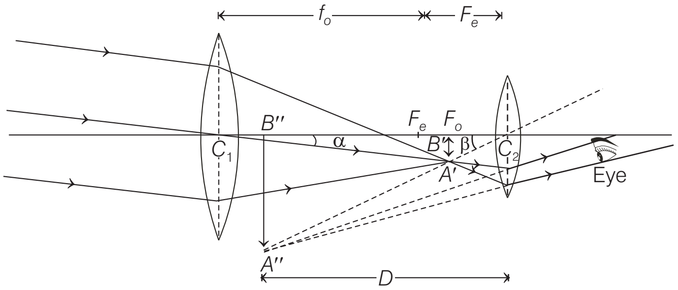
Length of the telescope tube,

$$L = f_o + f_e$$

***Case* II When final image is formed at near point**

Using lens equation $\left(\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f}\right)$ for the eyepiece,

$$\frac{1}{-D} - \frac{1}{(-u_e)} = \frac{1}{f_e} \Rightarrow \frac{1}{u_e} = \frac{1}{f_e} + \frac{1}{D}$$



or $$\frac{f_o}{u_e} = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$$

$$\Rightarrow \qquad M = -\frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right) \qquad \left[\because M = \frac{f_o}{u_e}\right]$$

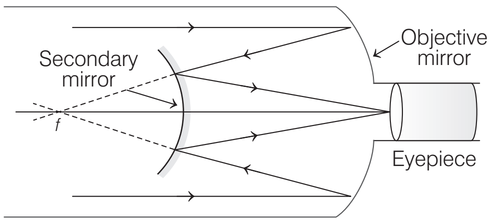
Length of the tube, $L = f_o + \dfrac{Df_e}{f_e + D}$

Objective of large aperture should be used only as it will not only make the magnified image brighter, it will also have resolving power due to which objects with minute details can be viewed.

(ii) Reflecting Telescope

This type of telescope is an improvement over refracting telescope.

Reflecting telescope consists of concave mirror of large aperture and large focal length (objective). A convex mirror is placed between the concave mirror and its focus. A small convex lens works as eyepiece.In the reflecting telescope, parallel rays from a distant object are intercepted and focused by a reflecting concave mirror rather than a refracting lens.



Advantages of Reflecting Telescope over Refracting Telescope

In reflecting telescope, a mirror has several advantages over a objective lens. A mirror is easier to produce with a larger diameter, so that it can gather more light coming from a distant object.

The mirror can be made parabolic to reduce spherical aberration. Due to use of mirrors, chromatic aberration defect can be avoided in reflecting telescopes.

Characteristics of a Good Telescope

A good telescope must have the following characteristics:

(i) **High resolving power** Resolving power of a telescope is its ability to see two very closely situated objects just separate. The angular limit of resolution of a telescope is given by

$$\Delta\theta = \frac{1.22\lambda}{D}$$

where, λ = wavelength of light
and D = diameter of the objective.

(ii) **High magnifying power** Higher magnification is useful only if the objects to be viewed are already resolved. For a telescope, magnifying power M can be given as $M = \frac{f_o}{f_e}$

where, f_o = focal length of the objective
and f_e = focal length of eyepiece.

So, a higher magnification can be achieved by having an objective of larger focal length and an eyepiece of smaller focal length.

(iii) **High brightness ratio** It is defined as the ratio between amount of light entering the objective of the telescope to that entering the pupil of unaided eye.

$$\therefore \text{Brightness ratio} = \frac{\text{Area of objective}}{\text{Area of eye pupil}} = \frac{\pi D^2/4}{\pi d^2/4} = \frac{D^2}{d^2}$$

where, D = diameter of the objective
and d = diameter of the eye pupil.

So, to have a brighter image, objectives of larger diameter should be used.

PRACTICE QUESTIONS

Exam', Textbook's & Other Imp. Questions

1 MARK *Questions*

Exams' Questions

Q.1 The focal lengths f_o and f_e of an astronomical telescope are 30 cm and 6 cm, respectively. What is the distance between its objective and eyepiece when set for normal adjustment? **[2012]**

Sol Distance, $L = f_o + f_e = 30 + 6 = 36$ cm **(1)**

Q.2 What is the magnifying power of a reading glass of focal length of 5 cm when the distance of distinct vision is 25 cm. **[2012 Instant]**

Or

A convex lens of focal length 5 cm is used as a simple microscope. What is its magnifying power? **[2002]**

Sol Since, $M = 1 + \frac{D}{f} = 1 + \frac{25}{5} = 6$ **(1)**

Q.3 The magnifying power of an astronomical telescope is 50. Focal length of the eyepiece is 5 cm. The focal length of objective is .... (Fill in the blank). **[2011 Instant]**

Sol Since, $f_o = f_e \times M = 50 \times 5 = 250$ cm **(1)**

Q.4 What is the magnifying power of a reading glass of focal length 0.03 m, given the distance of distinct vision = 0.30 m. **(2009)**

Sol Since, $M = 1 + \frac{D}{f} = 1 + \frac{0.30}{0.03} = 11$ **(1)**

Important Questions

Q.5 With a simple microscope, if the final image is located at the least distance of distinct vision, (i.e. D), from the eye placed close to the lens, then the magnifying power is **[Textbook]**

(a) $\frac{D}{f_e}$ (b) $1+\frac{D}{f_e}$ (c) $\frac{f_e}{D}$ (d) $f_e \times D$

Sol (*b*) $\therefore$ Magnifying power, $M_e = 1 + \frac{D}{f_e}$ **(1)**

Q.6 The ratio of the focal length of the objective to the focal length of the eyepiece is greater than 1 for a **[Textbook]**

(a) telescope
(b) microscope
(c) Both telescope and microscope
(d) Neither telescope nor microscope

Sol (*a*) Telescope has ratio $\frac{f_o}{f_e} >> 1$, whereas microscope has ratio $\frac{f_o}{f_e} << 1$. **(1)**

Q.7 With a simple microscope, if the final image is located at infinity, then its magnifying power is **[Textbook]**

(a) D/f (b) $1+D/f$ (c) f/D (d) $D\times f$

Sol (*a*) When final image at infinity, $M=\dfrac{D}{f}$ **(1)**

Q.8 An observer looks at a tree of height 15 m with a telescope of magnifying power 10. To him the tree appears **[Textbook]**

(a) 10 times taller (b) 15 times taller
(c) 10 times nearer (d) 15 times nearer

Sol (*c*) Since, magnifying power is 10. So, tree appears 10 times nearer. **(1)**

Q.9 An astronomical telescope has a converging eyepiece of focal length 5 cm and objective of focal length 80 cm. When the final image is formed at the least distance of distinct vision (25 cm), the separation between the two lenses is **[Textbook]**

(a) 75 cm (b) 80 cm (c) 84.2 cm (d) 85 cm

Sol (*c*) $\therefore$ Separation between the two lenses,

$$L=f_o+\frac{D\,f_e}{f_e+D}=80+\frac{25\times5}{25+5}\simeq 84.2 \text{ cm}$$ **(1)**

Q.10 For an astronomical telescope used in normal adjustment, objective and the eyepiece are separated by a distance of 55 cm. If the magnifying power of the telescope is 10, the power of the objective is **[Textbook]**

(a) 5D (b) 50D (c) 2D (d) 0.5D

Sol (*c*) Since, for normal adjustment,

$$M=\frac{f_o}{f_e} \text{ and } L=f_o+f_e$$

$$\Rightarrow \quad 10=\frac{f_o}{f_e} \text{ and } 55 \text{ cm}=f_o+f_e$$

which give $f_o=50$ cm and $f_e=5$ cm.

Hence, power, $P_o=\dfrac{1}{f_o}=\dfrac{1}{50\times10^{-2}}\Rightarrow P_o=2\text{D}$ **(1)**

Q.11 In a compound microscope, the focal lengths of objective and eyepiece are 1.2 cm and 3 cm, respectively. If the object is put 1.25 cm away from the objective lens and the final image is formed at infinity, the magnifying power of the microscope is **[Textbook]**

(a) 150 (b) 200 (c) 250 (d) 400

Sol (*b*) As, $\dfrac{1}{v_o}=\dfrac{1}{f_o}-\dfrac{1}{u_o}$

$$\Rightarrow \quad v_o=\frac{1.2\times1.25}{0.05}$$

So, $M=\dfrac{v_o}{u_o}\dfrac{D}{f_e}=\dfrac{1.2\times1.25\times25}{1.25\times0.05\times3}\Rightarrow M=200$ **(1)**

Q.12 In order to increase the magnifying power of a microscope, **[Textbook]**

(a) the focal powers of the objectives and eyepiece should be large
(b) objective should have small focal length and the eyepiece large
(c) Both should have large focal lengths
(d) the objectives should have large focal length and eyepiece should have small focal length

Sol (*b*) For high magnifying power of microscope, the objective should have small focal length and the eyepiece should have large focal length. **(1)**

Q.13 You are supplied with four convex lenses of focal lengths 100 cm, 25 cm, 3 cm and 2 cm. For designing an astronomical telescope, you will use lenses of focal lengths **[Textbook]**

(a) 100 cm and 25 cm (b) 100 cm and 3 cm
(c) 25 cm and 2 cm (d) 100 cm and 2 cm

Sol (*d*) We use objective of largest focal length, i.e. 100 cm and eyepiece of smallest focal length, i.e. 2 cm. **(1)**

Q.14 The length of a simple astronomical telescope is **[Textbook]**

(a) the difference of the focal lengths of two lenses
(b) half the sum of the focal lengths
(c) the sum of the focal lengths
(d) product of the focal lengths

Or

The length of an astronomical telescope tube for normal vision is **[Textbook]**

(a) $f_o\times f_e$ (b) f_o/f_e (c) f_o+f_e (d) f_e/f_o

Sol (*c*) Length of a simple astronomical telescope, $L=f_o+f_e$. **(1)**

Q.15 A compound microscope has an objective and eyepiece as thin lenses of focal lengths 1 cm and 5 cm, respectively. The distance between the objective and eyepiece is 20 cm. The distance at which the object must be placed in front of the objective, if the final image is located at 25 cm from the eyepiece is numerically. **[Textbook]**

(a) 95/6 cm (b) 5 cm (c) 95/89 cm (d) 25/6 cm

Sol (*c*) Given, $f_o=1$ cm, $f_e=5$ cm

and $\quad L=20$ cm.

$$\therefore \quad L=v_o+\frac{D\,f_e}{D+f_e}$$

$$\Rightarrow \quad v_o=20-\frac{25\times5}{30}=\frac{95}{6} \text{ cm}$$

and $\quad \dfrac{1}{u_o}=\dfrac{1}{f_o}-\dfrac{1}{v_o}=\dfrac{1}{1}-\dfrac{6}{95}=\dfrac{89}{95}$

$$\Rightarrow \quad u_o=\frac{95}{89} \text{ cm}$$ **(1)**

Q.16 A telescope has an objective of focal length 50 cm and an eyepiece of focal length 5 cm. It is focused for distinct vision on a scale 200 cm away from the objective. Then, the optical length of the telescope is **[Textbook]**

(a) 200/3 cm (b) 25/6 cm
(c) 425/6 cm (d) 375/6 cm

Sol (*c*) Given, $f_o = 50$ cm, $f_e = 5$ cm and $u_o = 200$ cm

So, $$\frac{1}{v_o} = \frac{1}{f_o} - \frac{1}{u_o} = \frac{1}{50} - \frac{1}{200} = \frac{3}{200}$$

and length, $L = v_o + \dfrac{D f_e}{D + f_e} = \dfrac{200}{3} + \dfrac{25 \times 5}{30} = \dfrac{425}{6}$ cm **(1)**

Q.17 The magnifying power of compound microscope in terms of the magnification m_o due to objective and magnifying power m_e by the eyepiece is given by **[Textbook]**

(a) m_o/m_e (b) $m_o \times m_e$
(c) $m_o + m_e$ (d) m_e/m_o

Sol (*b*) $\therefore$ Magnifying power of compound microscope,

$$M = m_o \times m_e$$ **(1)**

Q.18 Large aperture of telescope is used for **[Textbook]**

(a) greater magnification
(b) greater resolution
(c) reducing lens-aberration
(d) ease of manufacture

Sol (*b*) To achieve greater resolution, large aperture of telescope is used. **(1)**

Q.19 The image of a distant object as seen through an astronomical telescope is **[Textbook]**

(a) erect (b) inverted
(c) perverted (d) None of these

Sol (*b*) Image formed by an astronomical telescope is inverted in nature. **(1)**

Q.20 The objective of telescope has small aperture. (Correct the statement, if necessary) **[Textbook]**

Sol The objective of telescope has **large** aperture. **(1)**

Q.21 For a simple microscope with image at infinity, the magnifying power M is given as $M = \left(1 + \dfrac{D}{f}\right)$, where D is the distance of distinct vision and f is the focal length of the lens used in simple microscope. (Correct the statement, if necessary) **[Textbook]**

Sol For a simple microscope with image at infinity, the magnifying power M is given as $M = \left(\dfrac{D}{f}\right)$, where D is the distance of distinct vision and f is the focal length of the lens used in simple microscope. **(1)**

Q.22 To increase magnifying power of a simple microscope, what type of lens you will choose : Higher or smaller focal length? **[Textbook]**

Sol A lens of smaller focal length is used. **(1)**

Q.23 For a telescope, in which case, the magnifying power is maximum. Normal adjustment or near point adjustment.

Sol Near point adjustment is required for maximum magnifying power. **(1)**

2 MARKS *Questions*

Exams' Questions

Q.24 Compare between objective and eyepiece of a compound microscope. **[2013]**

Sol (i) In a compound microscope, focal length of eyepiece is more than the focal length of the objective. **(1)**

(ii) Objective produces real image, while eyepiece produces virtual image. **(1)**

Q.25 The magnifying power of an astronomical telescope is 10 in normal adjustment and the corresponding tube length is 110 cm. Calculate the focal lengths of objective and eyepiece. **[2011]**

Sol Given, $M = 10$ and $f_o + f_e = 110$ cm

As, $M = \dfrac{f_o}{f_e} = 10$

$\therefore$ $f_o = 10\, f_e$ ...(i) **(1)**

As, $f_o + f_e = 110$

$\Rightarrow$ $10\, f_e + f_e = 110$ [from Eq. (i)]

or $11\, f_e = 110$

$\therefore$ $f_e = 10$ cm

Now for Eq (i), $f_o = 10 \times 10 = 100$ cm **(1)**

Q.26 Write the essential differences between a microscope and telescope. **[2011 Instant]**

Sol (i) A microscope forms large image of close and minute objects, whereas telescope is used for observing distinct images of heavenly objects like stars, planets, etc. **(1)**

(ii) In a compound microscope, focal length of eyepiece is more than the focal length of objective, whereas in telescope, focal length of eyepiece is less than the focal length of objective. **(1)**

Q.27 An astronomical telescope has an objective lens of focal length 144 cm and an eyepiece of focal length 1.2 cm. Calculate the magnifying power and the separation between the objective and the eyepiece. **[2010 Instant]**

Sol Given, $f_o = 144$ cm and $f_e = 1.2$ cm

As, $M = \frac{f_o}{f_e} = \frac{144 \text{ cm}}{1.2 \text{ cm}} = 120$ **(1)**

$\therefore$ Separation between lenses,

$$L = f_o + f_e = 144 + 1.2 = 145.2 \text{ cm}$$ **(1)**

Q.28 A simple magnifier can magnify the size of an object three times in distinct vision. Calculate its focal length. **[2008]**

Sol Given, $M = 3$ and $D = 25$ cm

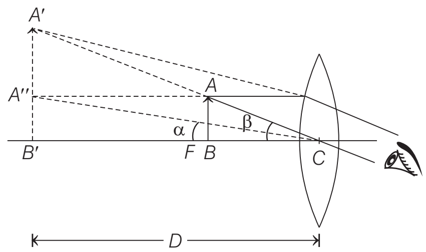
As, $M = 1 + \frac{D}{f} \Rightarrow 3 = 1 + \frac{25}{f}$ **(1)**

$\Rightarrow 3 - 1 = \frac{25}{f} \Rightarrow 2 = \frac{25}{f}$

$\therefore$ Focal length, $f = \frac{25}{2} = 12.5$ cm **(1)**

Q.29 Draw a neat ray diagram showing image formation by a simple microscope. **[2008, 2006]**

Sol



This is the image formation by a simple microscope. **(2)**

Q.30 Calculate the magnifying power of a magnifying glass of focal length 0.05 m. The least distance of distinct vision = 0.25 m. **[2008 Instant]**

Sol Given, $f = 0.05$ m and $D = 0.25$ m

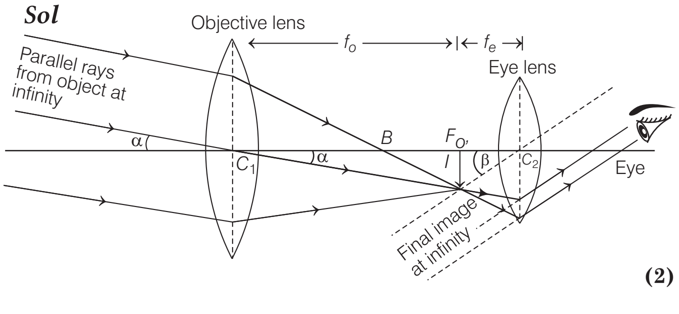
As, magnifying power, $M = 1 + \frac{D}{f}$ **(1)**

$\Rightarrow M = 1 + \frac{0.25}{0.05} \Rightarrow M = 1 + 5$

$\therefore M = 6$ **(1)**

Q.31 Give the ray diagram of image formation by an astronomical telescope. **[2005]**

Sol



(2)

Q.32 Draw the ray diagram of a simple magnifier. Give an expression for its magnification. **[2004]**

Sol **Ray diagram** Refer to solution 29. **(1)**

The magnification of a simple magnifier is

$$m = 1 + \frac{D}{f}$$ **(1)**

Important Questions

Q.33 A simple microscope is made of a combination of two lens in contact of power +15D and +5D. Calculate the magnifying power of the microscope, if the image is formed at least distance of distinct vision 0.25 m. **[Textbook]**

Sol $\because$ Power combination, $P = 15 + 5 = +20$ D

$\therefore$ Focal length, $f = \frac{1}{P} = 5$ cm **(1)**

$\therefore$ Magnifying power, $m = 1 + \frac{D}{f} = 1 + \frac{25}{5} = 6$ **(1)**

Q.34 The objective and eyepiece of a microscope have focal lengths 1 cm and 2 cm respectively and separated by 12 cm.

A person, whose distance of distinct vision is 25 cm uses the microscope to see a small object. Where must the object be placed? **[Textbook]**

Sol Given, $f_o = 1$ cm, $f_e = 2$ cm and $L = 12$ cm

$\because v_o = L - f_e = 12 - 2 = 10$ cm

Using formula, $\frac{1}{f_o} = \frac{1}{v_o} - \frac{1}{u_o}$

$\Rightarrow u_o = \frac{v_o f_o}{f_o - v_o} = \frac{10}{9}$

(object must be place at 1.11 cm from the objective)

$\therefore u_o = 1.11$ cm **(2)**

Q.35 A telescope tube 80 cm long provides a magnification of 19. Calculate the focal length of the objective and eyepiece. **[Textbook]**

Sol $\therefore$ Telescope tube length,

$$L = f_o + f_e = 80 \text{ cm} \quad \ldots\text{(i)}$$

$\therefore$ Magnification, $m = \frac{f_o}{f_e} = 19$ ...(ii) **(1)**

Solving Eqs. (i) and (ii), we get

$f_o = 76$ cm and $f_e = 4$ cm **(1)**

Q.36 Draw a ray diagram to shows the image formation in a refracting type astronomical telescope in the near point adjustment. **[Textbook]**

Sol **Image formation in a refracting telescope at near point** Refer to figure on page 214. **(2)**

Q.37 The focal lengths of objective and eyepiece of compound microscope are 2 cm and 4 cm, respectively. If an object is placed at a distance of 4 cm from the objective. What is the magnification produced by the microscope?

Sol Given, $f_o = 2$ cm, $f_e = 4$ cm, $u_o = -4$ cm

and $D = 25$ cm

Using $\frac{1}{f_o} = \frac{1}{v_o} - \frac{1}{u_o}$

$\Rightarrow \frac{1}{2} = \frac{1}{v_o} - \left(\frac{1}{-4}\right)$

$\Rightarrow v_o = 4$ cm **(1)**

As, $M = \frac{v_o}{u_o}\left(1 + \frac{D}{f_e}\right) = \frac{4}{-4}\left(1 + \frac{25}{4}\right)$

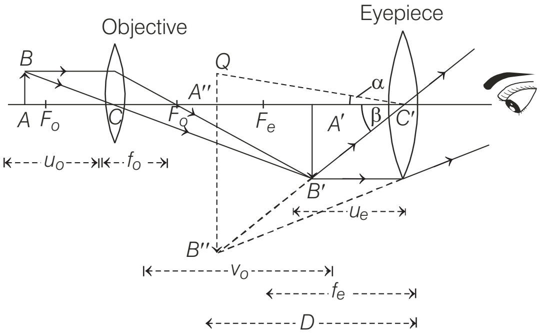
$\therefore M = -\left(1 + \frac{25}{4}\right) = \frac{-29}{4} = -7.25$

Negative sign indicates that the final image is inverted. **(1)**

Q.38 Draw a ray diagram to show the formation of final image at the least distance of distinct vision by a compound microscope. **[Textbook]**

Sol When the image is formed at near point,

{$\because f_e$ is the focal length of eyepiece}



(2)

Q.39 How does a magnification of a magnifying glass differ from its magnifying power?

Sol Magnification, $m = \frac{\text{Image distance}}{\text{Object distance}} = \frac{v}{u}$ **(1/2)**

Magnifying power,

$M = \frac{\text{Angle subtended by image at eye}}{\text{Angle subtended by object at eye}}$

$= \frac{D}{u}$ (when both object and image are located at least distance of distinct vision) **(1)**

Clearly, $m = M$ and unless $v = D$. **(1/2)**

Q.40 Why a compound microscope considered superior to a magnifying glass? **[Textbook]**

Sol In compound microscope, two coaxial lenses separated from each other, give a much higher angular magnification than a simple microscope.

Therefore, a compound microscope is more suitable to have magnified image. **(2)**

Q.41 The focal lengths of objective and eyepiece of an astronomical telescope are 100 cm and 5 cm, respectively. Calculate the magnifying power, when the final image is formed at the least distance of distinct vision.

Sol Given, $f_o = 100$ cm, $f_e = 5$ cm and $D = 25$ cm

Using $M = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$

$= \frac{100}{5}\left(1 + \frac{5}{25}\right)$ **(1)**

$= 20\left(1 + \frac{1}{5}\right) = \frac{120}{5}$

$\therefore$ Magnifying power, $M = 24$ **(1)**

3 MARKS *Questions*

Important Questions

Q.42 What is magnifying power of an astronomical telescope? Draw the necessary ray diagram for the final image at distinct vision by an astronomical telescope.

Sol Magnifying power of telescope,

$$M = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$$ **(1)**

Ray diagram of astronomical telescope Refer to text on page 214. **(2)**

Q.43 What do you mean by normal setting of a compound microscope? How its magnifying power differs, when it is set with the final image at infinity? **[Textbook]**

Sol Normal setting of a compound microscope means the final image is formed at the near point D equals to 25 cm. **(1)**

Magnification produced in normal setting,

$$M = -\left(\frac{v_o}{f_o} - 1\right)\left(1 + \frac{D}{f_e}\right)$$

Whereas, magnification produced when the image is at infinity, **(1)**

$$M_\infty = -\left(\frac{v_o}{f_o} - 1\right)\frac{D}{f_e}$$

Thus, M_∞ decreases by a factor of $\left(\frac{v_o}{f_o} - 1\right)$ than M. **(1)**

7 MARKS *Questions*

Exams' Questions

Q.44 With a neat ray diagram, explain the working of a compound microscope. Obtain an expression for its magnifying power. **[2015]**

Sol **Compound microscope** Refer to text on page 213.

(2 + 3 + 2)

Q.45 With a neat ray diagram, describe the construction and working of an astronomical telescope. **[2013 Instant]**

Sol **Refracting telescope** Refer to text on page 214. **(2 + 2 + 3)**

Q.46 With a neat ray diagram, explain the construction and working principle of a compound microscope. Obtain an expression for its magnifying power. **[2012, 2010]**

Sol **Compound microscope** Refer to text on page 213. **(1 + 2 + 3 + 1)**

Important Questions

Q.47 With a neat ray diagram, describe the principle, working and use of a compound microscope. What should be done for achieving large magnifying power? **[Textbook]**

Sol **Compound microscope** Refer to text on page 213.

High mangfying power Refer to text on page 215. **(2 + 2 + 3)**

Q.48 With a neat ray diagram, describe the principle, working and use of an astronomical telescope. **[Textbook]**

Sol **Refracting (astronomical) telescope** Refer to text on page 214. **(3 + 4)**

Chapter Test

1 MARK Questions

1 The final image produced by a simple microscope is **[Textbook]**
(a) erect
(b) inverted
(c) real and erect
(d) real and inverted

2 The magnification is more than unity when object is placed at a distance d from a convex lens. Its focal length is 20 cm. What is the value of d? **[Textbook]**
(a) Greater than 20 cm
(b) Less than 20 cm
(c) 40 cm
(d) Greater than 20 cm but less than 40 cm

3 When the length of a microscope tube increases, its magnifying power **[Textbook]**
(a) decreases
(b) increases
(c) does not change
(d) may increase or decrease

4 The focal length of the objective of a microscope is **[Textbook]**
(a) greater than the focal length of the eyepiece
(b) less than the focal length of the eyepiece
(c) equal to the focal length of the eyepiece
(d) None of these

5 The length of a telescope is 100 cm and magnification is 18. The focal lengths of objectives and eye lens are are nearly **[Textbook]**
(a) 90 cm and 10 cm
(b) 85 cm and 15 cm
(c) 80 cm and 20 cm
(d) 95 cm and 5 cm

6 The distance between objective and eyepiece of an astronomical telescope for normal vision setting, if $(f_o + f_e)/2$. (Correct the incorrect statement) **[Textbook]**

7 What is the distance between objects and eyepiece of an astronomers telescope for normal vision-setting? **[Textbook]**

8 If m_1 and m_2 are the magnifying powers of the two lenses of a compound microscope, what will be the magnifying power of the microscope?

9 What is the function of objective lens in an astronomical telescope?

2 MARKS Questions

10 Astronomers prefer to use telescope with large objective diameters to observe astronomical objects. Why, explain? **[Textbook]**

11 What is the function of the objective lens in an astronomical telescope? Why should it have a long focal length and a large aperture? **[Textbook]**

12 "The aperture of the objective of a microscope should be small". Comment.

13 Write the steps that should be taken to increase the brightness of the final image of a telescope.

14 Give any two applications of simple microscope.

3 MARKS Questions

15 How can we increase the magnifying power of a simple microscope?

16 Draw a ray diagram to show the final image formation by an astronomical telescope. Write its working also.

17 A telescope has an objective of focal length 50cm and an eyepiece of focal length 5 cm. The least distance of distinct vision is 25 cm. The telescope is focused for distinct vision on a scale 200 cm away from the object. Calculate the separation of the objective and the eyepiece. **[Textbook]**

18 In a compound microscope, an object is placed at a distance of 1.5 cm from the objective of focal length 1.25 cm. If the eyepiece has a focal length of 5 cm and the final image is formed at the near point, estimate the magnifying power of the microscope. **[Textbook]**

7 MARKS *Questions*

19 What is meant by the normal setting of an astronomical telescope? How its magnifying power differs, when it is set with the final image at near point?

20 Write notes on magnifying power of
(i) a magnifier,
(ii) a compound microscope and
(iii) an astronomical telescope. **[Textbook]**

21 What is a microscope? Describe a simple microscope and derive an expression for its magnifying power. **[Textbook]**

HINTS and ANSWERS

1. (a)

2. (d) body should be placed between f and $2f$

3. (b)

4. (c)

5. (d), **Hint** $L = f_o + f_e$ and $M = \frac{f_o}{f_e}$

6. If $(f_o + f_e)/2 \rightarrow$ is $(f_o + f_e)$

8. $m_1 \times m_2$

17. **Hint** $\frac{1}{f_o} = \frac{1}{v_o} - \frac{1}{u_o}, \frac{1}{f_e} = \frac{1}{v_o} - \frac{1}{u_e}$ [**Ans.** 70.84 cm]

and $L = v_o + u_e$

18. **Hint** $\frac{1}{f_e} = \frac{1}{v_o} - \frac{1}{u_o}$ and $M = \frac{v_o}{|u_o|}\left(1 + \frac{D}{f_e}\right)$ [**Ans.** 30]