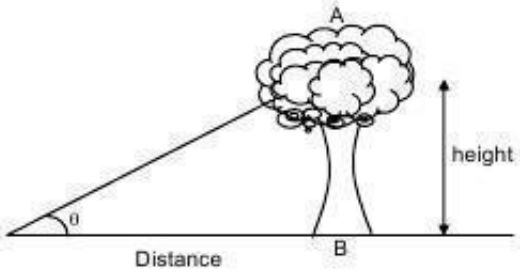
# SOLUTIONS TO CONCEPTS
## CHAPTER 19

1. The visual angles made by the tree with the eyes can be calculated be below.




$$\theta = \frac{\text{Height of the tree}}{\text{Distance from the eye}} = \frac{AB}{OB} \Rightarrow \theta_A = \frac{2}{50} = 0.04$$

similarly, $\theta_B = 2.5 / 80 = 0.03125$

$\theta_C = 1.8 / 70 = 0.02571$

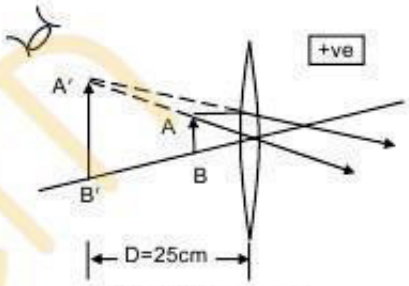
$\theta_D = 2.8 / 100 = 0.028$

Since, $\theta_A > \theta_B > \theta_D > \theta_C$, the arrangement in decreasing order is given by A, B, D and C.

2. For the given simple microscope,

f = 12 cm and D = 25 cm

For maximum angular magnification, the image should be produced at least distance of clear vision.



(Simple Microscope)

So, v = – D = –25 cm

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

$$\Rightarrow \frac{1}{u} = \frac{1}{v} - \frac{1}{f} = \frac{1}{-25} - \frac{1}{12} = -\frac{37}{300}$$

$\Rightarrow u = -8.1$ cm

So, the object should be placed 8.1 cm away from the lens.

3. The simple microscope has, m = 3, when image is formed at D = 25 cm

a) $m = 1 + \frac{D}{f} \Rightarrow 3 = 1 + \frac{25}{f}$

$\Rightarrow f = 25/2 = 12.5$ cm

b) When the image is formed at infinity (normal adjustment)

Magnifying power = $\frac{D}{f} = \frac{25}{12.5} = 2.0$

4. The child has D = 10 cm and f = 10 cm

The maximum angular magnification is obtained when the image is formed at near point.

$$m = 1 + \frac{D}{f} = 1 + \frac{10}{10} = 1 + 1 = 2$$

5. The simple microscope has magnification of 5 for normal relaxed eye (D = 25 cm).

Because, the eye is relaxed the image is formed at infinity (normal adjustment)

So, $m = 5 = \frac{D}{f} = \frac{25}{f} \Rightarrow f = 5$ cm

For the relaxed farsighted eye, D = 40 cm

So, $m = \frac{D}{f} = \frac{40}{5} = 8$

So, its magnifying power is 8X.

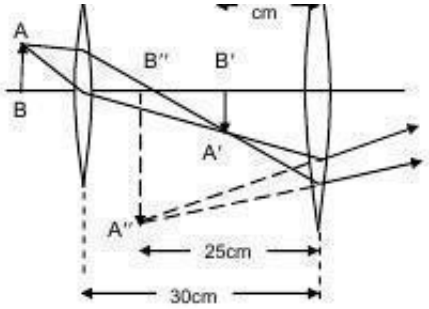
6. For the given compound microscope

$f_0 = \frac{1}{25 \text{ diopter}} = 0.04$ m = 4 cm, $f_e = \frac{1}{5 \text{ diopter}} = 0.2$ m = 20 cm

D = 25 cm, separation between objective and eyepiece = 30 cm



D = 25 cm, separation between objective and eyepiece = 30 cm




The magnifying power is maximum when the image is formed by the eye piece at least distance of clear vision i.e. D = 25 cm

for the eye piece, $v_e = -25$ cm, $f_e = 20$ cm

For lens formula, $\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e}$

$\Rightarrow \frac{1}{u_e} = \frac{1}{v_e} - \frac{1}{f_e} \Rightarrow \frac{1}{-25} - \frac{1}{20}$ $\Rightarrow u_e = 11.11$ cm

So, for the objective lens, the image distance should be

$v_0 = 30 - (11.11) = 18.89$ cm

Now, for the objective lens,

$v_0 = +18.89$ cm (because real image is produced)

$f_0 = 4$ cm

So, $\frac{1}{u_o} = \frac{1}{v_o} - \frac{1}{f_o} \Rightarrow \frac{1}{18.89} - \frac{1}{4} = 0.053 - 0.25 = -0.197$

$\Rightarrow u_o = -5.07$ cm

So, the maximum magnificent power is given by

$$m = -\frac{v_o}{u_o}\left[1+\frac{D}{f_e}\right] = -\frac{18.89}{-5.07}\left[1+\frac{25}{20}\right]$$

$= 3.7225 \times 2.25 = 8.376$

7. For the given compound microscope

$f_o = 1$ cm, $f_e = 6$ cm, D = 24 cm

For the eye piece, $v_e = -24$ cm, $f_e = 6$ cm

Now, $\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e}$

$\Rightarrow \frac{1}{u_e} = \frac{1}{v_e} - \frac{1}{f_e} \Rightarrow -\left[\frac{1}{24} + \frac{1}{6}\right] = -\frac{5}{24}$

$\Rightarrow u_e = -4.8$ cm

a) When the separation between objective and eye piece is 9.8 cm, the image distance for the objective lens must be (9.8) – (4.8) = 5.0 cm

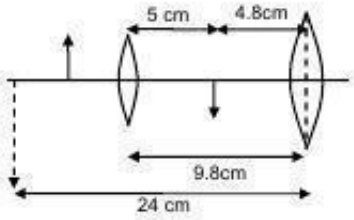


Fig-A

Now, $\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0}$

$\Rightarrow \frac{1}{u_0} = \frac{1}{v_0} - \frac{1}{f_0} = \frac{1}{5} - \frac{1}{1} = -\frac{4}{5}$

$\Rightarrow u_0 = -\frac{5}{4} = -1.25$ cm

So, the magnifying power is given by,

$$m = \frac{v_0}{u_o}\left[1+\frac{D}{f}\right] = \frac{-5}{-1.25}\left[1+\frac{24}{6}\right] = 4 \times 5 = 20$$

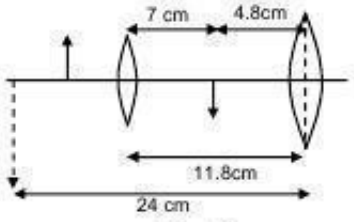


Fig-B

(b) When the separation is 11.8 cm,

$v_0 = 11.8 - 4.8 = 7.0$ cm, $f_0 = 1$ cm

$\Rightarrow \frac{1}{u_0} = \frac{1}{v_0} - \frac{1}{f_0} = \frac{1}{7} - \frac{1}{1} = -\frac{6}{7}$

$$\text{So, } m = -\frac{v_0}{u_o}\left[1+\frac{D}{f}\right] = \frac{-7}{-\left(\frac{7}{6}\right)}\left[1+\frac{24}{6}\right] = 6 \times 5 = 30$$

So, the range of magnifying power will be 20 to 30.

8. For the given compound microscope.

$f_0 = \frac{1}{20D} = 0.05$ m = 5 cm, $f_e = \frac{1}{10D} = 0.1$ m = 10 cm.

D = 25 cm, separation between objective & eyepiece= 20 cm

For the minimum separation between two points which can be distinguished by eye using the microscope, the magnifying power should be maximum.

For the eyepiece, $v_0 = -25$ cm, $f_e = 10$ cm

So, $\frac{1}{u_e} = \frac{1}{v_e} - \frac{1}{f_e} = \frac{1}{-25} - \frac{1}{10} = -\left[\frac{2+5}{50}\right] \Rightarrow u_e = -\frac{50}{7}$ cm

So, the image distance for the objective lens should be,

$V_0 = 20 - \frac{50}{7} = \frac{90}{7}$ cm

Now, for the objective lens,

$\frac{1}{u_0} = \frac{1}{v_0} - \frac{1}{f_0} = \frac{7}{90} - \frac{1}{5} = -\frac{11}{90}$

$\Rightarrow u_0 = -\frac{90}{11}$ cm

So, the maximum magnifying power is given by,

$m = \frac{-v_0}{u_0}\left[1 + \frac{D}{f_e}\right]$

$= \frac{\left(\frac{90}{7}\right)}{\left(-\frac{90}{11}\right)}\left[1 + \frac{25}{10}\right]$

$= \frac{11}{7} \times 3.5 = 5.5$

Thus, minimum separation eye can distinguish = $\frac{0.22}{5.5}$ mm = 0.04 mm

9. For the give compound microscope,

$f_0 = 0.5$cm, tube length = 6.5cm

magnifying power = 100 (normal adjustment)

Since, the image is formed at infinity, the real image produced by the objective lens should lie on the focus of the eye piece.

So, $v_0 + f_e = 6.5$ cm ...(1)

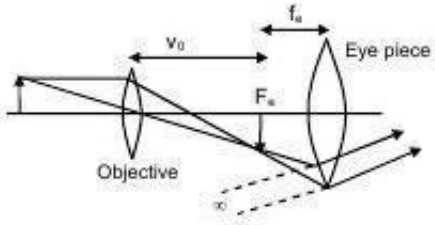
Again, magnifying power= $\frac{v_0}{u_0} \times \frac{D}{f_e}$ [for normal adjustment]

$\Rightarrow m = -\left[1 - \frac{v_0}{f_0}\right]\frac{D}{f_e}$ $\left[\because \frac{v_0}{u_0} = 1 - \frac{v_0}{f_0}\right]$

$\Rightarrow 100 = -\left[1 - \frac{v_0}{0.5}\right] \times \frac{25}{f_e}$ [Taking D = 25 cm]

$\Rightarrow 100 f_e = -(1 - 2v_0) \times 25$

$\Rightarrow 2v_0 - 4f_e = 1$ ...(2)




Solving equation (1) and (2) we can get,

$V_0 = 4.5$ cm and $f_e = 2$ cm

So, the focal length of the eye piece is 2cm.

10. Given that,

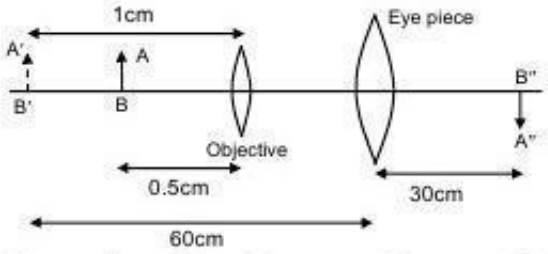
$f_o = = 1$ cm, $f_e = 5$ cm, $u_0 = 0.5$ cm, $v_e = 30$ cm

For the objective lens, $u_0 = -0.5$ cm, $f_0 = 1$ cm.

From lens formula,

$\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0}$ $\Rightarrow \frac{1}{v_0} = \frac{1}{u_0} + \frac{1}{f_0} = \frac{1}{-0.5} + \frac{1}{1} = -1$

$\Rightarrow v_0 = -1$ cm




So, a virtual image is formed by the objective on the same side as that of the object at a distance of 1 cm from the objective lens. This image acts as a virtual object for the eyepiece.

cm from the objective lens. This image acts as a virtual object for the eyepiece.

For the eyepiece,

$$\frac{1}{v_0}-\frac{1}{u_0}=\frac{1}{f_0} \qquad \Rightarrow \frac{1}{u_0}=\frac{1}{v_0}-\frac{1}{f_0}=\frac{1}{30}-\frac{1}{5}=\frac{-5}{30}=\frac{-1}{6} \Rightarrow u_0=-6\text{ cm}$$

So, as shown in figure,

Separation between the lenses = $u_0 - v_0 = 6 - 1 = 5$ cm

11. The optical instrument has

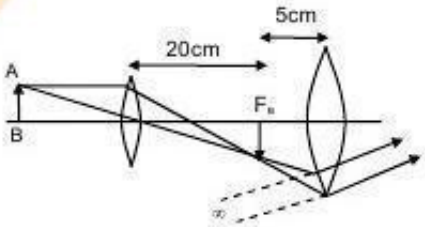
$$f_0=\frac{1}{25D}=0.04\text{ m}=4\text{ cm}$$

$$f_e=\frac{1}{20D}=0.05\text{ m}=5\text{ cm}$$

tube length = 25 cm (normal adjustment)

(a) The instrument must be a microscope as $f_0 < f_e$

(b) Since the final image is formed at infinity, the image produced by the objective should lie on the focal plane of the eye piece.




So, image distance for objective = $v_0 = 25 - 5 = 20$ cm

Now, using lens formula.

$$\frac{1}{v_0}-\frac{1}{u_0}=\frac{1}{f_0} \qquad \Rightarrow \frac{1}{u_0}=\frac{1}{v_0}-\frac{1}{f_0}=\frac{1}{20}-\frac{1}{4}=\frac{-4}{20}=\frac{-1}{5} \Rightarrow u_0=-5\text{ cm}$$

So, angular magnification = $m=-\frac{v_0}{u_0}\times\frac{D}{f_e}$ [Taking D = 25 cm]

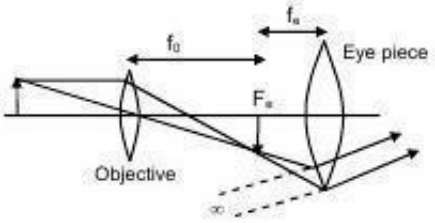
$$=-\frac{20}{-5}\times\frac{25}{5}=20$$

12. For the astronomical telescope in normal adjustment.

Magnifying power = m = 50, length of the tube = L = 102 cm

Let $f_0$ and $f_e$ be the focal length of objective and eye piece respectively.

$$m=\frac{f_0}{f_e}=50 \Rightarrow f_0=50\,f_e \quad \ldots(1)$$




and, $L = f_0 + f_e = 102$ cm $\quad \ldots(2)$

Putting the value of $f_0$ from equation (1) in (2), we get,

$f_0 + f_e = 102 \Rightarrow 51 f_e = 102 \Rightarrow f_e = 2$ cm $= 0.02$ m

So, $f_0 = 100$ cm $= 1$ m

$\therefore$ Power of the objective lens $=\frac{1}{f_0}=1\text{D}$

And Power of the eye piece lens $=\frac{1}{f_e}=\frac{1}{0.02}=50\text{D}$

13. For the given astronomical telescope in normal adjustment,

$F_e = 10$ cm, $\quad L = 1$ m $= 100$cm

S0, $f_0 = L - f_e = 100 - 10 = 90$ cm

and, magnifying power $=\frac{f_0}{f_e}=\frac{90}{10}=9$

14. For the given Galilean telescope, (When the image is formed at infinity)

$f_0 = 30$ cm, $\quad L = 27$ cm

Since $L = f_0 - |f_e|$

[Since, concave eyepiece lens is used in Galilean Telescope]

$\Rightarrow f_e = f_0 - L = 30 - 27 = 3$ cm

15. For the far sighted person,

$u = -20$ cm, $\quad v = -50$ cm

from lens formula $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$

$$\frac{1}{f}=\frac{1}{50}-\frac{1}{20}=\frac{1}{30}-\frac{1}{50}=\frac{3}{100} \qquad \Rightarrow f=\frac{100}{3}\text{ cm}=\frac{1}{3}\text{m}$$

f −50 −20 20 50 100 3 3

So, power of the lens = $\frac{1}{f}$ = 3 Diopter

16. For the near sighted person,
u = ∞ and v = – 200 cm = – 2m

So, $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{-2}-\frac{1}{\infty}=-\frac{1}{2}=-0.5$

So, power of the lens is –0.5D

17. The person wears glasses of power –2.5D
So, the person must be near sighted.

u = ∞, v = far point, $f=\frac{1}{-2.5}=-0.4m=-40$ cm

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

$\Rightarrow \frac{1}{v}=\frac{1}{u}+\frac{1}{f}=0+\frac{1}{-40} \Rightarrow v=-40$ cm

So, the far point of the person is 40 cm

18. On the 50th birthday, he reads the card at a distance 25cm using a glass of +2.5D.
Ten years later, his near point must have changed.
So after ten years,

u = – 50 cm, $f=\frac{1}{2.5D}=0.4m=40$ cm v = near point

Now, $\frac{1}{v}-\frac{1}{u}=\frac{1}{f} \Rightarrow \frac{1}{v}=\frac{1}{u}+\frac{1}{f}=\frac{1}{-50}+\frac{1}{40}=\frac{1}{200}$

So, near point = v = 200cm
To read the farewell letter at a distance of 25 cm,
U = – 25 cm
For lens formula,

$\frac{1}{v}-\frac{1}{u}=\frac{1}{f} \Rightarrow \frac{1}{f}=\frac{1}{200}-\frac{-}{-25}=\frac{1}{200}+\frac{1}{25}=\frac{9}{200} \Rightarrow f=\frac{200}{9}$ cm $=\frac{2}{9}$ m

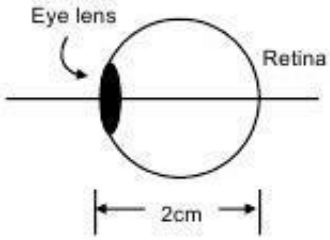
$\Rightarrow$ Power of the lens = $\frac{1}{f}=\frac{9}{2}=4.5D$

∴ He has to use a lens of power +4.5D.

19. Since, the retina is 2 cm behind the eye-lens
v = 2cm
(a) When the eye-lens is fully relaxed
u = ∞, v = 2cm = 0.02 m

$\Rightarrow \frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{0.02}-\frac{1}{\infty}=50D$

So, in this condition power of the eye-lens is 50D




(b) When the eye-lens is most strained,
u = – 25 cm = – 0.25 m, v = +2 cm = +0.02 m

$\Rightarrow \frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{0.02}-\frac{1}{-0.25}=50+4=54D$

In this condition power of the eye lens is 54D.

20. The child has near point and far point 10 cm and 100 cm respectively.
Since, the retina is 2 cm behind the eye-lens, v = 2cm
For near point u = – 10 cm = – 0.1 m, v = 2 cm = 0.02 m

So, $\frac{1}{f_{near}}=\frac{1}{v}-\frac{1}{u}=\frac{1}{0.02}-\frac{1}{-0.1}=50+10=60D$

For far point, u = – 100 cm = – 1 m, v = 2 cm = 0.02 m

So, $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{0.02}-\frac{1}{-1}=50+1=51D$

$f_{far}$ v u 0.02 –1

So, the rage of power of the eye-lens is +60D to +51D

21. For the near sighted person,

v = distance of image from glass

= distance of image from eye – separation between glass and eye

= 25 cm – 1cm = 24 cm = 0.24m

So, for the glass, u = ∞ and v = – 24 cm = –0.24m

So, $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{-0.24}-\frac{1}{\infty}=-4.2\ D$

22. The person has near point 100 cm. It is needed to read at a distance of 20cm.

(a) When contact lens is used,

u = – 20 cm = – 0.2m, v = – 100 cm = –1 m

So, $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{-1}-\frac{1}{-0.2}=-1+5=+4D$

(b) When spectacles are used,

u = – (20 – 2) = – 18 cm = – 0.18m, v = – 100 cm = –1 m

So, $\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{-1}-\frac{1}{-0.18}=-1+5.55=+4.5D$

23. The lady uses +1.5D glasses to have normal vision at 25 cm.

So, with the glasses, her least distance of clear vision = D = 25 cm

Focal length of the glasses = $\frac{1}{1.5}m=\frac{100}{1.5}cm$

So, without the glasses her least distance of distinct vision should be more

If, u = – 25cm, $f=\frac{100}{1.5}cm$

Now, $\frac{1}{v}-\frac{1}{u}=\frac{1}{f}=\frac{1.5}{100}-\frac{1}{25}=\frac{1.5-4}{100}=\frac{-2.5}{100}$ $\Rightarrow$ v = – 40cm = near point without glasses.

Focal length of magnifying glass = $\frac{1}{20}m = 0.05m = 5\ cm = f$

(a) The maximum magnifying power with glasses

$m=1+\frac{D}{f}=1+\frac{25}{5}=6$ [$\because$ D = 25cm]

(b) Without the glasses, D = 40cm

So, $m=1+\frac{D}{f}=1+\frac{40}{5}=9$

24. The lady can not see objects closer than 40 cm from the left eye and 100 cm from the right eye.

For the left glass lens,

v = – 40 cm, u = – 25 cm

$\therefore \frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{-40}-\frac{1}{-25}=\frac{1}{25}-\frac{1}{40}=\frac{3}{200}$ $\Rightarrow f=\frac{200}{3}cm$

For the right glass lens,

v = – 100 cm, u = – 25 cm

$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}=\frac{1}{-100}-\frac{1}{-25}=\frac{1}{25}-\frac{1}{100}=\frac{3}{100}$ $\Rightarrow f=\frac{100}{3}cm$

(a) For an astronomical telescope, the eye piece lens should have smaller focal length. So, she should use the right lens ($f=\frac{100}{3}cm$) as the eye piece lens.

(b) With relaxed eye, (normal adjustment)

$f_0=\frac{200}{3}cm$, $f_e=\frac{100}{3}cm$

magnification = $m=\frac{f_0}{f_e}=\frac{(200/3)}{(100/3)}=2$