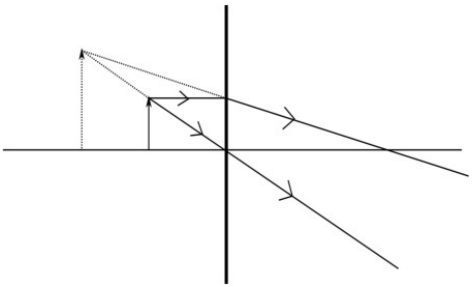
9. Light – Reflection and Refraction - Board Exam Questions

2 Mark Questions

1) *The given figure shows the formation of an image by a lens shown by a thick line. Analyse the figure and answer the following questions. A. What is the type of lens used? B. What is the nature of the image? C. If the image is formed at a distance of 30 cm from the lens and the image is twice the size of the object, then where is the object placed?*



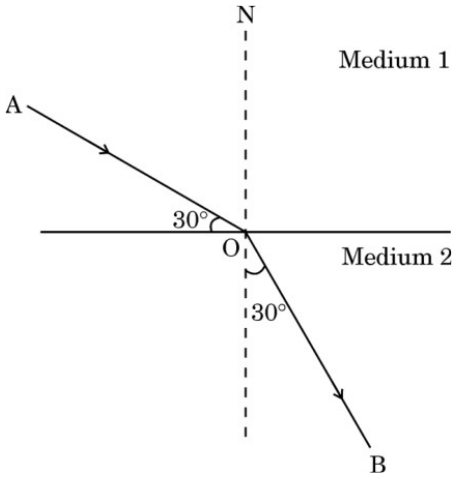
A. Convex lens

B. Virtual (and erect)

C. Magnification m = v/u = 2, and v = −30 cm (same side as the object).

So −30/u = 2, which gives u = −15 cm. The object is 15 cm in front of the lens.

2) *With the help of the given ray diagram, calculate the refractive index of Medium 2 with respect to Medium 1. (Given that √3 = 1.732)*

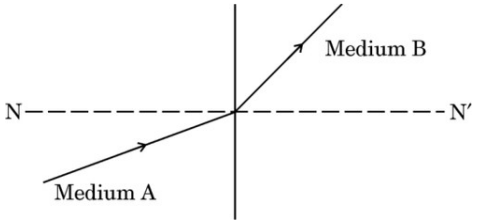


n = sin i / sin r

Angle of incidence i = 90° − 30° = 60°, angle of refraction r = 30°.

n = sin 60° / sin 30° = (√3/2) / (1/2) = √3 = 1.732

3) *A ray of light enters into medium B from medium A as shown in the given figure: (a) Which one of these two media is optically denser than the other medium? Justify your answer. (b) If the speed of light in medium A is V_A and in medium B is V_B, then what is the refractive index of medium B with respect to medium A?*



(a) Medium A. The ray bends away from the normal NN′ when it goes into B, so B is rarer and A is denser.

(b) $n_{BA} = V_A / V_B$

4) *(a) Relate the speed of light in the given medium with its optical density. (b) Using the information given in the table below, arrange the medium A, B and C in the ascending order of their optical density.*

Medium	Speed of light (m/s)
A	2.25×10^8
B	2×10^8
C	2.08×10^8

(a) Light is faster in an optically rarer medium and slower in an optically denser medium.

(b) A < C < B

5) *A. State Snell's Law of refraction. B. Define the refractive index of a material with respect to another material giving the mathematical expression.*

A. For light of a given colour and a given pair of media, sin i / sin r is a constant.

B. If light goes from medium 1 (speed v_1) into medium 2 (speed v_2), the refractive index of medium 2 with respect to medium 1 is $n_{21} = v_1 / v_2$.

6) *An object is placed at a distance of 60 cm from a concave lens of focal length 30 cm. Use lens formula to find the position of the image formed in this case.*

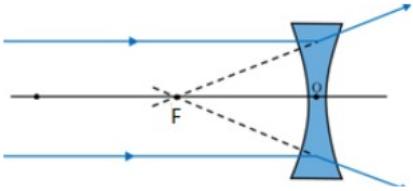
u = −60 cm, f = −30 cm

1/f = 1/v − 1/u, so 1/v = 1/f + 1/u = −1/30 − 1/60 = −3/60

v = −20 cm. The image is 20 cm from the lens, on the same side as the object.

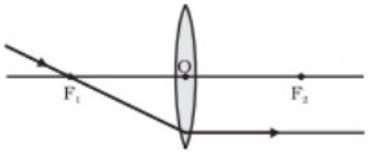
7) *Out of the two lenses, one concave and the other convex, state which one will diverge a parallel beam of light falling on it. Draw a ray diagram to show the principal focus of the lens.*

Concave lens



8) *A ray of light after refraction from a convex lens emerges parallel to its principal axis. (i) Draw a labelled ray diagram to show it. (ii) In this case, the incident ray before refraction from the lens passes through a point on its principal axis. Name the point.*

(i)



(ii) Principal focus (F_1)

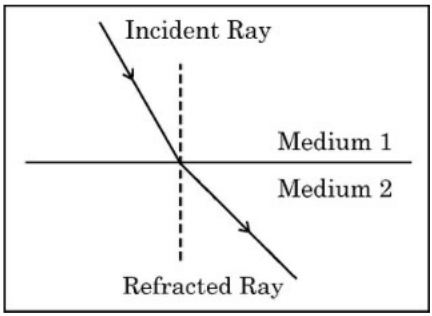
9) *The values of absolute refractive indices of kerosene and water are 1.44 and 1.33 respectively. Compare the two media on the basis of their (a) optical density (b) mass density (c) relative speed of propagation of light. What do you infer on the basis of above comparisons?*

	Kerosene (1.44)	Water (1.33)
(a)	Higher optical density	Lower optical density
(b)	Lower mass density	Higher mass density
(c)	Light is slower	Light is faster

Inference: Kerosene is optically denser than water, but its mass density is less. So optical density is not the same as mass density.

10) *Study the figure in which the path of a ray of light going from Medium 1 to Medium 2 is shown. (a) Out of the two Media – Medium 1 and Medium 2, in which is the speed of light more? (b) State reason of bending of*

the refracted ray away from the normal. (c) Express refractive index of Medium 2 with respect to Medium 1 in terms of speed of light in two media.

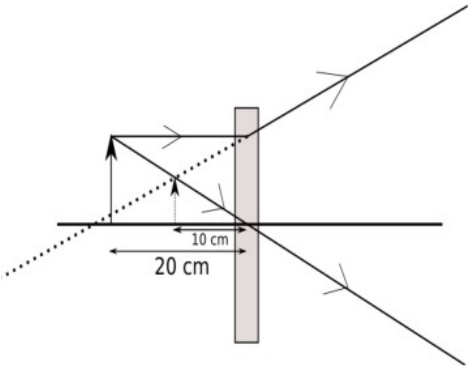


(a) Medium 2

(b) The ray goes from an optically denser medium to a rarer medium, so it bends away from the normal.

(c) n_{21} = speed of light in medium 1 / speed of light in medium 2

11) *The given image shows the formation of an image with an optical instrument. A. Identify the optical instrument (shown schematically as a rectangle) in the image. B. What type of image is formed in this case? C. Based on the measurements given in the image, calculate the focal length of the instrument.*



A. Concave lens

B. Virtual image

C. u = −20 cm, v = −10 cm (the image is on the same side as the object).

$1/f = 1/v - 1/u = -1/10 + 1/20 = -1/20$

$f = -20$ cm

12) *An object is placed at a distance of 10 cm from a convex mirror of focal length 15 cm. Find the position of the image formed by the mirror.*

$u = -10$ cm, $f = +15$ cm

$1/v + 1/u = 1/f$, so $1/v = 1/15 - 1/(-10) = 1/15 + 1/10 = 1/6$

$v = +6$ cm. The image is 6 cm behind the mirror.

13) *State two laws of refraction of light.*

(i) The incident ray, the refracted ray and the normal at the point of incidence all lie in the same plane.

(ii) For light of a given colour and a given pair of media, sin i / sin r is a constant (Snell's law).

14) *Define the term absolute refractive index of a medium. A ray of light enters from vacuum to glass of absolute refractive index 1.5. Find the speed of light in glass. The speed of light in vacuum is 3×10^8 m/s.*

Absolute refractive index = speed of light in vacuum (or air) / speed of light in the medium.

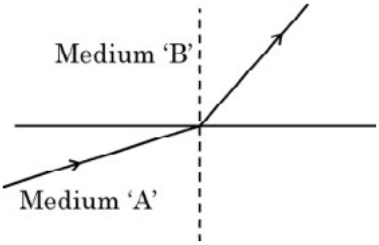
$n_m = c / v_m$, so $v_m = c / n_m = (3 \times 10^8) / 1.5 = 2 \times 10^8$ m/s

15) *The heat produced at a point due to concentration of sunlight by a convex lens burns a paper. (a) Explain why it happens. (b) Name the term (in the context of the lens used) given to the point at which the paper starts burning. What does the bright spot formed on the paper represent?*

(a) The convex lens brings the sunlight together at one point. The heat there makes the paper burn.

(b) Principal focus. The bright spot is the real image of the Sun.

16) *A light ray enters from medium A to medium B as shown in the figure. (a) Which one of the two media is denser w.r.t. other medium? Justify your answer. (b) If the speed of light in medium A is v_a and in medium B is v_b, what is the refractive index of B with respect to A.*

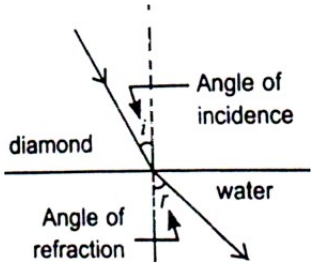


(a) Medium B, because the ray bends towards the normal when it enters B.

(b) $n_{BA} = v_a / v_b$

17) *(a) A ray of light starting from diamond is incident on the interface separating diamond and water. Draw a labelled ray diagram to show the refraction of light in this case. (b) Absolute refractive indices of diamond and water are 2.42 and 1.33 respectively. Find the value of refractive index of water w.r.t. diamond.*

(a) The ray goes from a denser to a rarer medium, so it bends away from the normal.



(b) Refractive index of water w.r.t. diamond = n_water / n_diamond = 1.33 / 2.42 = 0.55

18) *The refractive indices of three media are given below: A ray of light is travelling from A to B and another ray is travelling from B to C. (a) In which of the two cases the refracted ray bends towards the normal? (b) In which case does the speed of light increase in the second medium? Give reasons for your answer.*

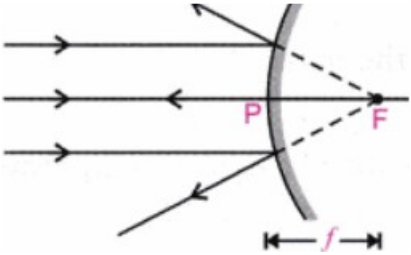
Medium	Refractive Index
A	1.6
B	1.8
C	1.5

(a) From A to B. A ray bends towards the normal when it goes from a rarer to a denser medium, and $n_B > n_A$.
(b) From B to C. Speed $v = c/n$, and $n_C < n_B$, so light goes faster in C.

3 Mark Questions

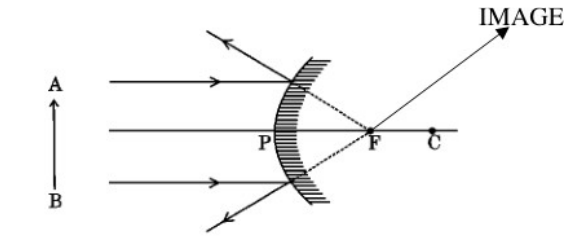
1) *Define the following terms in the context of a diverging mirror: (i) Principal focus (ii) Focal length. Draw a labelled ray diagram to illustrate your answer.*

(i) Principal focus: the point on the principal axis from which rays parallel to the axis appear to spread out after reflection from the convex mirror.
(ii) Focal length: the distance between the pole and the principal focus.



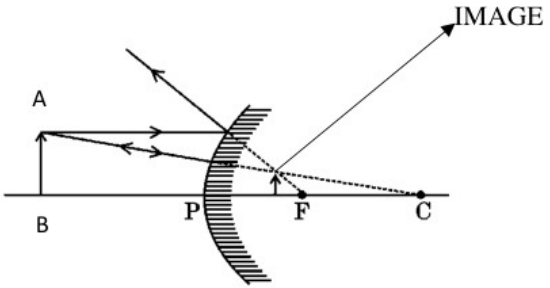
2) *Draw ray diagrams to show the nature, position and relative size of the image formed by a convex mirror when the object is placed (i) at infinity and (ii) between infinity and pole P of the mirror.*

(i) Image at F behind the mirror: virtual, erect, highly diminished (point-sized).



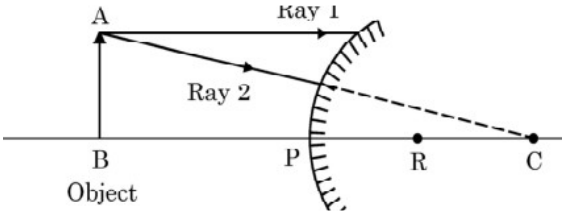
OBJECT

(ii) Image between P and F behind the mirror: virtual, erect, diminished.

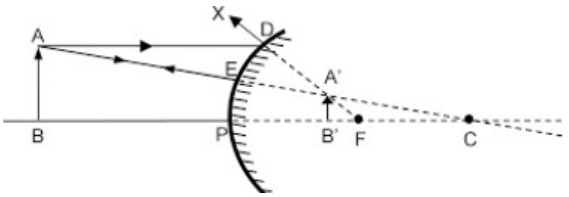


OBJECT

3) *(a) Complete the following ray diagram to show the formation of image. (b) Mention the nature, position and size of the image formed in this case. (c) State the sign of the image distance in this case using the Cartesian sign convention.*

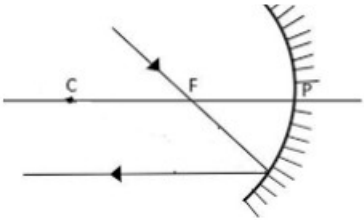


(a) A′B′ is the image.



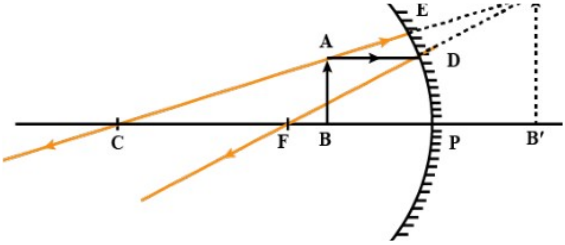
(b) Nature: virtual and erect. Position: behind the mirror, between P and F. Size: diminished.
(c) Positive

4) *(a) A ray of light after reflection from a concave mirror becomes parallel to its principal axis. Draw a labelled ray diagram to show this. (b) (i) Differentiate between the virtual images formed by a convex mirror and concave mirror. (ii) "The value of magnification 'm' for a mirror is –2." Calculate the height of object if the height of image is 20 cm.*
(a) The ray passes through F before it falls on the mirror.



(b) (i) A convex mirror forms a virtual image for every position of the object. A concave mirror forms a virtual image only when the object is between P and F.
(ii) m = h′/h. With m = −2, the image is inverted, so h′ = −20 cm.
h = h′/m = −20/−2 = 10 cm

5) *Rohit wants to have an erect image of an object using a converging mirror of focal length 40 cm. (a) Specify the range of distance where the object can be placed in front of the mirror. Justify. (b) Draw a ray diagram to show image formation in this case. (c) State one use of the mirror based on the above kind of image formation.*
(a) Between 0 and 40 cm (between P and F). Only then does a concave mirror form a virtual, erect and magnified image.
(b)



(c) As a shaving mirror.

6) *If we want to obtain a virtual and magnified image of an object by using a concave mirror of focal length 18 cm, where should the object be placed? Use mirror formula to determine the object distance for an image of magnification +2 produced by this mirror to justify your answer.*

The object must be between F and P, that is, less than 18 cm from the mirror.

m = −v/u = +2, so v = −2u. f = −18 cm.

1/v + 1/u = 1/f: 1/(−2u) + 1/u = 1/(−18), so 1/(2u) = −1/18

u = −9 cm. The object is 9 cm in front of the mirror (less than 18 cm, as expected).

7) *A student has focussed the image of an object of height 3 cm on a white screen using a concave mirror of focal length 12 cm. If the distance of the object from the mirror is 18 cm, find the values of the following: (i) Distance of the image from the mirror (ii) Height of the image*

h = 3 cm, f = −12 cm, u = −18 cm

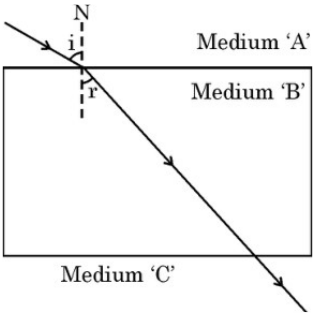
(i) 1/v = 1/f − 1/u = 1/(−12) − 1/(−18) = −1/36

v = −36 cm. The image is 36 cm in front of the mirror.

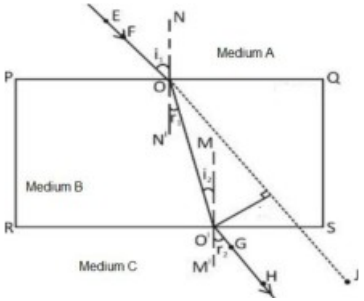
(ii) h′ = −(v/u) × h = −(−36/−18) × 3 = −6 cm. The image is 6 cm tall and inverted.

8) *(a) Observe the given ray diagram and compare: (i) the speed of light in medium A and the speed of light in medium B. (ii) the optical densities of medium B and medium C. (b) Draw a ray diagram for refraction where the optical density of medium 'A' becomes equal to the optical density of*

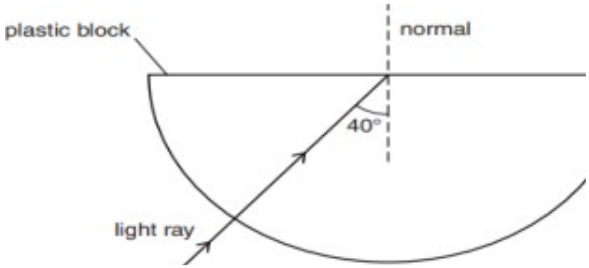
medium 'C' and optical density of medium 'B' is greater than the optical density of medium 'A' and medium 'C'.



(a) (i) Light is faster in A than in B.
(ii) B and C have the same optical density.
(b)



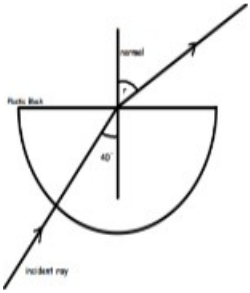
9) *(i) Explain why the refractive index of any material with respect to air is always greater 1. (ii) In the figure below a light ray travels from air into the semi-circular plastic block. Give a reason why the ray does not deviate at the semi-circular boundary of the plastic block. (iii) Complete the ray diagram of the above scenario when the light ray comes out of the plastic block from the top flat end.*



(i) n = speed of light in air / speed of light in the material. Light is always slower in a material than in air, so n is always more than 1.

(ii) The ray falls along the normal (radius) of the curved surface, so it goes straight without bending.

(iii) The ray bends away from the normal as it comes out into air.



10) *Define power of a lens. The focal length of a lens is -10 cm. Write the nature of the lens and find its power. If an object is placed at a distance of 20 cm from the optical centre of this lens, according to the New Cartesian Sign Convention, what will be the sign of magnification in this case?*

Power of a lens is its ability to converge or diverge the light rays falling on it.

It is a diverging (concave) lens.

P = 100 / f (in cm) = 100 / (−10) = −10 D

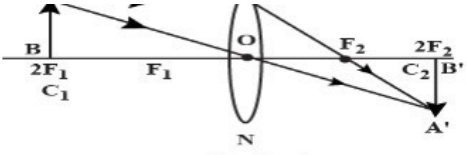
Sign of magnification: positive (a concave lens forms an erect image).

11) *The power of a lens is +4D. Find the focal length of this lens. An object is placed at a distance of 50 cm from the optical centre of this lens. State*

the nature and magnification of the image formed by the lens and also draw a ray diagram to justify your answer.

f = 1/P = 1/4 m = 0.25 m = 25 cm

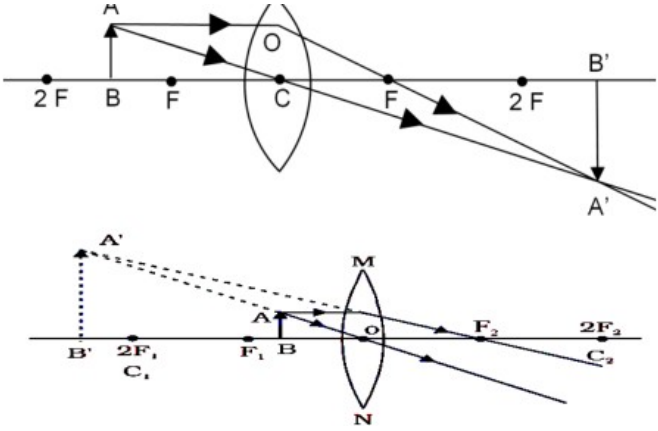
The object is at 50 cm = 2F, so the image is at 2F on the other side: real, inverted and the same size. Magnification = −1.



12) *A convex lens can form a (i) real, inverted and magnified image as well as (ii) virtual, erect and magnified image of an object. If the focal length of the lens is 10 cm, what should be the range of the object distance in both cases? Draw ray diagrams to justify your answer.*

(i) Between 10 cm and 20 cm (between F and 2F).

(ii) Less than 10 cm (between O and F).



13) *A student placed a candle flame at different distances from a convex lens and focused its image on a screen. He recorded his observation in tabular form as given below. Analyse the observation table and on the basis of your analysis only, answer the following questions (without doing any calculations): (a) What is the focal length of the convex lens*

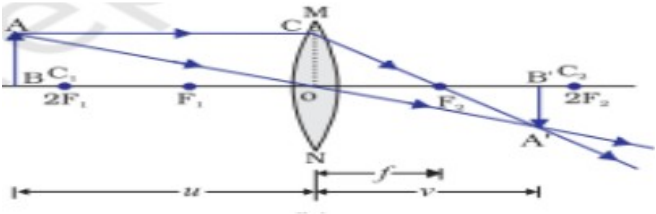
used? Give reason to justify your answer. (b) Which one of the sets of observations is not correct and why? (c) Draw ray diagram to show image formation for any correct set of observation.

S.No.	Distance of flame (cm)	Distance of image (cm)
1	–90	+18
2	–60	+20
3	–40	+24
4	–30	+30
5	–24	+40
6	–20	+60
7	–18	+90
8	–12	+120

(a) f = 15 cm. In observation 4, the object and image distances are equal (30 cm). This happens when the object is at 2F, so 2f = 30 cm.

(b) Observation 8. At 12 cm the object is between O and F, so the image forms on the same side as the object. v should be negative, not +120 cm.

(c)



14) *(a) Write the expression for the magnification produced by a lens in terms of object distance and image distance. (b) A 4 cm tall object is placed perpendicular to the principal axis of a convex lens of focal length 20 cm. Calculate the size of the image formed, if the distance of the object from the lens is 10 cm.*

(a) $m = v/u$

(b) $h = +4$ cm, $f = +20$ cm, $u = -10$ cm

$1/v = 1/f + 1/u = 1/20 - 1/10 = -1/20$, so $v = -20$ cm

$m = v/u = -20/-10 = 2$

Image height $= 2 \times 4$ cm $= 8$ cm

15) *An object of height 10 cm is placed 25 cm away from the optical centre of a converging lens of focal length 15 cm. Calculate the image-distance and height of the image formed.*

$f = +15$ cm, $u = -25$ cm, $h = 10$ cm

$1/v = 1/f + 1/u = 1/15 - 1/25 = 2/75$

$v = 37.5$ cm

$h' = (v/u) \times h = (37.5/-25) \times 10 = -15$ cm. The image is 15 cm tall and inverted.

16) *A convex lens forms an 8.0 cm long image of a 2.0 cm long object which is kept at a distance of 6.0 cm from the optical centre of the lens. If the object and the image are on the same side of the lens, find (i) the nature of the image, (ii) the position of the image, and (iii) the focal length of the lens.*

(i) Virtual and erect

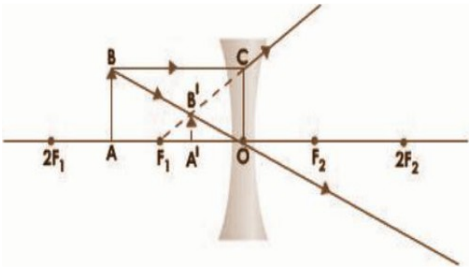
(ii) $h' = +8.0$ cm, $h = +2.0$ cm, $u = -6$ cm

$m = h'/h = v/u$, so $8/2 = v/(-6)$, which gives $v = -24$ cm. The image is 24 cm from the lens.

(iii) $1/f = 1/v - 1/u = 1/(-24) + 1/6 = 3/24 = 1/8$

$f = 8$ cm

17) *A concave lens forms an image that is 1/3rd the size of the object, as shown in the diagram. If the object is placed 24 cm in front of the lens, determine: A. the type of lens. B. the image distance C. the focal length of the lens*



A. Concave (diverging) lens

B. The image is erect and diminished, so m = +1/3. u = −24 cm.

v = m × u = (1/3) × (−24) = −8 cm. The image is 8 cm from the lens, on the same side as the object.

C. 1/f = 1/v − 1/u = −1/8 + 1/24 = −2/24 = −1/12

f = −12 cm

18) *(i) An object of 5 cm height is placed at a distance of 20 cm from the optical centre of a concave lens of focal length 18 cm. Calculate (1) image distance and (2) the magnification in this case. (ii) Compare the values of magnification obtained by a concave lens and a convex lens when both the lenses form virtual images.*

h = 5 cm, u = −20 cm, f = −18 cm

(i) (1) 1/v = 1/f + 1/u = −1/18 − 1/20 = −38/360

v = −360/38 = −9.47 cm

(2) m = v/u = −9.47/−20 = 0.47

(ii) Convex lens: m is more than 1 (magnified). Concave lens: m is less than 1 (diminished).

19) *(a) A lens of focal length 5 cm is being used by Debashree in the laboratory as a magnifying glass. Her least distance of distinct vision is 25 cm. (i) What is the magnification obtained by using the glass? (ii) She*

keeps a book at a distance 10 cm from her eyes and tries to read. She is unable to read. What is the reason for this? (b) Ravi kept a book at a distance of 10 cm from the eyes of his friend Hari. Hari is not able to read anything written in the book. Give reasons for this?

(a) (i) The image is formed at 25 cm: v = −25 cm, f = 5 cm.

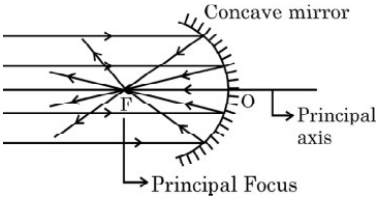
1/u = 1/v − 1/f = −1/25 − 1/5 = −6/25, so u = −25/6 cm

m = v/u = (−25) / (−25/6) = 6

(ii) and (b) The least distance of distinct vision is 25 cm. A book at 10 cm is too close to be seen clearly.

4 Mark Questions (Case Study)

1) *Hold a concave mirror in your hand and direct its reflecting surface towards the sun. Direct the light reflected by the mirror on to a white card-board held close to the mirror. Move the card-board back and forth gradually until you find a bright, sharp spot of light on the board. This spot of light is the image of the sun on the sheet of paper; which is also termed as "Principal Focus" of the concave mirror.*



(a) List two applications of concave mirror. (1)

Torches and shaving mirrors

(b) If the distance between the mirror and the principal focus is 15 cm, find the radius of curvature of the mirror. (1)

R = 2f = 2 × 15 = 30 cm

(c) Draw a ray diagram to show the type of image formed when an object is placed between pole and focus of a concave mirror. (2)

(refer 5th 3 mark question)

OR (c) An object 10 cm in size is placed at 100 cm in front of a concave mirror. If its image is formed at the same point where the object is located,

find: (i) focal length of the mirror, and (ii) magnification of the image formed with sign as per Cartesian sign convention.

(i) u = −100 cm, v = −100 cm (image at the same point, so the object is at C)

1/f = 1/v + 1/u = −1/100 − 1/100 = −2/100, so f = −50 cm

(ii) m = −v/u = −(−100)/(−100) = −1

2) *A student took three concave mirrors of different focal lengths and performed the experiment to see the image formation by placing an object at different distances with these mirrors as shown in the following table.*

Case No.	Object distance	Focal length
I	45 cm	20 cm
II	30 cm	15 cm
III	20 cm	30 cm

(a) List two properties of the image formed in Case I. (1)

Real and inverted (and diminished, as the object is beyond C).

(b) In which one of the cases given in the table, the mirror will form real image of same size and why? (1)

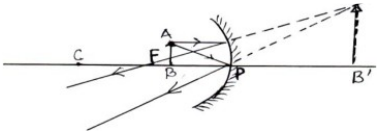
Case II. The object at 30 cm is at C (2 × 15 cm), so the image is real and the same size.

(c) Name the type of mirror used by dentists. Give reason why do they use such type of mirrors. (2)

Concave mirrors. When the tooth is very close to it, a concave mirror forms an erect and enlarged image.

OR (c) Look at the table and identify the situation (object distance and focal length) which resembles the situation in which concave mirrors are used as shaving mirrors? Draw a ray diagram to show the image formation in this case.

Case III (object at 20 cm, between P and F of a 30 cm mirror).



3) *Study the data given below showing the focal length of three concave mirrors A, B and C and the respective distances of objects placed in front of the mirrors:*

Case	Mirror	Focal Length (cm)	Object Distance (cm)
1	A	20	45
2	B	15	30
3	C	30	20

(i) In which one of the above cases the mirror will form a diminished image of the object? Justify your answer. (1)

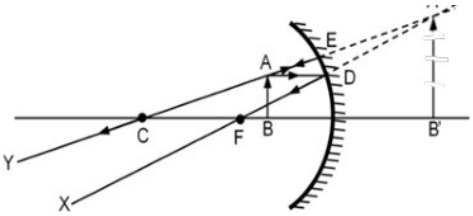
Mirror A. The object (45 cm) is beyond C (40 cm).

(ii) List two properties of the image formed in case 2. (1)

Real and the same size (the object is at C).

(iii) (A) What is the nature and size of the image formed by mirror C? Draw ray diagram to justify your answer. (2)

Virtual, erect and magnified (the object is between P and F).



OR (iii) (B) An object is placed at a distance of 18 cm from the pole of a concave mirror of focal length 12 cm. Find the position of the image formed in this case.

(refer 7th 3 mark question)

4) *A highly polished surface such as a mirror reflects most of the light falling on it. In our daily life we use two types of mirrors — plane and spherical. The reflecting surface of a spherical mirrors may be curved inwards or outwards. In concave mirrors, reflection takes place from the inner surface, while in convex mirrors reflection takes place from the outer surface.*

(a) Define the principal axis of a concave mirror. (1)

The straight line through the pole and the centre of curvature of the mirror.

(b) A ray of light is incident on a concave mirror, parallel to its principal axis. If this ray after reflection from the mirror passes through the principal axis from a point at a distance of 10 cm from the pole of the mirror, find the radius of curvature of the mirror. (1)

That point is the focus, so f = 10 cm and R = 2f = 20 cm.

(c) (i) An object is placed at a distance of 10 cm from the pole of a convex mirror of focal length 15 cm. Find the position of the image. (2)

(refer 12th 2 mark question)

OR (c) (ii) A mirror forms a virtual, erect and diminished image of an object. Identify the type of this mirror. Draw a ray diagram to show the image formation in this case.

Convex mirror. Ray diagram: (refer 2nd 3 mark question, part (ii))

5) *The ability of a medium to refract light is expressed in terms of its optical density. Optical density has a definite connotation. It is not the same as mass density. On comparing two media, the one with the large refractive index is optically denser medium than the other. The other medium with a lower refractive index is optically rarer. Also the speed of light through a given medium is inversely proportional to its optical density.*

(i) Determine the speed of light in diamond if the refractive index of diamond with respect to vacuum is 2.42. Speed of light in vacuum is 3 × 10^8 m/s. (1)

$v = c/n = (3 \times 10^8) / 2.42 = 1.23 \times 10^8$ m/s

(ii) Refractive indices of glass, water and carbon disulphide are 1.5, 1.33 and 1.62 respectively. If a ray of light is incident in these media at the same angle (say θ), then write the increasing order of the angle of refraction in these media. (1)

Carbon disulphide < glass < water (the higher the refractive index, the more the ray bends, so the smaller the angle).

(iii) (A) The speed of light in glass is 2×10^8 m/s and in water is 2.25×10^8 m/s. (a) Which one of the two is optically denser and why? (b) A ray of light is incident normally at the water-glass interface when it enters a thick glass container filled with water. What will happen to the path of the ray after entering the glass? Give reason. (2)

(a) Glass, because light is slower in glass than in water.

(b) It goes straight on without bending. The angle of incidence is 0, so the angle of refraction is also 0.

OR (iii) (B) The absolute refractive indices of water and glass are 4/3 and 3/2 respectively. If the speed of light in glass is 2×10^8 m/s, find the speed of light in (i) vacuum and (ii) water.

(i) $c = n_{glass} \times v_{glass} = (3/2) \times 2 \times 10^8 = 3 \times 10^8$ m/s

(ii) $v_{water} = c / n_{water} = (3 \times 10^8) / (4/3) = 2.25 \times 10^8$ m/s

6) *Many optical instruments consist of a number of lenses. They are combined to increase the magnification and sharpness of the image. The net power (P) of the lenses placed in contact is given by the algebraic sum of the powers of the individual lenses P_1, P_2, P_3 ... as $P = P_1 + P_2 + P_3$ ... This is also termed as the simple additive property of the power of lens, widely used to design lens systems of cameras, microscopes and telescopes. These lens systems can have a combination of convex lenses and also concave lenses.*

(a) What is the nature (convergent / divergent) of the combination of a convex lens of power +4 D and a concave lens of power -2 D? (1)

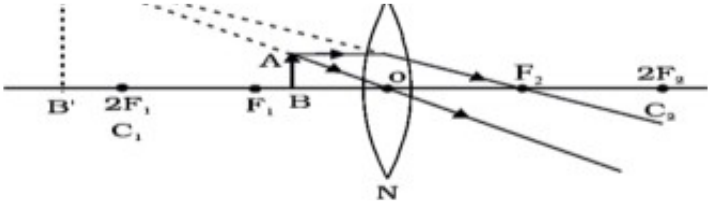
Convergent (P = +4 − 2 = +2 D, which is positive).

(b) Calculate the focal length of a lens of power -2.5 D. (1)

f = 1/P = 1/(−2.5) = −0.4 m = −40 cm

(c) Draw a ray diagram to show the nature and position of an image formed by a convex lens of power +0.1 D, when an object is placed at a distance of 20 cm from its optical centre. (2)

f = 1/0.1 = 10 m, so the object at 20 cm is between O and F. The image is virtual, erect and enlarged, on the same side as the object.



OR (c) How is a virtual image formed by a convex lens different from that formed by a concave lens? Under what conditions do a convex and a concave lens form virtual images?

A convex lens forms a magnified virtual image. A concave lens forms a diminished one.

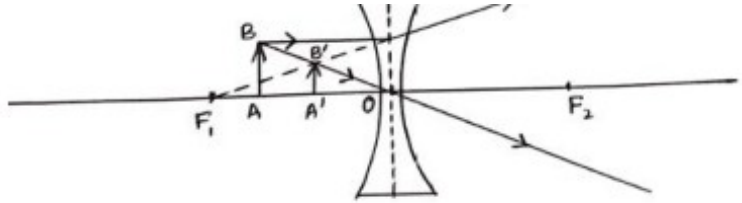
Convex lens: when the object is between O and F. Concave lens: for any position of the object.

7) *Lenses can form different types of images depending upon their focal length and position of object. A convex lens can create real, inverted or virtual, erect images, while a concave lens forms only virtual and diminished images. The focal length determines the power of lens. Convex lenses have positive focal length while concave lenses have negative focal length by convention. When lenses are placed together, their combined power is determined by the sum of their individual powers. Ray diagrams help to visualize how light converges or diverges through lens to form an image.*

(a) A convex lens of focal length 20 cm is used to form an image. If an object is placed at 40 cm from the lens, what will be the position and nature of image? (1)

At 40 cm (2F) on the other side of the lens. Real and inverted.

(b) Illustrate the formation of image with the help of ray diagram, when the object is placed between the optical centre and principal focus of concave lens. (1)



(c) (i) A lens combination consists of a convex lens of focal length 30 cm and a concave lens of focal length 15 cm placed together. Find the equivalent focal length and power of this lens combination. (2)

$f_1 = +0.3$ m, $f_2 = -0.15$ m

$P_1 = 1/0.3 = +3.33$ D, $P_2 = 1/(-0.15) = -6.67$ D

$P = P_1 + P_2 = -3.33$ D

$f = 1/P = -0.3$ m $= -30$ cm

OR (c) (ii) Two lenses are placed in contact. One is a concave lens with focal length 2 m and the other is a convex lens with focal length 1.5 m. What type of lens will the combination behave as (convex or concave)? Give reason.

It behaves as a convex lens.

$P = -1/2 + 1/1.5 = +1/6$ D, so f = +6 m. The power and focal length are positive.

8) *The variation of image distance (v) with the object distance (u) for a convex lens is given in the following observation table. Analyse it and answer the questions given below:*

S.No.	Object distance (u) cm	Image distance (v) cm
1	–150	+30
2	–75	+37.5
3	–50	+50
4	–37.5	+75
5	–30	+150
6	–15	+37.5

(a) Without calculation, find out the focal length of the given convex lens. Justify your answer. (1)

In observation 3, the object and image distances are equal (50 cm). This happens only at 2F, so 2f = 50 cm and f = 25 cm.

(b) Which one of the observations given in the table is not correct and why? (1)

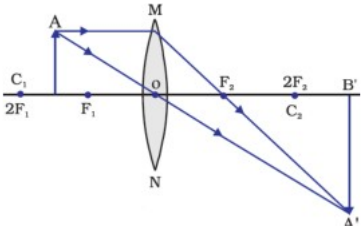
Observation 6. The object (15 cm) is between O and F, so the image forms on the same side and v should be negative.

(c) (i) Find out the value of magnification for u = –30 cm. Write the nature of the image formed. Give reason for your answer. (2)

m = v/u = 150/(−30) = −5

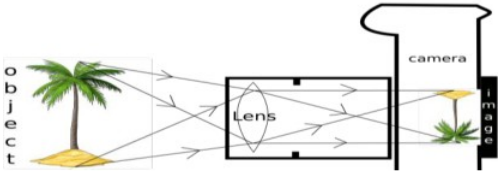
The image is real and inverted, because m is negative.

OR (c) (ii) Analyse the data given in the table above and draw the labelled ray diagram for u = –30 cm and v = 150 cm.



9) *The above image is that of a Digital Single Lense Reflector (DSLR) Camera which are used to take high resolution photographs by professional photographers. The second image of the above two is a schematic diagram of how an image is formed on the sensor of the camera. Based on your understanding of the lenses, answer the following questions.*





A. What type of lens is used in the DSLR camera shown in the image? (1)

Convex lens

B. What type of image is formed on the sensor? (1)

Real and inverted

C. A photographer is using a DSLR camera with a lens of focal length f = 50 mm to take a close-up photograph of a small object. The lens projects an image onto the camera sensor that is located 60 mm behind the lens. Calculate the object distance (i.e., the distance between the object and the lens). (2)

f = 50 mm, v = 60 mm

1/u = 1/v − 1/f = 1/60 − 1/50 = −10/3000 = −1/300

u = −300 mm. The object is 300 mm in front of the lens.

OR D. A photographer is using a DSLR camera to take a picture of a flower. The flower is positioned 150 mm away from the camera lens. The actual height of the flower is 80 mm, and the image height formed on the

camera's sensor is measured to be 20 mm. Calculate the focal length of the camera lens.

The image is real and inverted, so m = −20/80 = −0.25.

v = m × u = −0.25 × (−150) = 37.5 mm

1/f = 1/v − 1/u = 1/37.5 + 1/150 = 5/150 = 1/30

f = 30 mm

10) *The above images are that of a specialized slide projector. Slides are small transparencies mounted in sturdy frames ideally suited to magnification and projection, since they have a very high resolution and a high image quality. There is a tray where the slides are to be put into a particular orientation so that the viewers can see the enlarged erect images of the transparent slides. This means that the slides will have to be inserted upside down in the projector tray. To show her students the images of insects that she investigated in the lab, Mrs. Iyer brought a slide projector. Her slide projector produced a 500 times enlarged and inverted image of a slide on a screen 10 m away.*



(a) Based on the text and data given in the above paragraph, what kind of lens must the slide projector have? (1)

Convex lens

(b) If v is the symbol used for image distance and u for object distance then with one reason state what will be the sign for v/u in the given case? (1)

Negative, because the image is real and inverted.

(c) A slide projector has a convex lens with a focal length of 20 cm. The slide is placed upside down 21 cm from the lens. How far away should

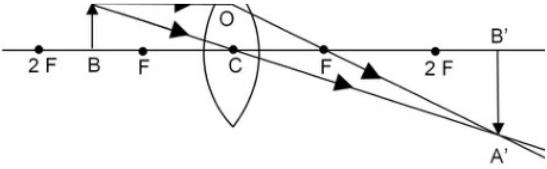
the screen be placed from the slide projector's lens so that the slide is in focus? (2)

f = 20 cm, u = −21 cm

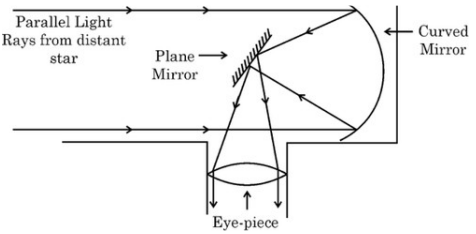
1/v = 1/f + 1/u = 1/20 − 1/21 = 1/420

v = 420 cm. The screen should be 420 cm (4.2 m) from the lens.

OR (c) When a slide is placed 15 cm behind the lens in the projector, an image is formed 3 m in front of the lens. If the focal length of the lens is 14 cm, draw a ray diagram to show image formation. (not to scale)



11) *The above ray diagram is to show image formation by a reflecting telescope. Reflecting telescope revolutionized our way of looking into the sky. Reflecting telescopes employ large mirrors to gather and focus light rather than relying solely on lenses as we do in the refracting telescopes. These telescopes utilize precisely shaped and polished mirrors to capture incoming light and reflect it to a focal point, where the telescope forms an image for observation.*



(a) What kind of image of a star is seen by the observer in the eye-piece? (1)

A real, magnified image.

(b) What kind of mirror is used in this reflecting telescope? (1)

A concave (converging) mirror, and a plane mirror.

(c) Explain with the reason, what kind of optical device (type of lens or mirror) is used at the eye-piece. (2)

A convex lens. It magnifies the image formed by the curved mirror.

OR (c) What is the role of plane mirror in image formation by this telescope?

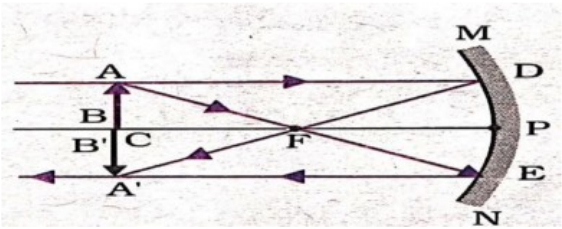
It reflects the rays coming from the curved mirror towards the eye-piece.

5 Mark Questions

1) *(i) A student wishes to study the image formation by a concave mirror using candle flame as object. State the type of the image formed by the mirror and mention the change in the image formed, if any, that he observes when the candle flame is gradually moved away from the pole of the mirror. Draw a ray diagram to show the image formation when the object distance is nearly equal to the radius of curvature of the mirror. (ii) A convex mirror used for rear-view on an automobile has a focal length of 3.0 m. If a bus is located at 6.0 m from this mirror, use mirror formula to find the position of the image of the bus as seen in the mirror.*

(i) Real and inverted (the image is focused on a screen).

As the flame is moved away from the pole, the image becomes smaller.



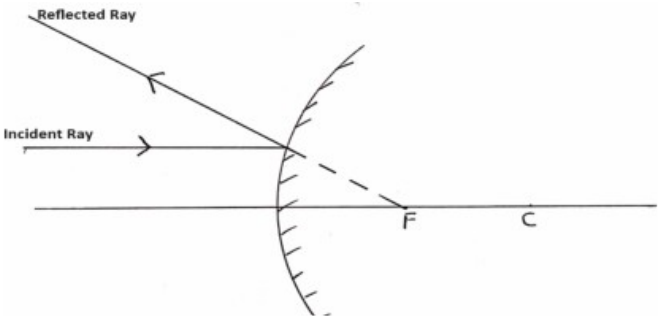
(ii) u = −6.0 m, f = +3.0 m

1/v = 1/f − 1/u = 1/3 + 1/6 = 3/6

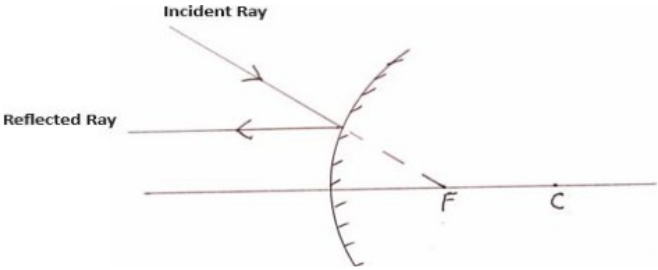
v = +2.0 m. The image is 2 m behind the mirror.

2) *(i) Draw a ray diagram to show the path of the reflected ray in each of the following cases: A ray of light incident on a convex mirror (1) parallel to its principal axis, and (2) is directed towards its principal focus*
(ii) A 1.5 cm tall candle flame is placed perpendicular to the principal axis of a concave mirror of focal length 12 cm. If the distance of the flame from the pole of the mirror is 18 cm, use mirror formula to determine the position and size of the image formed.

(i) (1)



(2)



(ii) f = −12 cm, u = −18 cm, h = 1.5 cm

1/v = 1/f − 1/u = −1/12 + 1/18 = −1/36

v = −36 cm. The image is 36 cm in front of the mirror.

h′ = −(v/u) × h = −(−36/−18) × 1.5 = −3.0 cm. The image is 3 cm tall and inverted.

3) *A 10 cm long pencil is placed 5 cm in front of a concave mirror having a radius of curvature of 40 cm.*
(i) Determine the position of the image formed by this mirror.

(ii) What is the size of the image?

(iii) Draw a ray diagram to show the formation of the image as mentioned in the part (i).

(i) u = −5 cm, f = R/2 = −20 cm

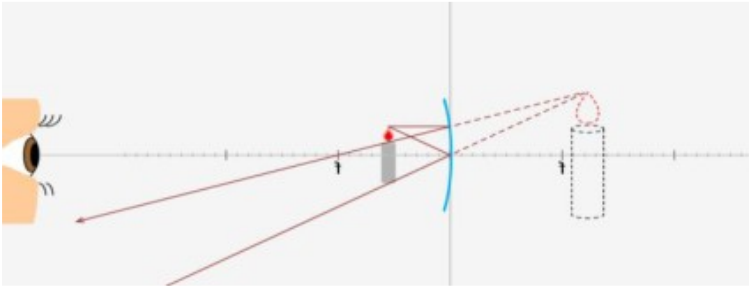
1/v = 1/f − 1/u = −1/20 + 1/5 = 3/20

v = 20/3 = 6.67 cm. The image is 6.67 cm behind the mirror.

(ii) m = −v/u = −(20/3)/(−5) = 4/3

Image size = 4/3 × 10 = 13.3 cm

(iii)

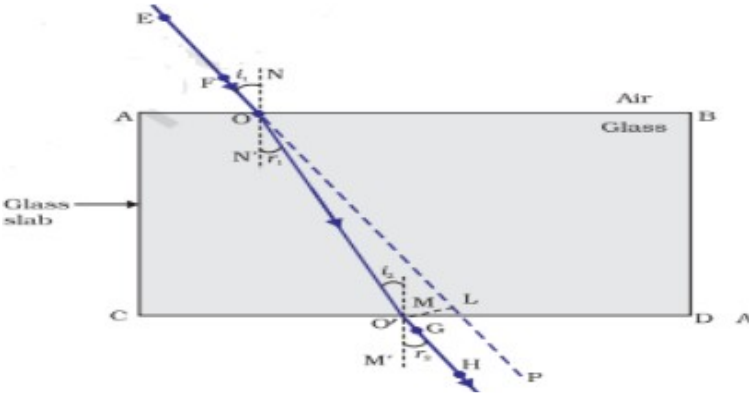


4) *(i) Draw a ray diagram to show the refraction of a ray of light through a rectangular glass slab when it falls obliquely from air into glass.*

(ii) State Snell's law of refraction of light.

(iii) Differentiate between the virtual images formed by a convex lens and a concave lens on the basis of: (I) object distance, and (II) magnification.

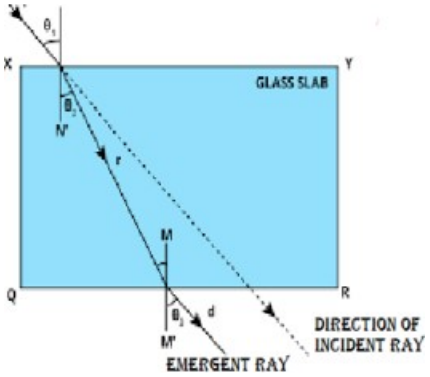
(i)



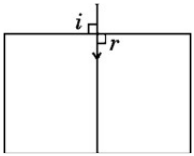
(ii) (refer 5th 2 mark question)
(iii)

	Convex lens	Concave lens
(I) Object distance	Object between O and F	Object anywhere in front of the lens
(II) Magnification	Magnified image	Diminished image

5) *(i) "In refraction of light through a rectangular glass slab, the emergent ray is always parallel to the direction of the incident ray." Why? Explain with the help of a ray diagram. What happens when a ray of light falls normally on one of the faces of a rectangular glass prism? Draw diagram.*
(ii) An object is placed at a distance of 30 cm from the optical centre of a concave lens of focal length 20 cm. Use Lens formula to determine the position of the image formed in this case.
(i) The ray bends at the two opposite, parallel faces of the slab by equal amounts in opposite directions. So it comes out parallel to the incident ray.



When the ray falls normally (along the normal), it goes straight through without bending.



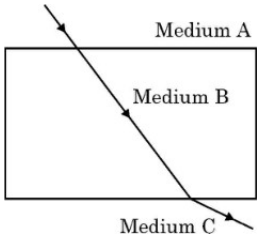
(ii) u = −30 cm, f = −20 cm

1/v = 1/f + 1/u = −1/20 − 1/30 = −1/12

v = −12 cm. The image is 12 cm from the lens, on the same side as the object.

6) *(a) Observe the following diagram and compare (i) speed of light and (ii) optical densities of the three media A, B and C. Also give justification for your answer of any one of the two cases in terms of refractive indices of A, B and C.*

(b) Redraw the path of a ray of light through the three media, if the ray of light starting from medium A falls on the medium B (i) Obliquely and the optical density of medium B is made more than that of A and C. (ii) The ray falls normally from medium A to medium B.

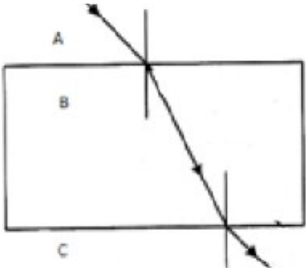


(a) (i) Light has the same speed in A and B. It is faster in C.

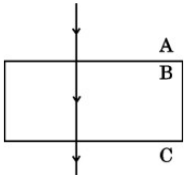
(ii) A and B have the same optical density. C is optically rarer than A and B.

Reason: the ray does not bend from A to B, so A and B have the same refractive index. It bends away from the normal from B to C, so C has a smaller refractive index.

(b) (i) Oblique incidence:



(ii) Normal incidence:



7) *(i) Define principal axis of a lens. Draw a ray diagram to show what happens when a ray of light parallel to the principal axis of a concave lens passes through it.*
(ii) The focal length of a concave lens is 20 cm. At what distance from the lens should a 5 cm tall object be placed so that its image is formed at a distance of 15 cm from the lens? Also calculate the size of the image formed.

(i) The principal axis is an imaginary line through the two centres of curvature of the lens.

Ray diagram: (refer 7th 2 mark question)

(ii) f = −20 cm, h = 5 cm, v = −15 cm

$1/u = 1/v - 1/f = -1/15 + 1/20 = -1/60$

u = −60 cm. The object must be 60 cm from the lens.

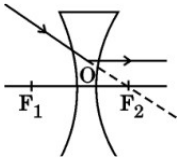
$h' = (v/u) \times h = (-15/-60) \times 5 = 1.25$ cm

8) *(i) Draw a ray diagram to show the path of the refracted ray in each of the following cases: A ray of light incident on a concave lens (1) parallel to its principal axis, and (2) is directed towards its principal focus.*
(ii) A 4 cm tall object is placed perpendicular to the principal axis of

convex lens of focal length 24 cm. The distance of object from the lens is 16 cm. Find the position and size of image formed.

(i) (1) (refer 7th 2 mark question)

(2)



(ii) u = −16 cm, f = +24 cm, h = 4 cm

1/v = 1/f + 1/u = 1/24 − 1/16 = −1/48

v = −48 cm. The image is 48 cm from the lens, on the same side as the object.

h′ = (v/u) × h = (−48/−16) × 4 = 12 cm

9) *(i) The power of a lens 'X' is –2.5 D. Name the lens and determine its focal length in cm. For which eye defect of vision will an optician prescribe this type of lens as a corrective lens?*

(ii) "The value of magnification 'm' for a lens is –2." Using new Cartesian Sign Convention and considering that an object is placed at a distance of 20 cm from the optical centre of this lens, state: (I) the nature of the image formed; (II) size of the image compared to the size of the object; (III) position of the image, and (IV) sign of the height of the image.

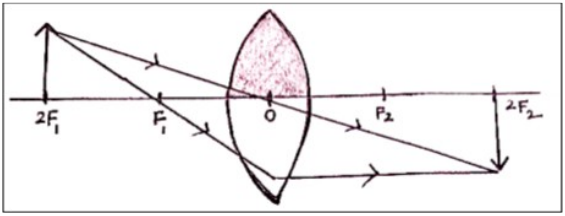
(iii) The numerical values of the focal lengths of two lenses A and B are 10 cm and 20 cm respectively. Which one of the two will show higher degree of convergence/divergence? Give reason to justify your answer.

(i) Concave lens. f = 1/P = 1/(−2.5) = −0.4 m = −40 cm. It corrects myopia (short-sightedness).

(ii) (I) Real and inverted (II) Magnified (twice the size) (III) Beyond 2F on the other side (IV) Negative

(iii) Lens A (10 cm). The shorter the focal length, the greater the power to converge or diverge light.

10) *(a) Upper half of a convex lens is covered with a black paper. Draw a ray diagram to show the formation of image of an object placed at a distance of 2F from such a lens. Mention the position and nature of the image formed. State the observable difference in the image obtained if the lens is uncovered. Give reason to justify your answer.*
(b) An object is placed at a distance of 30 cm from the optical centre of a concave lens of focal length 15 cm. Use lens formula to determine the distance of the image from the optical centre of the lens.
(a)



Position: at 2F on the other side. Nature: real and inverted (and the full image still forms).

If the lens is uncovered, the image is brighter, because more light passes through the lens to form it.

(b) u = −30 cm, f = −15 cm

1/v = 1/f + 1/u = −1/15 − 1/30 = −3/30

v = −10 cm. The image is 10 cm from the lens.

11) *(a) An object is placed in front of a convex lens of focal length f. If the distance of the object from the lens is 2f, draw a ray diagram to show the formation of the image. Write the value of magnification in this case.*
(b) A student has focussed the image of a candle flame on a white screen using a convex lens. The situation is as given below: Length of the flame = 2 cm; Focal length of the lens = 12 cm; Distance of the flame from the lens = 16 cm. If the flame is perpendicular to the principal axis of the lens, calculate the values of the following: (i) Distance of the image from the lens (ii) Length of the image formed
(a) (refer 11th 3 mark question)

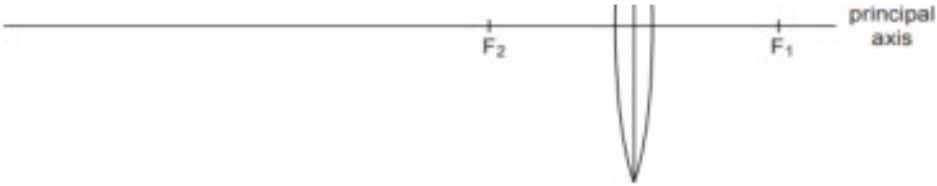
(b) (i) u = −16 cm, f = +12 cm

1/v = 1/f + 1/u = 1/12 − 1/16 = 1/48

v = +48 cm

(ii) h′ = (v/u) × h = (48/−16) × 2 = −6 cm. The image is 6 cm long and inverted.

12) *The above image shows a thin lens of focal length 5 m.*
(i) What is the kind of lens shown in the above figure?
(ii) If a real inverted image is to be formed by this lens at a distance of 7 m from the optical centre, then show with calculation where should the object be placed?
(iii) Draw a neatly labelled diagram of the image formation mentioned in (ii)



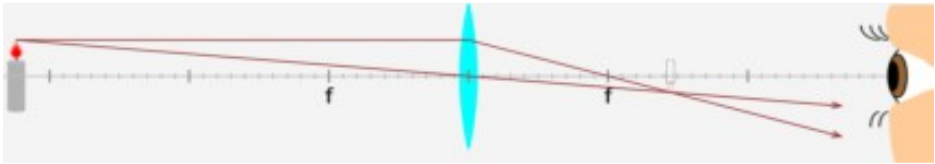
(i) Convex lens

(ii) f = +5 m, v = +7 m

1/u = 1/v − 1/f = 1/7 − 1/5 = −2/35

u = −17.5 m. The object is 17.5 m in front of the lens.

(iii)



13) *Analyse the following observation table showing variation of image distance (v) with object distance (u) in case of a convex lens and answer the questions that follow without doing any calculations:*
(a) Determine the focal length of the lens. Give reason for your answer.
(b) Find magnification of the image formed in Observation No. 3.

(c) The numerical value of magnifications in cases of observation 1 and 2 is same. List two differences in the images formed in these two cases.

Observation	Object distance (u) cm	Image distance (v) cm
1	–15	–60
2	–25	+100
3	–30	+60
4	–40	+40
5	–60	+30
6	–100	+25

(a) f = 20 cm. In observation 4, the object and image are both at 40 cm. This happens at 2F, so 2f = 40 cm.

(b) m = v/u = +60/−30 = −2

(c) Observation 1: the image is virtual and erect. Observation 2: the image is real and inverted.

14) *The variation of image distance (v) with object distance (u) for a convex lens is given in the following observation table. Analyse it and answer the questions that follow:*

(i) Without calculation, find the focal length of the convex lens. Justify your answer.

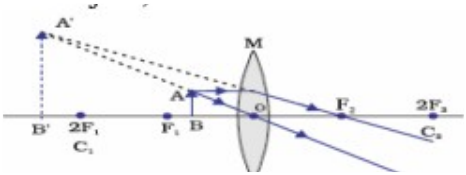
(ii) Which observation is not correct? Why? Draw ray diagram to find the position of the image formed for this position of the object.

(iii) Find the approximate value of magnification for u = -30 cm.

S. No.	Object distance (u) cm	Image distance (v) cm
1	−150	+30
2	−75	+37.5
3	−50	+50
4	−37.5	+75
5	−30	+150
6	−15	+37.5

(i) f = 25 cm. In S. No. 3, the object and image distances are equal (50 cm), so the object is at 2F and 2f = 50 cm.

(ii) S. No. 6. For u = −15 cm the object is between O and F, so the image forms on the same side and v must be negative.



(iii) m = v/u = +150/−30 = −5