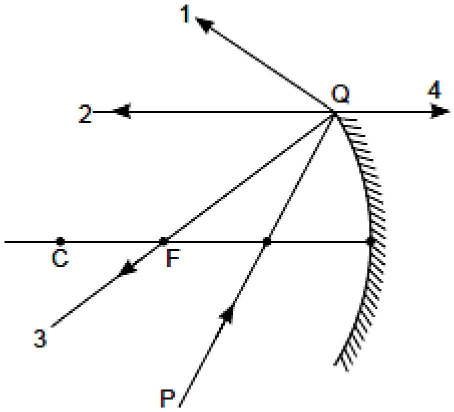
PRACTICE PAPER 09
CHAPTER 09 RAY OPTICS AND OPTICAL INSTRUMENTS

SUBJECT: PHYSICS **MAX. MARKS : 40**
CLASS : XII **DURATION : 1½ hrs**

General Instructions:
(i). **All** questions are compulsory.
(ii). This question paper contains 2**0** questions divided into five Sections A, B, C, D and E.
(iii). **Section A** comprises of **10 MCQs** of **1 mark** each. **Section B** comprises of 4 questions of **2 marks** each. **Section C** comprises of 3 questions of **3 marks** each. **Section D** comprises of 1 question of **5 marks** each and **Section E** comprises of 2 Case Study Based Questions of **4 marks** each.
(iv). There is no overall choice.
(v). Use of Calculators is not permitted

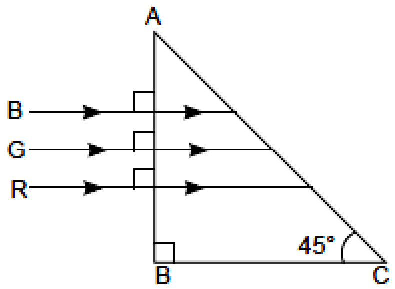
SECTION – A
Questions 1 to 10 carry 1 mark each.

1. The direction of ray of light incident on a concave mirror is shown by PQ while directions in which the ray would travel after reflection is shown by four rays marked 1, 2, 3 and 4. Which of the four rays correctly shows the direction of reflected ray?



(a) 1 (b) 2 (c) 3 (d) 4

2. A beam of light consisting of red, green and blue colours is incident on a right angled prism. The refractive index of the material of the prism for red, green and blue wavelengths are 1.39, 1.44 and 1.47 respectively. The prism will

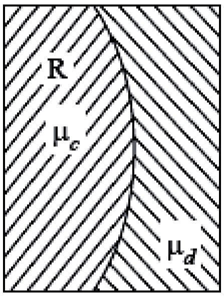


(a) separate the red colour part from the green and blue colours.
(b) separate the blue colour part from the red and green colours.
(c) separate all the three colours from one another.
(d) not separate the three colours at all.

3. Four lenses of focal lengths ± 15 cm and ± 150 cm are available for making a telescope. To produce the largest magnification, the focal length of the eyepiece should be
(a) + 15 cm (b) + 150 cm (c) – 150 cm (d) – 15 cm

4. A biconvex lens of focal length f is cut into two identical plano convex lenses. The focal length of each part will be
(a) f (b) f/2 (c) 2f (d) 4f

5. A plano-convex lens of refractive index $\mu_c = 1.7$ and a plano-concave lens of refractive index $\mu_d = 1.5$, are combined as shown so as to construct a plane glass plate.



If the radius of curvature of the curved side to both the lens is same, which of the following system will the glass plate function as?
(a) Convergent system with positive focal length
(b) Divergent system with negative focal length
(c) Plane glass slab with zero focal length
(d) Plane glass slab with infinite focal length

6. A ray of light of wavelength 600 nm propagates from air into a medium. If its wavelength in the medium becomes 400 nm, the refractive index of the medium is:
(a) 1.4 (b) 1.5 (c) 1.6 (d) 1.8

7. A ray of monochromatic light propagating in air, is incident on the surface of water. Which of the following will be the same for the reflected and refracted rays?
(a) Energy carried (b) Speed (c) Frequency (d) Wavelength

8. A ray passing through or directed towards centre of curvature of a spherical mirror is reflected such that it trace back of its path, because
(a) it does not follow law of reflection
(b) angle of incidence is 0°
(c) centre of curvature is midway between object and pole
(d) distance of centre of curvature from focus is equal to its distance from pole R

In the following questions 9 and 10, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:
(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).
(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).
(c) Assertion (A) is true but reason (R) is false.
(d) Assertion (A) is false but reason (R) is true.

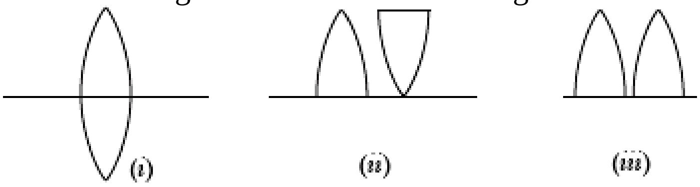
9. **Assertion (A):** Propagation of light through an optical fibre is due to total internal reflection taking place at the core-cladding interface.
Reason (R): Refractive index of the material of the cladding of the optical fibre is greater than that of the core.

10. **Assertion (A):** If the focal length of two convex lenses is the same, the lens with the larger diameter will produce brighter images.
Reason (R): Convex lenses with larger diameters are able to focus light better.

SECTION – B

Questions 11 to 14 carry 2 marks each.

11. A thin double convex lens of focal length f is broken into two equal halves at the axis. The two halves are combined as shown in figure. What is the focal length of combination in (ii) and (iii)?

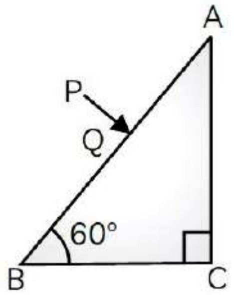


OR

Using the lens formula, show that an object placed between the optical centre and the focus of a convex lens produces a virtual and an enlarged image.

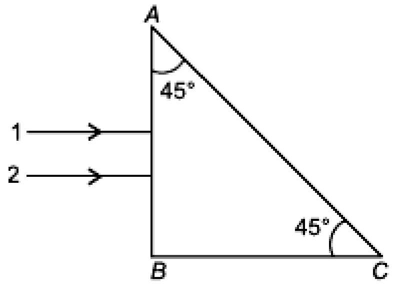
12. Define resolving power of a compound microscope. How does the resolving power of a compound microscope change when
(i) refractive index of the medium between the object and objective lens increases?
(ii) wavelength of the radiation used is increased?

13. A ray PQ incident normally on the refracting face BA is refracted in the prism BAC made of material of refractive index 1.5. Complete the path of ray through the prism. From which face will the ray emerge? Justify your answer.

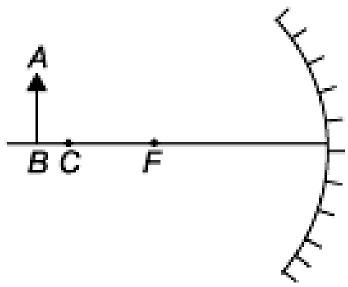


OR

Two monochromatic rays of light are incident normally on the face *AB* of an isosceles right angled prism *ABC*. The refractive indices of the glass prism for the two rays 1 and 2 are respectively 1.35 and 1.45. Trace the path of these rays after entering through the prism.



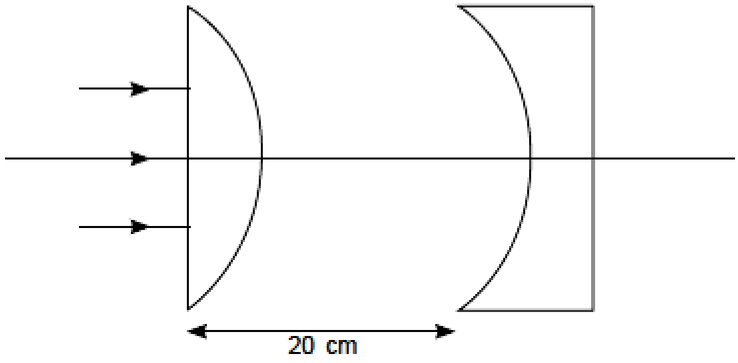
14. An object AB is kept in front of a concave mirror as shown in the figure.



(i) Complete the ray diagram showing the image formation of the object.
(ii) How will the position and intensity of the image be affected if the lower half of the mirror's reflecting surface is painted black?

OR

In the given figure the radius of curvature of curved face in the plano-convex and the plano-concave lens is 15 cm each. The refractive index of the material of the lenses is 1.5. Find the final position of the image formed.

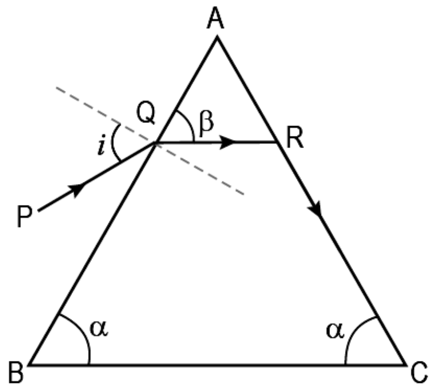


SECTION – C

Questions 15 to 17 carry 3 marks each.

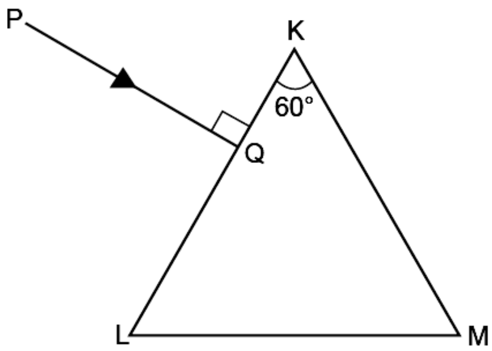
15. A convex lens made up of glass of refractive index 1.5 is dipped, in turn, in
(i) a medium of refractive index 1.65, (ii) a medium of refractive index 1.33.
(a) Will it behave as a converging or a diverging lens in the two cases?
(b) How will its focal length change in the two media?

16. A ray of light incident on the face AB of an isosceles triangular prism makes an angle of incidence (i) and deviates by angle β as shown in the figure. Show that in the position of minimum deviation ∠β = ∠α. Also find out the condition when the refracted ray QR suffers total internal reflection.



OR

A triangular prism of refracting angle 60° is made of a transparent material of refractive index $\frac{2}{\sqrt{3}}$. A ray of light is incident normally on the face KL as shown in the figure. Trace the path of the ray as it passes through the prism and calculate the angle of emergence and angle of deviation.



17. (a) Draw a labelled ray diagram of a compound microscope.

(b) Derive an expression for its magnifying power.

(c) Why is objective of a microscope of short aperture and short focal length? Give reason.

SECTION – D

Questions 18 carry 5 marks.

18. (i) Draw a neat labelled ray diagram of an astronomical telescope in normal adjustment. Explain briefly its working.

(ii) An astronomical telescope uses two lenses of powers 10 D and 1 D. What is its magnifying power in normal adjustment?

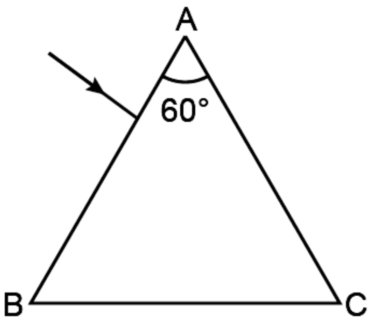
OR

Draw a labelled ray diagram of a reflecting telescope. Mention its two advantages over the refracting telescope.

SECTION – E (Case Study Based Questions)

Questions 19 to 20 carry 4 marks each.

19. Refraction through Prism: Strontium titanate is a rare oxide a natural mineral found in Siberia. It is used as a substitute for diamond because its refractive index and critical angle are 2.41 and 24.5˚, respectively, which are approximately equal to the refractive index and critical angle of diamond. It has all the properties of diamond. Even an expert jeweller is unable to differentiate between diamond and strontium titanate. A ray of light is incident normally on one face of an equilateral triangular prism ABC made of strontium titanate.



(i) The necessary conditions for total internal reflection is

(a) the angle of incidence in denser medium must be smaller than the critical angle for two media

(b) the angle of refraction in denser medium must be greater than the critical angle for two media

(c) the angle of incidence in denser medium must be greater than the critical angle for two media

(d) none of these

(ii) The speed of light in a medium whose critical angle is 30° is

(a) 3 × 108 m/s (b) 2 × 108 m/s (c) 1.5 × 108 m/s (d) 2.5 × 108 m/s

(iii) Dispersion power depends upon

(a) height of the prism (b) angle of prism (c) material of prism (d) the shape of prism

(iv) A ray of light incident at an angle i on refracting face of a prism emerges from the other normally. If the angle of the prism is 30° and the prism is made up of a material of refractive index 1.5, the angle of incidence is

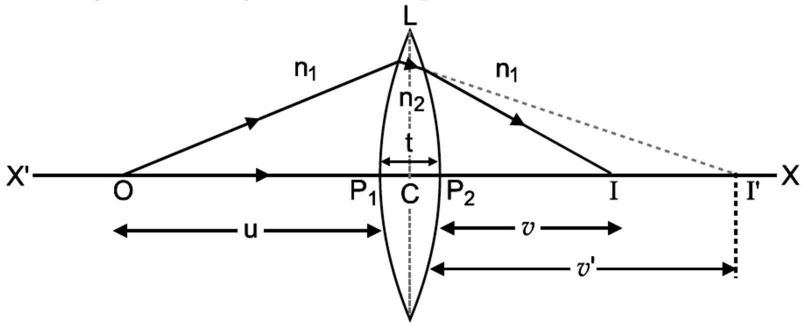
(a) 30° (b) 45° (c) 60° (d) 90°

OR

When light rays are incident on a prism at an angle of 45°, the minimum deviation is obtained. If refractive index of prism is 2 , then the angle of prism will be

(a) 60° (b) 40° (c) 50° (d) 30°

20. Lens Maker's Formula: The lens maker's formula is useful to design lenses of desired focal lengths using surfaces of suitable radii of curvature. The focal length also depends on the refractive index of the material of the lens and the surrounding medium. The refractive index depends on the wavelength of the light used. The power of a lens is related to its focal length.



(i) How will the power of lens affected with an increase of wave length of light?
(a) increases (b) decreases
(c) first increases then decreases (d) first decreases then increases

(ii) The radius of curvatures of two surface of a convex lens is R. For what value of n of its material will its focal length become equal to R?
(a) 1 (b) 1.5 (c) 2 (d) infinite

(iii) An object is immersed in a fluid. In order that the object becomes invisible, it should
(a) behave as perfect reflector
(b) absorb all the light falling on it
(c) have refractive index 1
(d) have refractive index exactly matching with that of the surrounding fluid

(iv) An object is placed in front of a Lens Which forms its erect image of magnification 3. The Power of the lens is 5D. Calculate the distance of the image from the lens.
(a) – 40 cm (b) 40 cm (c) – 80 cm (d) 80 cm

OR

The focal length of a concave lens of $\mu = 1.5$ is 20 cm is air. It is completely immersed in water $\mu = 4/3$. Its focal length in water will be
(a) 20 cm (b) 40 cm (c) 60 cm (d) 80 cm

PRACTICE PAPER 09
CHAPTER 09 RAY OPTICS AND OPTICAL INSTRUMENTS
(ANSWERS)

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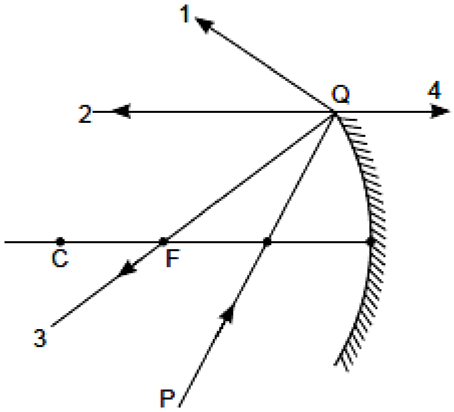
SECTION – A

Questions 1 to 10 carry 1 mark each.

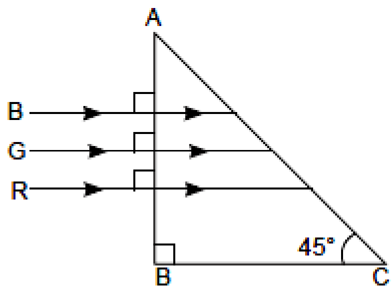
1. The direction of ray of light incident on a concave mirror is shown by PQ while directions in which the ray would travel after reflection is shown by four rays marked 1, 2, 3 and 4. Which of the four rays correctly shows the direction of reflected ray?



(a) 1 (b) 2 (c) 3 (d) 4

Ans. (b) 2

2. A beam of light consisting of red, green and blue colours is incident on a right angled prism. The refractive index of the material of the prism for red, green and blue wavelengths are 1.39, 1.44 and 1.47 respectively. The prism will



(a) separate the red colour part from the green and blue colours.
(b) separate the blue colour part from the red and green colours.
(c) separate all the three colours from one another.
(d) not separate the three colours at all.

Ans. (a) separate the red colour part from the green and blue colours.

For total internal reflection, i > i_c or sin i > sin i_c or $\sin 45^0 > \frac{1}{\mu} \Rightarrow \mu > \sqrt{2} \Rightarrow \mu > 1.414$

As for green and violet $\mu > 1.414$, they will suffer Total Internal Reflection, but red will be refracted.

3. Four lenses of focal lengths ± 15 cm and ± 150 cm are available for making a telescope. To produce the largest magnification, the focal length of the eyepiece should be

(a) + 15 cm (b) + 150 cm (c) – 150 cm (d) – 15 cm

Ans. (a) + 15 cm

For telescope magnification, $m = \dfrac{f_o}{f_e}$

$f_e < f_o$ to produce large magnification.

4. A biconvex lens of focal length f is cut into two identical plano convex lenses. The focal length of each part will be

(a) f (b) f/2 (c) 2f (d) 4f

Ans. (c) 2f

Focal length of a bifocal convex lens of focal length f is

$$\frac{1}{f} = (\mu - 1)\frac{2}{R} \qquad ...(i)$$

Focal length of a plano convex lens, f' is

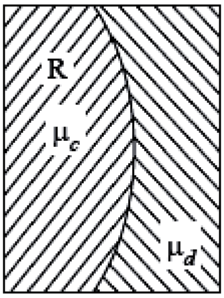
$$\frac{1}{f'} = (\mu - 1)\frac{1}{R} \qquad ...(ii)$$

∴ **Dividing (*i*) by (*ii*)**

$$\frac{f'}{f} = (\mu - 1)\frac{2}{R} \times \frac{R}{(\mu - 1)} = 2$$

$$\therefore \quad f' = 2f$$

5. A plano-convex lens of refractive index $\mu_c = 1.7$ and a plano-concave lens of refractive index $\mu_d = 1.5$, are combined as shown so as to construct a plane glass plate.



If the radius of curvature of the curved side to both the lens is same, which of the following system will the glass plate function as?

(a) Convergent system with positive focal length

(b) Divergent system with negative focal length

(c) Plane glass slab with zero focal length

(d) Plane glass slab with infinite focal length

Ans. (a) Convergent system with positive focal length

Lens maker formula to each lens:

$$\frac{1}{f_c} = (\mu_c - 1)\left[\frac{1}{\infty} - \frac{1}{-R}\right] = \frac{\mu_c - 1}{R}$$

$$\frac{1}{f_d} = (\mu_d - 1)\left[\frac{1}{-R} - \frac{1}{\infty}\right] = \frac{-(\mu_d - 1)}{R}$$

For a lens combination,

$$\frac{1}{F} = \frac{1}{f_c} + \frac{1}{f_d}$$

$$F = \frac{R}{\mu_c - \mu_d}$$

Since $\mu_c > \mu_d$, F is positive. So the system behaves convergent.

6. A ray of light of wavelength 600 nm propagates from air into a medium. If its wavelength in the medium becomes 400 nm, the refractive index of the medium is:

(a) 1.4 (b) 1.5 (c) 1.6 (d) 1.8

Ans. (b) 1.5

7. A ray of monochromatic light propagating in air, is incident on the surface of water. Which of the following will be the same for the reflected and refracted rays?

(a) Energy carried (b) Speed (c) Frequency (d) Wavelength

Ans. (c) Frequency

When a ray of monochromatic light is incident on the surface of water, some of the light will be reflected and some will be refracted. The speed of light changes as it passes through different medium, and the wavelength of the light also changes. However, the frequency of the light remains constant. Therefore, the property that will be the same for the reflected and refracted rays is the frequency of the light.

8. A ray passing through or directed towards centre of curvature of a spherical mirror is reflected such that it trace back of its path, because

(a) it does not follow law of reflection

(b) angle of incidence is 0°

(c) centre of curvature is midway between object and pole

(d) distance of centre of curvature from focus is equal to its distance from pole R

Ans. (b) angle of incidence is 0°

As we know, angle i = 0° and angle r = 0°, when light ray is passes through centre of curvature of a spherical mirror is reflected such that it trace back its path.

In the following questions 9 and 10, a statement of assertion (A) is followed by a statement of reason (R). Mark the correct choice as:

(a) Both assertion (A) and reason (R) are true and reason (R) is the correct explanation of assertion (A).

(b) Both assertion (A) and reason (R) are true but reason (R) is not the correct explanation of assertion (A).

(c) Assertion (A) is true but reason (R) is false.

(d) Assertion (A) is false but reason (R) is true.

9. Assertion (A): Propagation of light through an optical fibre is due to total internal reflection taking place at the core-cladding interface.

Reason (R): Refractive index of the material of the cladding of the optical fibre is greater than that of the core.

Ans. (c) Assertion is true but Reason is false.

Cladding in optical fibres is one or more layers of materials of lower refractive index in intimate contact with a core material of higher refractive index. The cladding causes light to be confined to the core of the fibre by total internal reflection at the boundary between the core and cladding.

10. Assertion (A): If the focal length of two convex lenses is the same, the lens with the larger diameter will produce brighter images.

Reason (R): Convex lenses with larger diameters are able to focus light better.

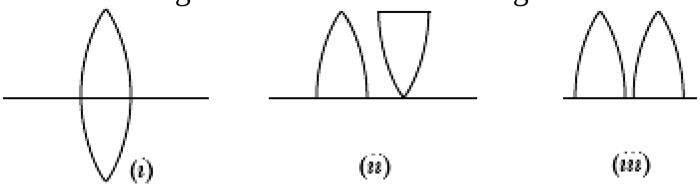
Ans. (c) Assertion is true but Reason is false.

The larger aperture means more light entering the lens hence a brighter image. The focal length of the lens determines the power of the lens i.e. its ability to converge or diverge the light.

SECTION – B

Questions 11 to 14 carry 2 marks each.

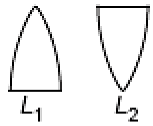
11. A thin double convex lens of focal length f is broken into two equal halves at the axis. The two halves are combined as shown in figure. What is the focal length of combination in (ii) and (iii)?



Ans.

Case (*ii*): If f_1 and f_2 are the focal length of lenses L_1 and L_2 respectively then.

$$f_1 = f, f_2 = -f$$



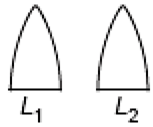
$\therefore$ Focal length of combination f will be given by

$$\frac{1}{f_1} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{f} - \frac{1}{f} = 0 \Rightarrow f = \infty$$

Case (*iii*): In this case, the focal lengths of both the lenses L_1 and L_2 are same.

$\therefore$ $$f_1 = f_2 = f$$

$\therefore$ $$\frac{1}{f'} = \frac{1}{f} + \frac{1}{f} = \frac{2}{f} \Rightarrow f' = \frac{f}{2}$$



OR

Using the lens formula, show that an object placed between the optical centre and the focus of a convex lens produces a virtual and an enlarged image.

Ans.

We know that $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$

For a convex lens, $f > 0$ and $u < 0$

Given that $0 < |u| < f$

From lens formula, $\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \left[\frac{1}{|f|} - \frac{1}{|u|}\right] < 0$

$\therefore$ $v < 0$, i.e. v is negative.

This shows that the image is virtual and lies on the same side as that of the object.

As $\frac{1}{|v|} < \frac{1}{|u|}$, we get $|v| > |u| \Rightarrow m = \frac{|v|}{|u|} > 1$

This shows that the image is enlarged.

12. Define resolving power of a compound microscope. How does the resolving power of a compound microscope change when

(i) refractive index of the medium between the object and objective lens increases?

(ii) wavelength of the radiation used is increased?

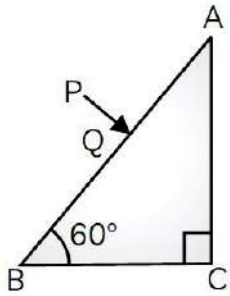
Ans. The resolving power of a microscope is the reciprocal of the minimum separation of two points seen a distinct.

$$\text{Resolving Power} = \frac{1}{d_{\min}} = \frac{2\mu \sin\beta}{1.22\,\lambda}$$

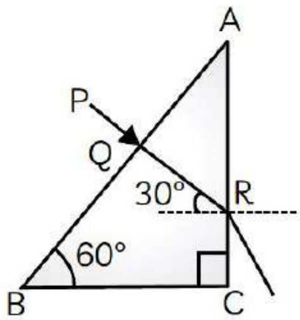
(i) As resolving power is proportional to μ, hence, on increasing the refractive index of the medium between an object and an objective lens, the resolving power increases.

(ii) As resolving power is proportional to 1/λ, hence, on increasing the wavelength of the radiation, the resolving power decreases.

13. A ray PQ incident normally on the refracting face BA is refracted in the prism BAC made of material of refractive index 1.5. Complete the path of ray through the prism. From which face will the ray emerge? Justify your answer.



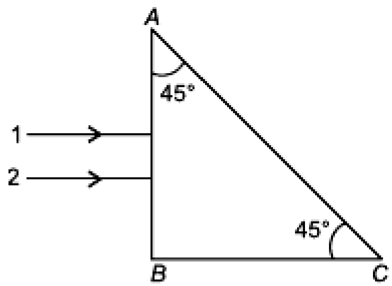
Ans. We know that, $n = 1/\sin i_c$
where, n = Refractive index



$\Rightarrow \sin i_c = 1/n = 1/1.5 = 0.667$
$\Rightarrow \sin i_c = \sin 41° 49' \Rightarrow i_c = 41° 49' \Rightarrow i_c > 30°$
i.e., incidence angle is less than the critical angle.
Thus, the light ray PQ will emerge out from face AC.

OR

Two monochromatic rays of light are incident normally on the face *AB* of an isosceles right angled prism *ABC*. The refractive indices of the glass prism for the two rays 1 and 2 are respectively 1.35 and 1.45. Trace the path of these rays after entering through the prism.



Ans.

We know that $\sin C = \frac{1}{n}$

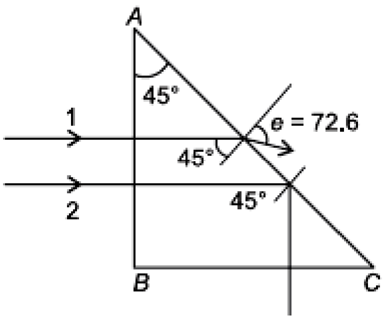
$$\Rightarrow n = \frac{1}{\sin i_C} = \frac{1}{\sin 45°} = 1.414$$

We conclude that for greater value of refractive index, the value of critical angle is lesser, i.e. the total internal reflection will take place. Here $n_1 < n_2$, so, the ray will get internally reflected.

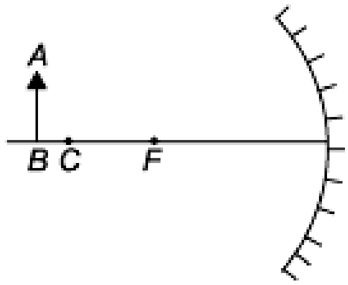
For the 1st ray, $n_1 = 1.35$

$$\frac{\sin e}{\sin 45} = 1.45$$

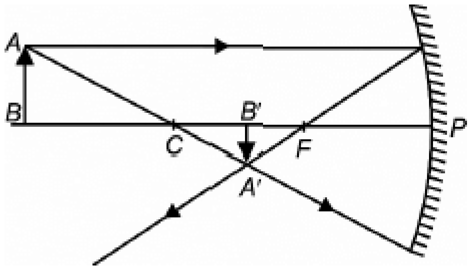
$$\Rightarrow \quad \sin e = \frac{1.35 \times 1}{\sqrt{2}} = 72.6°$$



14. An object AB is kept in front of a concave mirror as shown in the figure.



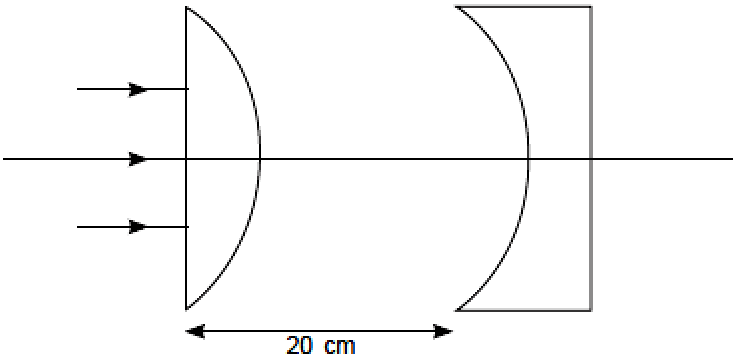
(i) Complete the ray diagram showing the image formation of the object.
(ii) How will the position and intensity of the image be affected if the lower half of the mirror's reflecting surface is painted black?
Ans. (i)



(ii) The position of the image remains same and the intensity of image gets reduced.

OR

In the given figure the radius of curvature of curved face in the plano-convex and the plano-concave lens is 15 cm each. The refractive index of the material of the lenses is 1.5. Find the final position of the image formed.



Ans. For Plano-convex lens, $\frac{1}{f_1} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

(Here, $R_1 = 15$, $R_2 = \infty$)

$$\frac{1}{f_1} = (1.5 - 1)\left(\frac{1}{15} - \frac{1}{\infty}\right) = \frac{1}{30}$$

Similarly, for Plano-concave lens,

$$\frac{1}{f_2} = (1.5 - 1)\left(\frac{1}{\infty} - \frac{1}{15}\right) = \frac{-1}{30}$$

(Here, $R_1 = \infty$, $R_2 = 15$ cm)

So, image is first formed at 30 cm from the convex lens. Since the two lenses are at a distance of 20 cm from each other. Therefore, for concave lens, u = +10 cm

$$v = \frac{uf}{u + f} = \frac{10 \times (-30)}{10 - 30} = +15 \text{ cm}$$

= image distance from concave lens.

SECTION – C

Questions 15 to 17 carry 3 marks each.

15. A convex lens made up of glass of refractive index 1.5 is dipped, in turn, in
(i) a medium of refractive index 1.65, (ii) a medium of refractive index 1.33.
(a) Will it behave as a converging or a diverging lens in the two cases?
(b) How will its focal length change in the two media?
Ans.

(a) According to the lens maker's formula,

$$\frac{1}{f} = (\mu_{gm} - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

(i) When the lens ($\mu = \mu_g$) is dipped in a medium of $\mu_m = 1.65$, then

$$\frac{\mu_g}{\mu_m} < 1 \qquad (\because \mu_g < \mu_m)$$

i.e. $$\mu_{gm} < 1 \text{ and } \mu_{gm} - 1 < 0$$

$$\frac{1}{f_m} < 1 \Rightarrow f_m < 1$$

i.e. the lens will behave like a diverging lens.

(ii) When lens is dipped in a medium of $\mu'_m = 1.33$.

$$\frac{\mu_g}{\mu'_m} < \mu_g \Rightarrow \mu'_{gm} < \mu_g$$

$$\mu'_{gm} - 1 < \mu_g - 1$$

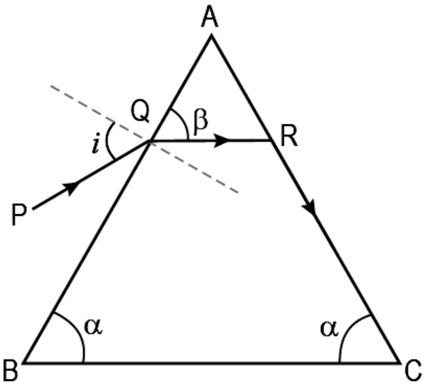
$$\frac{1}{f'_m} < \frac{1}{f} \Rightarrow f < f'_m$$

i.e. the lens will behave like a converging lens with increased focal length.

(b) (i) $$\frac{f_m}{f} = \frac{\mu_g - 1}{\mu_{gm} - 1} = \frac{1.5 - 1}{\frac{1.5}{1.65} - 1} = \frac{0.5 \times 1.65}{-0.15} = -5.5 \Rightarrow f_m = -5.5\,f$$

(ii) $$\frac{f'_m}{f} = \frac{\mu_g - 1}{\mu'_{gm} - 1} = \frac{f'_m}{f} = \frac{1.5 - 1}{\frac{1.5}{1.33} - 1} = \frac{0.5 \times 1.33}{0.17} \Rightarrow f'_m = 3.9\,f$$

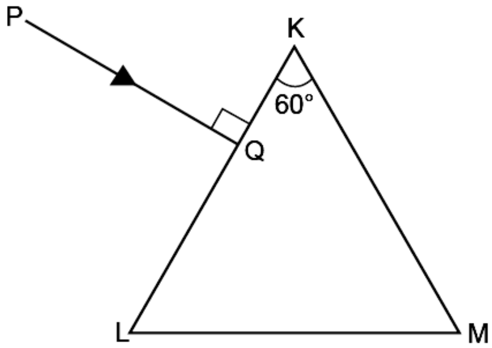
16. A ray of light incident on the face AB of an isosceles triangular prism makes an angle of incidence (i) and deviates by angle β as shown in the figure. Show that in the position of minimum deviation ∠β = ∠α. Also find out the condition when the refracted ray QR suffers total internal reflection.



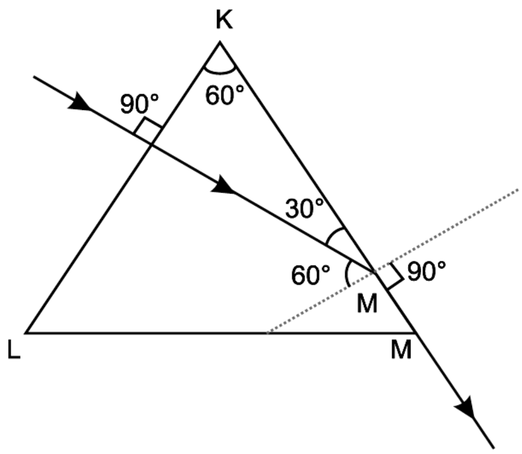
Ans. For minimum deviation, $r_1 + r_2 = A$
Also, $(90 - \beta) + (90 - \beta) = A$
$\Rightarrow 180 - 2\beta = A$
$\Rightarrow 2\beta = 180 - A$
$\Rightarrow 2\beta = 2\alpha$
$\Rightarrow \beta = \alpha$
We have, $r_1 + r_2 = A$
$\Rightarrow r_1 + i_c = A$ (Take $r_2 = i_c$)
$\Rightarrow i_c = A - r_1$
$\therefore i_c = A - (90 - \beta)$

OR

A triangular prism of refracting angle 60° is made of a transparent material of refractive index $\frac{2}{\sqrt{3}}$. A ray of light is incident normally on the face KL as shown in the figure. Trace the path of the ray as it passes through the prism and calculate the angle of emergence and angle of deviation.



Ans. When light ray incident on face KL, it is pass undeviated, because it is normal to the surface and incident on face KM.



The angle of incidence for face KM is equal to 60°.

$$\frac{\sin 60^0}{\sin r} = \frac{n_2}{n_1}$$, where, n_2 = Second medium = air

n_1 = Glass medium = $\frac{2}{\sqrt{3}}$

$$\Rightarrow \frac{\sin 60^0}{\sin r} = \frac{1}{2/\sqrt{3}} = \frac{\sqrt{3}}{2} \Rightarrow \sin r = \frac{\sin 60^0}{\frac{\sqrt{3}}{2}} = 1$$

$\Rightarrow \sin r = 1 \Rightarrow r = 90°$

Angle of emergence = 90°

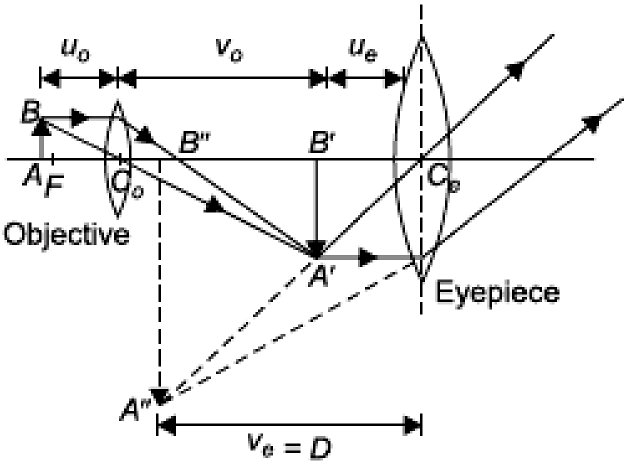
Angle of deviation = 30°

17. (a) Draw a labelled ray diagram of a compound microscope.

(b) Derive an expression for its magnifying power.

(c) Why is objective of a microscope of short aperture and short focal length? Give reason.

Ans. (a)



A compound microscope

(b) Total magnifying power of a compound mircroscope is given by

$$m = m_o \times m_e$$

$$\because \quad m_o = -\frac{v_o}{u_o} \text{ and } m_e = 1 + \frac{D}{f_e}$$

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

For the better resolution, we keep the object very close to the focus.

Hence, $u_o \approx f_o$

$v_o \approx L$

L is called the tube length of the microscope.

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

(c) We know that resolving power is $\frac{2\mu \sin\beta}{1.22\,\lambda}$. The shorter is the focal length, the greater is the value of sin β. Hence, the higher is the resolving power.

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

Again the shorter is the focal length, the higher is the magnifying power.

To reduce the spherical aberration, the aperture of objective is taken shorter.

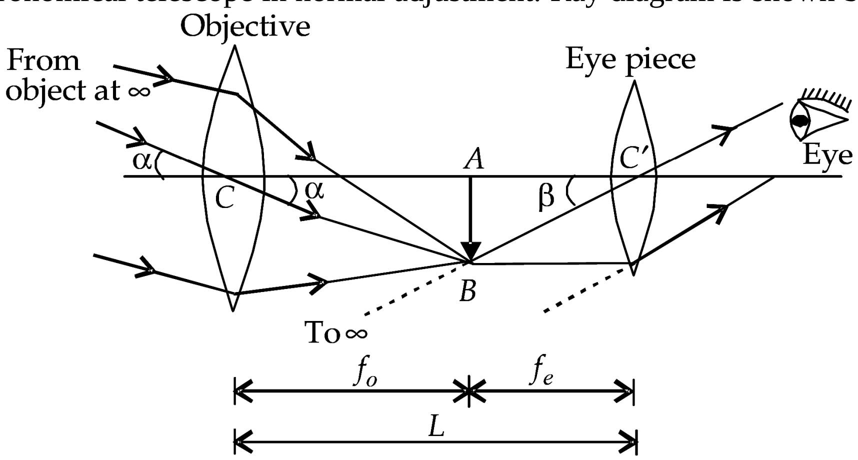
SECTION – D

Questions 18 carry 5 marks.

18. (i) Draw a neat labelled ray diagram of an astronomical telescope in normal adjustment. Explain briefly its working.

(ii) An astronomical telescope uses two lenses of powers 10 D and 1 D. What is its magnifying power in normal adjustment?

Ans: (i) An astronomical telescope in normal adjustment. Ray diagram is shown below.



It is used to see distant objects.

It consists of two lenses:

- Objective of large aperture and large focal length f_o
- Eyepiece of small aperture and short focal length f_e

Working : A parallel beam of light from an astronomical object at infinity is made to fall on objective lens. It forms a real, inverted and diminished image *AB* of the object. In normal adjustment, *AB* lies at focus of the eye piece. So a highly magnified, erect image (w.r.t. *AB*) is formed at infinity.

(ii) Here, power of objective lens = 1 D

Power of eye piece = 10 D
In normal adjustment

Magnifying power, $M = -\frac{f_0}{f_e} = -\frac{P_e}{P_0} \Rightarrow M = -10$

OR

Draw a labelled ray diagram of a reflecting telescope. Mention its two advantages over the refracting telescope.

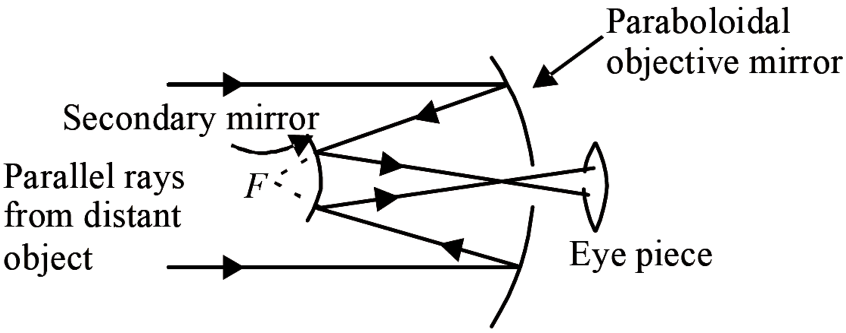
Ans: **Reflecting type telescope:** It is a telescope with concave parabolic mirror as objective. It has several advantages over refracting type telescope like having no chromatic aberration, no spherical aberration, has huge light gathering power and low cost.

The magnifying power of reflecting telescope is given by

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

(i) Cassegrain Reflecting Telescope

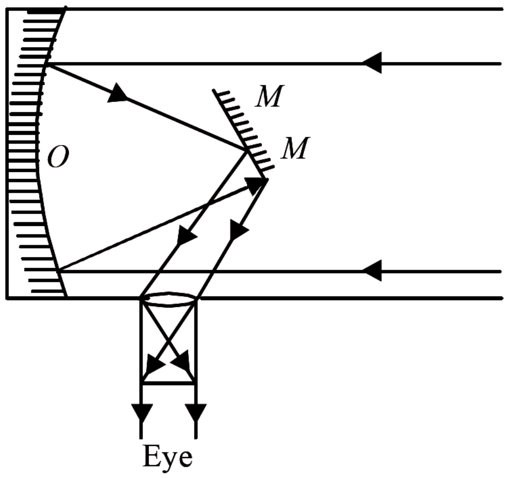
It consist of a large primary concave parabolic shape mirror having a hole at its centre. Another secondary convex mirror before the focus of primary mirror forms the image



The parallel rays from astronomical object are reflected by primary concave mirror and then are further reflected by convex mirror before getting focussed at eye piece. Eyepiece removes the defects from the image and also act as magnifier.

(ii) Newtonian Telescope

Primary concave mirror of large aperture as objective reflects the parallel rays from astronomical object.



Plane mirror M is placed at 45° with the axis of the tube. Light reflected from concave mirror falls on plane mirror M and further deviated to form a real image at eyepiece located at convenient place for observer. The eyepiece removes the defects from image and also act as magnifier.

Advantage of reflecting type telescope over refracting type :

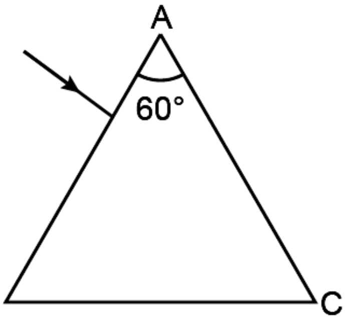
(i) In refracting type the final image is formed after two times of partial refraction through the lens major losses in the intensity take places due to partial reflection and refractions. In reflecting

type all the light intensity incident formes the final image as no loss of intensity can be ensured in reflection.
(ii) Glass of lens offers different refractive index to different colours hence chromatic aberration due to which coloured image is formed take place in refracting type telescope. Reflecting telescope is free from chromatic aberration as no refraction.

SECTION – E (Case Study Based Questions)

Questions 19 to 20 carry 4 marks each.

19. Refraction through Prism: Strontium titanate is a rare oxide a natural mineral found in Siberia. It is used as a substitute for diamond because its refractive index and critical angle are 2.41 and 24.5˚, respectively, which are approximately equal to the refractive index and critical angle of diamond. It has all the properties of diamond. Even an expert jeweller is unable to differentiate between diamond and strontium titanate. A ray of light is incident normally on one face of an equilateral triangular prism ABC made of strontium titanate.



(i) The necessary conditions for total internal reflection is
(a) the angle of incidence in denser medium must be smaller than the critical angle for two media
(b) the angle of refraction in denser medium must be greater than the critical angle for two media
(c) the angle of incidence in denser medium must be greater than the critical angle for two media
(d) none of these

(ii) The speed of light in a medium whose critical angle is 30° is
(a) 3 × 108 m/s (b) 2 × 108 m/s (c) 1.5 × 108 m/s (d) 2.5 × 108 m/s

(iii) Dispersion power depends upon
(a) height of the prism (b) angle of prism (c) material of prism (d) the shape of prism

(iv) A ray of light incident at an angle i on refracting face of a prism emerges from the other normally. If the angle of the prism is 30° and the prism is made up of a material of refractive index 1.5, the angle of incidence is
(a) 30° (b) 45° (c) 60° (d) 90°

OR

When light rays are incident on a prism at an angle of 45°, the minimum deviation is obtained. If refractive index of prism is 2 , then the angle of prism will be
(a) 60° (b) 40° (c) 50° (d) 30°
Ans. (i) (c) For Total Internal Reflection, $i > i_c$
(ii) (c) Here, $i_c = 30°$

As $n = \frac{c}{v} = \frac{1}{\sin i_c} \Rightarrow v = c \sin i_c$

$\Rightarrow v = 3 \times 10^8 \times 0.5$
$\therefore v = 1.5 \times 10^8$ m/s
(iii) (c) Dispersive power of prism depends upon nature of material of prism.
(iv) (b) We know that, $\delta = (n - 1)A$ and $\delta = i - r$
$\Rightarrow \delta = (1.5 - 1) 30 = 0.5 \times 30 = 15°$
Also, $\delta = i - r = \theta - r$

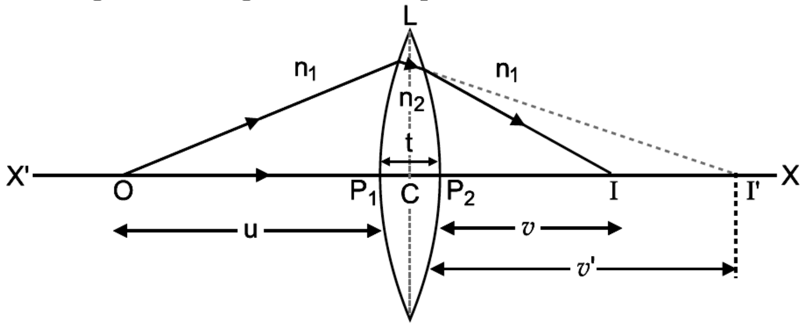
$\Rightarrow$ 15° = θ – 30° [∵ ∠r = 30°]
∴ θ = 15° + 30° = 45°
∴ θ = i = 45°

OR

(a) $n = \dfrac{\sin\left(\dfrac{A+\delta_m}{2}\right)}{\sin\left(\dfrac{A}{2}\right)}$ but $\dfrac{A+\delta_m}{2} = i = 45^0$

$\sqrt{2} = \dfrac{\sin 45^0}{\sin\left(\dfrac{A}{2}\right)} \Rightarrow \sin\dfrac{A}{2} = \dfrac{1}{2} = \sin 30^0 \Rightarrow \dfrac{A}{2} = 30^0 \Rightarrow A = 60^0$

20. Lens Maker's Formula: The lens maker's formula is useful to design lenses of desired focal lengths using surfaces of suitable radii of curvature. The focal length also depends on the refractive index of the material of the lens and the surrounding medium. The refractive index depends on the wavelength of the light used. The power of a lens is related to its focal length.



(i) How will the power of lens affected with an increase of wave length of light?
(a) increases (b) decreases
(c) first increases then decreases (d) first decreases then increases

(ii) The radius of curvatures of two surface of a convex lens is R. For what value of n of its material will its focal length become equal to R?
(a) 1 (b) 1.5 (c) 2 (d) infinite

(iii) An object is immersed in a fluid. In order that the object becomes invisible, it should
(a) behave as perfect reflector
(b) absorb all the light falling on it
(c) have refractive index 1
(d) have refractive index exactly matching with that of the surrounding fluid

(iv) An object is placed in front of a Lens Which forms its erect image of magnification 3. The Power of the lens is 5D. Calculate the distance of the image from the lens.
(a) – 40 cm (b) 40 cm (c) – 80 cm (d) 80 cm

OR

The focal length of a concave lens of μ = 1.5 is 20 cm is air. It is completely immersed in water μ = 4/3. Its focal length in water will be
(a) 20 cm (b) 40 cm (c) 60 cm (d) 80 cm

Ans. (i) (b) As from lens make's formula, $\dfrac{1}{f} \propto (n-1)$ and $P = \dfrac{1}{f} \Rightarrow P \propto (n-1)$

Also, $n \propto \dfrac{1}{\lambda}$, Hence $P \propto \dfrac{1}{\lambda}$

Thus, if wavelength (λ) of light increases then power of lens decreases.
(ii) (b) From Lens maker's formula,

$$\frac{1}{f}=(n-1)\left(\frac{1}{R_1}+\frac{1}{R_2}\right)\Rightarrow\frac{1}{f}=(n-1)\left(\frac{2}{f}\right) \qquad (\because f = \text{R})$$

$$\Rightarrow\frac{1}{2}=(n-1)\Rightarrow n=1.5$$

(iii) (d) When the refractive index of the object is same as that of the media around it, then the rays pass undeflected and the object appears to be invisible.

(iv) (a) For virtual and erect image, $m=\frac{v}{u}\Rightarrow 3=\frac{v}{u}\Rightarrow v=3u$

and $f=\frac{1}{P}\Rightarrow f=\frac{1}{5}=0.2m=20cm$

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

$$\Rightarrow\frac{1}{20}=\frac{1}{3u}-\frac{1}{u}\Rightarrow\frac{1-3}{3u}=\frac{1}{20}\Rightarrow u=-\frac{40}{3}cm$$

and $v=3u=3\times-\frac{40}{3}=-40cm$

OR

(d) Using lens maker's formula, $\frac{1}{f}=(n-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$

$$\Rightarrow\frac{1}{20}=(1.5-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right) \qquad \text{……… (i)}$$

And, $\frac{1}{f_w}=\left(\frac{1.5}{4/3}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$ ……… (ii)

From equation (*i*) and (*ii*), we get, $\frac{\frac{1}{20}}{\frac{1}{f_w}}=\frac{0.5}{\frac{1}{8}}=4\Rightarrow\frac{f_w}{20}=4\Rightarrow f_w=80cm$