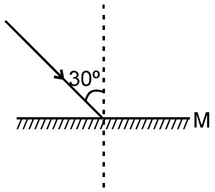
Exercise-1

✍ **Marked Questions can be used as Revision Questions.**

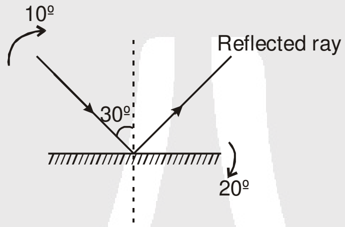
PART - I : SUBJECTIVE QUESTIONS

SECTION (A) : PLANE MIRROR

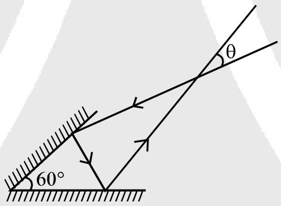
A-1. Find the angle of deviation (both clockwise and anticlockwise) suffered by a ray incident on a plane mirror, (as shown in figure) at an angle of incidence 30º.



A-2. Figure shows a plane mirror on which a light ray is incident. If the incident light ray is turned by 10º and the mirror by 20º, as shown, find the angle turned by the reflected ray.

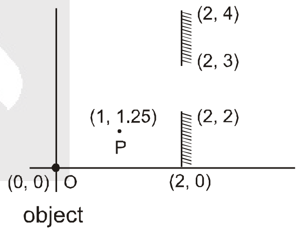


A-3. A light ray is incident on a plane mirror, which after getting reflected strikes another plane mirror, as shown in figure. The angle between the two mirrors is 60º. Find the angle 'θ' shown in figure.

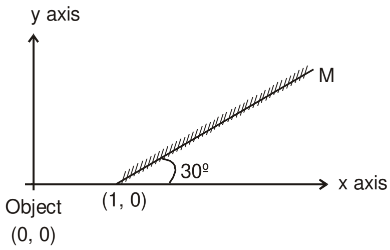


A-4. Sun rays are incident at an angle of 24° with the horizon. How can they be directed parallel to the horizon using a plane mirror?

A-5. Two plane mirrors are placed as shown in the figure and a point object 'O' is placed at the origin
(a) How many images will be formed.
(b) Find the position(s) of image(s).
(c) Will the incident ray passing through a point 'P' (1, 1.25) take part in image formation.



A-6. A point object is placed at (0, 0) and a plane mirror 'M' is placed, inclined 30º with the x axis.
(a) Find the position of image.
(b) If the object starts moving with velocity 1 $\hat{i}$ m/s and the mirror is fixed find the velocity of image.



SECTION (B) : SPHERICAL MIRROR

B-1. A rod of length 5 cm lies along the principal axis of a concave mirror of focal length 10 cm in such a way that the end farther from the pole is 15 cm away from it. Find the length of the image.

B-2. A point source is at a distance 35 cm on the optical axis from a spherical concave mirror having a focal length 25 cm. At what distance measured along the optical axis from the concave mirror should a plane mirror (perpendicular to principal axis) be placed for the image it forms (due to rays falling on it after reflection from the concave mirror) to coincide with the point source?

B-3. Find the diameter of the image of the moon formed by a spherical concave mirror of focal length 11.4 m. The diameter of the moon is 3450 km and the distance between the earth and the moon is 3.8×10^5 km.

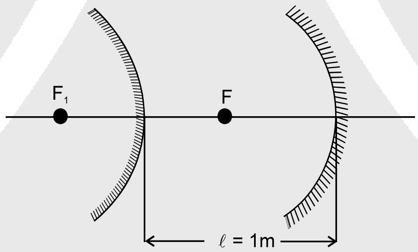
B-4. The radius of curvature of a convex spherical mirror is 1.2 m. How far away from the mirror is an object of height 1.2 cm if the distance between its virtual image and the mirror is 0.35 m? What is the height of the image? [Apply formula for paraxial rays]

B-5. A converging beam of light rays is incident on a concave spherical mirror whose radius of curvature is 0.8 m. Determine the position of the point on the optical axis of the mirror where the reflected rays intersect, if the extensions of the incident rays intersect the optical axis 40 cm from the mirror's pole.

B-6. A point object is placed on the principal axis at 60 cm in front of a concave mirror of focal length 40 cm on the principal axis. If the object is moved with a velocity of 10 cm/s (a) along the principal axis, find the velocity of image (b) perpendicular to the principal axis, find the velocity of image at that moment.

B-7. A man uses a concave mirror for shaving. He keeps his face at a distance of 20 cm from the mirror and gets an image which is 1.5 times enlarged. Find the focal length of the mirror.

B-8. Two spherical mirrors (convex and concave) having the same focal length of 36 cm are arranged as shown in figure so that their optical axes coincide. The separation between the mirrors is 1 m. At what distance from the concave mirror should an object be placed so that its images formed by the concave and convex mirrors independently are identical in size?

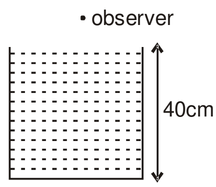


SECTION (C) : REFRACTION IN GENERAL, REFRACTION AT PLANE SURFACE AND T.I.R.

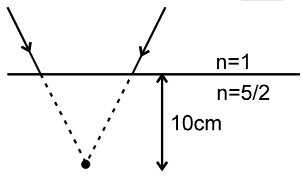
C-1. A light ray falling at an angle of 60° with the surface of a clean slab of ice of thickness 1.00 m is refracted into it at an angle of 15°. Calculate the time taken by the light rays to cross the slab. Speed of light in vacuum = 3×10^8 m/s.

C-2. A light ray is incident at 45° on a glass slab. The slab is 3 cm thick, and the refractive index of the glass is 1.5. What will the lateral displacement of the ray be as a result of its passage through the slab? At what angle will the ray emerge from the slab?

C-3. In the given figure an observer in air (n = 1) sees the bottom of a beaker filled with water (n = 4/3) upto a height of 40 cm. What will be the depth felt by this observer.

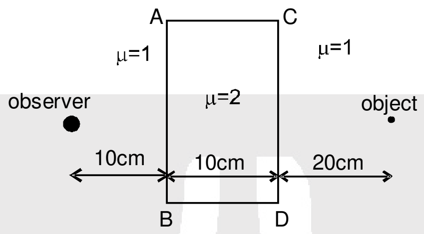


C-4. In the given figure rays incident on an interface would converge 10 cm below the interface if they continued to move in straight lines without bending. But due to refraction, the rays will bend and meet some where else. Find the distance of meeting point of refracted rays below the interface, assuming the rays to be making small angles with the normal to the interface.

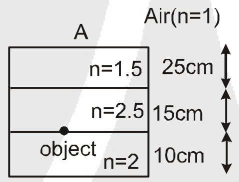


C-5. A fish is rising up vertically inside a pond with velocity 4 cm/s, and notices a bird, which is diving vertically downward along the same vertical line as that of fish and its velocity appears to be 16 cm/s (to the fish). What is the real velocity of the diving bird, if refractive index of water is 4/3?

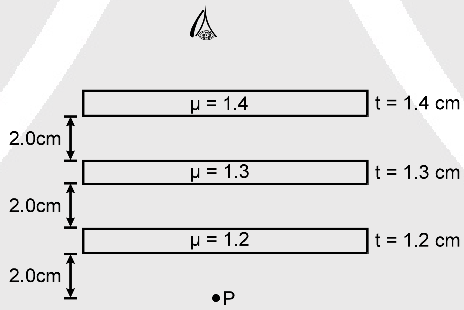
C-6✍. Find the apparent distance between the observer and the object shown in the figure and shift in the position of object.



C-7. Find the apparent depth of the object seen by observer A (in the figure shown)



C-8✍. Locate the image of the point P as seen by the eye in the figure.

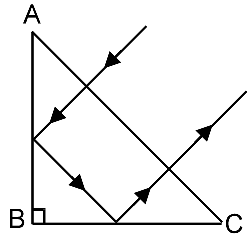


C-9. A small object is placed at the centre of the bottom of a cylindrical vessel of radius 3 cm and height $3\sqrt{3}$ cm filled completely with a liquid. Consider the ray leaving the vessel through a corner. Suppose this ray and the ray along the axis of the vessel are used to trace the image. Find the apparent depth of the image. Refractive index of liquid = $\sqrt{3}$.

C-10. A point source is placed at a depth h below the surface of water (refractive index = μ).The medium above the surface of water is air (μ =1).Find the area on the surface of water through which light comes in air from water.

C-11. Light is incident from glass (μ = 3/2) side on interface of glass and air. Find the angle of incidence for which the angle of deviation is 90º.

C-12. At what values of the refractive index of a rectangular prism can a ray travel as shown in figure. The section of the prism is an isosceles triangle and the ray is normally incident onto the face AC.

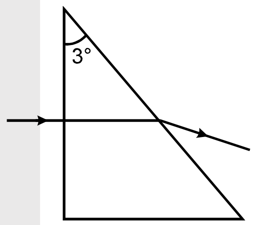


SECTION D : REFRACTION BY PRISM

D-1. A prism (n = 2) of apex angle 90° is placed in air (n = 1). What should be the angle of incidence so that light ray strikes the second surface at an angle of incidence 60º.

D-2. The cross section of a glass prism has the form of an equilateral triangle. A ray is incident onto one of the faces perpendicular to it. Find the angle θ between the incident ray and the ray that leaves the prism. The refractive index of glass is $\mu = 1.5$.

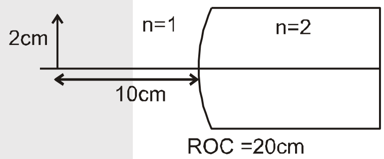
D-3. Find the angle of deviation suffered by the light ray shown in figure for following two conditions The refractive index for the prism material is $\mu = 3/2$.
(i) When the prism is placed in air ($\mu = 1$)
(ii) When the prism is placed in water ($\mu = 4/3$)



D-4. The refractive index of a prism is μ. Find the maximum angle of the prism for which a ray incident on it will be transmitted through other face without total internal reflection.

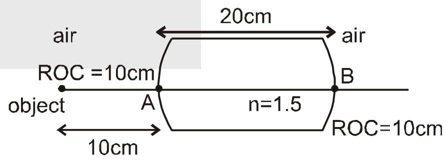
SECTION (E) : REFRACTION BY SPHERICAL SURFACE

E-1. An extended object of size 2 cm is placed at a distance of 10 cm in air (n = 1) from pole, on the principal axis of a spherical curved surface. The medium on the other side of refracting surface has refractive index n = 2. Find the position, nature and size of image formed after single refraction through the curved surface.

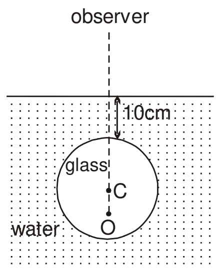


E-2. A point object lies inside a transparent solid sphere of radius 20 cm and of refractive index n = 2. When the object is viewed from air through the nearest surface it is seen at a distance 5 cm from the surface. Find the apparent distance of object when it is seen through the farthest curved surface.

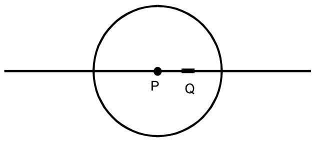
E-3. An object is placed 10 cm away from a glass piece (n = 1.5) of length 20 cm bounded by spherical surfaces of radii of curvature 10 cm. Find the position of final image formed after two refractions at the spherical surfaces.



E-4. There is a small air bubble inside a glass sphere ($\mu = 1.5$) of radius 5 cm. The bubble is at 'O' at 7.5 cm below the surface of the glass. The sphere is placed inside water ($\mu = 4/3$) such that the top surface of glass is 10 cm below the surface of water. The bubble is viewed normally from air. Find the apparent depth of the bubble.

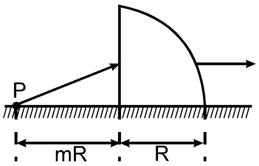


E-5. A small object Q of length 1 mm lies along the principal axis of a spherical glass of radius R = 10 cm and refractive index is 3/2. The object is seen from air along the principal axis from left. The distance of object from the centre P is 5 cm. Find the size of the image. Is it real, inverted?



E-6. A narrow parallel beam of light is incident paraxially on a solid transparent sphere of radius r kept in air. What should be the refractive index if the beam is to be focused
(a) at the farther surface of the sphere, (b) at the centre of the sphere.

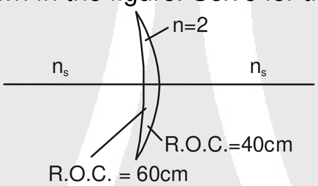
E-7. A quarter cylinder of radius R and refractive index 1.5 is placed on a table. A point object P is kept at a distance of mR from it. Find the value of m for which a ray from P will emerge parallel to the table as shown in the figure.



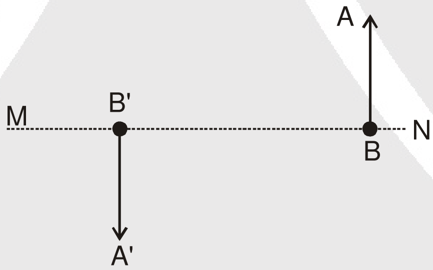
SECTION (F) : LENS

F-1. Lenses are constructed by a material of refractive index 2. The magnitude of the radii of curvature are 20 cm and 30 cm. Find the focal lengths of the possible lenses with the above specifications.

F-2. Find the focal length of lens shown in the figure. Solve for three cases $n_s = 1.5$, $n_s = 2.0$, $n_s = 2.5$.



F-3. Given an optical axis MN and the positions of a real object AB and its image A 'B', determine diagrammatically the position of the lens (its optical centre O) and its foci. Is it a converging or diverging lens? Is the image real or virtual?



F-4. A thin lens made of a material of refractive index μ_2 has a medium of refractive index μ_1 on one side and a medium of refractive index μ_3 on the other side. The lens is biconvex and the two radii of curvature has equal magnitude R. A beam of light travelling parallel to the principal axis is incident on the lens. Where will the image be formed if the beam is incident from (a) the medium μ_1 and (b) from the medium μ_3?

F-5. Two glasses with refractive indices of 1.5 & 1.7 are used to make two identical double-convex lenses.
(i) Find the ratio of their focal lengths.
(ii) How will each of these lenses act on a ray parallel to its optical axis if the lenses are submerged into a transparent liquid with a refractive index of 1.6?

F-6. An object of height 1 cm is set at right angles to the optical axis of a double convex lens of optical power 5 D and 25 cm away from the lens. Determine the focal length of the lens, the position of the image, the linear magnification of the lens, and the height of the image formed by it.

F-7. A lens placed between a candle and a fixed screen forms a real triply magnified image of the candle on the screen. When the lens is moved away from the candle by 0.8 m without changing the position of the candle, a real image one-third the size of the candle is formed on the screen. Determine the focal length of the lens.

F-8. A pin of length 1 cm lies along the principal axis of a converging lens, the centre being at a distance of 5.5 cm from the lens. The focal length of the lens is 3 cm. Find the size of the image.

F-9. The radius of the sun is 0.75×10^9 m and its distance from the earth is 1.5×10^{11} m. Find the diameter of the image of the sun formed by a lens of focal length 40 cm.

F-10. A 2.5 dioptre lens forms a virtual image which is 4 times the object placed perpendicularly on the principal axis of the lens. Find the required distance of the object from the lens.

F-11. A diverging lens of focal length 20 cm is placed coaxially 5 cm towards left of a converging mirror of focal length 10 cm. Where should an object be placed towards left of the lens so that a real image is formed at the object itself ?

F-12. A convex lens and a convex mirror are placed at a separation of 15 cm. The focal length of the lens is 25 cm and radius of curvature of the mirror is 80 cm. Where should a point source be placed between the lens and the mirror so that the light, after getting reflected by the mirror and then getting refracted by the lens, comes out parallel to the principal axis?

F-13. A point object is placed on the principal axis of a converging lens of focal length 15 cm at a distance of 30 cm from it. A glass plate (μ = 1.50) of thickness 3 cm is placed on the other side of the lens perpendicular to the axis. Find the position of the image of the point object.

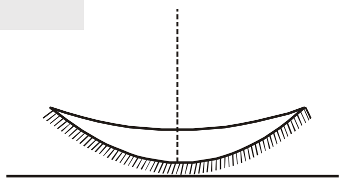
F-14. A converging lens of focal length 10 cm and a diverging lens of focal length 5 cm are placed 5 cm apart with their principal axes coinciding. A beam of light travelling parallel to the principal axis and having a beam diameter 5.0 mm, is incident on the combination. Show that the emergent beam is parallel to the incident one. Find the beam diameter of the emergent beam. Also find out the ratio of emergent and incident intensities.

SECTION (G) : COMBINATION OF LENSES/LENS AND MIRRORS.

G-1. Two identical thin converging lenses brought in contact so that their axes coincide are placed 12.5 cm from an object. What is the optical power of the system and each lens, if the real image formed by the system of lenses is four times as large as the object?

G-2. A point object is placed at a distance of 15 cm from a convex lens. The image is formed on the other side at a distance of 30 cm from the lens. When a concave lens is placed in contact with the convex lens, the image shifts away further by 30 cm. Calculate the focal lengths of the two lenses.

G-3. The convex surface of a thin concavo-convex lens of glass of refractive index 1.5 has a radius of curvature 20 cm. the concave surface has a radius of curvature 60 cm. The convex side is silvered and placed on a horizontal surface as shown in figure. (a) Where should a pin be placed on the axis so that its image is formed at the same place? (b) If the concave part is filled with water (μ = 4/3), find the distance through which the pin should be moved so that the image of the pin again coincides with the pin.

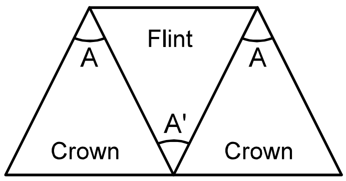


SECTION (H) : DISPERSION OF LIGHT

H-1. A certain material has refractive indices 1.53, 1.60 and 1.68 for red, yellow and violet light respectively. (a) Calculate the dispersive power. (b) Find the angular dispersion produced by a thin prism of angle 6° made of this material.

H-2. A flint glass prism and a crown glass prism are to be combined in such a way that the deviation of the mean ray is zero. The refractive index of flint and crown glasses for the mean ray are 1.6 and 1.9 respectively. If the refracting angle of the flint prism is 6°, what would be the refracting angle of crown prism?

H-3. Three thin prisms are combined as shown in figure. The refractive indices of the crown glass for red, yellow and violet rays are μ_r, μ_y and μ_v respectively and those for the flint glass are μ_r', μ_y' and μ_v' respectively. Find the ratio A′/A for which (a) system produces deviation without dispersion (achromatic combination) and (b) system produces dispersion without deviation (direct vision arrangement).



H-4. The focal lengths of a convex lens for red, yellow and violet rays are 100 cm, 99 cm and 98 cm respectively. Find the dispersive power of the material of the lens.

H-5. A thin prism of angle 5.0°, ω = 0.07 and μ_y = 1.30 is combined with another thin prism having ω' = 0.08 and μ'_y = 1.50. The combination produces no deviation in the mean ray. (a) Find the angle of the second prism. (b) Find the net angular dispersion produced by the combination when a beam of white light passes through it. (c) If the prisms are similarly directed, what will be the deviation in the mean ray? (d) Find the angular dispersion in the situation described in (c).

SECTION (I) : FOR JEE MAIN

I-1. A small telescope has an objective lens of focal length 144 cm and an eye-piece of focal length 6.0 cm. What is the magnifying power of the telescope? What is the separation between the objective and the eye-piece ?

I-2. An angular magnification (magnifying power) of 30 X is desired using an objective of focal length 1.25cm and an eye-piece of focal length 5 cm. How will you set up the compound microscope for normal adjustment (Final image at ∞)?

I-3. A compound microscope consists of an objective lens of focal 2.0 cm and an eye-piece of focal length 6.25 cm separated by a distance of 15 cm. How far from the objective should an object be placed in order to obtain the final image at (a) least distance of distinct vision (25 cm), (b) infinity? What is the magnifying power of the microscope in each case ?

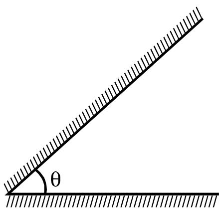
PART - II : ONLY ONE OPTION CORRECT TYPE

SECTION (A) : PLANE MIRROR

A-1. Two plane mirrors are inclined to each other at an angle 60°. If a ray of light incident on the first mirror is parallel to the second mirror, it is reflected from the second mirror

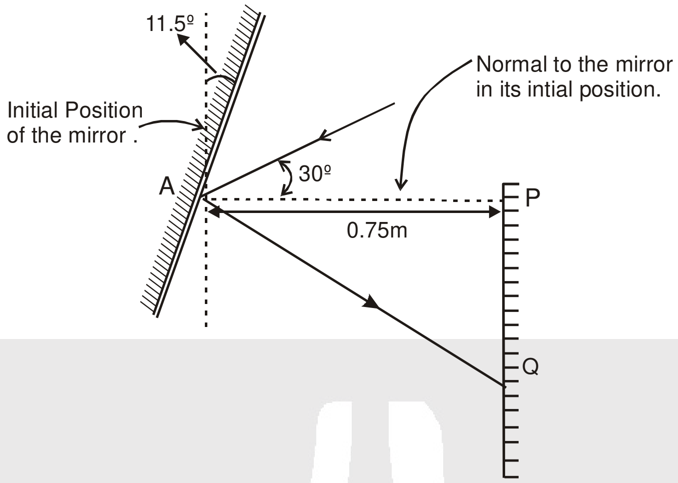
(A) Perpendicular to the first mirror
(B) Parallel to the first mirror
(C) Parallel to the second mirror
(D) Perpendicular to the second mirror

A-2. Two mirrors are inclined at an angle θ as shown in the figure. Light ray is incident parallel to one of the mirrors. Light will start retracing its path after third reflection if :



(A) θ = 45° (B) θ = 30° (C) θ = 60° (D) all three

A-3. The view in the figure is from above a plane mirror suspended by a thread connected to the centre of the mirror at point A. A scale is located 0.75 m (the distance from point A to point P) to the right of the centre of the mirror. Initially, the plane of the mirror is parallel to the side of the scale; and the angle of incidence of a light ray which is directed at the centre of the mirror is 30º. A small torque applied to the thread causes the mirror to turn 11.5° away from its initial position. The reflected ray then intersects the scale at point Q.



The distance from point P to point Q on the scale is :

(A) 1.00 m (B) 0.56 m (C) 1.02 m (D) 0.86 m.

A-4. A point object is kept in front of a plane mirror. The plane mirror is performing SHM of amplitude 2 cm. The plane mirror moves along the x-axis and x- axis is normal to the mirror. The amplitude of the mirror is such that the object is always infront of the mirror. The amplitude of SHM of the image is

(A) zero (B) 2 cm (C) 4 cm (D) 1 cm

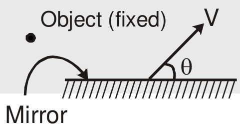
A-5. A person's eye is at a height of 1.5 m. He stands infront of a 0.3m long plane mirror which is 0.8 m above the ground. The length of the image he sees of himself is:

(A) 1.5m (B) 1.0m (C) 0.8m (D) 0.6m

A-6. An unnumbered wall clock shows time 04: 25: 37, where 1st term represents hours, 2nd represents minutes and the last term represents seconds. What time will its image in a plane mirror show.

(A) 08: 35: 23 (B) 07: 35: 23 (C) 07: 34: 23 (D) none of these

A-7. An object and a plane mirror are as shown in figure. Mirror is moved with velocity V as shown. The velocity of image is :



(A) 2 V sinθ (B) 2 V (C) 2V cosθ (D) none of these

A-8. A plane mirror is moving with velocity $4\hat{i}+5\hat{j}+8\hat{k}$. A point object in front of the mirror moves with a velocity $3\hat{i}+4\hat{j}+5\hat{k}$. Here $\hat{k}$ is along the normal to the plane mirror and facing towards the object. The velocity of the image is :

(A) $-3\hat{i}-4\hat{j}+5\hat{k}$ (B) $3\hat{i}+4\hat{j}+11\hat{k}$ (C) $-3\hat{i}-4\hat{j}+11\hat{k}$ (D) $7\hat{i}+9\hat{j}+11\hat{k}$

A-9. Two plane mirrors are parallel to each other and spaced 20 cm apart. An object is kept in between them at 15 cm from A. Out of the following at which point(s) image(s) is/are not formed in mirror A (distance measured from mirror A):

(A) 15 cm (B) 25 cm (C) 45 cm (D) 55 cm

SECTION (B) : SPHERICAL MIRROR

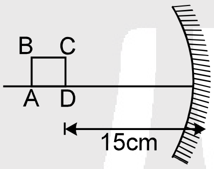
B-1. An object of height 1 cm is kept perpendicular to the principal axis of a convex mirror of radius of curvature 20 cm. If the distance of the object from the mirror is 20 cm then the distance (in cm) between heads of the image and the object will be:

(A) $\sqrt{\frac{6404}{9}}$ (B) $\sqrt{\frac{6414}{9}}$ (C) $\frac{40}{3}$ (D) none of these

B-2. A point object is kept between a plane mirror and a concave mirror facing each other. The distance between the mirrors is 22.5 cm. Plane mirror is placed perpendicular to principal axis of concave mirror. The radius of curvature of the concave mirror is 20 cm. What should be the distance of the object from the concave mirror so that after two successive reflections the final image is formed on the object itself? (Consider first reflection from concave mirror)

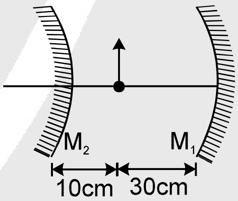
(A) 5 cm (B) 15 cm (C) 10 cm (D) 7.5 cm

B-3. A square ABCD of side 1mm is kept at distance 15 cm infront of the concave mirror as shown in the figure. The focal length of the mirror is 10 cm. The length of the perimeter of its image will be(nearly):



(A) 8 mm (B) 2 mm (C) 12 mm (D) 6 mm

B-4. In the figure shown find the total magnification after two successive reflections first on M_1 and then on M_2 .



(A) + 1 (B) – 2 (C) + 2 (D) – 1

B-5. A luminous point object is moving along the principal axis of a concave mirror of focal length 12 cm towards it. When its distance from the mirror is 20 cm its velocity is 4 cm/s. The velocity of the image in cm/s at that instant is

(A) 6, towards the mirror (B) 6, away from the mirror
(C) 9, away from the mirror (D) 9, towards the mirror.

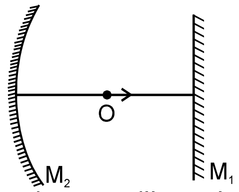
B-6. A particle is moving towards a fixed spherical mirror. The image:

(A) must move away from the mirror
(B) must move towards the mirror
(C) may move towards the mirror
(D) will move towards the mirror, only if the mirror is convex.

B-7. A point object on the principal axis at a distance 15 cm in front of a concave mirror of radius of curvature 20 cm has velocity 2 mm/s perpendicular to the principal axis. The magnitude of velocity of image at that instant will be:

(A) 2 mm/s (B) 4 mm/s (C) 8 mm/s (D) 16 mm/s

B-8. In the figure M_1 and M_2 are two fixed mirrors as shown. If the object ' O ' moves towards the plane mirror, then the image I (which is formed after two successive reflections from M_1 & M_2 respectively) will move



(A) towards right (B) towards left
(C) with zero velocity (D) cannot be determined

B-9. A point object at 15 cm from a concave mirror of radius of curvature 20 cm is made to oscillate along the principal axis with amplitude 2 mm. The amplitude of its image will be
(A) 2 mm (B) 4 mm (C) 8 mm (D) 16 mm

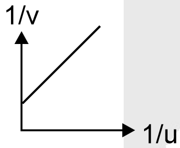
B-10. The distance of an object from the focus of a convex mirror of radius of curvature ' a ' is ' b '. Then the distance of the image from the focus is:
(A) $b^2 / 4a$ (B) a / b^2 (C) $a^2 / 4b$ (D) $4b / a^2$

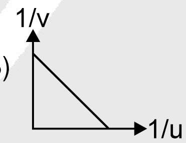
B-11. The largest distance of the image of a real object from a convex mirror of focal length 20 cm can be:
(A) 20 cm (B) infinite
(C) 10 cm (D) depends on the position of the object

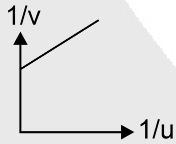
B-12. Which of the following can form erect, virtual, diminished image?
(A) plane mirror (B) concave mirror (C) convex mirror (D) none of these

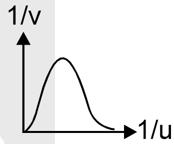
B-13. I is the image of a point object O formed by spherical mirror, then which of the following statements is **incorrect** :
(A) If O and I are on same side of the principal axis, then they have to be on opposite sides of the mirror.
(B) If O and I are on opposite side of the principal axis, then they have to be on same side of the mirror.
(C) If O and I are on opposite side of the principal axis, then they can be on opposite side of the mirror as well.
(D) If O is on principal axis then I has to lie on principal axis only.

B-14. An object is placed at a distance u from a concave mirror and its real image is received on a screen placed at a distance of v from the mirror. If f is the focal length of the mirror, then the graph between 1/v versus 1/u is

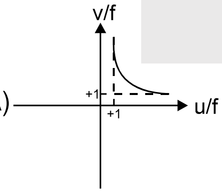
(A) 

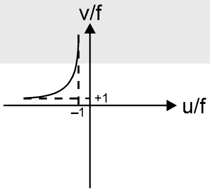
(B) 

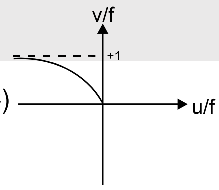
(C) 

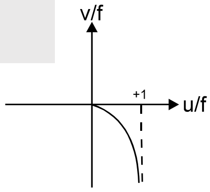
(D) 

B-15. A real inverted image in a concave mirror is represented by graph (u, v, f are coordinates)

(A) 

(B) 

(C) 

(D) 

B-16. When observed from the earth the angular diameter of the sun is 0.5 degree. The diameter of the image of the sun when formed in a concave mirror of focal length 0.5 m will be about
(A) 3.0 mm (B) 4.4 mm (C) 5.6 mm (D) 8.8 mm

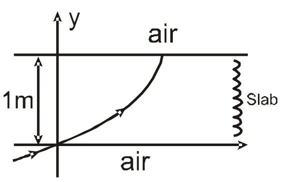
SECTION (C) : LAWS OF REFRACTION, REFRACTION AT PLANE SURFACE AND T.I.R.

C-1. The wavelength of light in vacuum is 6000 Aº and in a medium it is 4000 Aº. The refractive index of the medium is:
(A) 2.4 (B) 1.5 (C) 1.2 (D) 0.67

C-2. A ray of light passes from vacuum into a medium of refractive index n. If the angle of incidence is twice the angle of refraction, then the angle of incidence is:
(A) $\cos^{-1}(n/2)$ (B) $\sin^{-1}(n/2)$ (C) $2\cos^{-1}(n/2)$ (D) $2\sin^{-1}(n/2)$

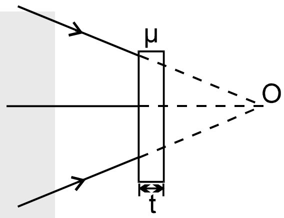
C-3. A ray of light is incident on a parallel slab of thickness t and refractive index n. If the angle of incidence θ is small, then the displacement in the incident and emergent ray will be:
(A) $\frac{t\theta(n-1)}{n}$ (B) $\frac{t\theta}{n}$ (C) $\frac{t\theta n}{n-1}$ (D) none of these

C-4. A ray of light travelling in air is incident at grazing incidence on a slab with variable refractive index, $n(y) = [k y^{3/2} + 1]^{1/2}$ where $k = 1\ m^{-3/2}$ and follows path as shown in the figure. What is the total deviation produced by slab when the ray comes out.



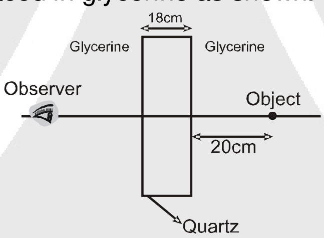
(A) 60º (B) 53º (C) $\sin^{-1}(4/9)$ (D) no deviation at all

C-5. A beam of light is converging towards a point. A plane parallel plate of glass of thickness t, refractive index μ is introduced in the path of the beam as shown in the figure. The convergent point is shifted by (assume near normal incidence):



(A) $t\left(1-\frac{1}{\mu}\right)$ away (B) $t\left(1+\frac{1}{\mu}\right)$ away
(C) $t\left(1-\frac{1}{\mu}\right)$ nearer (D) $t\left(1+\frac{1}{\mu}\right)$ nearer

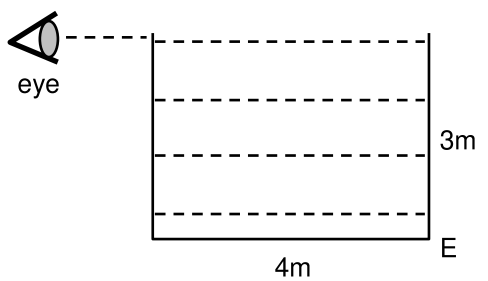
C-6. Given that, velocity of light in quartz = 1.5×10^8 m/s and velocity of light in glycerine = $(9/4) \times 10^8$ m/s. Now a slab made of quartz is placed in glycerine as shown. The shift of the object produced by slab is



(A) 6 cm (B) 3.55 cm (C) 9 cm (D) 2 cm

C-7. The critical angle of light going from medium A to medium B is θ. The speed of light in medium A is v. The speed of light in medium B is:
(A) $\frac{v}{\sin\theta}$ (B) $v\sin\theta$ (C) $v\cot\theta$ (D) $v\tan\theta$

C-8. A rectangular metal tank filled with a certain liquid is as shown in the figure. The observer, whose eye is in level with the top of the tank can just see the corner E of the tank. Therefore, the minimum refractive index of the liquid is **[Olympiad-2016; Stage-I]**



(A) 1.67 (B) 1.50 (C) 1.33 (D) 1.25

C-9. A point source of light is viewed through a plate of glass of thickness t and of refractive index 1.5. The source appears **[Olympiad 2017 (Stage–I)]**
(A) closer by a distance 2t/3
(B) closer by a distance t/3
(C) farther by a distance t/3
(D) farther by a distance 2t/3

SECTION (D) : REFRACTION BY PRISM

D-1. A ray of monochromatic light is incident on one refracting face of a prism of angle 75^0. It passes through the prism and is incident on the other face at the critical angle. If the refractive index of the material of the prism is $\sqrt{2}$, the angle of incidence on the first face of the prism is
(A) 30^0 (B) 45^0 (C) 60^0 (D) 0^0

D-2. A prism having refractive index $\sqrt{2}$ and refracting angle 30º, has one of the refracting surfaces polished. A beam of light incident on the other refracting surface will retrace its path if the angle of incidence is:
(A) 0º (B) 30º (C) 45º (D) 60º

D-3. A ray of light is incident at angle i on a surface of a prism of small angle A and emerges normally from the opposite surface. If the refractive index of the material of the prism is μ, the angle of incidence i is nearly equal to :
(A) A/μ (B) $A/(2\mu)$ (C) μA (D) $\mu A/2$

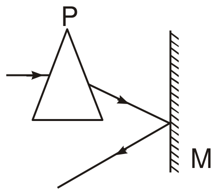
D-4. A prism of refractive index $\sqrt{2}$ has refracting angle 60º. Answer the following questions
(a) In order that a ray suffers minimum deviation it should be incident at an angle :
(A) 45^0 (B) 90^0 (C) 30^0 (D) none of these

(b) Angle of minimum deviation is :
(A) 45^0 (B) 90^0 (C) 30^0 (D) none of these

(c) Angle of maximum deviation is :
(A) 45^0
(B) $\sin^{-1}(\sqrt{2}\sin 15º)$
(C) $30º + \sin^{-1}(\sqrt{2}\sin 15º)$
(D) none of these

D-5. The maximum refractive index of a material, of a prism of apex angle 90º, for which light may be transmitted is:
(A) $\sqrt{3}$ (B) 1.5 (C) $\sqrt{2}$ (D) None of these

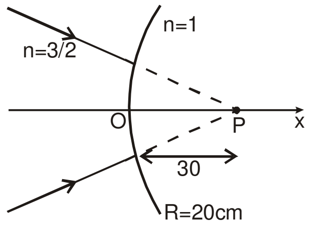
D-6. A prism having an apex angle of 4° and refractive index of 1.50 is located in front of a vertical plane mirror as shown in the figure. A horizontal ray of light is incident on the prism. The total angle through which the ray is deviated is
(A) 4^0 clockwise
(B) 178^0 clockwise
(C) 2^0 clockwise
(D) 8^0 clockwise



SECTION (E) : REFRACTION BY SPHERICAL SURFACE

E-1. There is a small black dot at the centre C of a solid glass sphere of refractive index μ. When seen from outside, the dot will appear to be located:
(A) away from C for all values of μ
(B) at C for all values of μ
(C) at C for $\mu = 1.5$, but away from C for $\mu \neq 1.5$
(D) at C only for $\sqrt{2} \leq \mu \leq 1.5$.

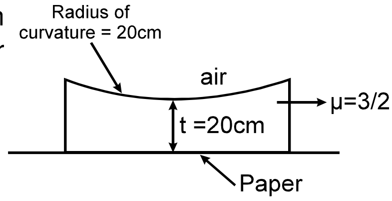
E-2. The image for the converging beam after refraction through the curved surface (in the given figure) is formed at:



(A) x = 40 cm (B) $x = \frac{40}{3}$ cm

(C) $x = -\frac{40}{3}$ cm (D) $x = \frac{180}{7}$ cm

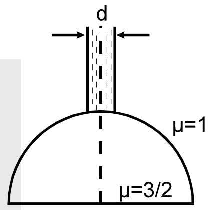
E-3. In the given figure a plano-concave lens is placed on a paper on which a flower is drawn. How far above its actual position does the flower appear to be ?



(A) 10 cm (B) 15 cm

(C) 50 cm (D) none of these

E-4. A beam of diameter ' d ' is incident on a glass hemisphere as shown in the figure. If the radius of curvature of the hemisphere is very large in comparison to d, then the diameter of the beam at the base of the hemisphere will be:



(A) $\frac{3}{4}$d (B) d

(C) $\frac{d}{3}$ (D) $\frac{2}{3}$d

SECTION (F) : LENS

F-1. A convexo - concave diverging lens is made of glass of refractive index 1.5 and focal length 24 cm. Radius of curvature for one surface is double that of the other. Then radii of curvature for the two surfaces are (in cm):

(A) 6, 12 (B) 12, 24 (C) 3, 6 (D) 18, 36

F-2. Two symmetric double convex lenses A and B have same focal length, but the radii of curvature differ so that, $R_A = 0.9\, R_B$. If $n_A = 1.63$, find n_B.

(A) 1.7 (B) 1.6 (C) 1.5 (D) 4/3

F-3. When a lens of power P (in air) made of material of refractive index μ is immersed in liquid of refractive index μ_0. Then the power of lens is:

(A) $\frac{\mu - 1}{\mu - \mu_0}P$ (B) $\frac{\mu - \mu_0}{\mu - 1}P$ (C) $\frac{\mu - \mu_0}{\mu - 1} \cdot \frac{P}{\mu_0}$ (D) none of these

F-4. A lens behaves as a converging lens in air and a diverging lens in water. The refractive index of the material is (refractive index of water = 1.33)

(A) equal to unity (B) equal to 1.33

(C) between unity and 1.33 (D) greater than 1.33

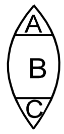
F-5. The diameter of the sun subtends an angle of 0.5^0 at the surface of the earth. A converging lens of focal length 100 cm is used to provide an image of the sun on to a screen. The diameter (in mm) of the image formed is nearly

(A) 1 (B) 3 (C) 5 (D) 9

F-6. A thin lens of focal length f and its aperture diameter d, forms a real image of intensity I. Now the central part of the aperture upto diameter (d/2) is blocked by an opaque paper. The focal length and image intensity would change to :

(A) f/2, I/2 (B) f, I/4 (C) 3f/4, I/2 (D) f, 3I/4

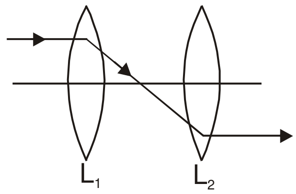
F-7. A thin symmetrical double convex lens of power P is cut into three parts, as shown in the figure. Power of A is:



(A) 2 P (B) $\frac{P}{2}$

(C) $\frac{P}{3}$ (D) P

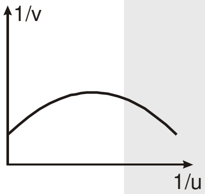
F-8. In the figure given below, there are two convex lens L_1 and L_2 having focal length of f_1 and f_2 respectively. The distance between L_1 and L_2 will be :

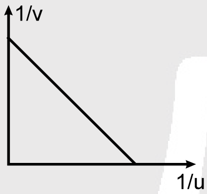


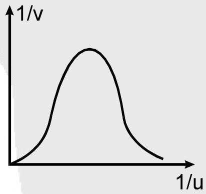
(A) f_1 (B) f_2

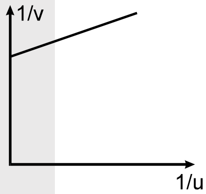
(C) $f_1 + f_2$ (D) $f_1 - f_2$

F-9. An object is placed at a distance u from a **converging lens** and its real image is received on a screen placed at a distance of v from the lens. If f is the focal length of the lens, then the graph between 1/v versus 1/u is:

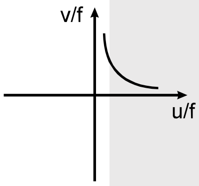
(A) 

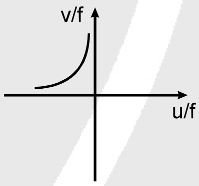
(B) 

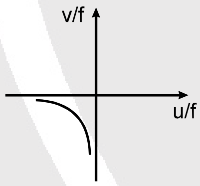
(C) 

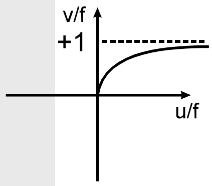
(D) 

F-10. A virtual erect image by a **diverging lens** is represented by (u, v, f are coordinates)

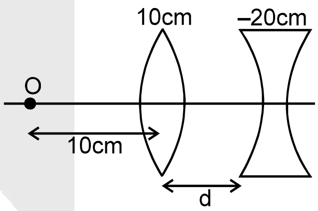
(A) 

(B) 

(C) 

(D) 

F-11. What should be the value of distance d so that final image is formed on the object itself? (Focal lengths of the lenses are as given in the figure).



(A) 10 cm
(B) 20 cm
(C) 5 cm
(D) none of these

F-12. A thin linear object of size 1 mm is kept along the principal axis of a convex lens of focal length 10 cm. The object is at 15 cm from the lens. The length of the image is:
(A) 1 mm (B) 4 mm (C) 2 mm (D) 8 mm

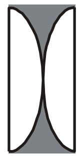
F-13. A biconvex lens is used to project a slide on screen. The slide is 2 cm high and placed at 10 cm from the lens. The image is 18 cm high. What is the focal length of the lens?
(A) 9 cm (B) 18 cm (C) 4.5 cm (D) 20 cm

F-14. The minimum distance between a real object and its real image formed by a thin converging lens of focal length f is
(A) 4f (B) 2f (C) f (D) f/2

F-15. A small fish, 4cm below the surface of a lake, is viewed through a thin converging lens of focal length 30 cm held 2 cm above the water surface. Refractive index of water is 1.33. The image of the fish from the lens is at a distance of
(A) 10 cm (B) 8 cm (C) 6 cm (D) 4 cm

SECTION (G) : COMBINATION OF THIN LENS/LENS AND MIRRORS.

G-1. Two plano-convex lenses each of focal length 10 cm & refractive index 3/2 are placed as shown in the figure. In the space left, water $\left(R.I.=\frac{4}{3}\right)$ is filled. The whole arrangement is in air. The optical power of the system is (in dioptre):



(A) 6.67 (B) – 6.67 (C) 33.3 (D) 20

G-2. A plano-convex lens, when silvered at its plane surface is equivalent to a concave mirror of focal length 28 cm. When its curved surface is silvered and the plane surface not silvered, it is equivalent to a concave mirror of focal length 10 cm, then the refractive index of the material of the lens is:
(A) 9/14 (B) 14/9 (C) 17/9 (D) none of these

G-3. In the above question the radius of curvature of the curved surface of plano-convex lens is :
(A) $\frac{280}{9}$ cm (B) $\frac{180}{7}$ cm (C) $\frac{39}{3}$ cm (D) $\frac{280}{11}$ cm

G-4. The focal length of a plano-concave lens is –10 cm, then its focal length when its plane surface is polished is (n = 3/2):
(A) 20 cm (B) – 5 cm (C) 5 cm (D) none of these

G-5. A convex lens of focal length 25 cm and a concave lens of focal length 20 cm are mounted coaxially separated by a distance d cm. If the power of the combination is zero, d is equal to
(A) 45 (B) 30 (C) 15 (D) 5

SECTION (H) : DISPERSION OF LIGHT

H-1. The dispersion of light in a medium implies that :
(A) lights of different wavelengths travel with different speeds in the medium
(B) lights of different frequencies travel with different speeds in the medium
(C) the refractive index of medium is different for different wavelengths
(D) all of the above.

H-2. Critical angle of light passing from glass to air is minimum for
(A) red (B) green (C) yellow (D) violet

H-3. A plane glass slab is placed over various coloured letters. The letter which appears to be raised the least is:
(A) violet (B) yellow (C) red (D) green

H-4. A medium has n_v = 1.56, n_r = 1.44. Then its dispersive power is:
(A) 3/50 (B) 6/25 (C) 0.03 (D) none of these

H-5. All the listed things below are made of flint glass. Which one of these have greatest dispersive power (ω).
(A) prism (B) glass slab (C) biconvex lens (D) all have same ω

H-6. Light of wavelength 4000 Å is incident at small angle on a prism of apex angle 4º. The prism has n_v = 1.5 & n_r = 1.48. The angle of dispersion produced by the prism in this light is:
(A) 0.2º (B) 0.08º (C) 0.192º (D) None of these

SECTION (I) : FOR JEE MAIN

I-1. A simple microscope has a focal length of 5 cm. The magnification at the least distance of distinct vision is-
(A) 1 (B) 5 (C) 4 (D) 6

I-2. In a compound microscope, the intermediate image is -
(A) virtual, erect and magnified (B) real, erect and magnified
(C) real, inverted and magnified (D) virtual, erect and reduced

I-3. A Galileo telescope has an objective of focal length 100 cm & magnifying power 50. The distance between the two lenses in normal adjustment will be
(A) 150 cm (B) 100 cm (C) 98 cm (D) 200 cm

I-4. The convex lens is used in-
(A) Microscope (B) Telescope (C) Projector (D) All of the above

I-5. The magnifying power of a simple microscope can be increased if an eyepiece of :
(A) shorter focal length is used (B) longer focal length is used
(C) shorter diameter is used (D) longer diameter is used

I-6. The focal length of the objective of a microscope is
(A) arbitrary (B) less than the focal length of eyepiece
(C) equal to the focal length of eyepiece (D) greater than the focal length of eyepiece

I-7. An astronomical telescope has an eyepiece of focal-length 5 cm. If the angular magnification in normal adjustment is 10, when final image is at least distance of distinct vision (25cm) from eye piece, then angular magnification will be :
(A) 10 (B) 12 (C) 50 (D) 60

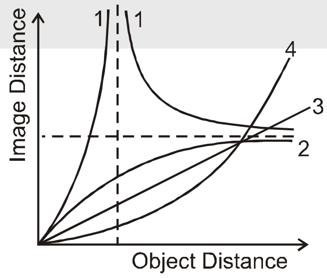
I-8. A person with a defective sight is using a lens having a power of +2D. The lens he is using is
(A) concave lens with f = 0.5 m (B) convex lens with f = 2.0 m
(C) concave lens with f = 0.2 m (D) convex lens with f = 0.5 m

I-9. The focal lengths of the objective and eye-lens of a microscope are 1 cm and 5 cm respectively. If the magnifying power for the relaxed eye is 45, then the length of the tube is :
(A) 30 cm (B) 25 cm (C) 15 cm (D) 12 cm

I-10. If the focal length of objective and eye lens are 1.2 cm and 3 cm respectively and the object is put 1.25 cm away from the objective lens and the final image is formed at infinity. The magnifying power of the microscope is :
(A) 150 (B) 200 (C) 250 (D) 400

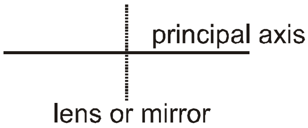
PART - III : MATCH THE COLUMN

1. A small particle is placed at the pole of a concave mirror and then moved along the principal axis to a large distance. During the motion, the distance between the pole of the mirror and the image is measured. The procedure is then repeated with a convex mirror, a concave lens and a convex lens. The graph is plotted between image distance versus object distance. Match the curves shown in the graph with the mirror or lens that is corresponding to it. (Curve 1 has two segments)



Lens/Mirror	**Curve**
(A) Converging lens	(p) 1
(B) Converging Mirror	(q) 2
(C) Diverging Lens	(r) 3
(D) Diverging Mirror	(s) 4

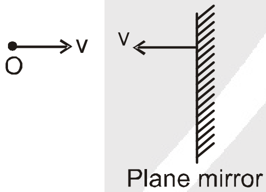
2. Column-I gives certain situations regarding a point object and its image formed by an optical instrument. The possible optical instruments are diverging and conveging mirrors or lenses as given in Column-II. Same side of principal axis means both image and object should either be above the principal axis or both should be below the principal axis as shown in figure. Same side of optical instrument means both image and object should be either left of the optical instrument or both should be on right of the optical instrument as shown in figure. Match the statements in column-I with the corresponding statements in column-II.

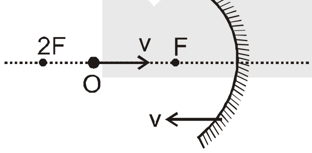


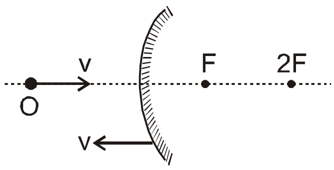
Column I	Column II
(A) If point object and its image are on same side of principal axis and opposite sides of the optical instrument then the optical instrument is	(p) Concave mirror
(B) If point object and its image are on opposite side of principal axis and same sides of the optical instrument then the optical instrument is	(q) Convex mirror
(C) If point object and its image are on same side of principal axis and same sides of the optical instrument then the optical instrument is	(r) Diverging lens
(D) If point object and its image are on opposite side of principal axis and opposite sides of the optical instrument then the optical instrument is	(s) Converging lens

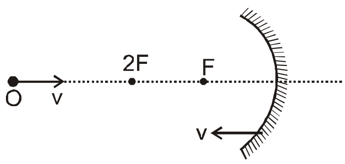
3. Column–I shows velocity of a point object 'O' (along principal axis in case of convex or concave mirror) and mirrors with respect to ground. Here speed of mirror and object 'O' is v and F is the focus of mirror. Match the Column -I and Column-II for given instant.

Column - I

(A) 

(B) 

(C) 

(D) 

Column - II

(p) Speed of image with respect to mirror is same as speed of object with respect to mirror.

(q) Speed of image with respect to mirror is greater than as speed of object with respect to mirror.

(r) Speed of image with respect to mirror is less than as speed of object with respect to mirror.

(s) Distance between image and mirror decreases

Exercise-2

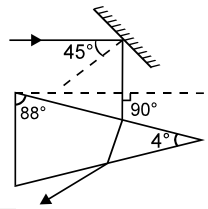
✍ **Marked Questions can be used as Revision Questions.**

PART - I : ONLY ONE OPTION CORRECT TYPE

1. An object is placed 30 cm (from the reflecting surface) in front of a block of glass 10 cm thick having its farther side silvered. The final image is formed at 23.2 cm behind the silvered face. The refractive index of glass is :

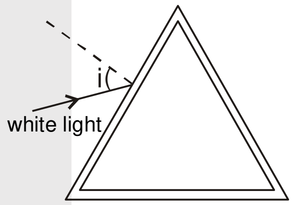
(A) 1.41 (B) 1.46 (C) 200/ 132 (D) 1.61

2. A ray of light strikes a plane mirror at an angle of incidence 45º as shown in the figure. After reflection, the ray passes through a prism of refractive index 1.50, whose apex angle is 4º. The angle through which the mirror should be rotated if the total deviation of the ray is to be 90º is:



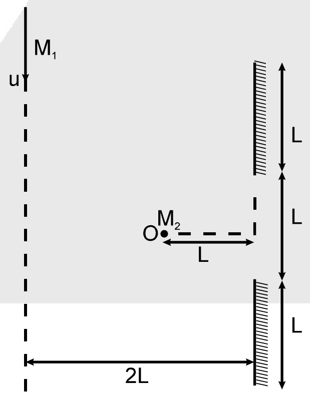
(A) 1^0 clockwise (B) 1^0 anticlockwise
(C) 2^0 clockwise (D) 2^0 anticlockwise

3. A beam of white light is incident on hollow prism of glass as shown in figure. Then :



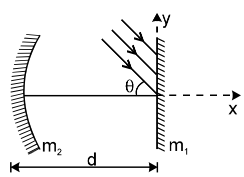
(A) the light emerging from prism gives no dispersion
(B) the light emerging from prism gives spectrum but the bending of all colours is away from base.
(C) the light emerging from prism gives spectrum, all the colours bend towards base, the violet the most and red the least.
(D) the light emerging from prism gives spectrum, all the colours bend towards base, the violet the least and red the most.

4. Two plane mirrors of length L are separated by distance L and a man M_2 is standing at distance L from the connecting line of mirrors as shown in figure. A man M_1 is walking in a straight line at distance 2 L parallel to mirrors at speed u, then man M_2 at O will be able to see image of M_1 for time:



(A) $\frac{4L}{u}$ (B) $\frac{3L}{u}$ (C) $\frac{6L}{u}$ (D) $\frac{9L}{u}$

5. In the figure shown a thin parallel beam of light is incident on a plane mirror m_1 at small angle 'θ'. m_2 is a concave mirror of focal length 'f'. After three successive reflections of this beam the x and y coordinates of the image is

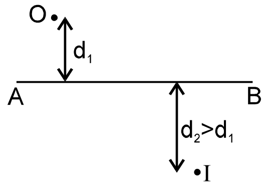


(A) x = f – d, y = fθ (B) x = d + f , y = fθ (C) x = f – d, y = – fθ (D) x = d – f , y = – fθ

6. The distance between an object and its doubly magnified image by a concave mirror is: [Assume f = focal length]

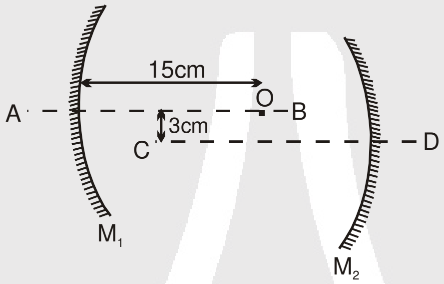
(A) 3 f/2　　　(B) 2 f/3
(C) 3 f　　　(D) depends on whether the image is real or virtual.

7. In the figure shown, the image of a real object is formed at point I. AB is the principal axis of the mirror. The mirror must be:



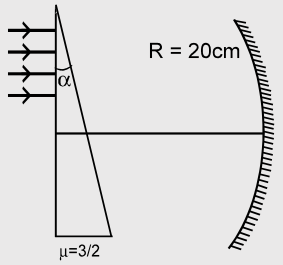
(A) concave and placed towards right of I
(B) concave and placed towards left of O
(C) convex and placed towards right of I
(D) convex and placed towards left of I.

8. In the shown figure M_1 and M_2 are two concave mirrors of the same focal length 10 cm. AB and CD are their principal axes respectively. A point object O is kept on the line AB at a distance 15 cm from M_1. The distance between the mirrors is 20 cm. Considering two successive reflections first on M_1 and then on M_2. The distance of final image from the line AB is:



(A) 3 cm　　　(B) 1.5 cm　　　(C) 4.5 cm　　　(D) 1 cm

9. In the given figure a parallel beam of light is incident on the upper part of a prism of angle 1.8º and R.I. 3/2. The light coming out of the prism falls on a concave mirror of radius of curvature 20 cm. The distance of the point (where the rays are focused after reflection from the mirror) from the principal axis is: [use π = 3.14]

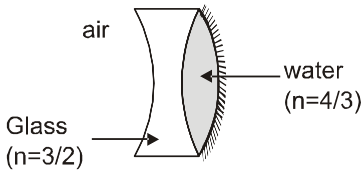


(A) 9 cm　　　(B) 1.5 7 mm　　　(C) 3.14 mm　　　(D) none of these

10. For a prism kept in air, of apex angle 45^0, it is found that the angle of emergence is 45^0 for grazing incidence. Calculate the refractive index of the prism.

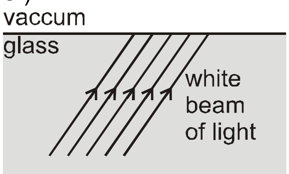
(A) $(2)^{1/2}$　　　(B) $(3)^{1/2}$　　　(C) 2　　　(D) $(5)^{1/2}$

11. In the figure shown the radius of curvature of the left & right surface of the concave lens are 10 cm & 15 cm respectively. The radius of curvature of the mirror is 15 cm. equivalent focal length of the combination is :



(A) the system behaves like a convex mirror of focal length 18cm
(B) the system behaves like a concave mirror of focal length 18cm
(C) the system behaves like a convex mirror of focal length 36cm
(D) the system behaves like a concave mirror of focal length 36cm

12. **STATEMENT – 1:** A thin white parallel beam of light is incident on a plane glass- vacuum interface as shown. The beam may not undergo dispersion after suffering deviation at the interface (The beam is not incident normally on the interface.)

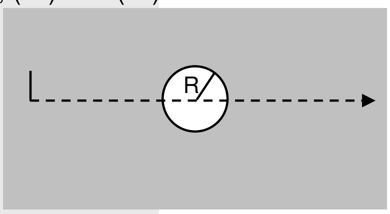


STATEMENT – 2: Vacuum has same refractive index for all colours of white light.
(A) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1
(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True.

13. Two identical lenses made of the same material of refractive index 1.5 have the focal length 12 cm. These lenses are kept in contact and immersed in a liquid of refractive index 1.35. The combination behaves as **[Olympiad stage–I 2016]**
(A) convex lens of focal length 27 cm
(B) concave lens of focal length 6 cm
(C) convex lens of focal length 9 cm
(D) convex lens of focal length 6 cm

14. In cases of real images formed by a thin convex lens, the linear magnification is (I) directly proportional to the image distance, (II) inversely proportional to the object distance, (III) directly proportional to the distance of image from the nearest principal focus, (IV) inversely proportional to the distance of the object from the nearest principal focus. From these the correct statements are : **[Olympiad 2017 (Stage–I)]**
(A) (I) and (II) only.
(B) (III) and (IV) only
(C) (I), (II),(III) and (IV) all.
(D) None of (I), (II), (III) and (IV).

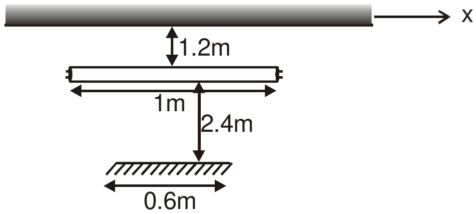
15. Rays from an object immersed in water (μ = 1.33) traverse a spherical air bubble of radius R. If the object is located far away from the bubble, its image as seen by the observer located on the other side of the bubble will be **[Olympiad 2017 (Stage–I)]**



(A) virtual, erect and diminished
(B) real, inverted and magnified
(C) virtual, erect and magnified
(D) real, inverted and diminished

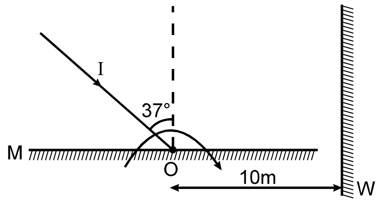
PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

1. A fluorescent lamp of length 1 m is placed horizontally at a depth of 1.2 m below a ceiling. A plane mirror of length 0.6 m is placed below the lamp parallel to and symmetric to the lamp at a distance 2.4 m from it as shown in figure. Find the length in meters (distance between the extreme points of the visible region along x-axis) of the reflected patch of light on the ceiling.



2. A plane mirror 50 cm long, is hung on a vertical wall of a room, with its lower edge 50 cm above the ground. A man stands infront of the mirror at a distance 2 m away from the mirror. If his eyes are at a height 1.8 m above the ground, then the length (distance between the extreme points of the visible region perpendicular to the mirror) of the floor visible to him due to reflection from the mirror is $\frac{x}{26}$ m. Find the value of x.

3. A light ray I is incident on a plane mirror M. The mirror is rotated in the direction as shown in the figure by an arrow at frequency $9/\pi$ rps. The light reflected by the mirror is received on the wall W at a distance 10 m from the axis of rotation. When the angle of incidence becomes 37º the speed of the spot (a point) on the wall is $V \times 10^2$ m/s. Find the value of V.



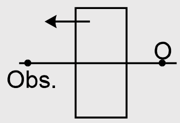
4. A burning candle is placed in front of a concave spherical mirror on its principal optical axis at a distance of (4/3)F from the pole of the mirror (here F is the focal length of the mirror). The candle is arranged at right angle to the axis. The image of the candle in the concave mirror impinges upon a convex mirror of focal length 2 F. The distance between the mirrors is 3F and their axes coincide. The image of the candle in the first mirror plays the part of a virtual object with respect to the second mirror and gives a real image arranged between the two mirrors, Find the total linear magnification (magnitude only) of the system.

5. A concave mirror forms the real image of a point source lying on the optical axis at a distance of 50 cm from the mirror. The focal length of the mirror is 25 cm. The mirror is cut into two halves and its halves are drawn a distance of 1 cm apart (from each other) in a direction perpendicular to the optical axis. Find the distance (in cm) between the two images formed by the two halves of the mirror.

6. A convex mirror and a concave mirror each of focal length 10 cm are placed coaxially. They are separated by 40cm and their reflecting surfaces face each other. A point object is kept on the principle axis at a distance x cm from the concave mirror such that final image after two reflections, first on the concave mirror, is on the object itself. Find the integer next to x.

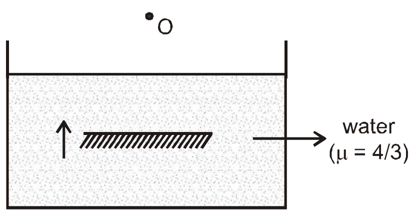
7. The x-y plane is the boundary between two transparent media. Medium-1 with $z > 0$ has refractive index $\sqrt{2}$ and medium 2 with $z < 0$ has a refractive index $\sqrt{3}$. A ray of light in medium-1 given by the vector $\vec{A} = 6\sqrt{3}\,\hat{i} + 8\sqrt{3}\,\hat{j} - 10\hat{k}$ is incident on the plane of separation. If the unit vector in the direction of refracted ray in medium – 2 is $\frac{1}{5}\left(a\hat{i} + b\hat{j} - \frac{5}{\sqrt{2}}\hat{k}\right)$ then find the value of ab.

8. (a) In the figure shown a slab of refractive index 3/2 is moved towards a stationary observer with speed 6 cm/s. A point 'O' is observed by the observer with the help of paraxial rays through the slab. Both 'O' and observer lie in air. Find the velocity (in cm/s) with which the image will appear to move to observer.

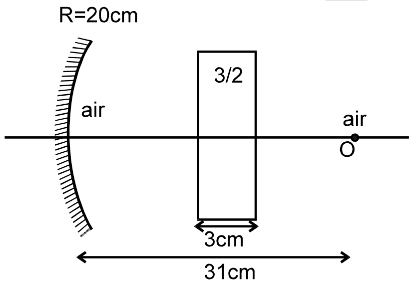


(b) In the previous question if the object moves towards right with a velocity of 6 cm/s and then the velocity of the final image (in cm/s) as seen by observer :

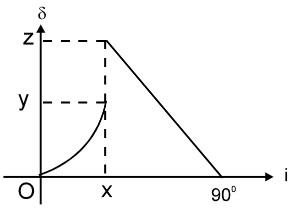
9. Mirror in the arrangement shown in figure is moving up with speed 4 cm/sec. Find the speed of final image of object O (in cm/s) formed after two refraction and one reflection.



10. A point object is placed on principal axis of a concave mirror of radius of curvature 20 cm at a distance 31 cm from poll of the mirror. A glass slab of thikness 3 cm and refractive index 1.5 is placed between object and mirror as shown in the figure.
Find the distance (in cm) of final image formed by the system from the mirror .

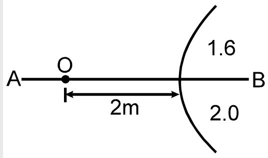


11. Light is incident from glass to air. The variation of the angle of deviation δ with the angle of incidence i for $0 < i < 90°$ is shown. The refractive index of glass is $\frac{2}{\sqrt{3}}$. If the value of (x+y+z) is $\frac{n\pi}{6}$ then find value of n.

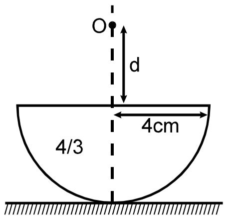


12. A hemispherical portion of the surface of a solid glass sphere ($\mu = 1.5$) of radius 10 cm (surrounding is air) is silvered to make the inner side reflecting. An object is placed on the axis of the hemisphere at a distance 30cm from the centre of the sphere. The light from the object is refracted at the unsilvered part, then reflected from the silvered part and again refracted at the unsilvered part. What is distance (in cm) of final image from pole of reflecting surface.

13. In the figure shown a point object O is placed in air. A spherical boundary of radius of curvature 1.0 m separates two media. AB is principal axis. The refractive index above AB is 1.6 and below AB is 2.0. Find the separation between the images (in m) formed due to refraction at spherical surface.

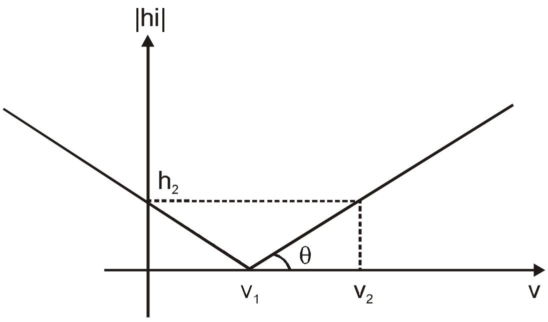


14. A glass hemisphere of refractive index 4/3 and of radius 4 cm is placed on a plane mirror. A point object is placed on axis of this sphere at a distance 'd' from O as shown in the figure. If the final image is formed at infinity, then find the value of ' d ' in mm.

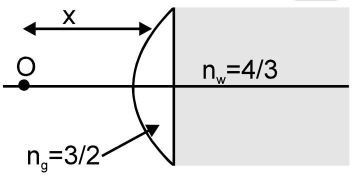


15. A converging lens of focal length 15 cm and a converging mirror of focal length 10 cm are placed 50 cm apart with common principal axis. A point source is placed in between the lens and the mirror at a distance of 40 cm from the lens. Find the distance (in cm) between the final two images formed.

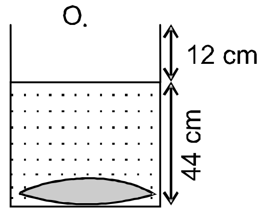
16. An object of height $h_0 = 1$ cm is moved along principal axis of a convex lens of focal length f = 10 cm. Figure shows variation of magnitude of height of image with image distance (v). Find $v_2 - v_1$ in cm.



17. In the given figure an object ' O ' is kept in air in front of a thin plano convex lens of radius of curvature 10 cm. It's refractive index is 3/2 and the medium towards right of plane surface is water of refractive index 4/3. What should be the distance ' x ' (in cm) of the object so that the rays become parallel finally.



18. An object O is kept in air and a lens of focal length 10 cm (in air) is kept at the bottom of a container which is filled upto a height 44 cm by water. The refractive index of water is 4/3 and that of glass is 3/2. The bottom of the container is closed by a thin glass slab of refractive index 3/2. Find the distance (in cm) of the final image formed by the system from bottom of container (refer to figure shown).



19. The dispersive power of the material of a lens is 0.04 and the focal length of the lens is 10 cm. Find the difference in the focal length (in mm) of the lens for violet and red colour.

PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

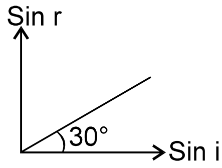
1. The image (of a real object) formed by a concave mirror is twice the size of the object. The focal length of the mirror is 20 cm. The distance of the object from the mirror is (are)

(A) 10 cm (B) 30 cm (C) 25 cm (D) 15 cm

2. Which of the following statements are **incorrect** for spherical mirrors.

(A) a concave mirror forms only virtual images for any position of real object
(B) a convex mirror forms only virtual images for any position of a real object
(C) a concave mirror forms only a virtual diminished image of an object placed between its pole and the focus
(D) a convex mirror forms a virtual enlarged image of an object if it lies between its pole and the focus.

3. A ray of monochromatic light is incident on the plane surface of separation between two media x and y with angle of incidence 'i' in the medium x and angle of refraction 'r' in the medium y. The graph shows the relation between sin r and sin i.



(A) the speed of light in the medium y is $(3)^{1/2}$ times than in medium x.
(B) the speed of light in the medium y is $(1/3)^{1/2}$ times than in medium x.
(C) the total internal reflection can take place when the incidence is in x.
(D) the total internal reflection can take place when the incidence is in y.

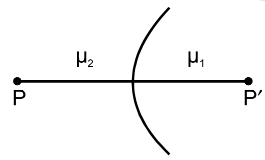
4. For the refraction of light through a prism kept in air

(A) For every angle of deviation there are two angles of incidence.
(B) The light travelling inside an isosceles prism is necessarily parallel to the base when prism is set for minimum deviation.
(C) There are two angles of incidence for maximum deviation.
(D) Angle of minimum deviation will increase if refractive index of prism is increased keeping the outside medium unchanged.

5. An equilateral prism deviates a ray through 40° for two angles of incidence differing by 20°. The possible angles of incidences are:

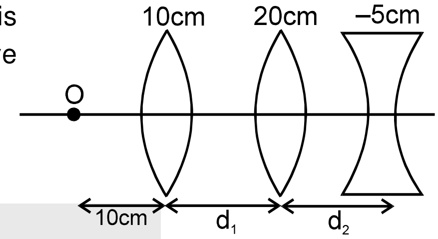
(A) 40° (B) 50° (C) 20° (D) 60°

6. Two refracting media are separated by a spherical interface as shown in the figure. P P ′ is the principal axis, μ_1 and μ_2 are the refractive indices of medium of incidence and medium of refraction respectively. Then:



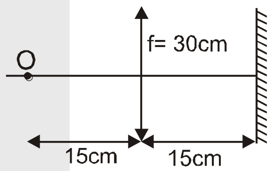
(A) if $\mu_2 > \mu_1$, then there cannot be a real image of real object
(B) if $\mu_2 > \mu_1$, then there cannot be a real image of virtual object
(C) if $\mu_1 > \mu_2$, then there cannot be a virtual image of virtual object
(D) if $\mu_1 > \mu_2$, then there cannot be a real image of real object

7. The values of d_1 & d_2 for final rays to be parallel to the principal axis are : (focal lengths of the lenses are written above the respective lenses in the given figure)



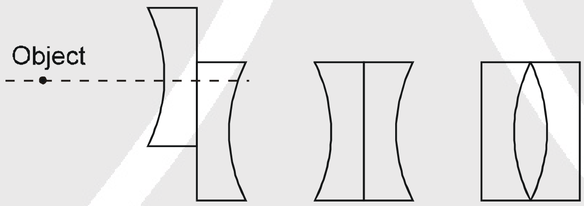
(A) d_1 = 10 cm, d_2 = 15 cm
(B) d_1 = 20 cm, d_2 = 15 cm
(C) d_1 = 30 cm, d_2 = 15 cm
(D) None of these

8. An object O is kept infront of a converging lens of focal length 30 cm behind which there is a plane mirror at 15 cm from the lens as shown in the figure.



(A) the final image is formed at 60 cm from the lens towards right of it
(B) the final image is at 60 cm from lens towards left of it
(C) the final image is real
(D) the final image is virtual.

9. If a symmetrical biconcave thin lens is cut into two identical halves. They are placed in different ways as shown:



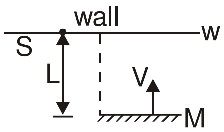
Fig(i) Fig(ii) Fig(iii)

(A) three images will be formed in case (i)
(B) two images will be formed in the case (i)
(C) the ratio of focal lengths in (ii) & (iii) is 1
(D) the ratio of focal lengths in (ii) & (iii) is 2

10. A narrow beam of white light goes through a slab having parallel faces
(A) The light never splits in different colours
(B) The emergent beam is white
(C) The light inside the slab is split into different colours
(D) The light inside the slab is white

11. By properly combining two prisms made of different materials, it is possible to
(A) have dispersion without average deviation
(B) have deviation without dispersion
(C) have both dispersion and average deviation
(D) have neither dispersion nor average deviation

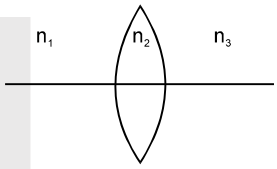
12. A flat mirror M is arranged parallel to a wall W at a distance L from it as shown in the figure. The light produced by a point source S kept on the wall is reflected by the mirror and produces a light patch on the wall. The mirror moves with velocity v towards the wall.



(A) The patch of light will move with the speed v on the wall.
(B) The patch of light will not move on the wall.
(C) As the mirror comes closer the patch of light will become larger and shift away from the wall with speed larger than v.
(D) The width of the light patch on the wall remains the same.

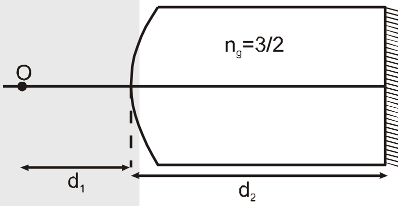
13. A man wants to photograph a white donkey as a Zebra after fitting a glass with black streaks onto the lens of his camera.
(A) The image will look like a white donkey on the photograph.
(B) The image will look like a Zebra on the photograph
(C) The image will be more intense compared to the case in which no such glass is used.
(D) The image will be less intense compared to the case in which no such glass is used.

14. An equiconvex lens of refractive index n_2 is placed such that the refractive index of the surrounding media is as shown. Then the lens :



(A) must be diverging if n_2 is less than the arithmetic mean of n_1 and n_3
(B) must be converging if n_2 is greater than the arithmetic mean of n_1 and n_3
(C) may be diverging if n_2 is less than the arithmetic mean of n_1 and n_3
(D) will neither be diverging nor converging if n_2 is equal to arithmetic mean of n_1 and n_3

15. In the figure shown a point object O is placed in air on the principal axis. The radius of curvature of the spherical surface is 60 cm. I_f is the final image formed after all the refractions and reflections.



(A) If d_1 = 120 cm, then the 'I_f' is formed on 'O' for any value of d_2.
(B) If d_1 = 240 cm, then the 'I_f' is formed on 'O' only if d_2 = 360 cm.
(C) If d_1 = 240 cm, then the 'I_f' is formed on 'O' for all values of d_2.
(D) If d_1 = 240 cm, then the 'I_f' cannot be formed on 'O'.

16. An object is kept on the principal axis of a convex mirror of focal length 10 cm at a distance of 10 cm from the pole. The object starts moving at a velocity 20 mm/sec towards the mirror at angle 30º with the principal axis. What will be the speed of its image and direction with the principal axis at that instant.

(A) speed = $5\frac{\sqrt{7}}{4}$ mm/sec (B) speed = $\frac{5\sqrt{7}}{2}$ mm/sec

(C) $\tan^{-1}\left(\frac{2}{\sqrt{3}}\right)$ with the principal axis (D) none of these

17. A particle is moving towards a fixed convex mirror. The image also moves. If V_i = speed of image and V_O = speed of the object, then
(A) $V_i < V_O$ if $|u| < |F|$ (B) $V_i > V_O$ if $|u| > |F|$ (C) $V_i < V_O$ if $|u| > |F|$ (D) $V_i = V_O$ if $|u| = |F|$

18. A small air bubble is trapped inside a transparent cube of size 12 cm. When viewed from one of the vertical faces, the bubble appears to be at 5 cm from it. When viewed from opposite face, it appears at 3 cm from it.
(A) The distance of the air bubble from the first face is 7.5 cm.
(B) The distance of the air bubble from the first face is 9 cm.
(C) Refractive index of the material of the cube is 2.0.
(D) Refractive index of the material of the cube is 1.5.

19. A parallel beam of light is incident normally on the flat surface of a hemisphere of radius 6 cm and refractive index 1.5, placed in air as shown in figure (i). Assume paraxial ray approximation.

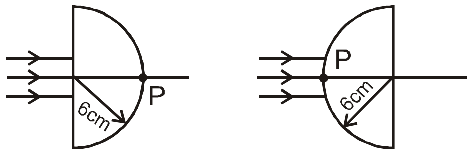


figure (i) figure (ii)

(A) The rays are focused at 12 cm from the point P to the right, in the situation as shown in figure (i)
(B) The rays are focused at 16 cm from the point P to the right, in the situation as shown in figure (i)
(C) If the rays are incident at the curved surface (figure (ii)) then these are focused at distance 18 cm from point P to the right.
(D) If the rays are incident at the curved surface (figure (ii)) then these are focused at distance 14 cm from point P to the right.

20. A ray is incident on a refracting surface of RI μ at an angle of incidence i and the corresponding angle of refraction is r. The deviation of the ray after refraction is given by δ = i-r. Then, one may conclude that **[Olympiad 2017 (Stage–I)]**

(A) r increases with I
(B) δ increases with i
(C) δ decreases with I
(D) the maximum value of δ is $\cos^{-1}\left(\frac{1}{\mu}\right)$

21. A convex lens and concave lens are kept in contact and the combination is used for the formation of image of a body by keeping it at different places on the principal axis. The image formed by this combination of lenses can be : **[Olympiad 2017 (Stage –I)]**

(A) Magnified, inverted and real
(B) Diminished, inverted and real
(C) Diminished, erect and virtual
(D) Magnified, erect and virtual

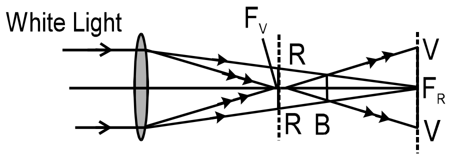
PART - IV : COMPREHENSION

COMPREHENSION-1

Chromatic Aberration

The image of a white object in white light formed by a lens is usually coloured and blurred. This defect of image is called chromatic aberration and arises due to the fact that focal length of a lens is different for different colours. As R.I. μ of lens is maximum for violet while minimum for red, violet is focused nearest to the lens while red farthest from it as shown in figure.

As a result of this, in case of convergent lens if a screen is placed at F_V centre of the image will be violet and focused while sides are red and blurred. While at F_R, reverse is the case, i.e., centre will be red and focused while sides violet and blurred. The difference between f_V and f_R is a measure of the longitudinal chromatic aberration (L.C.A), i.e.,



L.C.A. = $f_R - f_V = -df$ with $df = f_V - f_R$ ....(1)

However, as for a single lens,

$$\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \quad ....(2)$$

$$\Rightarrow \quad -\frac{df}{f^2} = d\mu\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \quad ....(3)$$

Dividing Eqn. (3) by (2) ;

$$-\frac{df}{f} = \frac{d\mu}{(\mu - 1)} = \omega \qquad \left[\omega = \frac{d\mu}{(\mu - 1)}\right] = \text{dispersive power}........(4)$$

And hence, from Eqns. (1) and (4),

L.C.A. = –df = ωf

Now, as for a single lens neither f nor ω can be zero, we cannot have a single lens free from chromatic aberration.

Condition of Achromatism :

In case of two thin lenses in contact

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} \qquad \text{i.e.,} \qquad -\frac{dF}{F^2} = -\frac{df_1}{f_1^2} - \frac{df_2}{f_2^2}$$

The combination will be free from chromatic aberration if dF = 0

i.e., $\frac{df_1}{f_1^2} + \frac{df_2}{f_2^2} = 0$

which with the help of Eqn. (4) reduces to

$$\frac{\omega_1 f_1}{f_1^2} + \frac{\omega_2 f_2}{f_2^2} = 0 \qquad \text{i.e.,} \qquad \frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0 \qquad ....(5)$$

This condition is called condition of achromatism (for two thin lenses in contact) and the lens combination which satisfies this condition is called achromatic lens**,** from this condition, i.e., from Eqn. (5) it is clear that in case of achromatic doublet :

(1) The two lenses must be of different materials.

Since, if $\omega_1 = \omega_2$, $\frac{1}{f_1} + \frac{1}{f_2} = 0$ i.e., $\frac{1}{F} = 0$ or $F = \infty$

i.e., combination will not behave as a lens, but as a plane glass slab.

(2) As ω_1 and ω_2 are positive quantities, for equation (5) to hold, f_1 and f_2 must be of opposite nature, i.e. if one of the lenses is converging the other must be diverging.

(3) If the achromatic combination is convergent,

$$f_C < f_D \quad \text{and as} \quad -\frac{f_C}{f_D} = \frac{\omega_C}{\omega_D}, \qquad \omega_C < \omega_D$$

i.e., in a convergent achromatic doublet, convex lens has lesser focal length and dispersive power than the divergent one.

1. Chromatic aberration in the formation of images by a lens arises because :
(A) of non-paraxial rays.
(B) the radii of curvature of the two sides are not same.
(C) of the defect in grinding.
(D) the focal length varies with wavelength.

2. Chromatic aberration of a lens can be corrected by :
(A) providing different suitable curvatures of its two surfaces.
(B) proper polishing of its two surfaces.
(C) suitably combining it with another lens.
(D) reducing its aperture.

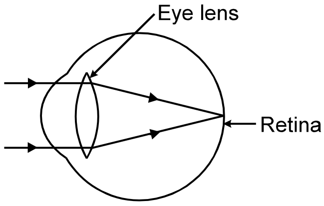
3. A combination is made of two lenses of focal lengths f and f' in contact ; the dispersive powers of the materials of the lenses are ω and ω′. The combination is achromatic when :
(A) $\omega = \omega_0$, $\omega' = 2\omega_0$, $f' = 2f$
(B) $\omega = \omega_0$, $\omega' = 2\omega_0$, $f' = f/2$
(C) $\omega = \omega_0$, $\omega' = 2\omega_0$, $f' = -f/2$
(D) $\omega = \omega_0$, $\omega' = 2\omega_0$, $f' = -2f$

4. The dispersive power of crown and flint glasses are 0.02 and 0.04 respectively. An achromatic converging lens of focal length 40 cm is made by keeping two lenses, one of crown glass and the other of flint glass, in contact with each other. The focal lengths of the two lenses are :
(A) 20 cm and 40 cm
(B) 20 cm and –40 cm
(C) –20cm and 40 cm
(D) 10 cm and –20cm

5. Chromatic aberration in a spherical concave mirror is proportional to :
(A) f
(B) f^2
(C) $1/f$
(D) None of these

COMPREHENSION-2

The ciliary muscles of eye control the curvature of the lens in the eye and hence can alter the effective focal length of the system. When the muscles are fully relaxed, the focal length is maximum. When the muscles are strained the curvature of lens increases (that means radius of curvature decreases) and focal length decreases. For a clear vision the image must be on retina. The image distance is therefore fixed for clear vision and it equals the distance of retina from eye-lens. It is about 2.5 cm for a grown-up person (Refer the figure below).



A person can theoretically have clear vision of objects situated at any large distance from the eye. The smallest distance at which a person can clearly see is related to minimum possible focal length. The ciliary muscles are most strained in this position. For an average grown-up person minimum distance of object should be around 25 cm.

A person suffering for eye defects uses spectacles (eye glass). The function of lens of spectacles is to form the image of the objects within the range in which person can see clearly. The image of the spectacle-lens becomes object for eye-lens and whose image is formed on retina.

The number of spectacle-lens used for the remedy of eye defect is decided by the power of the lens required and the number of spectacle-lens is equal to the numerical value of the power of lens with sign. For example power of lens required is +3D (converging lens of focal length $\frac{100}{3}$ cm) then number of lens will be + 3.

For all the calculations required you can use the lens formula and lens maker's formula. Assume that the eye lens is equiconvex lens. Neglect the distance between eye lens and the spectacle lens.

6. Minimum focal length of eye lens of a normal person is

(A) 25 cm (B) 2.5 cm (C) $\frac{25}{9}$ cm (D) $\frac{25}{11}$ cm

7. Maximum focal length of eye lens of normal person is

(A) 25 cm (B) 2.5 cm (C) $\frac{25}{9}$ cm (D) $\frac{25}{11}$ cm

8. A nearsighted man can clearly see object only upto a distance of 100 cm and not beyond this. The number of the spectacles lens necessary for the remedy of this defect will be.

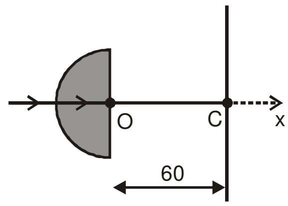
(A) +1 (B) – 1 (C) + 3 (D) – 3

9. A farsighted man cannot see object clearly unless they are at least 100 cm from his eyes. The number of the spectacles lens that will make his range of clear vision equal to an average grown up person :

(A) + 1 (B) – 1 (C) + 3 (D) – 3

COMPREHENSION-3

Figure shows a solid transparent semi cylinder of radius 10 cm. A screen is placed at a distance 60 cm from O. A narrow beam is incident along x-axis at O. If cylinder starts rotating about O in clockwise direction with angular speed 6 rad/s then spot formed on screen will move upward (Refractive index of material of cylinder = $\frac{5}{3}$)



10. What is initial angular velocity of ray refracted from plane surface.

(A) 2 rad/s (B) 10 rad/s (C) 16 rad/s (D) 4 rad/s

11. At what distance from C bright spot on screen will disappear.

(A) 100 cm (B) 80 cm (C) 120 cm (D) 100 cm

Exercise-3

✍ **Marked Questions can be used as Revision Questions.**

PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

*** Marked Questions may have more than one correct option.**

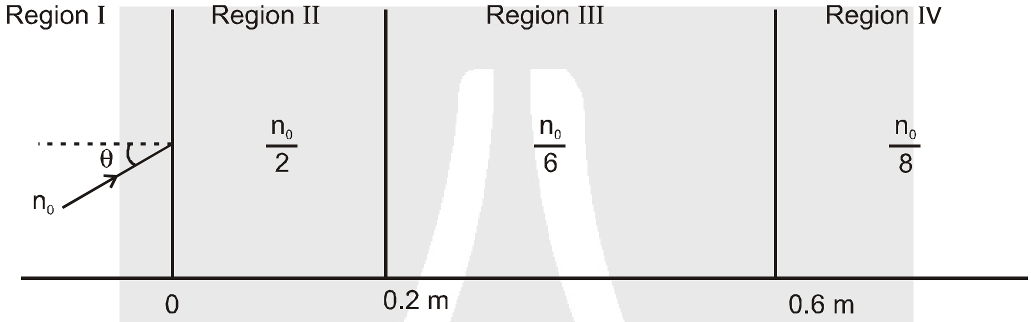
1. Two beams of red and violet colours are made to pass separately through a prism (angle of the prism is 60º). In the position of minimum deviation, the angle of refraction will be **[JEE' 2008_, 3/163]**

(A) 30º for both the colours (B) greater for the violet colour

(C) greater for the red colour (D) equal but not 30º for both the colours

2. A light beam is traveling from Region I to Region IV (Refer Figure). The refractive index in Regions I, II, III and IV are n_0, $\frac{n_0}{2}$, and $\frac{n_0}{8}$, respectively. The angle of incidence θ for which the beam just misses entering Region IV is **[JEE' 2008, 3/163]**

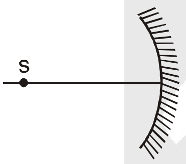
Figure :



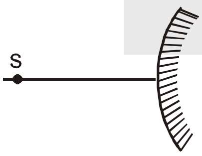
(A) $\sin^{-1}\left(\frac{3}{4}\right)$ (B) $\sin^{-1}\left(\frac{1}{8}\right)$ (C) $\sin^{-1}\left(\frac{1}{4}\right)$ (D) $\sin^{-1}\left(\frac{1}{3}\right)$

3.✍ An optical component and an object S placed along its optic axis are given in **Column I**. The distance between the object and the component can be varied. The properties of images are given in **Column II**. Match all the properties of images from **Column II** with the appropriate components given in **Column I**. **[JEE' 2008, 6/163, –1]**

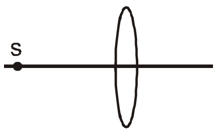
Column I **Column II**

(A) 

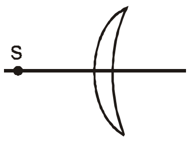
(p) Real image

(B) 

(q) Virtual image

(C) 

(r) Magnified image

(D) 

(s) Image at infinity

4. A ball is dropped from a height of 20 m above the surface of water in a lake. The refractive index of water is 4/3. A fish inside the lake, in the line of fall of the ball, is looking at the ball. At an instant, When the ball is 12.8 m above the water surface, the fish sees the speed of ball as [Take g = 10 m/s^2]

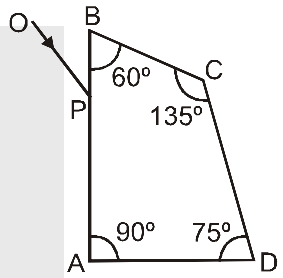
[JEE' 2009; 3/160, –1]

(A) 9 m/s (B) 12 m/s (C) 16 m/s (D) 21.33 m/s

5.* A student performed the experiment of determination of focal length of a concave mirror by u-v method using an optical bench of length 1.5 meter. The focal length of the mirror used is 24 cm. The maximum error in the location of the image can be 0.2 cm. The 5 sets of (u, v) values recorded by the student (in cm) are : (42, 56), (48, 48), (60, 40), (66, 33), (78, 39). The data set(s) that **cannot** come from experiment and is (are) incorrectly recorded, is (are) **[JEE' 2009; 4/160, –1]**

(A) (42, 56) (B) (48, 48) (C) (66, 33) (D) (78, 39)

6*. A ray OP of monochromatic light is incident on the face AB of prism ABCD near vertex B at an incident angle of 60º (see figure). If the refractive index of the material of the prism is $\sqrt{3}$, which of the following is (are) correct ? **[JEE' 2010; 3/163]**



(A) The ray gets totally internally reflected at face CD
(B) The ray comes out through face AD
(C) The angle between the incident ray and the emergent ray is 90º
(D) The angle between the incident ray and the emergent ray is 120º

7. The focal length of a thin biconvex lens is 20cm. When an object is moved from a distance of 25cm in front of it to 50cm, the magnification of its image changes from m_{25} to m_{50}. The ratio $\frac{m_{25}}{m_{50}}$ is :

[JEE 2010; 3/163]

8. A biconvex lens of focal length 15 cm is in front of a plane mirror. The distance between the lens and the mirror is 10 cm. A small object is kept at a distance of 30 cm from the lens. The final image is
(A) Virtual and at a distance of 16 cm from mirror
(B) Real and at distance of 16 cm from the mirror
(C) Virtual and at a distance of 20 cm form the mirror
(D) Real and at a distance of 20 cm from the mirror **[JEE' 2010; 5/163, –2]**

9. Image of an object approaching a convex mirror of radius of curvature 20 m along its optical axis is observed to move from $\frac{25}{3}$ m to $\frac{50}{7}$ m in 30 seconds. What is the speed of the object in km per hour.

[JEE' 2010; 3/163]

10. A large glass slab (μ = 5/3) of thickness 8 cm is placed over a point source of light on a plane surface. It is seen that light emerges out of the top surface of the slab from a circular area of radius R cm. What is the value of R? **[JEE' 2010; 3/163]**

11. Two transparent media of refractive indices μ_1 and μ_3 have a solid lens shaped transparent material of refractive index μ_2 between them as shown in figures in **column II.** A ray traversing these media is also shown in the figures. In **Column I** different relationships between μ_1, μ_2 and μ_3 are given. Match them to the ray diagrams shown in **Column II.** **[JEE' 2010; 8/163]**

Column I

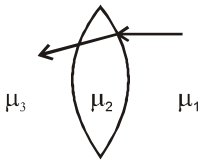
(A) $\mu_1 < \mu_2$

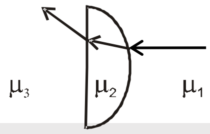
(B) $\mu_1 > \mu_2$

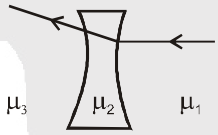
(C) $\mu_2 = \mu_3$

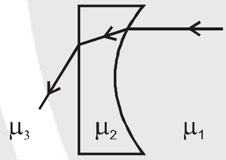
(D) $\mu_2 > \mu_3$

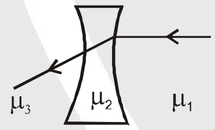
Column II

(p) 

(q) 

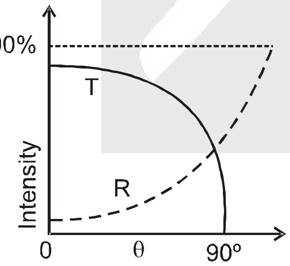
(r) 

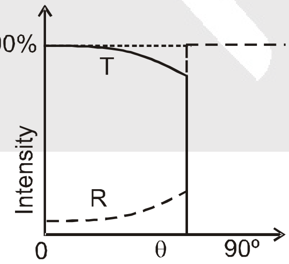
(s) 

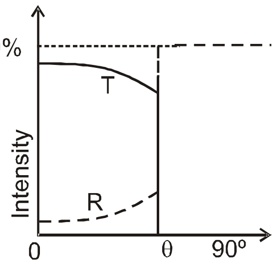
(t) 

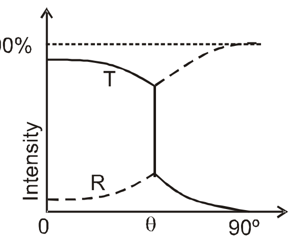
12. A light ray traveling in glass medium is incident on glass-air interface at an angle of incidence θ. The reflected (R) and transmitted (T) intensities, both as function of θ, are plotted. The correct sketch is

[JEE' 2011; 3/160, –1]

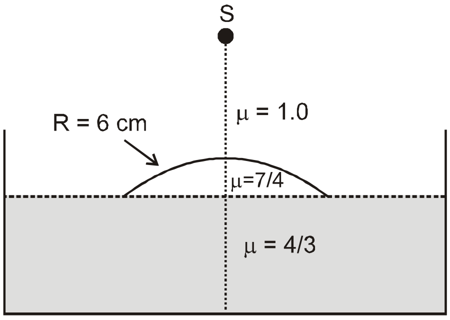
(A) 

(B) 

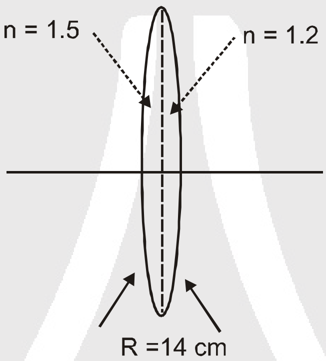
(C) 

(D) 

13. Water (with refractive index = 4/3) in a tank is 18 cm deep. Oil of refractive index 7/4 lies on water making a convex surface of radius of curvature 'R = 6 cm' as shown. Consider oil to act as a thin lens. An object 'S' is placed 24 cm above water surface. The location of its image is at 'x' cm above the bottom of the tank. Then 'x' is **[JEE' 2011; 4/160]**



14. A bi-convex lens is formed with two thin plano-convex lenses as shown in the figure. Refractive index n of the first lens is 1.5 and that of the second lens is 1.2. Both the curved surfaces are of the same radius of curvature R = 14 cm. For this bi-convex lens, for an object distance of 40 cm, the image distance will be **[IIT-JEE-2012; Paper-1 : 3/70, –1]**



(A) –280.0 cm (B) 40.0 cm (C) 21.5 cm (D) 13.3 cm

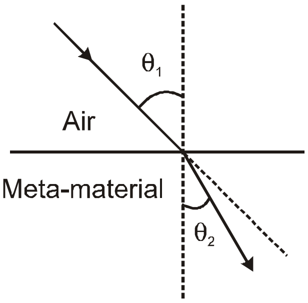
Paragraph for Question 15 and 16

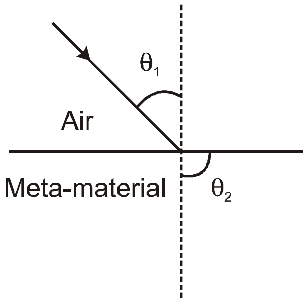
Most materials have the refractive index, n > 1. So, when a light ray from air enters a naturally occurring material, then by Snells' law, $\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$, it is understood that the refracted ray bends towards the normal. But it never emerges on the same side of the normal as the incident ray. According to electromagnetism, the refractive index of the medium is given by the relation, n = $\left(\frac{c}{v}\right) = \pm\sqrt{\varepsilon_r\mu_r}$ where c is the speed of electromagnetic waves in vacuum, v its speed in the medium, ε_r and μ_r are negative, one must choose the negative root of n. Such negative refractive index materials can now be artificially prepared and are called meta-materials. They exhibit significantly different optical behavior, without violating any physical laws. Since n is negative, it results in a change in the direction of propagation of the refracted light. However, similar to normal materials, the frequency of light remains unchanged upon refraction even in meta-materials. **[IIT-JEE-2012, Paper-2 : 3/66, –1]**

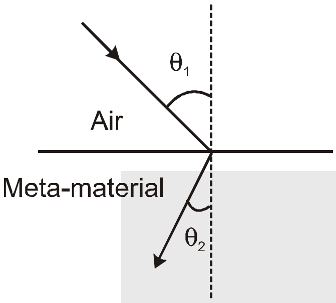
15. Choose the correct statement.
(A) The speed of light in the meta-material is v = c|n|
(B) The speed of light in the meta-material is v = $\frac{c}{|n|}$
(C) The speed of light in the meta-material is v = c.
(D) The wavelength of the light in the meta-material (λ_m) is given by $\lambda_m = \lambda_{air}$ |n|, where λ_{air} is the wavelength of the light in air.

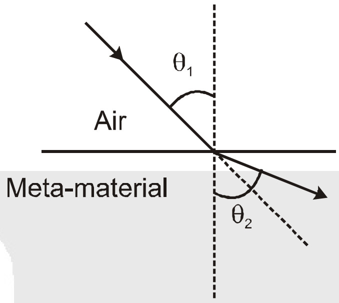
16. For light incident from air on a meta-material, the appropriate ray diagram is :

[IIT-JEE-2012, Paper-2 : 3/66, –1]

(A)


(B)


(C)


(D)


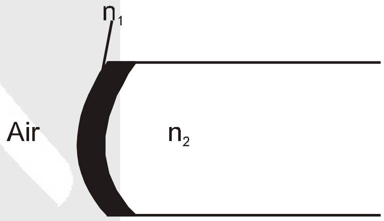
17. The image of an object, formed by a plano-convex lens at a distance of 8 m behind the lens, is real and is one-third the size of the object. The wavelength of light inside the lens is 2/3 times the wavelength in free space. The radius of the curved surface of the lens is : **[JEE-2013 (Advanced); 3/60, –1]**

(A) 1 m (B) 2 m (C) 3 m (D) 6 m

18. A ray of light travelling in the direction $\frac{1}{2}\left(\hat{i}+\sqrt{3}\hat{j}\right)$ is incident on a plane mirror. After reflection, it travels along the direction $\frac{1}{2}\left(\hat{i}-\sqrt{3}\hat{j}\right)$. The angle of incidence is : **[JEE-2013 (Advanced); 3/60, –1]**

(A) 30º (B) 45º (C) 60º (D) 75º

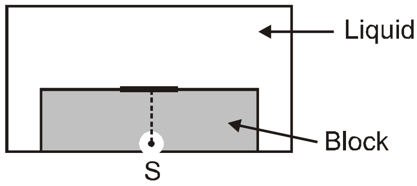
19.* A transparent thin film of uniform thickness and refractive index $n_1 = 1.4$ is coated on the convex spherical surface of radius R at one end of a long solid glass cylinder of refractive index $n_2 = 1.5$. as shown in the figure. Rays of light parallel to the axis of the cylinder traversing through the film from air to glass get focused at distance f_1 from the film, while rays of light traversing from glass to air get focused at distance f_2 from the film. Then



[JEE (Advanced)-2014,P-1, 3/60]

(A) $|f_1| = 3R$ (B) $|f_1| = 2.8R$
(C) $|f_2| = 2R$ (D) $|f_2| = 1.4R$

20. A point source S is placed at the bottom of a transparent block of height 10 mm and refractive index 2.72. It is immersed in a lower refractive index liquid as shown in the figure. It is found that the light emerging from the block to the liquid forms a circular bright spot of diameter 11.54 mm on the top of the block. The refractive index of the liquid is **[JEE (Advanced)-2014, 3/60, –1]**



(A) 1.21 (B) 1.30 (C) 1.36 (D) 1.42

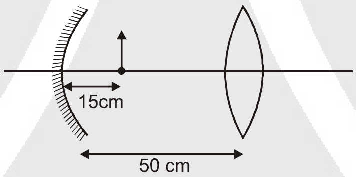
21. Four combinations of two thin lenses are given in List-I. The radius of curvature of all curved surface is r and the refractive index of all lenses is 1.5. Match lens combinations in List-I with their focal length in List-II and select the correct answer using the code given below the lists. **[JEE (Advanced) 2014, 3/60, –1]**

List-I		List-II	
P.		**1.**	2r
Q.		**2.**	r/2
R.		**3.**	–r
S.		**4.**	r

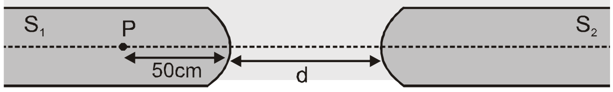
Code :

(A) P-1, Q-2, R-3, S-4 (B) P-2, Q-4, R-3, S-1 (C) P-4, Q-1, R-2, S-3 (D) P-2, Q-1, R-3, S-4

22. Consider a concave mirror and a convex lens (refractive index = 1.5) of focal length 10 cm each, separated by a distance of 50 cm in air (refractive index = 1) as shown in the figure. An object is placed at a distance of 15 cm from the mirror. Its erect image formed by this combination has magnification M_1. When the set-up is kept in a medium of refractive index 7/6, the magnification becomes M_2. The magnitude $\left|\frac{M_2}{M_1}\right|$ **[JEE (Advanced) 2015 ; P-1,4/88]**

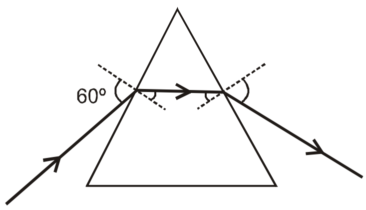


23. Two idenctical glass rods S_1 and S_2 (refractive index = 1.5) have one convex end of radius of curvature 10 cm. They are placed with the curved surfaces at a distance d as shown in the figure, with their axes (shown by the dashed line) aligned. When a point source of light P is placed inside rod S_1 on its axis at a distance of 50 cm from the curved face, the light rays emanating from it are found to be parallel to the axis inside S_2. The distance d is : **[JEE(Advanced) 2015 ; P-1,4/88, –2]**



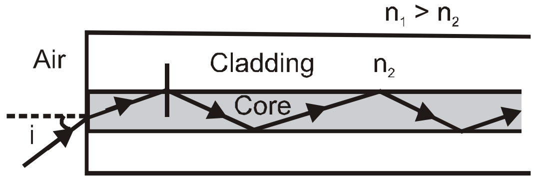
(A) 60 cm (B) 70 cm (C) 80 cm (D) 90 cm

24. A monochromatic beam of light is incident at 60º on one face of an equilateral prism of refractive index n and emerges from the opposite face making an angle θ(n) with the normal (see the figure). For $n = \sqrt{3}$ the value of θ is 60º and $\frac{d\theta}{dn}$ = m. The value of m is : **[JEE(Advanced) 2015 ; P-2,4/88]**



Paragraph for Question 25 and 26

Light guidance in an optical fiber can be understood by considering a structure comprising of thin solid glass cylinder of refractive index n_1 surrounded by a medium of lower refractive index n_2. The light guidance in the structure takes place due to successive total internal reflections at the interface of the media n_1 and n_2 as shown in the figure. All rays with the angle of incidence i less than a particular value i_m are confined in the medium of refractive index n_1. The numerical aperture (NA) of the structure is defined as sin i_m.



25.* For two structures namely S_1 with $n_1 = \sqrt{45}/4$ and n_2 = 3/2, and S_2 with n_1 = 8/5 and n_2 = 7/5 and taking the refractive index of water to be 4/3 and that of air to be 1, the correct option(s) is (are)

[JEE (Advanced) 2015 ; P-2,4/88, –2]

(A) NA of S_1 immersed in water is the same as that of S_2 immersed in a liquid of refractive index $\frac{16}{3\sqrt{15}}$

(B) NA of S_1 immersed in liquid of refractive index $\frac{6}{\sqrt{15}}$ is that as that of S_2 immersed in water

(C) NA of S_1 placed in air is the same as that of S_2 immersed in liquid of refractive index $\frac{4}{\sqrt{15}}$

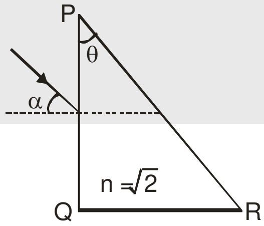
(D) NA of S_1 placed in air is the same as that of S_2 placed in water

26. If two structures of same cross-sectional area, but different numerical apertures NA_1 and NA_2 ($NA_2 < NA_1$) are joined longitudinally, the numerical aperture of the combined structure is

[JEE (Advanced) 2015 ; P-2,4/88, –2]

(A) $\frac{NA_1\ NA_2}{NA_1 + NA_2}$ (B) $NA_1 + NA_2$ (C) NA_1 (D) NA_2

27. A parallel beam of light is incident from air at an angle α on the side PQ of a right angled triangular prism of refractive index $n = \sqrt{2}$. Light undergoes total internal reflection in the prism at the face PR when α has a minimum value of 45º. The angle θ of the prism is : **[JEE Advanced 2016; P-1, 3/62, –1]**



(A) 15º (B) 22.5º (C) 30º (D) 45º

28.* A plano-convex lens is made of a material of refractive index n. When a small object is placed 30 cm away in from of the curved surface of the lens, an image of double the size of the object is produced. Due to reflection from the convex surface of the lens, another faint image is observed at a distance of 10 cm away from the lens. Which of the following statement (s) is(are) true?

(A) The refractive index of the lens is 2.5 **[JEE Advanced 2016 ; P-1, 4/62, –2]**

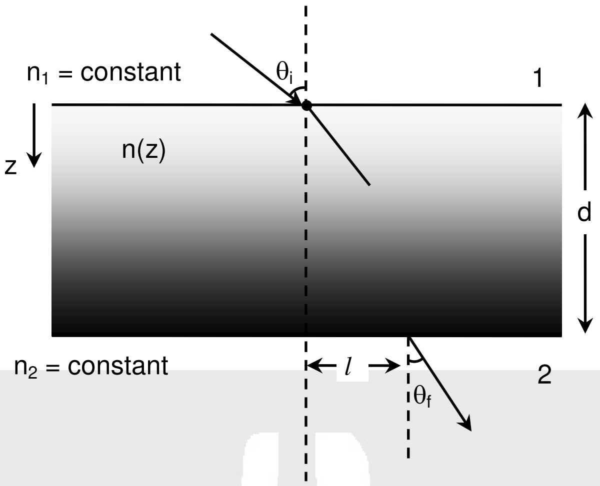
(B) The radius of curvature of the convex surface is 45 cm

(C) The faint image is erect and real

(D) The focal length of the lens is 20 cm

29.* A transparent slab of thickness d has a refractive index n(z) that increases with z. Here z is the vertical distance inside the slab, measured from the top. The slab is placed between two media with uniform refractive indices n_1 and n_2 (> n_1), as shown in the figure. A ray of light is incident with angle θ_i from medium 1 and emerges in medium 2 with refraction angle θ_f with a lateral displacement l :

[JEE Advanced 2016 ; P-1, 4/62, –2]



Which of the following statement(s) is (are) true ?

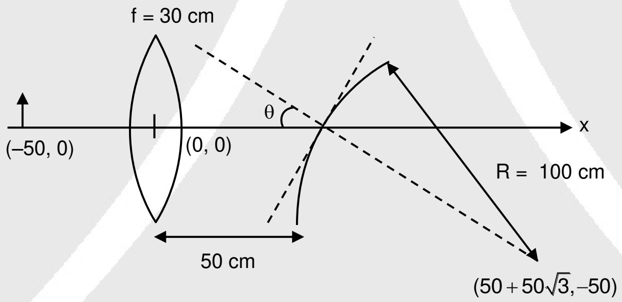
(A) $n_1 \sin \theta_i = n_2 \sin \theta_f$

(B) $n_1 \sin \theta_i = (n_2 - n_1) \sin \theta_f$

(C) l is independent of n_2

(D) l is dependent of n(z)

30. A smaller object is placed 50 cm to the left of a thin convex lens of focal length 30 cm. A convex spherical mirror of radius of curvature 100 cm is placed to the right of the lens at a distance of 50 cm. The mirror is tilted such that the axis of the mirror is at an angle θ = 30º to the axis of the lens, as shown in the figure. **[JEE Advanced 2016; P-2, 3/62, –1]**



If the origin of the coordinate system is taken to be at the centre of the lens, the coordinates (in cm) of the point (x, y) at which the image is formed are :

(A) $(125/3, 25/\sqrt{3})$ (B) $(25, 25\sqrt{3})$ (C) $(50 - 25\sqrt{3}, 25)$ (D) (0, 0)

31. For an isosceles prism of angle A and refractive index μ, it is found that the angle of minimum deviation δ_m = A. Which of the following options is/are correct ? **[JEE Advanced 2017; P-1, 4/61, –2]**

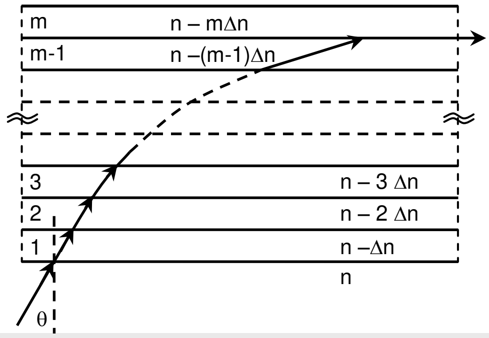
(A) At minimum deviation, the incident angle i_1 and the refracting angle r_1 at the first refracting surface are related by $r_1 = \left(\frac{i_1}{2}\right)$

(B) For this prism, the refractive index μ and the angle of prism A are related as $A = \frac{1}{2}\cos^{-1}\left(\frac{\mu}{2}\right)$

(C) For the angle of incidence i_1 = A, the ray inside the prism is parallel to the base of the prism

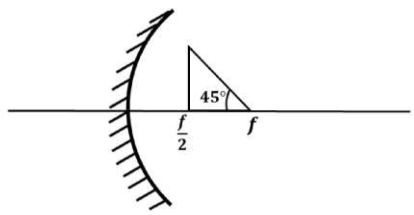
(D) For this prism, the emergent ray at the second surface will be tangential to the surface when the angle of incidence at the first surface is $i_1 = \sin^{-1}\left[\sin A\sqrt{4\cos^2\frac{A}{2} - 1} - \cos A\right]$

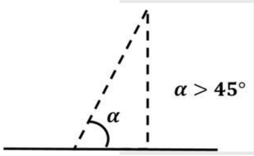
32. A monochromatic light is travelling in a medium of refractive index n = 1.6. It enters a stack of glass layers from the bottom side at an angle θ = 30°. The interfaces of the glass layers are parallel to each other. The refractive indices of different glass layers are monotonically decreasing as $n_m = n - m\Delta n$, where n_m is the refractive index of the m^{th} slab and Δn = 0.1 (see the figure). The ray is refracted out parallel to the interface between the $(m-1)^{th}$ and m^{th} slabs from the right side of the stack. What is the value of m ? **[JEE Advanced 2017; P-1, 3/61]**

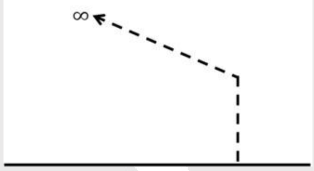


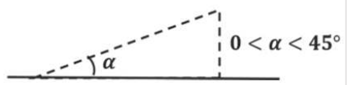
33. Sunlight of intensity 1.3 kWm^{-2} is incident normally on a thin convex lens of focal length 20 cm. Ignore the energy loss of light due to the lens and assume that the lens aperture size is much smaller than its focal length. The average intensity of light, in kWm^{-2}, at a distance 22 cm from the lens on the other side is __________. **[JEE (Advanced) 2018, P-1, 3/60]**

34*. A wire is bent in the shape of a right angled triangle and is placed in front of a concave mirror of focal length f, as shown in the figure. Which of the figures shown in the four options qualitatively represent(s) the shape of the image of the bent wire? (These figures are not to scale.)
[JEE (Advanced) 2018, P-2, 4/60, –2]



(A) 

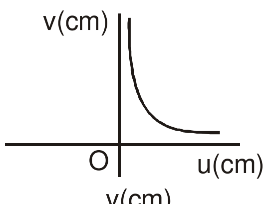
(B) 

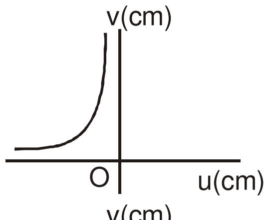
(C) 

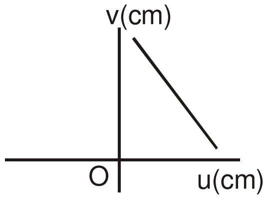
(D) 

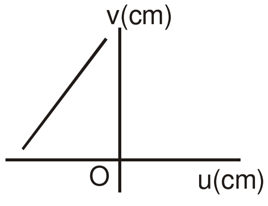
PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. A student measures the focal length of a convex lens by putting an object pin at a distance 'u' from the lens and measuring the distance 'v' of the image pin. The graph between 'u' and 'v' plotted by the student should look like - **[AIEEE-2008, 3/105]**

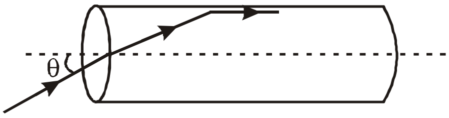
(1) 

(2) 

(3) 

(4) 

2. A transparent solid cylindrical rod has a refractive index of $\frac{2}{\sqrt{3}}$. It is surrounded by air. A light ray is incident at the mid-point of one end of the rod as shown in the figure. **[AIEEE-2009, 4/144]**



The incident angle (θ) for which the light ray grazes along the wall of the rod is:

(1) $\sin^{-1}\left(\frac{\sqrt{3}}{2}\right)$ (2) $\sin^{-1}\left(\frac{2}{\sqrt{3}}\right)$ (3) $\sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$ (4) $\sin^{-1}\left(\frac{1}{2}\right)$

3. In an optics experiment, with the position of the object fixed, a student varies the position of a convex lens and for each position, the screen is adjusted to get a clear image of the object. A graph between the object distance u and the image distance v, from the lens, is plotted using the same scale for the two axes. A straight line passing through the origin and making an angle of 45° with the x-axis meets the experimental curve at P. The coordinates of P will be: **[AIEEE-2009, 4/144]**

(1) $\left(\frac{f}{2}, \frac{f}{2}\right)$ (2) (f, f) (3) (4f, 4f) (4) (2f, 2f)

4. A car is fitted with a convex side–view mirror of focal length 20 cm. A second car 2.8 m behind the first car is overtaking the first car at a relative speed of 15 m/s. The speed of the image of the second car as seen in the mirror of the first one is : **[AIEEE - 2011, 4/120, –1]**

(1) $\frac{1}{10}$ m/s (2) $\frac{1}{15}$ m/s (3) 10 m/s (4) 15 m/s

5. Let the x - y plane be the boundary between two transparent media. Medium 1 in $z \geq 0$ has refractive index of $\sqrt{2}$ and medium 2 with $z < 0$ has a refractive index of $\sqrt{3}$. A ray of light in medium 1 given by the vector $\vec{A} = 6\sqrt{3}\ \hat{i} + 8\sqrt{3}\ \hat{j} - 10\ \hat{k}$ in incident on the plane of separation. The angle of refraction in medium 2 is : **[AIEEE - 2011, 4/120, –1]**

(1) 30º (2) 45º (3) 60º (4) 75º

6. A beaker contains water up to a height h_1 and kerosene of height h_2 above water so that the total height of (water + kerosene) is $(h_1 + h_2)$. Refractive index of water is μ_1 and that of kerosene is μ_2. The apparent shift in the position of the bottom of the beaker when viewed from above is : **[AIEEE 2011, 11 MAY; 4/120, –1]**

(1) $\left(1+\frac{1}{\mu_1}\right) h_1 - \left(1+\frac{1}{\mu_2}\right) h_2$ (2) $\left(1-\frac{1}{\mu_1}\right) h_1 + \left(1-\frac{1}{\mu_2}\right) h_2$

(3) $\left(1+\frac{1}{\mu_1}\right) h_2 - \left(1+\frac{1}{\mu_2}\right) h_1$ (4) $\left(1-\frac{1}{\mu_1}\right) h_2 + \left(1-\frac{1}{\mu_2}\right) h_1$

7. When monochromatic red light is used instead of blue light in a convex lens, its focal length will : **[AIEEE 2011, 11 MAY; 4/120, –1]**

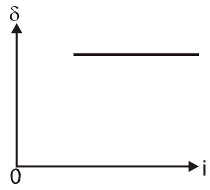
(1) increase (2) decrease
(3) remain same (4) does not depend on colour of light

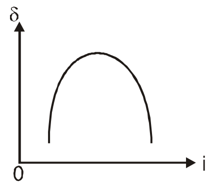
8. An object 2.4 m in front of a lens forms a sharp image on a film 12 cm behind the lens. A glass plate 1 cm thick, of refractive index 1.50 is interposed between lens and film with its plane faces parallel to film. At what distance (from lens) should object shifted to be in sharp focus on film ? **[AIEEE 2012 ; 4/120, –1]**

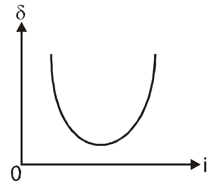
(1) 7.2 m (2) 2.4 m (3) 3.2 m (4) 5.6 m

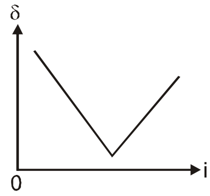
9. Diameter of a plano - convex lens is 6 cm and thickness at the centre is 3 mm. If speed of light in material of lens is 2×10^8 m/s, the focal length of the lens is : **[JEE(Main) 2013, 4/120, –1]**
(1) 15 cm (2) 20 cm (3) 30 cm (4) 10 cm

10. The graph between angle of deviation (δ) and angle of incidence (i) for a triangular prism is represented by : **[JEE (Main) 2013; 4/120, –1]**

(1)


(2)


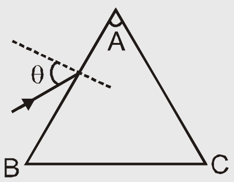
(3)


(4)


11. A thin convex lens made from crown glass $\left(\mu = \frac{3}{2}\right)$ has focal length f. When it is measured in two different liquids having refractive indices $\frac{4}{3}$ and $\frac{5}{3}$, it has the focal lengths f_1 and f_2 respectively. The correct relation between the focal length is : **[JEE (Main) 2014, 4/120, –1]**
(1) $f_1 = f_2 < f$ (2) $f_1 > f$ and f_2 becomes negative
(3) $f_2 > f$ and f_1 becomes negative (4) f_1 and f_2 both become negative

12. White light is incident from the water to the air - water interface at the critical angle (θ) for green light. Select the correct statement. **[JEE (Main) 2014; 4/120, –1]**
(1) The entire spectrum of visible light will come out of the water at an angle of 90º to the normal.
(2) The spectrum of visible light whose frequency is less than that of green light will come out to the air medium.
(3) The spectrum of visible light whose frequency is more than that of green light will come out to the air medium.
(4) The entire spectrum of visible light will come out of the water at various angles to the normal.

13. Monochromatic light is incident on a glass prism of angle A. If the refractive index of the material of the prism is μ, a ray, incident at an angle θ, on the face AB would get transmitted through the face AC of the prism provided: **[JEE (Main)-2015; 4/120, –1]**



(1) $\theta > \sin^{-1}\left[\mu \sin\left(A - \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$ (2) $\theta < \sin^{-1}\left[\mu \sin\left(A - \sin^{-1}\left(\frac{1}{\mu}\right)\right)\right]$
(3) $\theta > \cos^{-1}\left[\mu \sin\left(A + \sin\left(\frac{1}{\mu}\right)\right)\right]$ (4) $\theta < \cos^{-1}\left[\mu \sin\left(A + \sin\left(\frac{1}{\mu}\right)\right)\right]$

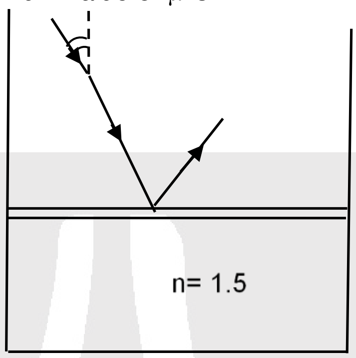
14. An observer looks at a distant tree of height 10 m with a telescope of magnifying power of 20. To the observer the tree appears: **[JEE (Main)-2016; 4/120, –1]**
(1) 10 times nearer (2) 20 times taller (3) 20 times nearer (4) 10 times taller

15. In an experiment for determination of refractive index of glass of a prism by i – δ, plot, it was found that a ray incident at angle 35°, suffers a deviation of 40° and that it emerges at angle 79°. In that case which of the following is closest to the maximum possible value of the refractive index ? **[JEE (Main)-2016; 4/120, –1]**
(1) 1.6 (2) 1.7 (3) 1.8 (4) 1.5

16. A diverging lens with magnitude of focal length 25cm is placed at a distance of 15 cm from a converging lens of magnitude of focal length 20 cm. A beam of parallel light falls on the diverging lens. The final image formed is : **[JEE Main 2017, 4/120, –1]**

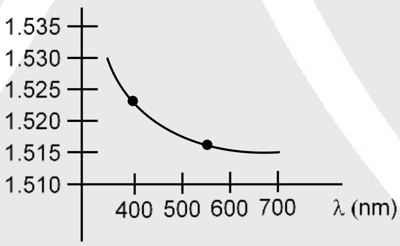
(1) real and at a distance of 6 cm from the convergent lens
(2) real and at a distance of 40 cm from convergent lens.
(3) virtual and at a distance of 40 cm from convergent lens
(4) real and at distance of 40 cm from the divergent lens.

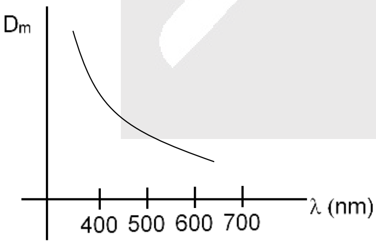
17. Consider a tank made of glass (refractive index 1.5) with a thick bottom. It is filled with a liquid of refractive index μ. A student finds that, irrespective of what the incident angle i (see figure) is for a beam of light entering the liquid, the light reflected from the liquid glass interface is never completely polarized. For this to happen, the minimum value of μ is : **[JEE Main 2019, 4/120, –1]**

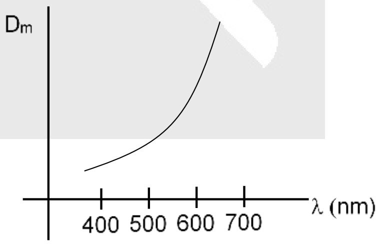


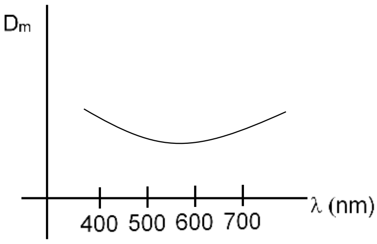
(1) $\frac{5}{\sqrt{3}}$ (2) $\frac{4}{3}$ (3) $\frac{3}{\sqrt{5}}$ (4) $\sqrt{\frac{5}{3}}$

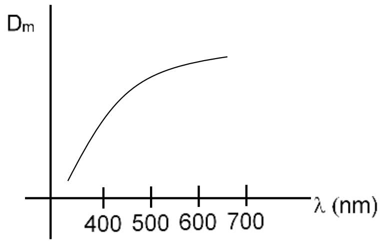
18. The variation of refractive index of a crown glass thin prism with wavelength of the incident light is shown. Which of the following graphs is the correct one, if D_m is the angle of minimum deviation ?
[JEE Main 2019, 4/120, –1]



(1)


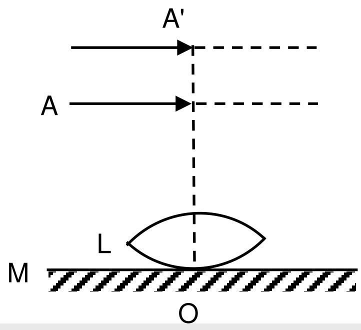
(2)


(3)


(4)


19. A thin convex lens L (refractive index = 1.5) is placed on a plane mirror M. When a pin is placed at A, such that OA = 18 cm, its real inverted image is formed at A itself, as shown in figure. When a liquid of refractive index μ_ℓ is put between the lens and the mirror, the pin has to be moved to A' such that OA' = 27 cm, to get its inverted real image A' itself. The value of μ_ℓ will be :

[JEE Main 2019 April, 4/120, –1]



(1) $\frac{4}{3}$ (2) $\sqrt{2}$ (3) $\sqrt{3}$ (4) $\frac{3}{4}$

Answers

EXERCISE-1

PART - I

SECTION (A) :

A-1. 120º anticlockwise and 240º clockwise.

A-2. 30º clockwise.

A-3. 60º

A-4. Mirror should be placed on the path of the rays at an ∠ of 78º or 12° to the horizontal

A-5. (a) 1 ; (b) (4, 0) ; (c) No

A-6. (a) Position of image

$= (1\cos 60^\circ\,\hat{i}\,,\ -1\sin 60^\circ\,\hat{j}\,)$

(b) Velocity of image

$= (1\cos 60^\circ,\ +1\sin 60^\circ)$ m/s.

SECTION (B) :

B-1. Infinitely large.

B-2. $\frac{245}{4}$ cm = 61.25 cm

B-3. 10.35 cm = $\frac{3933}{380}$ cm

B-4. 84 cm, 0.5 cm

B-5. 0.2 m from the mirror

B-6. (a) 40 cm/s opposite to the velocity of object., (b) 20 cm/s opposite to the velocity of object.

B-7. 60 cm **B-8.** 86 cm

SECTION (C) :

C-1. $2/3 \times 10^{-8}$ sec

C-2. $3\left(\frac{1}{\sqrt{2}} - \frac{1}{\sqrt{7}}\right)$cm = 9.9 mm, 45°

C-3. 30 cm **C-4.** 25 cm.

C-5. 9 cm/s **C-6.** 35 cm, Shift = 5 cm.

C-7. $\frac{68}{3}$ cm **C-8.** 0.9 cm above P

C-9. $\sqrt{3}$ cm **C-10.** $\frac{\pi h^2}{\mu^2 - 1}$

C-11. 45° **C-12.** $n > \sqrt{2}$

SECTION (D) :

D-1. 90º **D-2.** $\theta = 60°$

D-3. (i) 1.5°, (ii) $\frac{3°}{8}$ **D-4.** $2\sin^{-1}\frac{1}{\mu}$

SECTION (E) :

E-1. 40 cm from pole in the medium of refractive index 1, virtual, erect and 4 cm in size.

E-2. 80 cm **E-3.** 50 cm right of B.

E-4. $\frac{27}{2}$ = 13.5 cm below the surface of water

E-5. 8/3 mm, virtual at v = –20, no inversion

E-6. (a) 2, (b) not possible, it will focus close to the centre if the refractive index is large

E-7. m = 4/3

SECTION (F) :

F-1. ± 12 cm, ± 60 cm

F-2. 360 cm; ∞ ; – 600 cm

F-3. Converging ; real

F-4. (a) $\frac{\mu_3 R}{2\mu_2 - \mu_1 - \mu_3}$ (b) $\frac{\mu_1 R}{2\mu_2 - \mu_1 - \mu_3}$

F-5. **(i)** 7/5

(ii) In this liquid the 1st lens will be diverging & the 2nd a converging one

F-6. 20 cm, 1 m, –4, 4 cm **F-7.** 0.3 m

F-8. 1.5 cm **F-9.** 0.4 cm

F-10. 30 cm

F-11. 60 cm from the lens further away from the mirror

F-12. $\frac{5}{3}$ cm from the lens

F-13. 31 cm from the lens

F-14. 1.0 cm if the light is incident from the side of concave lens and 2.5 mm if it is incident from the side of the convex lens and the corresponding ratio of intensities are 1/4 and 4.

SECTION (G) :

G-1. 10 D, Optical power of each lens = 5 D.

G-2. 10 cm for convex lens and 60 cm for concave lens

G-3. (a) 15 cm from the lens on the axis (b) 1.14 cm towards the lens

SECTION (H) :

H-1. (a) 1/4 = 0.25 (b) 0.90°

H-2. 4°

H-3. (a) $\frac{2(\mu_v - \mu_r)}{\mu_v' - \mu_r'}$, (b) $\frac{2(\mu_y - 1)}{\mu_y' - 1}$

H-4. $\frac{99}{4900}$

H-5. (a) 3° (b) 0.015º (c) 3º (d) 0.225°

SECTION (I) :

I-1. 24; 150 cm

I-2. $u_0 = -1.45$, $v_0 = 8.75$, $L = v_0 + f_e = 13.75$

I-3. (a) v_e = – 2.5 cm and f_e = 6.25 cm give u_e = – 5 cm ; v_0 = (15 – 5) cm = 10 cm.
$f_0 = u_0$ = – 2.5 cm;
Magnifying power = 10/2.5 × 25/5 = 20
(b) u_e = – 6.25 cm, v_0 = (15 – 6.25) cm = 8.75, f_0 = 2.0 cm. Therefore,
u_0 = – (70/27) = – 2.59 cm.
Magnifying power = $v_0/|u_0|$ × (25/6.25) = 27/8 × 4 = 13.5

PART - II

SECTION (A) :

A-1.	(B)	**A-2.**	(B)	**A-3.**	(A)
A-4.	(C)	**A-5.**	(D)	**A-6.**	(C)
A-7.	(A)	**A-8.**	(B)	**A-9.**	(C)

SECTION (B) :

B-1.	(A)	**B-2.**	(B)	**B -3.**	(C)
B-4.	(C)	**B-5.**	(C)	**B-6.**	(C)
B-7.	(B)	**B-8.**	(A)	**B-9.**	(C)
B-10.	(C)	**B-11.**	(A)	**B-12.**	(C)
B-13.	(C)	**B-14.**	(B)	**B-15.**	(A)
B-16.	(B)				

SECTION (C) :

C-1.	(B)	**C-2.**	(C)	**C-3.**	(A)
C-4.	(D)	**C-5.**	(A)	**C-6.**	(A)
C-7.	(A)	**C-8.**	(D)	**C-9.**	(B)

SECTION (D) :

D-1 .	(B)	**D-2.**	(C)	**D-3.**	(C)	
D-4.	**(a)**	(A)	**(b)**	(C)	**(c)**	(C)
D-5.	(C)	**D-6.**	(B)			

SECTION (E) :

E-1.	(B)	**E-2.**	(A)	**E-3.**	(A)
E-4.	(D)				

SECTION (F) :

F-1.	(A)	**F-2.**	(A)	**F-3.**	(C)
F-4.	(C)	**F-5.**	(D)	**F-6.**	(D)
F-7.	(D)	**F-8.**	(C)	**F-9.**	(B)
F-10.	(D)	**F-11.**	(A)	**F-12.**	(B)
F-13.	(A)	**F-14.**	(A)	**F-15.**	(C)

SECTION (G) :

G-1.	(A)	**G-2.**	(B)	**G-3.**	(A)
G-4.	(C)	**G-5.**	(D)		

SECTION (H) :

H-1.	(D)	**H-2.**	(D)	**H-3.**	(C)
H-4.	(B)	**H-5.**	(D)	**H-6.**	(D)

SECTION (I) :

I-1.	(D)	**I-2.**	(C)	**I-3.**	(C)
I-4.	(D)	**I-5.**	(A)	**I-6.**	(B)
I-7.	(B)	**I-8.**	(D)	**I-9.**	(C)
I-10.	(B)				

PART - III

1. (A) – p ; (B) – p ; (C) – q ; (D) – q
2. (A) – p, q ; (B) – p,q ; (C) – r, s ; (D) – r, s
3. (A) – p, s ; (B) – q ; (C) – r, s ; (D) – r

EXERCISE-2

PART - I

1.	(C)	**2.**	(B)	**3.**	(A)
4.	(C)	**5.**	(D)	**6.**	(A)
7.	(B)	**8.**	(B)	**9.**	(B)
10.	(B)	**12.**	(B)	**13.**	(A)
14.	(B)	**15.**	(A)		

PART - II

1.	3	**2.**	45	**3.**	10
4.	6	**5.**	2	**6.**	13
7.	6	**8.**	(a) 0,	(b) 6	
9.	6	**10.**	16	**11.**	5
12.	0	**13.**	12	**14.**	30
15.	9	**16.**	10	**17.**	20
18.	90	**19.**	4		

PART - III

1.	(AB)	**2.**	(ACD)	**3.**	(BD)
4.	(CD)	**5.**	(AD)	**6.**	(AC)
7.	(ABC)	**8.**	(BC)	**9.**	(AC)
10.	(BC)	**11.**	(ABC)	**12.**	(BD)
13.	(AD)	**14.**	(ABD)	**15.**	(AB)
16.	(BC)	**17.**	(AC)	**18.**	(AD)
19.	(AD)	**20.**	(ABD)	**21.**	(ABCD)

PART - IV

1.	(D)	**2.**	(C)	**3.**	(D)
4.	(B)	**5.**	(D)	**6.**	(D)
7	(B)	**8.**	(B)	**9.**	(C)
10.	(D)	**11.**	(B)		

EXERCISE-3

PART – I

1. (A) **2.** (B)
3. (A) → (p,q,r,s); (B) → (q); (C) → (p,q,r,s); (D) → (p,q,r,s)

4.	(C)	**5**	(CD)	**6.**	(ABC)
7.	6	**8.**	(B)	**9.**	3
10.	6				

11. (A) – p, r ; (B) –q,s,t ; (C) – p,r,t ; (D) – q, s

12.	(C)	**13.**	2	**14.**	(B)
15.	(B)	**16.**	(C)	**17.**	(C)
18.	(A)	**19.**	(AC)	**20.**	(C)
21.	(B)	**22.**	7	**23.**	(B)
24.	2	**25.**	(AC)	**26.**	(D)
27.	(A)	**28.**	(AD)	**29.**	(ACD)
30.	(B)	**31.**	(ACD)	**32.**	(8)
33.	130.00		**34.**	(D)	

PART - II

1.	(1)	**2.**	(3)	**3.**	(4)
4.	(2)	**5.**	(2)	**6.**	(2)
7.	(1)	**8.**	(4)	**9.**	(3)
10.	(3)	**11.**	(2)	**12.**	(2)
13.	(1)	**14.**	(3)	**15.**	(4)
16.	(2)	**17.**	(3)	**18.**	(1)
19.	(1)				