HC VERMA Solutions for Class 11 Physics Chapter 19 Optical Instruments

Question 1

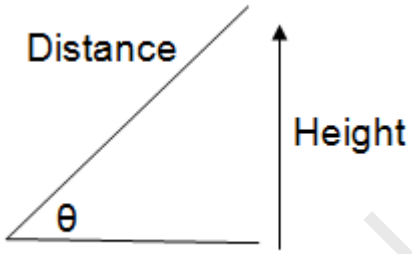
A person looks at different trees in an open space with the following details. Arrange the trees in decreasing order of their apparent sizes.

Tree	Height(m)	Distance from the eye(m)
A	2.0	50
B	2.5	80
C	1.8	70
D	2.8	100

Solution 1

For A,

$$A = \frac{\text{Height of tree A}}{\text{Distance from eye}} = \frac{2}{50} = 0.04$$



For B,

$$B = \frac{\text{Height of tree B}}{\text{Distance from eye}} = \frac{2.5}{80} = 0.0312$$

For C,

$$C = \frac{\text{Height of tree C}}{\text{Distance from eye}} = \frac{1.8}{70} = 0.025$$

For D,

$$D = \frac{\text{Height of tree D}}{\text{Distance from eye}} = \frac{2.8}{100} = 0.028$$

Now, A > B > D > C

Thus, decreasing order is A, B, D, C.

Question 2

An object is to be seen through a simple microscope of focal length 12cm. Where the object should be placed so as to produce maximum angular magnification? The least distance for clear vision is 25cm.

Solution 2

To get maximum angular magnification
v = - D = -25cm
and by formula

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

$$\frac{1}{-25}-\frac{1}{u}=\frac{1}{12}$$

$$u=-8.1cm$$

Object distance is 8.1cm away from lens.

Question 3

A simple microscope has a magnifying power of 3'0 when the image is formed at the near point (25cm) of a normal eye. (a) What is its focal length? (b) What will be its magnifying power if the image is formed at infinity?

Solution 3

(a) Magnification of simple microscope is given as:

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

$$3=1+\frac{25}{f}$$

f = 12.5cm
(b) Magnification of power is given as :

$$M=\frac{d}{f}=\frac{25}{12.5}$$

M =2

Question 4

A child has near point at 10 cm. What is the maximum angular magnification the child can have with a convex lens of focal length 10 cm?

Solution 4

Maximum angular magnification is given as :

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

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

m = 2

Question 5

A simple microscope is rated 5 X for a normal relaxed eye. What will be its magnifying power for a relaxed farsighted eye whose near point is 40 cm?

Solution 5

Magnification of simple microscope is given as :

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

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

f = 5cm

Now, for relaxed farsighted magnifying power is given as :

$$m = \frac{D}{f}$$

$$m = \frac{40}{5}$$

m = 8

Question 6

Find the maximum magnifying power of a compound Microscope having a 25diopter lens as the objective, a 5 diopter lens as the eyepiece and the separation 30cm between the two lenses. The least distance for clear vision is 25cm.

Solution 6

Focal length of objective lens is given as:

fo = 1/25 = "4cm"

Focal length of eyepiece lens is given as:

fe = 1/5 = "20cm"

Now using lens formula for eyepiece lens,

$$\frac{1}{ve} - \frac{1}{ue} = \frac{1}{fe}$$

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

$$ue = 11.11cm$$

Also, vo = 30 - ue= 30 - 11.11

vo = 18.89cm

Now using lens formula for objective lens,

$$\frac{1}{vo} - \frac{1}{uo} = \frac{1}{fo}$$

$$\frac{1}{18.89} - \frac{1}{4} = \frac{1}{uo}$$

uo = -5.07cm

Now maximum magnifying power is given as:

$$m = \left\{\frac{-vo}{uo}\right\}\left[1 + \frac{D}{fe}\right]$$

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

m = 8.376

Question 7

The separation between the objective and the eyepiece of a compound microscope can be adjusted between 9.8 cm to 11'8 cm. If the focal lengths of the objective and the eyepiece are 1'0 cm and 6 cm

respectively, find the range of the magnifying power if the image is always needed at 24 cm from the eye.

Solution 7

By applying lens formula,

$$\frac{1}{ve}-\frac{1}{ue}=\frac{1}{fe}$$

$$\frac{1}{-24}-\frac{1}{ue}=\frac{1}{6}$$

u_e = -4.8cm

(1) If separation is 9.8cm then, v_o =9.8 - 4.8 = 5cm

By applying lens formula,

$$\frac{1}{vo}-\frac{1}{uo}=\frac{1}{fo}$$

$$\frac{1}{5}-\frac{1}{uo}=\frac{1}{1}$$

u_o = -1.25cm

and magnifying power

$$m=\frac{vo}{uo}\left[1+\frac{D}{f}\right]$$

$$m=\frac{-5}{-1.25}\left[1+\frac{24}{6}\right]$$

m = 20

(2) If separation is 11.8cm then, v_o = 11.8 - 4.8 = 7cm

$$\frac{1}{vo}-\frac{1}{fo}=\frac{1}{uo}$$

$$\frac{1}{7}-\frac{1}{1}=\frac{1}{uo}$$

u_o =-1.16cm

And magnifying power,

$$m=\frac{vo}{uo}\left[1+\frac{D}{f}\right]$$

$$m=\frac{-7}{-1.16}\left[1+\frac{24}{6}\right]$$

m = 30

Thus range of magnifying power is 20 to30.

Question 8

An eye can distinguish between two points of an object if they are separated by more than 0.22 mm when the object is placed at 25cm from the eye. The object is now seen by a compound microscope having a 20 D objectives and 10 D eyepiece separated by a distance of 20 cm. The final image is formed at 25cm from the eye. What is the minimum separation between two points of the object which can now be distinguished?

Solution 8

From lens formula,

$$\frac{1}{ve}-\frac{1}{fe}=\frac{1}{ue}$$

$$\frac{1}{-25}-\frac{1}{10}=\frac{1}{ue}$$

u_e = -50/7cm
Image distance v_o = 20 - u_e
v_o = 90/7cm
Now applying lens formula on objective lens,

$$\frac{1}{vo}-\frac{1}{fo}=\frac{1}{uo}$$

$$\frac{7}{90}-\frac{1}{5}=\frac{1}{uo}$$

u_o = -90/11cm
Maximum magnification power

$$m=\frac{vo}{uo}\left[1+\frac{D}{f}\right]$$

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

m = 5.5
And minimum separation is given as:
0.22/m = 0.22/0.5 = 0.04mm

Question 9

A compound microscope has a magnifying power of 100 when the image is formed at infinity. The objective has a focal length of 0.5 cm and the tube length is 6.5 cm. Find the focal length of the eyepiece.

Solution 9

Magnifying power is given as,

$$m=-\left[1-\frac{vo}{fo}\right]\frac{D}{fo}$$

$$m=-\left[1-\frac{vo}{0.5}\right]\frac{25}{fo}$$

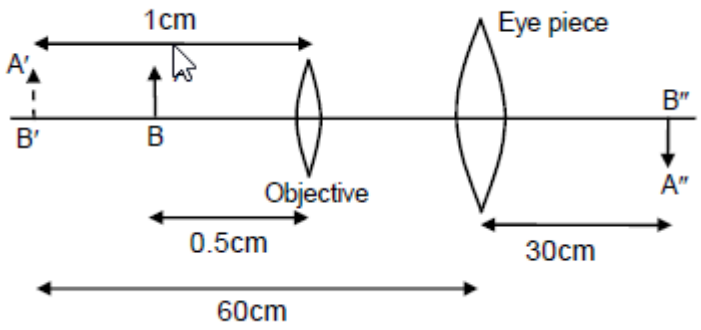
$2v_o - 4f_o = 1$……(1)
Also,
tube length $=v_o + f_o$
$6.5 = v_o + f_o$…….(2)
Solving equation 1 and 2,
v_o = 4.5cm
f_e = 2cm

Question 10

A compound microscope consists of an objective of focal length 1cm and an eyepiece of focal length 5cm. An object is placed at a distance of 0.5cm from the objective. What should be the separation between the lenses so that the microscope projects an inverted real image of the object on a screen 30cm behind the eyepiece?

Solution 10

Here we get figure as below,



By using lens formula (objective)

$$\frac{1}{vo}-\frac{1}{uo}=\frac{1}{fo}$$

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

vo = -1cm

By using lens formula (eyespiece)

$$\frac{1}{vo}-\frac{1}{uo}=\frac{1}{fo}$$

$$\frac{1}{30}-\frac{1}{uo}=\frac{1}{5}$$

uo = -6cm

Now from above figure,

Separation = u_o-v_o= 6-1 = 5cm

Question 11

An optical instrument used for angular magnification has a 25 D objective and a 20 D eyepiece. The tube length is 25 cm when the eye is least strained. (a) Whether it is a microscope or a telescope? (b) What is the angular magnification produced?

Solution 11

Focal length of objective and eyepiece is given as :

fo = 1/25 =4cm, fe= 1/20 = 5cm

(a) fo < fe : it is a microscope.

(b) Angular magnification is given as :

$$m=\frac{-vo}{uo}\times\frac{D}{fo}$$ .....(1)

Now, Vo =25-fe = 25-5 = 20cm

and by lens formula

$$\frac{1}{vo}-\frac{1}{fo}=\frac{1}{uo}$$

$$\frac{1}{20}-\frac{1}{4}=\frac{1}{uo}$$

uo= -5cm

putting values in equation (1)

m = (-20/-5) × 25/5

m = 20

Question 12

An astronomical telescope is to be designed to have a magnifying power of 50 in normal adjustment. If the length of the tube is 102 cm, find the powers of the objective and the eyepiece.

Solution 12

Magnification is given as :

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

$$50 = \frac{fo}{fe}$$

fo = 50fe ……(1)
Also,
L = fo + fe
102 = fo + fe ……(2)
Solving equation 1 and 2 we get,
fo =1cm and fe = 0.02cm
And power is given as :
Po = 1/fo = 1/1 =1D
Pe = 1/fe = 1/0.02 = 50D

Question 13

The eyepiece of an astronomical telescope has a focal length of 10cm. The telescope is focused for normal vision of distant objects when the tube length is 1.0m.
Find the focal length of the objective and the magnifying power of the telescope.

Solution 13

Focal length is given as :
fe = 10cm
and
fo = L - fe = 100 - 10
fo = 90cm
Magnifying power ,

$$m = \frac{fo}{fe} = \frac{90}{10}$$

m=9

Question 14

A Galilean telescope is 27 cm long when focused to form an image at infinity. If the objective has a focal length of 30 cm, what is the focal length of the eyepiece?

Solution 14

We know that,
L = fo - fe (concave eyepiece lens)
fe = fo - L = 30 - 27
fe = 3cm

Question 15

A farsighted person cannot see objects placed closer to 50cm. Find the power of the lens needed to see the objects at 20cm.

Solution 15

For sighted person, lens formula is

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

$$\frac{1}{-50}-\frac{1}{-20}=\frac{1}{f}$$

f = ⅓ m

Power, P $=\frac{1}{f}$ =3D

Question 16

A nearsighted person cannot clearly see beyond 200cm.
Find the power of the lens needed to see objects at large distance?

Solution 16

For near sighted person, formula is

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

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

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

f= -2

And power P $=\frac{1}{f}$
P = -0.5D

Question 17

A person wears glasses of power - 2.5 D. Is the person farsighted or nearsighted ? What is the far point of the person without the glasses?

Solution 17

Focal length is given as:

$$f=\frac{1}{P}=\frac{1}{-2.5}$$

f= -40cm
Lens formula is given as :

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

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

v = -40cm

Question 18

A professor reads a greeting card received on his 50th birthday with + 2.5 D glasses keeping the card 25cm away. Ten years later, he reads his farewell letter with the same glasses but he has 'to keep the letter 50 cm away. What power of lens should he now use?

Solution 18

After 10 years,

$$f = \frac{1}{P} = \frac{1}{-2.5}$$

f= -40cm
u = -50
and by lens formula

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

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

$$\frac{1}{40} + \frac{1}{-50} = \frac{1}{v}$$

v = 200cm
Now to read letter at u = -25cm and v = 200
focal length is:

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

$$\frac{1}{200} - \frac{1}{-25} = \frac{1}{f}$$

f = 2/9m
Power P = 1/f = 9/2 = 4.5 D

Question 19

A normal eye has retina 2 cm behind the eye-lens. What is the power of the eye-lens when the eye is (a) fully relaxed (b) most strained?

Solution 19

(a) When lens of eyes is relaxed,
u = ∞
v = 0.02m
and

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

$$\frac{1}{0.02} - \frac{1}{\infty} = \frac{1}{f}$$

f = 0.02m= 50 D
(b) When lens is in strained position,
u = -0.25
v = 0.02m
and

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

$$\frac{1}{0.02} - \frac{1}{-0.25} = \frac{1}{f}$$

f = 54D
Power P = 1/f = 54D

Question 20

The near point and the far point of a child are at 10cm and 100cm. If the retina is 2.0cm behind the eye-lens, what is the range of the power of the eye-lens?

Solution 20

Near point = 10cm , u = -10cm
Far point = 100cm , u = -100cm

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

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

fn = 1/60cm
P = 1/fn = 60D
Also,

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

$$\frac{1}{2}-\frac{1}{-100}=\frac{1}{fv}$$

fv = 1/51m

$$\mathrm{P}=\frac{1}{fv}=51\mathrm{D}$$

Question 21

A nearsighted person cannot see beyond 25 cm. Assuming that the separation of the glass from the eye is 1 cm, find the power of lens needed to see distant objects.

Solution 21

For near sightedness, distance of image from glass,
v = distance of image from eye - distance between glass and eye.
v = 25 - 1= 24 cm
v = 0.24m
and

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

$$\frac{1}{-0.24}-\frac{1}{\infty}=\frac{1}{f}$$

f = 1/0.24m= 2.4D
P = 4.2D

Question 22

A person has near point at 100cm. What power of lens is needed to read at 20cm if he/she uses (a) contact lens, (b) spectacles having glasses 2'0 cm separated from the eyes?

Solution 22

(a) What we use contact lens is used,

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

$$\frac{1}{-1}-\frac{1}{-0.2}=\frac{1}{f}$$

f = 1/4m

P $= \frac{1}{f}$ = 4D

(b) When we use spectacles,

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

$$\frac{1}{-1} - \frac{1}{0.18} = \frac{1}{f}$$

$$\mathrm{f} = \frac{1}{4.5}\mathrm{m}$$

$$\mathrm{P} = \frac{1}{f} = 4.5\mathrm{D}$$

Question 23

A lady uses +1.5D glasses to have normal vision from 25cm onwards. She uses a 20D lens as a simple microscope to see an object. Find the maximum magnifying power if she uses the microscope (a) together with her glass (b) without the glass. Do the answers suggest that an object can be more clearly seen through a microscope without using the correcting glasses?

Solution 23

Least distant of distinct vision of glass,

D = 25cm

Focal length of glasses $\mathrm{f} = \frac{1}{P} = 1/1.5\ \mathrm{m}$

$$\mathrm{f} = \frac{100}{1.5}\mathrm{cm}$$

$$\mathrm{f} = \frac{200}{3}\mathrm{cm}$$

Now, without glasses lady will have more value at least distance of distinct vision.

So,

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

$$\frac{1}{v} - \frac{1}{-25} = \frac{3}{200}$$

v = -40cm

Focal length of magnifying glass = $\frac{1}{20}\mathrm{m}$

f = 5cm

(a) Maximum magnifying power with glasses is given as :

$$m = 1 + \frac{D}{f} = 1 + \frac{25}{5}$$

m = 6

(b) Maximum magnifying power without glasses is given as :

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

m = 9

Question 24

A lady cannot see objects closer than 40cm from the left eye and/closer than 100cm from the right eye. While on a mountaineering' trip, she is lost from her team. She tries to make an astronomical telescope/ from her reading glasses to look for her teammates. (a) Which glass should she use as the eyepiece ? (b) What magnification can she get with relaxed eye?

Solution 24

As given in question,
v = -40cm, u = -25cm (for left lens of glass)

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

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

$$\mathrm{f}=\frac{200}{3}\mathrm{cm}$$

And, v = -100cm, u = -25cm (for right lens of glass)

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

$$\frac{1}{-100}-\frac{1}{-25}=\frac{1}{f}$$

$$\mathrm{f}=\frac{100}{3}\mathrm{cm}$$

(a) For astronomical telescope lady should use right lens having focal length 100/3 cm because eyepiece should have small value of focal length.
(b) With relaxed eye, lady can get magnification as:

$$m=\frac{fo}{fe}=\frac{200/3}{100/3}$$

m = 2