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Reflection of light by curved surfaces; Images formed by spherical mirrors, centre of curvature, principal axis, principal focus, focal length, mirror formula (Derivation not required), magnification.
Refraction; laws of refraction, refractive index.
Refraction of light by spherical lens; Image formed by spherical lenses; Lens formula (Derivation not required); Magnification. Power of a lens;

Formulae Handbook for Class 10 Maths and Science

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Question 1. Define the principal focus of a concave mirror?
Answer: Light rays that are parallel to the principal axis of a concave mirror converge at a specific point on its principal axis after reflecting from the mirror. This point is known as the principal focus of the concave mirror.

Question 2. The radius of curvature of a spherical mirror is 20 cm. What is its focal length?
Answer: Radius of curvature, R = 20 cm
Radius of curvature of a spherical mirror = 2 x Focal length (f)
f = R/2 = 20/2 =10cm

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Question 3. Name the mirror that can give an erect and enlarged image of an object.
Answer: When an object is placed between the pole and the principal focus of a concave mirror, the image formed is virtual, erect, and enlarged.

Question 4. Why do we prefer a convex mirror as a rear-view mirror in vehicles?
Answer: Convex mirrors give a virtual, erect, and diminished image of the objects placed in front of them. They are preferred as a rear-view mirror in vehicles because they give a wider field of view, which allows the driver to see most of the traffic behind him.

Question 1. Find the focal length of a convex mirror whose radius of curvature is 32 cm.
Answer: Radius of curvature, R = 32 cm
Radius of curvature = 2 x Focal length (f)
R = 2f
f = R/2 = 32/2 = 16 cm
Hence, the focal length of the given convex mirror is 16 cm.

Question 2. A concave mirror produces three times magnified (enlarged) real image of object placed at 10 cm in front of it. Where is the image located?
Answer: Given, u = -10 cm
Since image is real inverted so, m = -3
m = -v / u
=> -3 = -v / -10
v = -30 cm
Negative sign indicates the image will be real and image is formed at 30 cm in front of the mirror.
Question 3. Find out, from Table, the medium having highest optical density. Also find the medium with lowest optical density.

Answer:

Highest optical density = Diamond
Lowest optical density = Air

Optical density of a medium is directly related with the refractive index of that medium. A medium which has the highest refractive index will have the highest optical density and vice-versa.

It can be observed from Table 10.3 that diamond and air respectively have the highest and lowest refractive index. Therefore, diamond has the highest optical density and air has the lowest optical density.

Question 4. You are given kerosene, turpentine and water. In which of these does the light travel fastest?

Answer:
The light can travel fast through water.

**Question 5.** The refractive index of diamond is 2.42. What is the meaning of this statement?

**Answer:** Refractive index of a medium nm is related to the speed of light in that medium \( v \) by the relation:

\[
\text{Refractive index} \quad n_m = \frac{\text{Speed of light in air}}{\text{Speed of light in the medium}} = \frac{c}{v}
\]

Where, \( c \) is the speed of light in vacuum/air.

The refractive index of diamond is 2.42. This suggests that the speed of light in diamond will reduce by a factor 2.42 compared to its speed in air.

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**Question 1.** Define one dioptre of power of a lens?

**Answer:** One dioptre is the power of a lens of focal length 1m.

Power of lens is defined as the reciprocal of its focal length. If \( P \) is the power of a lens of focal length \( F \) in metres, then

\[
P = \frac{1}{F} \text{ (in meters)}
\]

The S.I. unit of power of a lens is Dioptre. It is denoted by \( D \).

1 dioptre is defined as the power of a lens of focal length 1 metre.

\[1 \text{ D} = 1 \text{ m}^{-1}\]

**Question 2.** A convex lens forms a real and inverted image of a needle at a distance of 50 cm from it. Where is the needle placed in front of the lens if the image is equal to the size of the object? Also find the power of the lens.

**Answer:** \( v = +50 \text{ cm} \)
Since image is real and of same size. The position of image should be double the focal length. Hence, the object should be at 2f.

V = 2f = 50, f = 25 cm.

Power = 1/f = 100/25 = 4D

**Question 3.** Find the power of a concave lens of focal length 2 m.

**Answer:**

**Ans.** As it is a concave lens, thus focal length,

\[ f = -2 \text{ m} \]

So, power of lens, \( P = \frac{1}{f} \)

\[ \Rightarrow P = \frac{1}{-2\text{m}} = -0.50 \text{ D} \]

\[ \Rightarrow P = -0.5 \text{ D} \]

Therefore power of the given lens is -0.5 D.

**Question 1.** Which one of the following materials cannot be used to make a lens?
(a) Water (b) Glass (c) Plastic (d) Clay

**Answer:** (d) Clay

**Question 2.** The image formed by a concave mirror is observed to be virtual, erect and larger than the object. Where should be the position of the object?
(a) Between the principal focus and the centre of Curvature
(b) At the centre of curvature
(c) Beyond the centre of curvature
(d) Between the pole of the mirror and Its principal focus.

**Answer:** (d) Between the pole of the mirror and its principal focus.

**Question 3.** Where should an object be placed In front of a convex lens to get a real image of the size of the object?
(a) At the principal focus of the lens
(b) At twice the focal length
(c) At infinity
(d) Between the optical centre of the lens and its principal focus.

**Answer:** (b) At twice the focal length

**Question 4.** A spherical mirror and a thin spherical lens have each a focal length of 15 cm. The mirror and the lens are likely to be:
(a) both concave
(b) both convex
(c) the mirror is concave, but the lens is convex
(d) the mirror is convex, but the lens is concave
**Answer:** (a) Both concave.

**Question 5.** No matter how far you stand from a mirror, your Image appears erect. The mirror is likely to be
(a) plane
(b) concave
(c) convex
(d) Either plane or convex
**Answer:** (d) Either plane or convex.

**Question 6.** Which of the following lenses would you prefer to use while reading small letters found in a dictionary?
(a) A convex lens of focal length 50cm
(b) A concave lens of focal length 50cm
(c) A convex lens of focal length 5 cm
(d) A concave lens of focal length 5 cm.
**Answer:** (c) A convex lens of focal length 5 cm.

**Question 7.** We wish to obtain an erect image of an object, using a concave mirror of focal length 15 cm. what should be the range of distance of the object from the mirror? What is the nature of the image? Is the image larger or smaller than the object? Draw a ray diagram to show the image formation in this case.
**Answer:**
We are given the focal length of the concave mirror as \( f = -15 \text{ cm} \).
For getting an erect image using a concave mirror, the object should be placed at a distance less than the focal length.
i.e. 15 cm from the pole. The image formed will be virtual, enlarged and erect.

![Image formation when the object is placed between focus and pole of a concave mirror](https://via.placeholder.com/150)

**Question 8.** Name the type of mirror used in the following situations.
(a) Headlights of a car
(b) Side/rear-view mirror of a vehicle
(c) Solar furnace
Support your answer with reason.
**Answer:** (a) Concave mirror, to get powerful and parallel beams of light.
(b) Convex mirror because it always gives an erect image and enables the driver to view much larger area.
(c) Concave or parabolic mirror because it can concentrate sunlight at the focus to produce heat in the solar furnace.

**Question 9.** One half of a convex lens is covered with a black paper. Will this lens produce a complete image of the object? Verify your answer experimentally. Explain your observations. **Answer:** Yes, even when one half of the lens is covered with a black paper, complete image of the object will be formed. Take a convex lens and focus the light from a distant object onto a screen. As expected an image (sharp) is formed at a distance equal to the focal length. Cover the lower or the upper half of the lens and focus the light from the same object onto the same screen. You will be able to get a sharp image again; however the brightness of the image will be less in the second case. The same effect will be seen even if the lens is half covered with black strips.

**Question 10.** An object 5cm in length is held 25cm away from a converging lens of focal length 10 cm. Draw a ray diagram and find the position, size and the nature of the image formed. **Answer:**

\[ \frac{1}{f} = \frac{1}{u} + \frac{1}{v} \]

\[ u = -25 \quad v = \frac{250}{15} = \frac{50}{3} \]

\[ m = \frac{v}{u} = \frac{h'}{h} \]

\[ \frac{50/3}{-25} = \frac{h}{5} \]

\[ h = -\frac{10}{3} = -3.33 \text{ cm} \]
Therefore, the image is formed between $F_2$ and $2F_2$ on the other side of the lens. It is real and inverted, and smaller in size than the object.

**Question 11.** A concave lens of focal length 15 cm forms an image 10 cm from the lens. How far is the object placed from the lens? Draw the ray diagram.

**Answer:**

\[
\frac{1}{f} = \frac{1}{u} + \frac{1}{v}
\]

Using lens formula, we have

\[
\frac{1}{15} = \frac{1}{u} + \frac{1}{10}
\]

\[
\frac{1}{u} = \frac{1}{30}
\]

\[
u = \frac{-150}{5} = -30 \text{ cm}
\]

Therefore, the object is placed at 30 cm from the lens. The ray diagram is given as follows:

![Ray diagram](image)

**Question 12.** An object is placed at a distance of 10 cm from a convex mirror of focal length 15 cm. Find the position and nature of the image.

**Answer:**

\[f = +15 \text{ cm}, \quad u = -10 \text{ cm}\]

For mirror, we have

\[
\frac{1}{f} = \frac{1}{u} + \frac{1}{v}
\]

\[
\frac{1}{v} = \frac{1}{f} - \frac{1}{u}
\]

\[
\frac{1}{v} = \frac{1}{15} - \frac{1}{10}
\]

\[
\frac{1}{v} = \frac{-15}{150} + \frac{10}{150}
\]

\[
v = \frac{150}{25} = 6 \text{ cm}
\]

The image must be virtual and erect.

**Question 13.** The magnification produced by a plane mirror is +1. What does this mean?

**Answer:** This means that size of the image is equal to the size of the object.
Question 14. An object 5.0 cm in length is placed at a distance of 20 cm in front of a convex mirror of radius of curvature 30 cm. Find the position of the image nature and size.

Answer:

\[ h_o = +5.0 \text{ cm}, \quad u = -20 \text{ cm}, \]

\[ f = \frac{R}{2} = +15 \text{ cm} \]

Using mirror formula, \( \frac{1}{f} = \frac{1}{v} + \frac{1}{u} \), we get

\[ \frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{15} - \frac{1}{-20} \]

\[ = \frac{20 + 15}{300} = \frac{35}{300} \]

\[ v = \frac{300}{35} = \frac{60}{7} = 8.57 \text{ cm}. \]

Using \( m = \frac{h_i}{h_o} = -\frac{v}{u} \), we get

\[ h_i = -5 \times \frac{8.57}{-20} = 2.16 \text{ cm}. \]

Since \( v \) is +ve, the image is virtual.

Since \( h_i = 2.16 \text{ cm} < 5.0 \text{ cm} \), the image is diminished.

Question 15. An object of size 7.0 cm is placed at 27 cm in front of a concave mirror of focal length 18 cm. At what distance from the mirror should a screen be placed, so that a sharp focused image can be obtained? Find the size and the nature of the image.
Question 16. Find the focal length of a lens of power -2.0 D. What type of lens is this?
Answer:

We know that 
\[ f = \frac{1}{P} \text{ m} \]
\[ \Rightarrow f = -\frac{1}{2} \text{ m} \]
\[ = -\frac{100}{2} \text{ cm} = -50 \text{ cm.} \]
As the focal length of lens is -ve, it will be a concave lens.

Question 17. A doctor has prescribed a corrective lens of power +1.5 D. find the focal length of the lens. Is the prescribed lens diverging or converging?
Answer:

\[ P = +1.5 \text{ D} \]
\[ f = \frac{100}{P} \text{ cm} = \frac{100}{1.5} \]
\[ = \frac{1000}{15} = +66.67 \text{ cm} = +0.67 \text{ m} \]
As the focal length is +ve, it is convex lens. Hence, it is a converging lens.
Multiple Choice Questions (MCQs) [1 mark each]

Question 1.
Hold a highly polished steel spoon curved inwards close to your face and move it slowly away from your face. What will you observe?
(a) Enlarged and erect image of your face
(b) Smaller and inverted image of your face
(c) Smaller and erect image of your face
(d) Enlarged and inverted image of your face
Answer:
(b) The inner curved surface of a highly polished steel spoon acts as a concave mirror. When the spoon is at a small distance from the face such that, the object lies between pole and focus of concave mirror, so an enlarged and erect image of your face will be observed but as the spoon is slowly moved away from the face, the image becomes smaller and appears inverted.

Question 2.
Which one of the following materials cannot be used to make a lens?
(a) Water
(b) Glass
(c) Plastic
(d) Clay
Answer:
(d) Clay can never be transparent, so it cannot be used to make lens.

Question 3.
No matter how far you stand from a mirror, your image appears erect. The mirror is likely to be
(a) plane
(b) concave
(c) convex
(d) either plane or convex
Answer:
(d) Plane mirrors and convex mirrors always form the erect images.

Question 4.
The image formed by a concave mirror is observed to be virtual, erect and larger than the object. Where should be the position of the object?
(a) Between principal focus and centre of curvature
(b) At centre of curvature
(c) Beyond centre of curvature
(d) Between pole of the mirror and its principal focus
Answer:
(d)

Question 5.
An object AB is placed in front of a convex lens at its centre of curvature as shown in figure below.
Four students traced the path of light ray after refraction through the lens. Which one of them is correct?

(a) Only I  
(b) Only II  
(c) Only III  
(d) Only IV  

**Answer:**
(d) When the object is placed at centre of curvature (2F) of convex lens, the same sized image is formed at 2F. The image formed is real and inverted.

**Question 6.**  
A spherical mirror and a thin spherical lens have each of a focal length -15 cm. The mirror and lens are likely to be [NCERT]  
(a) both concave  
(b) both convex  
(c) mirror is concave and lens is convex  
(d) mirror is convex and lens is concave

**Answer:**  
(a) The focal length is taken as negative for both concave mirror and concave lens.

**Question 7.**  
Which of the following can make a parallel beam of light when light from a point source is incident on it? [NCERT Exemplar]  
(a) Concave mirror as well as convex lens
(b) Convex mirror as well as concave lens  
(c) Two plane mirrors placed at 90° to each other  
(d) Concave mirror as well as concave lens  

**Answer:**  
(a) A ray passing through the principal focus of a concave mirror or convex lens, after reflection/refraction, will emerge parallel to the principal axis.

**Question 8.**  
Under which of the following conditions, a concave mirror can form an image larger than the actual object?  
(a) When an object is kept at a distance equal to its radius of curvature  
(b) When an object is kept at a distance less than its focal length  
(c) When an object is placed between the focus and centre of curvature  
(d) When an object is kept at a distance greater than its radius of curvature  

**Answer:**  
(c) A concave mirror can form an image enlarged, real and inverted than the actual object, beyond centre of curvature (C) when object is placed between the focus (F) and centre of curvature.

**Question 9.**  
A light ray enters from medium A to medium B as shown in the figure. The refractive index of medium B relative to A will be  

(a) greater than unity  
(b) less than unity  
(c) equal to unity  
(d) zero  

**Answer:**  
(a) Since, light rays in the medium B goes towards normal. So, it has greater refractive index.
and lesser velocity of light w.r.t. medium A. So, refractive index of medium B w.r.t. medium A is greater than unity.

Question 10.
Figure shows a ray of light as it travels from medium A to medium B. Refractive index of the medium B relative to medium A is

![Diagram of light ray from medium A to medium B]

**Answer:**
(a) Given, angle of incidence, \( i = 60^\circ \), angle of refraction, \( r = 45^\circ \)
Refractive index of the medium B relative to medium A,

\[
\mu_{BA} = \frac{\sin i}{\sin r} = \frac{\sin 60^\circ}{\sin 45^\circ} = \frac{\frac{\sqrt{3}}{2}}{\frac{1}{\sqrt{2}}} = \frac{\sqrt{3}}{\sqrt{2}}
\]

(b) \( \frac{\sqrt{3}}{\sqrt{2}} \)
(c) \( \frac{1}{\sqrt{2}} \)
(d) \( \sqrt{2} \)

Question 11.
Beams of light are incident through the holes A and B and emerge out of box through the holes C and D respectively, as Box shown in the figure.

![Diagram of beams of light through holes]

Which of the following could be inside the box? [NCERT Exemplar]
(a) A rectangular glass slab
(b) A convex lens
(c) A concave lens
(d) A prism

**Answer:**
(a) Here, the emergent rays are parallel to the direction of the incident ray. Therefore, a
rectangular glass slab could be inside the box as the extent of bending of light ray at the opposite parallel faces AB (air-glass interface) and CD (glass-air interface) of the rectangular glass slab are equal and opposite. This is why the ray emerges parallel to the incident ray.

**Question 12.**
A beam of light is incident through the holes on side A and emerges out of the holes on the other face of the box as shown in the figure. Which of the following could be inside the box? [NCERT Exemplar]

(a) Concave lens  
(b) Rectangular glass slab  
(c) Prism  
(d) Convex lens  

**Answer:**
(d) Since, in the figure all the parallel rays converge at a point. So, inside the box there must be a convex lens.

**Question 13.**
Which of the following statement is true? [NCERT Exemplar]  
(a) A convex lens has 4D power having a focal length 0.25 m  
(b) A convex lens has 4D power having a focal length -0.25 m  
(c) A concave lens has 4D power having a focal length 0.25 m  
(d) A concave lens has 4D power having a focal length -0.25 m  

**Answer:**
(a) The power P of a lens of focal length f is given by  
\[ P = \frac{1}{f} \]  
where f is the focal length in metre and P is the power in dioptre.  
\[ P = \frac{1}{f} \text{ or } f = \frac{1}{P} = \frac{1}{4} = 0.25 \text{ m} \]

**Question 14.**
Magnification produced by a rear view mirror fitted in vehicles [NCERT Exemplar]
(a) is less than one
(b) is more than one
(c) is equal to one
(d) can be more than or less than one depending upon the position of the object in front of it.

Answer:
(a) The convex mirror forms virtual, erect and diminished image of the object and rear view mirror also form same type of image. Therefore, magnification (m) produced by a rear view mirror fitted in vehicles is less than one, i.e. \( m < 1 \).

Question 15.
Rays from the Sun converge at a point 15 cm in front of a concave mirror. Where should an object be placed, so that size of its image is equal to the size of the object? [NCERT Exemplar]
(a) 15 cm in front of the mirror
(b) 30 cm in front of the mirror
(c) between 15 cm and 30 cm in front of the mirror
(d) more than 30 cm in front of the mirror

Answer:
(b) The rays from the Sun, i.e. from infinity, are parallel to principal axis after reflection converge at a point is known as focus. Therefore, focal length \( f \) of concave mirror is 15 cm. And we know that, same size, real and inverted image is formed by concave mirror when object is placed at focus \( 2A \) or centre of curvature, so to form same size of image, object will be placed at \( 15 \times 2 = 30 \) cm.

Question 16.
The path of a ray of light coming from air passing through a rectangular glass slab traced by four students shown as I, II, III and IV in the figure. Which one of them is correct? [NCERT Exemplar]

(a) Only I
(b) Only II
(c) Only III
(d) Only IV

Answer:
(b) In a rectangular glass slab, the emergent rays are parallel to the direction of the incident ray, because the lateral deviation of bending of the ray of light at the opposite parallel faces (air-glass interface) and (glass-air interface) of the rectangular glass slab are equal and opposite. This is why the ray emerges are parallel to the incident ray.

Question 17.
You are given water, mustard oil, glycerine and kerosene. In which of these media, a ray of light incident obliquely at same angle would bend the most? [NCERT Exemplar]
(a) Kerosene
(b) Water
(c) Mustard oil
(d) Glycerine
Answer:
(d) The given material having their refractive index as kerosene is 1.44, water is 1.33, mustard oil is 1.46 and glycerine is 1.74. Thus, glycerine is most optically denser and hence have the largest refractive index. Therefore, ray of light bend most in glycerine.

Question 18.
A student placed a light bulb in midway between the two plane mirrors inclined at an angle of 60°. How many images will be observed by him?
(a) 4
(b) 6
(c) 5
(d) 8
Answer:
(c) Number of images formed by two plane mirrors inclined at an angle 60° when a light bulb is placed in midway between them is
\[ N = \frac{360°}{60°} - 1 = 6 - 1 = 5 \]

Question 19.
Where should an object be placed in front of a convex lens to get a real image of the size of the object? [NCERT]
(a) At the principal focus of the lens
(b) At twice the focal length
(c) At infinity
(d) Between the optical centre of the lens and its principal focus
Answer:
(b) To set the real image of the size of the object, it should be placed at twice the focal length of a convex lens.

Question 20.
Which of the following lenses would you prefer to use while reading small letters found in dictionary? [NCERT]
(a) A convex lens of focal length 50 cm
(b) A concave lens of focal length 50 cm
(c) A convex lens of focal length 5 cm
(d) A concave lens of focal length 5 cm
Answer:
(c) Convex lens is used as magnifying glass. For better performance its focal length should be small.

Hope given NCERT Solutions for Class 10 Science Chapter 10 helpful to you.

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