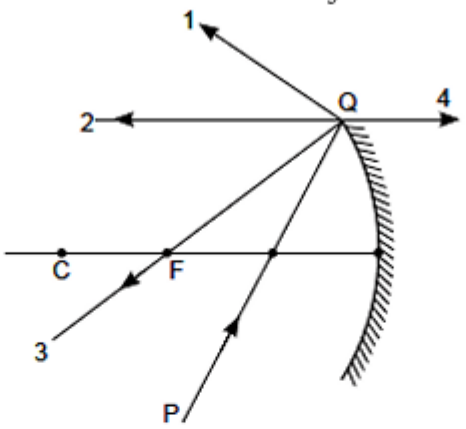
UNIT 09

RAY OPTICS AND OPTICAL INSTRUMENTS

SECTION – A

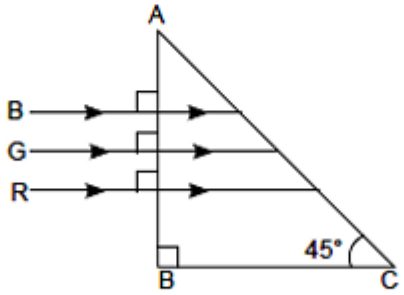
Questions 1 to 10 carry 1 mark each.

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

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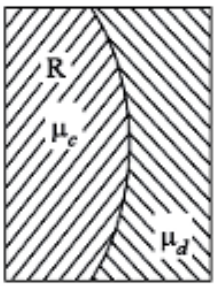
4. A biconvex lens of focal length f is cut into two identical plano convex lenses. The focal length of each part will be
(a) f (b) f/2 (c) 2f (d) 4f

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.

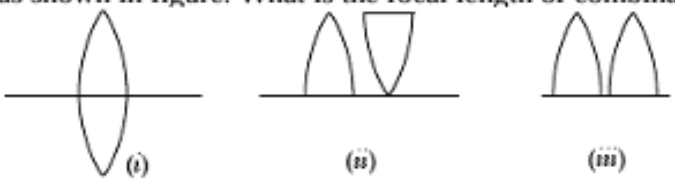
9. **Assertion (A):** Propagation of light through an optical fibre is due to total internal reflection taking place at the core-cladding interface.
Reason (R): Refractive index of the material of the cladding of the optical fibre is greater than that of the core.

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)?

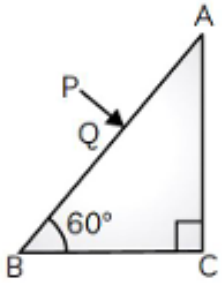


OR

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.

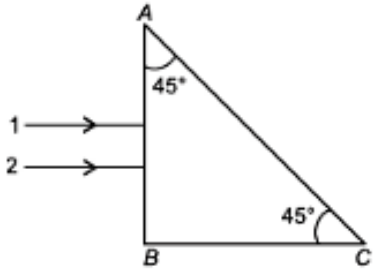
12. Define resolving power of a compound microscope. How does the resolving power of a compound microscope change when
(i) refractive index of the medium between the object and objective lens increases?
(ii) wavelength of the radiation used is increased?

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.

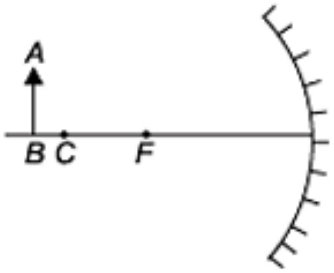


OR

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

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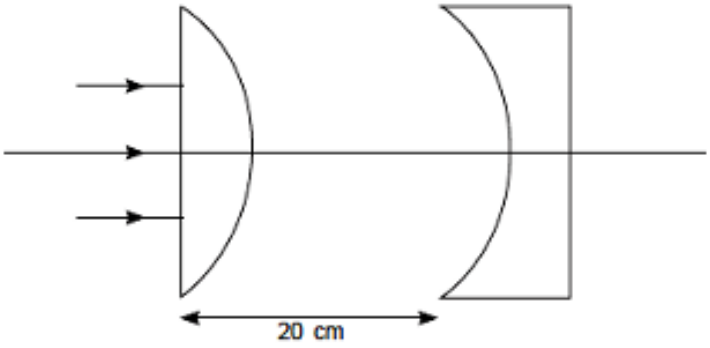
In the given figure the radius of curvature of curved face in the plano-convex and the plano-concave lens is 15 cm each. The refractive index of the material of the lenses is 1.5. Find the final position of the image formed.

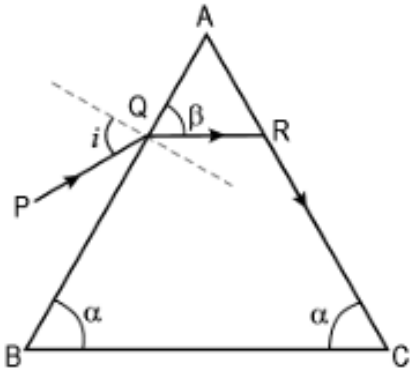


SECTION – C

Questions 15 to 17 carry 3 marks each.

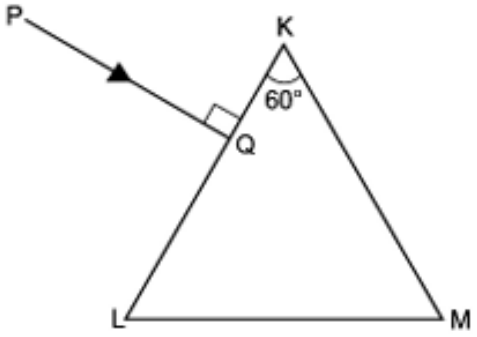
15. A convex lens made up of glass of refractive index 1.5 is dipped, in turn, in
(i) a medium of refractive index 1.65, (ii) a medium of refractive index 1.33.
(a) Will it behave as a converging or a diverging lens in the two cases?
(b) How will its focal length change in the two media?

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?

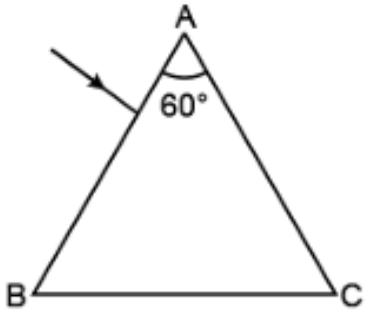
OR

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

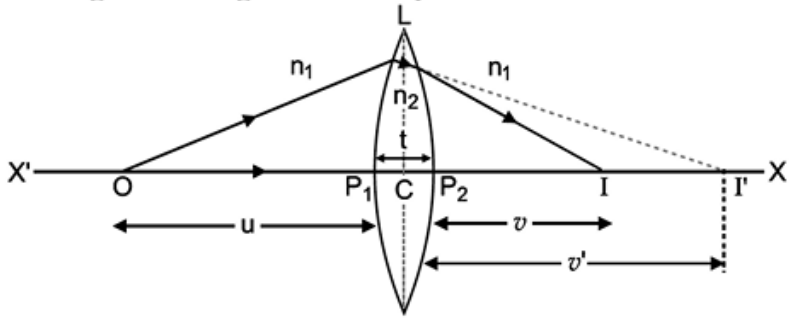
(iii) Dispersion power depends upon
(a) height of the prism (b) angle of prism (c) material of prism (d) the shape of prism

(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