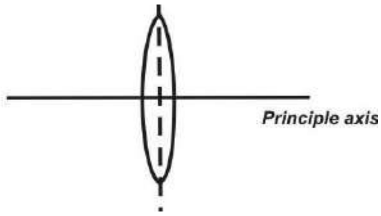
RAY OPTICS AND OPTICAL INSTRUMENTS

SECTION – A (1 MARK QUESTIONS)

(i) Multiple Choice Questions (1 Mark Questions)

1. An equiconvex lens of focal length 15 cm is cut into two halves as shown in figure. Find the focal length of each part?



(a) -30cm (b) -20cm

(c) 30cm (d) -15cm

Ans. (c)

2. How does the focal length of a convex lens changes if mono chromatic red light is used instead of violet light?

(a) Focal length is increased when red light is used

(b) Focal length is decreased when red light is used

(c) Focal length is remain same when red light is used

(d) Not depends on color of light.

Ans. (a)

3. A glass lens is immersed in water. What will be the effect on the power of lens?

(a) increase (b) decrease

(c) constant (d) not depends

Ans. (b)

5. How does the magnifying power of a telescope change on increasing the linear diameter of its objective?

(a) Power increases on increases diameter

(b) Power decreases on decreases diameter

(c) Power remain constant on increases diameter

(d) Power doesn't depends on diameter

Ans. (d)

6. What is the magnification and focal length of a plane mirror.

(a) $+1, \infty$ (b) $+1, 0$

(c) $-1, \infty$ (d) $-1, 0$

Ans. (a)

7. An object approaches a convergent lens from the left of the lens with a uniform speed 5 m/s and stops at the focus. The image

(a) moves away from the lens with an uniform speed 5 m/s.

(b) moves away from the lens with an uniform acceleration.

(c) moves away from the lens with a non-uniform acceleration.

(d) moves towards the lens with a non-uniform acceleration.

Ans- c

8. An astronomical telescope has a large aperture to:

(a) increase span of observation

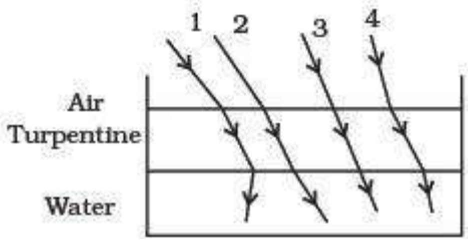
(b) have low dispersion

(c) reduce spherical aberration

(d) have high resolution

Ans-d

9. The optical density of turpentine is higher than that of water while its mass density is lower shows a layer of turpentine floating over water in a container. For which one of the four rays incident on turpentine in the path shown is correct?



(a) 1 (b) 2

(c) 3 (d) 4

Ans- b

10. When diameter of objective of an astronomical telescope is doubled ,its limit of resolution is

(a) doubled (b) one fourth

(c) halved (d) unaffected

Ans-(c)

14. Which one of the following cannot be polarised

(a) X rays (b) γ rays

(c) radio waves (d) sound waves

Ans-(d)

15. The angle between pass axis of polariser and analyser is 45^0 ,the percentage of polarised light passing through analyser is (relative to light incident on the polariser)

(a) 25% (b) 50%

(c) 75% (d) 100%

Ans-(a)

16. A short pulse of white light incident from air to glass slab at normal incidence. After travelling through the slab the first colour to emerge is

(a) violet (b) blue

(c) green (d) red

Ans-(d)

17. Two lenses of focal lengths 20 cm and - 40cm are held in contact. If an object lies at infinity, image formed by the lens combination will be at

(a) infinity (b) 20cm

(c) 40cm (d) 60cm

Ans-(c)

19. Resolving power of compound microscope is

(a) $d = \frac{\lambda}{2\mu sin\theta}$ (b) $\frac{1}{d} = \frac{2\mu sin\theta}{\lambda}$

(c) $d\theta = \frac{1.22\lambda}{D}$ (d) $\frac{1}{d\theta} = \frac{D}{1.22\lambda}$

Ans- (b)

20. Optical fibres are based on the phenomenon of

(a) reflection (b) refraction

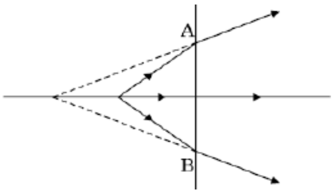
(c) dispersion (d) total internal reflection

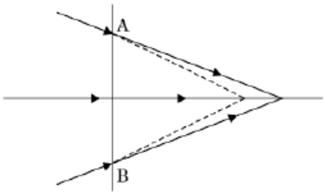
Ans- (d)

SECTION – B (2 MARKS QUESTIONS)

1. The line AB in the ray diagram represents a lens. State whether the lens is convex or concave ? **CBSE (AI)-2015**

(i) (ii)





[Ans. (i) Convex lens, Reason : refracted ray is bending towards the principal axis

(ii) **Concave lens, Reason** : refracted ray is bending away from the principal axis

2. State the conditions for the phenomenon of total internal reflection to occur. **CBSE (AI)-2016,(D)-2010**

[Ans. Conditions for TIR :

(i) light ray must travel from denser to a rarer medium

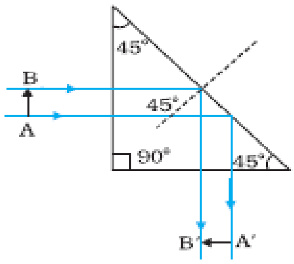
(ii) angle of incidence must be greater than the critical angle ( )

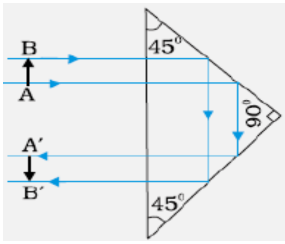
3. Draw a ray diagram to show how a right angled isosceles prism can be used to- **CBSE (AI)-2015,(DC)-2001**

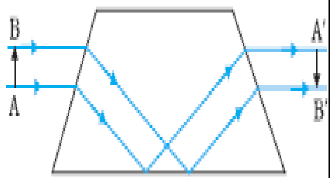
(i) deviate a light ray through (i) , (ii) deviate a light ray through to obtain the inverted image

(iii) to invert an image without the deviation of the rays ?

[Ans. (i) (ii) (iii)





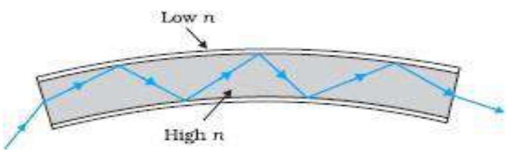


4. Draw a labelled diagram of an optical fibre. Explain how light propagates through the optical fiber.

[Ans. Phenomenon : Total internal reflection **CBSE (AI)-2016,(D)-2011**

Working :

When a signal in the form of light enters at one end of the fibre at suitable angle, it undergoes repeated total internal reflections and finally comes out at the other end.



5. Give reasons for the following observations on the surface of the moon : **CBSE (AI)-2000**

Sunrise and sunset are abrupt. (b) Sky appears dark (c) a rainbow is never formed.

[Ans. (a) Moon has no atmosphere. There is no scattering of light. Sunlight reaches the moon straight covering the short distance. Hence sunrise and sunset are abrupt.

6. Moon has no atmosphere. There is nothing to scatter sunlight towards the moon. No skylight reaches moon surface. Hence sky appears black in the day time as it does at night.

7. No water vapours are present at moon surface. No clouds are formed. There are no rains on the moon, so rainbow is never formed

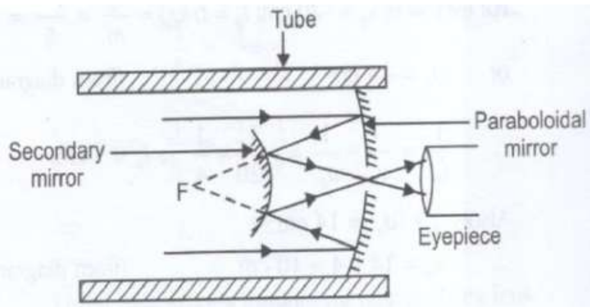
6. You are given the following three lenses. Which two lenses will you use as an eyepiece and as an objective to construct an astronomical telescope ? Give reason.

Lenses	Power (D)	Aperture (cm)
L_1	3	8
L_2	6	1
L_3	10	1

[Ans. Objective lens : Lens L_1 & **Eye piece** : Lens L_3

for higher magnification & brighter image, objective should have large aperture and large focal length & eye piece should have small aperture and small focal length

7. Draw a schematic diagram of a reflecting telescope.



8. State the advantages of reflecting telescope over refracting telescope.

[Ans. Advantages of reflecting telescope

(i) No chromatic aberration

(ii) No spherical aberration

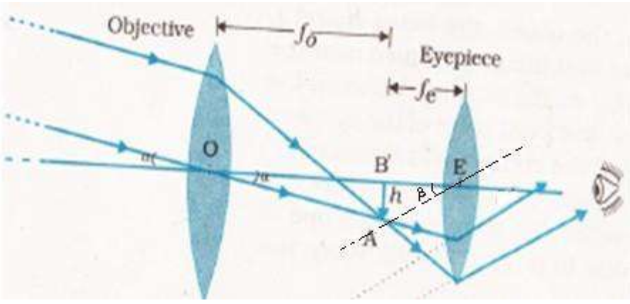
(iii) Brighter image

(iv) large magnifying power

(v) High resolving power

9. Draw a labelled ray diagram to show the image formation by an astronomical telescope in normal adjustment.

Ans



10. Write the main considerations required in selecting the objective and eye piece lenses in order to have large magnifying power and high resolution of the telescope

- Ans to have large magnifying power
  Hence, focal length of objective should be large, while focal length of eye piece should be small
- to have high resolving power D should be large. Hence aperture of objective should be large

SECTION – C (3 MARKS QUESTIONS)

1 Find the radius of curvature of the convex surface of a a plano convex lens ,whose focal length Is 0.3m & the refractive index of material is 1.5?

Sol) μ=1.5 ,f=0.3mm

Therefore ,for plano convex lens

R_1=R & R_2= -∞

So, $1/f = (\mu-1)(1/R_1 - 1/R_2)$

$1/0.3 = (1.5-1)(1/R + 1/\infty)$

$0.5/R = 1/0.3$

R=.15m

2 Show that the limiting value of the angle of prism is twice its critical angle.Hence define critical angle.

Sol) Angle of prism $A = r_1 + r_2$,

For limiting A ,A(max)= r_1(max) +r_2(max)

Value of angle of prism for r_1(max) means , i=90° , but when i=90° , r_1(max) =C = r_2(max)

Therefore , A(max) =C +C =2C .

The angle of incidence for which angle of refraction is 90° is called critical angle.

3 The magnifying power of an astronomical telescope in the normal adjustment position Is 100.The distance between objective & the eyepiece is 101cm.Find focal length of objective & eyepiece.

Sol)f(o)+f(e)=101 ……………(1)

M= f(o)/f(e)=100…………….(2)

Therefore f(o)=100f(e) ,using it in 1)

We have f(e)+100f(e)=101

So ,f(e)=1cm. & so f(o)=100cm.

4. Derive the relation $\frac{1}{f} = \frac{1}{f1} + \frac{1}{f2}$ nwhere f1 and f2 are the focal length of two thin lenses and f is the combined focal length in contact.

Ans : For first lens $\frac{1}{v1} - \frac{1}{u} = \frac{1}{f1}$ For second lens $\frac{1}{v} - \frac{1}{v1} = \frac{1}{f2}$

On adding the two we get $\frac{1}{f1} + \frac{1}{f2} = \frac{1}{v} - \frac{1}{u} + \frac{1}{v1} - \frac{1}{v1}$

$\frac{1}{f1} + \frac{1}{f2} = \frac{1}{v} - \frac{1}{u}$ Using Lens formula $\frac{1}{f1} + \frac{1}{f2} = \frac{1}{f}$

5. A 4.5 cm needle is placed 12 cm away from a convex mirror of focal length 15 cm. Give the location of the image and the magnification. Describe what happens as the needle is moved farther from mirror.

Ans : Height of the needle h_1 = 4.5 cm

u = - 12 cm , f = 15 cm

By mirror formula $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$, $\frac{1}{v} = \frac{1}{15} + \frac{1}{12}$, v = 6.7 cm

Image of the needle is 6.7 cm away from the mirror. Also it is on the other side of the mirror.

Magnification m = $\frac{h2}{h1} = \frac{-v}{u}$, h2 = $\frac{-v}{u} * h1$ $\frac{-6.7*4.5}{-12}$ = 2.5 cm

Magnification m = $\frac{h2}{h1} = \frac{2.5}{4.5}$ = 0.56

Height of image is 2.5 cm . +ve sign indicates that image is virtual and erect and diminished.

If the needle is moved farther from the mirror the image will also move away from the mirror and the size of image will reduce gradually.

6. A myopic person has been using spectacles of power – 1.0 D for distant vision. During old age he also needs to use separate reading glass of power + 2.0 D. Explain what may have happened?

Ans – P = - 1.0 D , F = $\frac{1}{P}$ = - 100 cm .

So far point is 100 cm. He might have a normal near point of 25 cm . When he uses the spectacles , the objects placed at infinity produce virtual image at 100 cm. He uses the ability of accommodation of eye lens to see the objects placed between 100 cm and 25 cm.

During old age , the person uses reading glass of power P = + 2.0 D so f = 20 cm so near point is receded and has difficulty in reading closer things.

7. A Small telescope has an objective lens of focal length 140cm & an eyepiece of focal length 5.0cm .What is the magnifying pwer of telescope for viewing distant object when a)The telescope is in normal adjustment (i.e when the final Image is at infinity)?$_{111}$b)The final image is formed at least distance of distant vision,25cm?

Ans: Focal length of objective lens , f(o)=140cm

Focal length of eyepiece ,f(e)=5cm

So,at normal adjustment ,magnifying power is m=$\frac{f(o)}{f(e)} = \frac{140}{5}$=28

b)when final image is formed at d=25cm,then magnifying power of telescope is

m=$\frac{f(o)}{f(e)}\left\{1 + \frac{f(e)}{d}\right\} = \frac{140}{5}\{1 + 0.2\}$

28x 1.2= 33.6

8. A Tank is filled with water to a height of 12.5cm.The apparent depth of a needle lying at Bottom of tank is measured by a microscope to be 9.4cm.What is the refractive of water ? If water is replaced by a liquid of refractive index 1.63,up to same height ,by what distance Microscope have to be moved to focus on needle again?

Ans: Given , Actual depth of needle in water h_1=12.5cm

Apparent depth of needle ,h_2=9.4 cm

Therefore , $\mu=\frac{h_1}{h_2}=\frac{12.5}{9.4}$ =1.33

If water is replaced by a liquid of refractive index 1.63 ,then actual depth will remain same but only apparent depth changes therefore $\mu(liq.)=\frac{h_2}{y}$

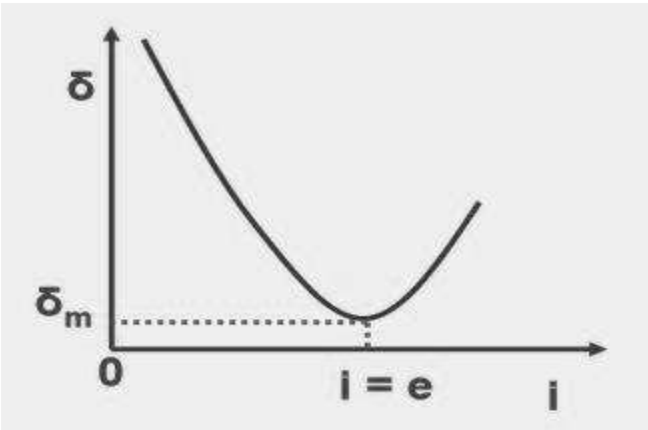
So ,$y=\frac{h_2}{\mu(liq)}=\frac{12.5}{1.63}$ =7.67 cm

Hence new apparent depth is 7.67cm .It is less than h_2 ,so to focus microscope has to be moved up by distance of 9.4 – 7.67=1.73cm.

SECTION – D (5 MARKS QUESTIONS)

Q1 Draw a graph to show the variation of the angle of deviation with that of angle of incidence for a monochromatic ray of light passing through a glass prism of refracting angle A. Hence derive the prism formula.

Ans: Graph to show the variation of the angle of deviation with that of angle of prism



PRISM FORMULA

When angle of incidence increases, the angle of deviation decreases.

At a particular value of angle of incidence the angle of deviation becomes minimum and is called 'angle of minimum deviation'.

At δ_m, i = e and $r_1 = r_2 = r$ (say)

After minimum deviation, angle of deviation increases with angle of incidence.

Refractive Index of Material of Prism:

$A = r_1 + r_2$

$A = 2r$

$r = A/2$

$i + e = A + \delta$

$2i = A + \delta_m$

$i = (A + \delta_m)/2$

According to Snell's law,

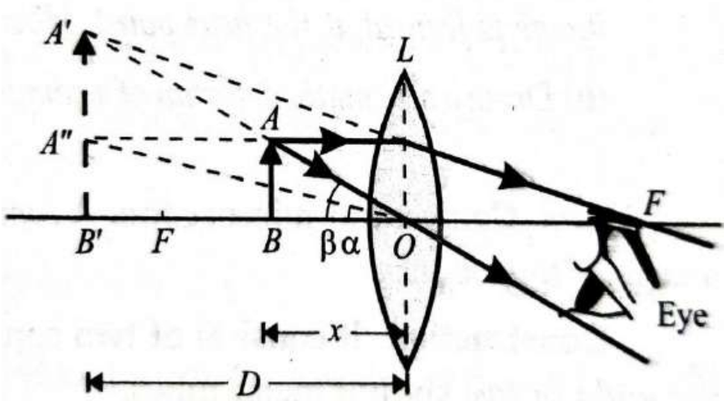
$$\mu = \frac{\sin i}{\sin r_1} = \frac{\sin i}{\sin r}$$

$$\therefore \mu = \frac{\sin \frac{(A + \delta_m)}{2}}{\sin \frac{A}{2}}$$

Q2(i) Draw a ray diagram of a simple microscope when the final image is formed at the least distance of distinct vision and hence deduce the formula for its angular magnification.

(ii) Draw a ray diagram of simple microscope when the final image is formed at infinity. Write an expression for magnifying power.

ANSWER:



Magnifying power: The magnifying power of a simple microscope is defined as the ratio of the angles subtended by the image and the object at the eye, when both are at the least distance of distinct visio

Thus

$$\text{Magnifying power} = \frac{\text{Angle subtended by the image at the least distance of distinct vision}}{\text{Angle subtended by the object at the least distance of distinct vision}}$$

or $$m = \frac{\beta}{\alpha} = \frac{\tan\beta}{\tan\alpha} \qquad [\because \alpha, \beta \text{ are small angles}]$$

$$= \frac{AB/OB}{A''B'/OB'} = \frac{AB/OB}{AB/OB'} \qquad [\because A''B' = AB]$$

$$= \frac{OB'}{OB} = \frac{-D}{-x} \quad \text{or} \quad m = \frac{D}{x}$$

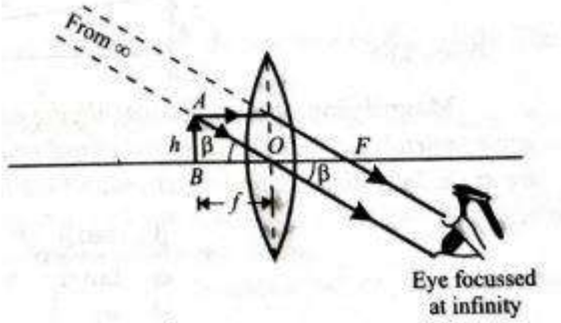
Let f be the focal length of the lens. As the image is formed at the least distance of distinct vision from the lens, so $v = -D$

Using *thin lens formula*, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

we get, $$\frac{1}{-D} - \frac{1}{-x} = \frac{1}{f} \quad \text{or} \quad \frac{1}{x} = \frac{1}{D} + \frac{1}{f} \quad \text{or} \quad \frac{D}{x} = 1 + \frac{D}{f} \quad \therefore \quad m = 1 + \frac{D}{f}$$

Thus shorter the focal length of the convex lens, the greater is its magnifying power.

(ii) Magnification power when the final image is formed at infinity:



$$m = \frac{\beta}{\alpha} = \frac{\tan\beta}{\tan\alpha} \qquad [\alpha, \beta \text{ are small}]$$

From Fig. 9.62(a),

$$\tan\beta = \frac{h}{f}$$

From Fig. 9.62(b),

$$\tan\alpha = \frac{h}{D}$$

$$\therefore \qquad m = \frac{h/f}{h/D} \qquad \text{or} \qquad m = \frac{D}{f}$$

Q3(i) Draw a ray diagram to show the refraction of light through a glass prism. Hence obtain the relation for angle of deviation in terms of angle of incidence, angle of emergence and angle of prism.

ANSWER

From the quadrilateral $AQNR$,

$$A + \angle QNR = 180^\circ$$

From the triangle QNR,

$$r + r' + \angle QNR = 180^\circ$$

$$\therefore \quad A = r + r'$$

Now, from the triangle MQR, the *deviation produced* by the prism is

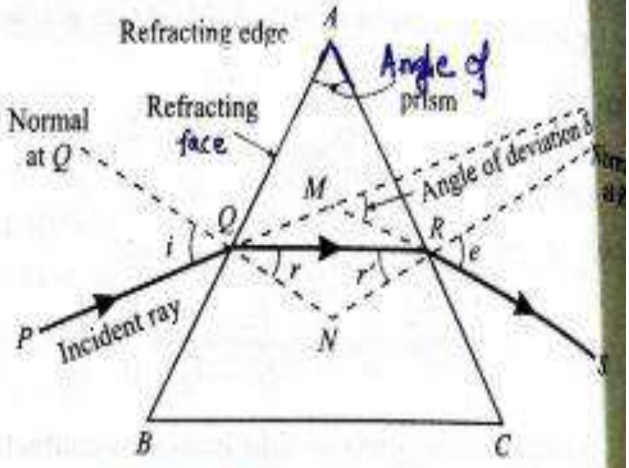


Figure 9.49 Refraction through a prism.

$$\delta = \angle MQR + \angle MRQ$$

$$= (i - r) + (e - r')$$

or $\quad \delta =$ deviation at the first face + deviation at the second face $= (i + e) - (r + r')$

or $\quad \delta = i + e - A$

or $\quad i + e = A + \delta$

So when a ray of light is refracted through a prism, the sum of angle of incidence is equal and the angle of emergence is equal to the sum of the angle of prism and angle of deviation.

(ii) A ray of light incident on an equilateral glass prism shows minimum deviation of 30°. Calculate the speed of light through the prism.

Solution. Here $A = 60^\circ, \delta_m = 30^\circ$

Refractive index,

$$\mu = \frac{\sin \frac{A + \delta_m}{2}}{\sin \frac{A}{2}} = \frac{\sin \frac{60^\circ + 30^\circ}{2}}{\sin \frac{60^\circ}{2}}$$

$$= \frac{\sin 45^\circ}{\sin 30^\circ} = \frac{1/\sqrt{2}}{1/2} = \sqrt{2} = 1.414$$

Velocity of light in glass,

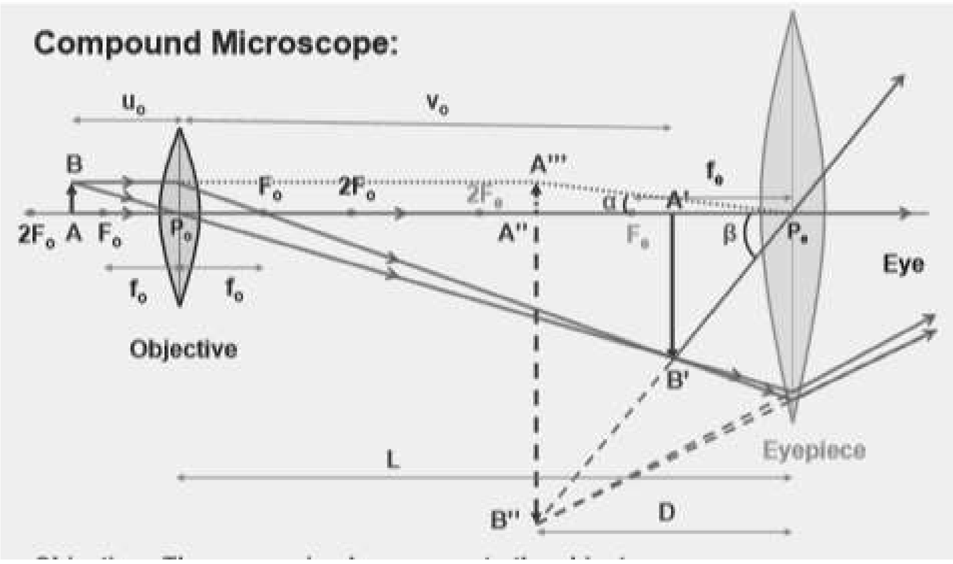
$$v = \frac{c}{\mu} = \frac{3 \times 10^8}{1.414}$$

$$= 2.12 \times 10^8 \text{ ms}^{-1}$$

Q3(a) Define magnifying power of a microscope. With the help of a ray diagram, explain the formation of image by a compound microscope. Derive the expression for its magnifying power when the final image is formed at the near point.

(b) Draw a schematic diagram of compound microscope when the final image is formed at infinity.

Answers (a) The magnifying power of a compound microscope is defined as the ratio of the angle subtended at the eye by the final virtual image to the angle subtended at the eye by the object when both lies at the least distance of distinct division from eye.



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

Since angles are small,
$\alpha = \tan\alpha$ and $\beta = \tan\beta$

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

$$M = \frac{A''B''}{D} \times \frac{D}{A''A'''}$$

$$M = \frac{A''B''}{D} \times \frac{D}{AB}$$

$$M = \frac{A''B''}{AB}$$

$$M = \frac{A''B''}{A'B'} \times \frac{A'B'}{AB}$$

$$M = M_e \times M_o$$

$$M_e = 1 - \frac{v_e}{f_e} \quad \text{or} \quad M_e = 1 + \frac{D}{f_e} \qquad (v_e = -D = -25\text{ cm})$$

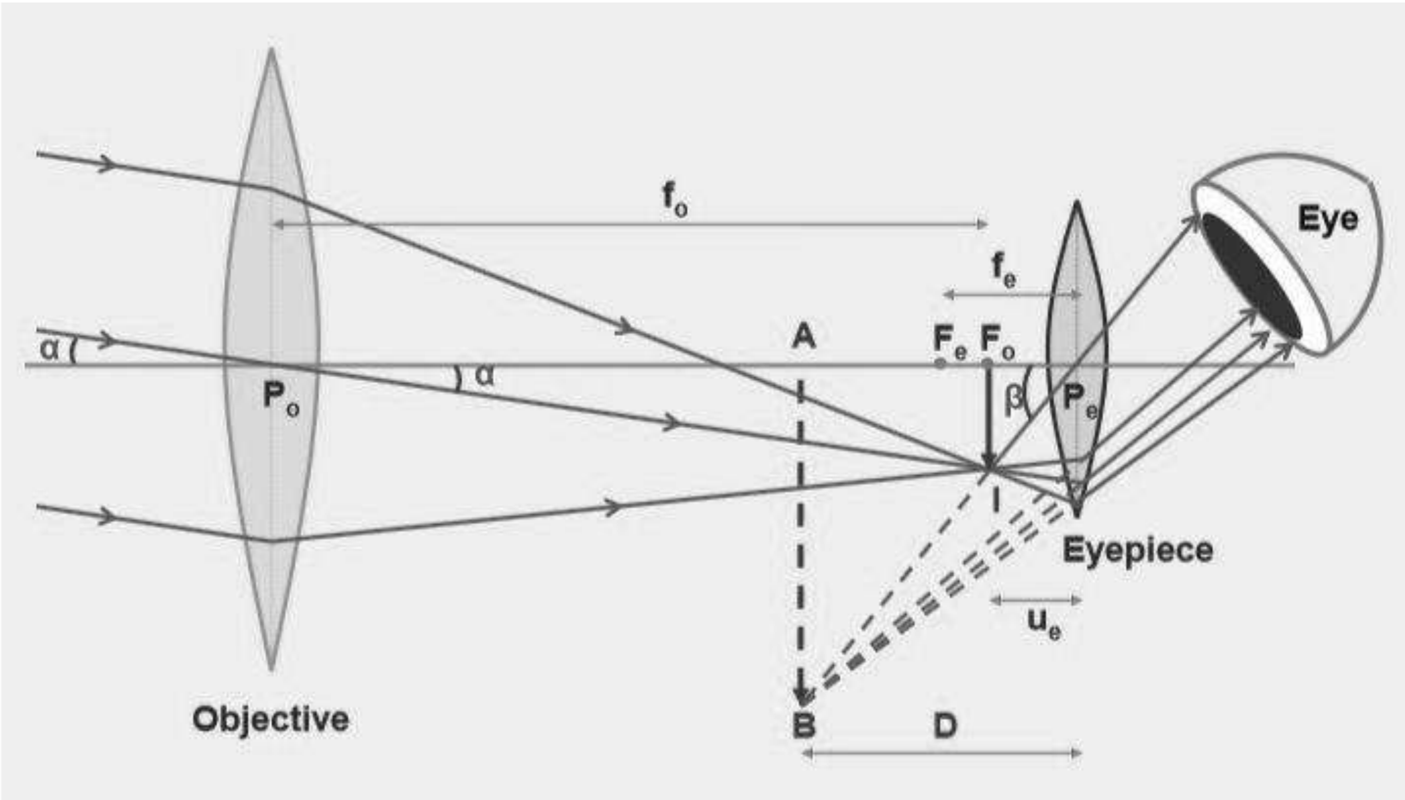
and $$M_o = \frac{v_o}{-u_o} \quad \therefore \quad M = \frac{v_o}{-u_o}\left(1 + \frac{D}{f_e}\right)$$

Since the object is placed very close to the principal focus of the objective and the image is formed very close to the eyepiece, $u_o \approx f_o$ and $v_o \approx L$

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

or $$M \approx \frac{-L}{f_o} \times \frac{D}{f_e}$$ (Normal adjustment i.e. image at infinity)

Q4 With the help of a ray diagram explain the formation of image in an astronomical telescope for a distant object. Define the term magnifying power of a telescope. Derive an expression for the magnifying power when the final image is formed at least distance of distinct vision.



Angular magnification or magnifying power of a telescope in this case is defined as the ratio of the angle β subtended at the eye by the final image formed at the least distance of distinct vision to the angle α subtended at the eye by the object lying at infinity when seen directly.

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

Since angles are small,
$\alpha = \tan\alpha$ and $\beta = \tan\beta$

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

$$M = \frac{F_oI}{P_eF_o} \Big/ \frac{F_oI}{P_oF_o}$$

$$M = \frac{P_oF_o}{P_eF_o} \quad \text{or} \quad M = \frac{+f_o}{-u_e}$$

Lens Equation

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \quad \text{becomes}$$

$$\frac{1}{-D} - \frac{1}{-u_e} = \frac{1}{f_e}$$

$$\text{or} \quad \frac{1}{u_e} = \frac{1}{f_e} + \frac{1}{D}$$

Multiplying by f_o on both sides and rearranging, we get

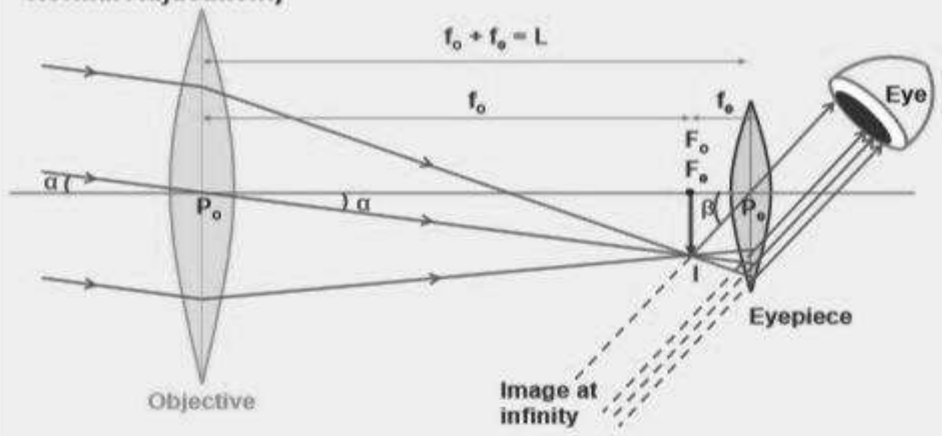
$$M = \frac{-f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$$

Clearly focal length of objective must be greater than that of the eyepiece for larger magnifying power.

Also, it is to be noted that in this case M is larger than that in normal adjustment position.

Q5 Draw a ray diagram to show the formation of image of a distant object by an astronomical telescope in the normal adjustment position. Obtain an expression for the magnifying power of the telescope in this adjustment.

Astronomical Telescope: (Image formed at infinity – Normal Adjustment)



Angular magnification or Magnifying power of a telescope in normal adjustment is the ratio of the angle subtended by the image at the eye as seen through the telescope to the angle subtended by the object as seen directly, when both the object and the image are at infinity.

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

Since angles are small, $\alpha = \tan\alpha$ and $\beta = \tan\beta$

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

$$M = \frac{F_e I}{P_e F_e} \Big/ \frac{F_e I}{P_o F_e}$$

$$M = \frac{-I}{-f_e} \Big/ \frac{-I}{f_o}$$

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

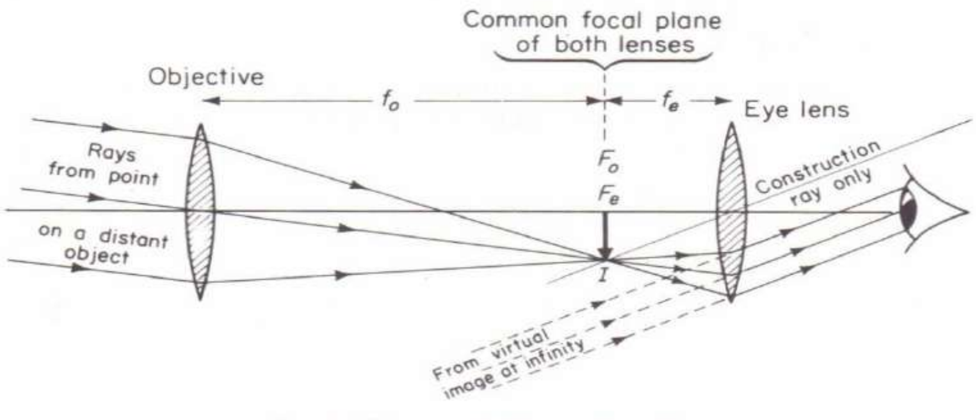
($f_o + f_e = L$ is called the length of the telescope in normal adjustment).

Q6 . Draw a labelled ray diagram to obtain the real image formed by an astronomical telescope in normal adjustment position its magnifying power. (b) You are given there lenses of power 0.5 D, 4D and 10D to design a telescope.(i)Which lenses should he used as objective and eyepiece ? Justify your answer.

(ii) Why is the aperture of the objective preferred to be large ?

(iii)Light from a point source in air falls on a convex spherical glass surface of refractive index 1.5 and radius of curvature 20 cm. The distance of light source from the glass surface is 100 cm. At what position is the image formed?

ANS



(a) Fig. 24.23. Astronomical telescope

(b) (i) 0.5 D for Objective lens and 10 D for eyepiece because M = f_0/f_e

(ii) To collect sufficient light to from a bright image

using $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2-n_1}{R}$

$n_1 = 1$, $n_2 = 1.5$, u = -100 cm, v = ? R = 20 Cm

$$\frac{1.5}{v} - \frac{1}{-100} = \frac{1.5-1}{20}$$

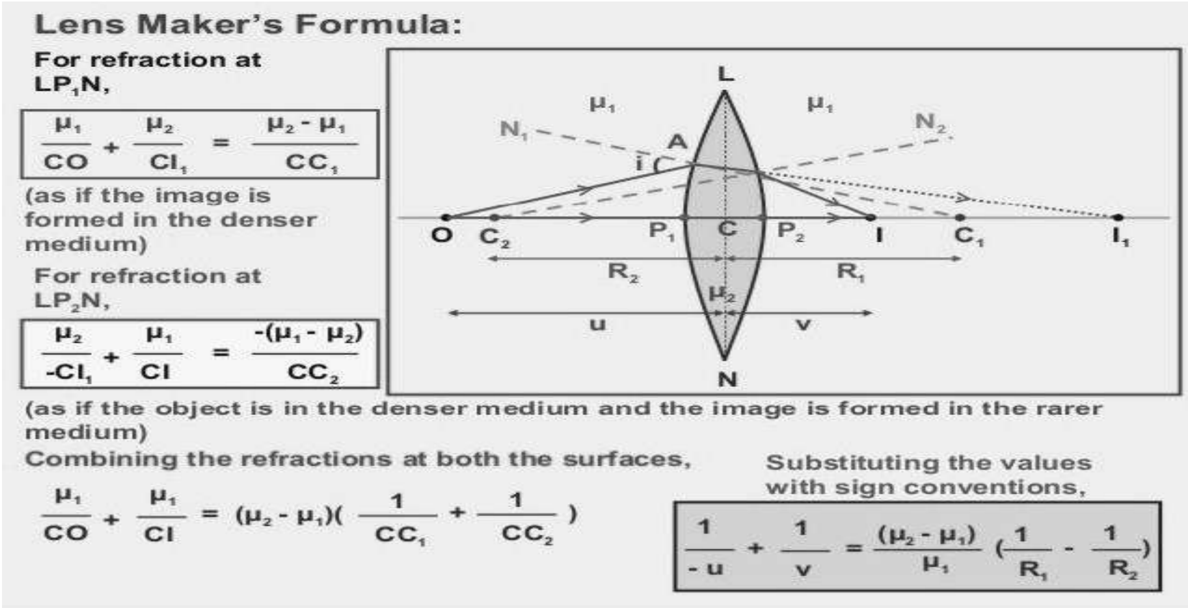
$$\frac{1.5}{v} + \frac{1}{100} = \frac{0.5}{20}$$

$\Rightarrow$ v =100 cm

Q.7 (i) Derive Lens Maker's Formula by using suitable diagram.

(ii) A convex lens of focal length 20 cm is placed coaxially with a convex mirror of radius ofcurvature 20 cm. The two are kept at 15 cm each other. A point object lies 60 cm in front ofthe convex lens. Determine the nature position of the image formed.

ANS (i)



ii) Ans : $1/v - 1/u = 1/f$

$1/v = 1/120 + 1/(-60)$

$\Rightarrow v = 60$ cm The positive sign shows that the image is formed to the right of the lens.

$1/v + 1/u = 1/f$

$u = -60$ and $f = 20\ cm$

v =15cm

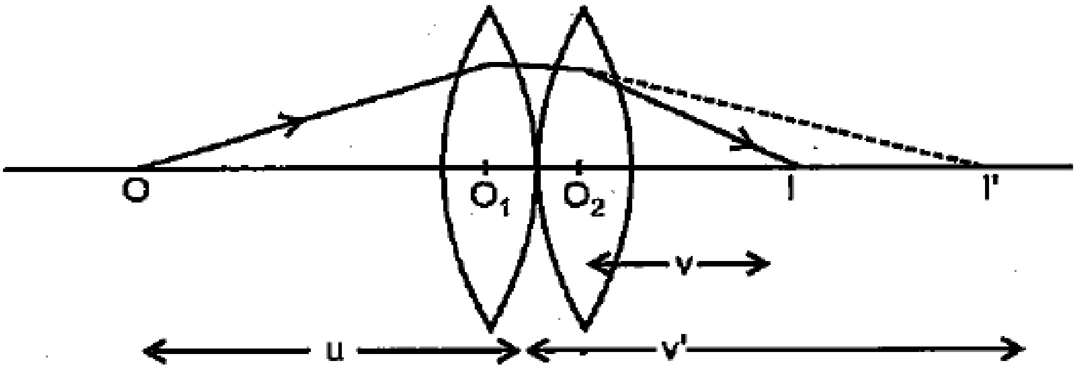
Q8

(a) **Draw a ray diagram to show the image formation by a combination of two thin convex lenses in contact. Obtain the expression for the power of this combination in terms of the focal lengths of the lenses.**

(b) **A ray of light passing from air through an equilateral glass prism undergoes minimum deviation when the angle of incidence is $\frac{3}{4}$ th of the angle of prism. Calculate the speed of light in the prism.**

ANS

(a)



For first lens, object is at O, and image is at I'.

$$\frac{1}{f_1} = \frac{1}{v'} - \frac{1}{u} \qquad \text{...(i)}$$

For second lens, object is at I and image is at I.

$$\frac{1}{f_2} = \frac{1}{v} - \frac{1}{v'} \qquad \text{...(ii)}$$

Adding (i) and (ii),

$$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{v} - \frac{1}{u} \qquad \text{...(iii)}$$

If f is the combined focal length then

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

From equation (iii),

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

$$P = \frac{1}{f_1} + \frac{1}{f_2} \qquad \left[\because \frac{1}{f} = P\right]$$

$$P = \frac{f_1 + f_2}{f_1 f_2}$$

(b) Given :

$$A = 60^\circ$$

$$i = \frac{3}{4} A$$

$$i = \frac{3}{4} \times 60^\circ$$

$$i = 45^\circ$$

For angle of minimum deviation,

$$r = A/2 = \frac{60^\circ}{2}$$

$$r = 30^\circ$$

$\because$ $$\mu = \frac{\sin i}{\sin r}$$

$$\frac{c}{v} = \frac{\sin 45^\circ}{\sin 30^\circ} \qquad [\because \mu = \frac{c}{v}]$$

$$\frac{3 \times 10^8}{v} = \frac{\frac{1}{\sqrt{2}}}{\frac{1}{2}}$$

$$\frac{3 \times 10^8}{v} = \sqrt{2}$$

$$v = \frac{3 \times 10^8}{1.414} \text{ m/s}$$

$\therefore$ Speed of light in the prism

$$vs = 2.12 \times 10^8 \text{ m/s}$$