Ray Optics and Optical Instruments — Assignment 1

Class 12 Physics · Topic-wise question bank covering every concept of the chapter · Narayan Gurukul Academy

Instructions: (1) Attempt all questions. This worksheet walks through every concept of the chapter, topic by topic.
(2) The interactive MCQ version of these questions (with instant answer reveal) is available on the notes page.
(3) Universal values: g = 10 m/s^2 unless stated. Give answers with correct SI units.

Reflection of Light and Plane Mirrors

MCQ Questions (choose the correct option)

1. A plane mirror produces an image that is —
   (A) virtual and behind the mirror
   (B) real and inverted
   (C) real and erect
   (D) virtual and inverted
2. On rotating a plane mirror by 30°, the reflected ray turns through —
   (A) 15°
   (B) 30°
   (C) 60°
   (D) 90°
3. If a plane mirror translates 5 cm towards a fixed object, the image moves —
   (A) 2.5 cm towards the mirror
   (B) 5 cm towards the mirror
   (C) 10 cm towards the mirror
   (D) 10 cm away from the mirror
4. The image formed by a plane mirror is laterally inverted. A letter written as ¦Ü¦ looks like —
   (A) the same letter
   (B) the letter flipped left–right
   (C) the letter upside down
   (D) a mirror image only in a concave mirror
5. Number of images formed when two plane mirrors are inclined at 60° to each other is —
   (A) 2
   (B) 3
   (C) 5
   (D) 6

1 Mark Questions

1. State the two laws of reflection of light.
2. Define the angle of deviation for reflection from a plane mirror.
3. Write the expression for deviation produced when a ray is reflected by a plane mirror.

2 Mark Questions

1. A ray of light makes an angle of 30° with a plane mirror. Find the angle of deviation produced on reflection.
2. A plane mirror is rotated by 20°. Through what angle does the reflected ray rotate? Justify.
3. Two plane mirrors are inclined at 60°. How many images of an object placed between them will be formed?

4. Why does a plane mirror form a laterally inverted image?

3 Mark Questions

1. Derive an expression for the number of images formed by two plane mirrors inclined at an angle θ with each other.
2. A point object is placed between two plane mirrors inclined at 40°. Find the number of images formed and explain the special case that arises.
3. Show with ray diagrams how the deviation of a ray reflected from a plane mirror depends on the angle of incidence.

Spherical Mirrors: Parameters and Sign Convention

MCQ Questions (choose the correct option)

1. A concave mirror has radius of curvature 40 cm. Its focal length is —
   (A) +40 cm
   (B) −40 cm
   (C) +20 cm
   (D) −20 cm
2. The focal length of a convex mirror is —
   (A) negative
   (B) positive
   (C) zero
   (D) infinite
3. In the Cartesian sign convention, the object distance u of a real object placed in front of a mirror is —
   (A) always positive
   (B) always negative
   (C) zero
   (D) either positive or negative
4. A ray parallel to the principal axis after reflection from a concave mirror —
   (A) passes through C
   (B) passes through F
   (C) appears to come from F
   (D) retraces its path
5. Which of the following is used as a rear-view mirror in vehicles?
   (A) plane mirror
   (B) concave mirror
   (C) convex mirror
   (D) parabolic mirror

1 Mark Questions

1. Define pole, centre of curvature and radius of curvature of a spherical mirror.
2. State the relation between the focal length and the radius of curvature of a spherical mirror.
3. State the New Cartesian sign convention for measuring distances in mirror problems.

2 Mark Questions

1. A concave mirror has a radius of curvature of 30 cm. Where is its focus?
2. Distinguish between concave and convex mirrors on the basis of the sign of their focal length.

3. Why can a convex mirror never form a real image of a real object?

3 Mark Questions

1. With a neat ray diagram, define the focus of (a) a concave mirror and (b) a convex mirror.

2. State the new Cartesian sign convention for reflection by spherical mirrors and apply it to write the value of u and R for a concave mirror with the object on the principal axis.

Mirror Formula, Magnification and Image Velocity

MCQ Questions (choose the correct option)

1. An object is placed 40 cm in front of a concave mirror of focal length 20 cm. The image is formed at —
   (A) 40 cm in front of the mirror
   (B) 40 cm behind the mirror
   (C) 20 cm in front of the mirror
   (D) infinity
2. A convex mirror of focal length 15 cm is used to view a needle 12 cm away. The image distance is —
   (A) +6.67 cm
   (B) −6.67 cm
   (C) +8.6 cm
   (D) −8.6 cm
3. The magnification produced by a concave mirror for a real image is —
   (A) positive and < 1
   (B) negative
   (C) zero
   (D) always +1
4. A candle of height 2.5 cm is placed 27 cm in front of a concave mirror of radius 36 cm. The image height is —
   (A) 2.5 cm
   (B) 5.0 cm
   (C) 1.25 cm
   (D) 0.5 cm
5. For a convex mirror the linear magnification of a real object is always —
   (A) m > 1
   (B) m = 1
   (C) 0 < m < 1
   (D) m < 0

1 Mark Questions

1. State the mirror formula for a spherical mirror.

2. Write the expression for the linear magnification of a spherical mirror.

3. What is the relation between image velocity and object velocity for a plane mirror?

2 Mark Questions

1. An object is placed 30 cm in front of a concave mirror of focal length 15 cm. Find the position, nature and size of the image.

2. A convex mirror has focal length 15 cm. A needle 12 cm from the mirror gives an image at what distance, and what is the magnification?

3. Use the mirror formula to show that a concave mirror forms a real image beyond 2f when the object lies between f and 2f.

3 Mark Questions

1. Derive the mirror formula 1/v + 1/u = 1/f for a concave mirror using a ray diagram and the Cartesian sign convention.

2. An object moves with speed 2 cm/s towards a concave mirror of focal length 20 cm along its principal axis. At the instant when the object is 40 cm from the mirror, find the velocity of the image.

3. Derive the relation for the velocity of the image of an object moving along the principal axis of a spherical mirror.

Refraction and Snell's Law

MCQ Questions (choose the correct option)

1. When light passes from air (n = 1) into glass (n = 1.5), the speed of light —
   (A) increases
   (B) decreases
   (C) stays the same
   (D) becomes zero
2. A tank of depth 12.5 cm of water gives an apparent depth of 9.4 cm. The refractive index of water is about —
   (A) 1.33
   (B) 1.50
   (C) 1.00
   (D) 1.09
3. The frequency of light when it enters a denser medium —
   (A) increases
   (B) decreases
   (C) remains the same
   (D) depends on wavelength
4. As light enters glass bending towards the normal, the angle of refraction is —
   (A) greater than the angle of incidence
   (B) less than the angle of incidence
   (C) equal to the angle of incidence
   (D) 90°
5. A slab of glass (n = 1.5) of thickness 15 cm raises an object viewed normally through it by —
   (A) 15 cm
   (B) 10 cm
   (C) 5 cm
   (D) 7.5 cm

1 Mark Questions

1. State the laws of refraction of light.

2. State Snell's law and define relative refractive index.

3. A glass slab of thickness t is placed over a table. By how much does a point on the table appear raised when viewed normally? (Write the expression.)

2 Mark Questions

1. The apparent depth of a needle at the bottom of a tank measured with a microscope is 9.4 cm for a water depth of 12.5 cm. Find the refractive index of water and the new apparent depth if the liquid is replaced by one with n = 1.63.

2. A glass slab of thickness 15 cm and refractive index 1.5 is held parallel to a table. A pin fixed on the table is viewed from above. By how much does it appear to rise? Does the answer depend on where the slab is kept?

3. Explain why a fish in water appears closer to the surface than it actually is.

3 Mark Questions

1. Derive the expression for the apparent shift of an object viewed through a glass slab of thickness t and refractive index n.

2. Light travels from air into a medium of refractive index 1.5 at an angle of incidence 60°. Find the angle of refraction and the angle of deviation.

Total Internal Reflection and Optical Fibres

MCQ Questions (choose the correct option)

1. Total internal reflection can occur when light travels —
   (A) from air to glass
   (B) from water to air at any angle
   (C) from water to air at an angle greater than the critical angle
   (D) from glass to water at 30°
2. The critical angle of glass relative to air is about —
   (A) 42°
   (B) 24°
   (C) 48°
   (D) 90°
3. The critical angle of a medium with refractive index 1/μ where μ is relative to —
   (A) air
   (B) the rarer medium in use
   (C) water
   (D) vacuum always
4. Light is confined inside an optical fibre because of —
   (A) refraction
   (B) total internal reflection
   (C) normal reflection
   (D) dispersion
5. A point source of light is at the bottom of a tank of water (n = 1.33) of depth 80 cm. The area of the water surface through which light emerges is about —
   (A) 1.3 m^2
   (B) 2.6 m^2
   (C) 5.2 m^2
   (D) 8.1 m^2

1 Mark Questions

1. Define critical angle.

2. State the two necessary conditions for total internal reflection.

3. Why does a diamond sparkle more than a glass piece of the same shape?

2 Mark Questions

1. A light pipe is made of a glass fibre of refractive index 1.68 clad with a material of refractive index 1.44. Find the range of angles of incidence with the axis for which total internal reflection guides light along the pipe.

2. The refractive index of water is 1.33. Find the critical angle for the water–air interface.

3. A small bulb is placed at the bottom of a tank of water 80 cm deep. Find the radius of the circular patch on the surface through which light emerges.

3 Mark Questions

1. Derive the condition for total internal reflection and obtain the expression for the critical angle in terms of the refractive indices.

2. Explain with a diagram the propagation of light in an optical fibre. A fibre with core index 1.68 and no cladding accepts light incident at any angle up to what value with its axis?

Refraction at Spherical Surfaces and Lenses

MCQ Questions (choose the correct option)

1. A convex lens of focal length 20 cm is placed 12 cm from a point where a converging beam would meet. The beam now converges at —
   (A) 7.5 cm beyond the lens
   (B) 48 cm beyond the lens
   (C) 20 cm beyond the lens
   (D) 12 cm in front of the lens
2. A concave lens of focal length 21 cm and an object at 14 cm give an image —
   (A) on the same side at 8.4 cm, virtual
   (B) on the other side at 8.4 cm, real
   (C) at 21 cm, virtual
   (D) at infinity
3. For a diverging lens an object placed anywhere gives an image that is —
   (A) real and inverted
   (B) virtual and erect
   (C) real and erect
   (D) virtual and inverted
4. The power of a lens is 2 dioptre. Its focal length is —
   (A) 50 cm
   (B) 20 cm
   (C) 2 m
   (D) 0.5 cm
5. Which of the following is a converging lens?
   (A) double-concave lens
   (B) plano-concave lens
   (C) double-convex lens
   (D) concavo-convex lens with very thick edges

1 Mark Questions

1. State the lens formula for a thin lens.

2. Define optical centre of a lens.

3. Distinguish between concave and convex lenses by the sign of the focal length.

2 Mark Questions

1. An object 3.0 cm tall is placed 14 cm in front of a concave lens of focal length 21 cm. Describe the image and what happens as the object is moved farther away.

2. A convex lens of focal length 30 cm and a concave lens of focal length 20 cm are placed in contact. Is the combination converging or diverging?

3. A converging beam falls on a convex lens of focal length 20 cm placed 12 cm from the point of convergence. Where does the beam converge now?

3 Mark Questions

1. Derive the refraction formula at a spherical surface for light going from rarer to denser medium at a convex refracting surface.

2. Obtain the lens formula $1/v - 1/u = 1/f$ for a thin convex lens using the refraction formula for a single spherical surface, stating clearly the assumptions used.

Lens Maker's Formula, Power and Combination

MCQ Questions (choose the correct option)

1. Two thin lenses of focal lengths 30 cm and −20 cm are in contact. The effective focal length is —
   (A) −60 cm
   (B) +60 cm
   (C) +10 cm
   (D) −10 cm
2. A double-convex lens is made of glass (n = 1.55) with equal radii of curvature. If f = 20 cm, each radius is —
   (A) 11 cm
   (B) 22 cm
   (C) 31 cm
   (D) 44 cm
3. A lens of focal length 2 m has a power of —
   (A) 0.5 D
   (B) 2 D
   (C) −0.5 D
   (D) 5 D
4. The power of a concave lens is always —
   (A) positive
   (B) negative
   (C) zero
   (D) infinite
5. In the displacement method, object and screen are 90 cm apart and the two conjugate positions differ by 20 cm. The focal length is about —
   (A) 21.4 cm

(B) 10.7 cm

(C) 45 cm

(D) 20 cm

1 Mark Questions

1. Write the lens maker's formula and name each symbol.

2. Define the power of a lens. State its SI unit.

3. State the formula for the effective power of two thin lenses placed in contact.

2 Mark Questions

1. A double-convex lens of n = 1.55 is wanted with f = 20 cm and both faces of equal radius. Find the required radius of curvature.

2. A convex lens of f = 30 cm and a concave lens of f = 20 cm are in contact. Find the focal length and nature of the combination.

3. Object and screen are 90 cm apart. A convex lens gives two sharp images separated by 20 cm. Find the focal length of the lens.

3 Mark Questions

1. Derive the lens maker's formula for a thin double-convex lens stating all assumptions.

2. Show that two thin lenses in contact behave as a single lens of focal length F with $1/F = 1/f_1 + 1/f_2$.

Prism and the Angle of Minimum Deviation

MCQ Questions (choose the correct option)

1. The deviation produced by a prism is $\delta = i + e - A$. At minimum deviation —

(A) $i = e$

(B) $e = 0$

(C) $i = 0$

(D) $A = 60°$

2. A prism of angle 60° gives a minimum deviation of 40°. Its refractive index is about —

(A) 1.33

(B) 1.53

(C) 1.73

(D) 1.50

3. The deviation of a thin prism of small angle A is —

(A) $(n - 1)A$

(B) $(n + 1)A$

(C) $2A$

(D) A/n

4. At minimum deviation the ray inside the prism travels —

(A) parallel to the base

(B) perpendicular to the base

(C) symmetric to the two refracting faces

(D) through the centre of curvature

5. When the prism of Q9.6 is dipped in water (n = 1.33), the new angle of minimum deviation —

(A) increases
(B) decreases
(C) stays the same
(D) becomes zero

1 Mark Questions

1. Define the refracting angle of a prism and the angle of deviation.
2. State the condition for minimum deviation in a prism.
3. Write the thin-prism expression for deviation.

2 Mark Questions

1. A prism of refracting angle 60° gives minimum deviation 40° for sodium light. Find its refractive index.
2. If the same prism is placed in water (n = 1.33), estimate the new angle of minimum deviation.
3. A ray is incident on a prism of angle 60° with refractive index 1.524. Find the angle of incidence at which it just suffers total internal reflection at the other face.

3 Mark Questions

1. Derive the prism formula n = sin((A + δ_m)/2) / sin(A/2).
2. Show that the deviation is minimum when the ray passes symmetrically through the prism, and obtain the relation between the angle of incidence and the angle of emergence at minimum deviation.

Dispersion of Light

MCQ Questions (choose the correct option)

1. Dispersion of white light occurs because the refractive index of a material —
   (A) is constant for all colours
   (B) varies with wavelength
   (C) is zero for violet
   (D) is equal to 1 for red
2. The colour that deviates the most through a prism is —
   (A) violet
   (B) red
   (C) yellow
   (D) green
3. The dispersive power of a medium is defined as —
   (A) (n_v − n_r)/(n_y − 1)
   (B) (n_y − 1)/(n_v − n_r)
   (C) n_v/n_r
   (D) (n_v + n_r)/(n_y − 1)
4. Two prisms of crown and flint glass placed base-to-base can —
   (A) produce achromatic combination
   (B) always increase dispersion
   (C) stop refraction
   (D) form real images
5. The angle of deviation is the largest for —

(A) violet light
(B) red light
(C) green light
(D) all colours equally

1 Mark Questions

1. Define dispersion of light.
2. Define the dispersive power of a material.
3. Which colour has the highest refractive index in glass?

2 Mark Questions

1. Why is violet light deviated more than red light when passing through a prism?
2. A thin prism gives angular dispersion $(n_v - n_r)A$. What does this quantity represent?
3. How would you combine a crown and a flint glass prism so that white light is deviated without dispersion?

3 Mark Questions

1. Derive the expression for the dispersive power of a prism material in terms of the refractive indices of two colours.
2. Explain the formation of a rainbow, mentioning the roles of refraction, dispersion and total internal reflection in water droplets.

Optical Instruments: The Eye, Microscope and Telescope

MCQ Questions (choose the correct option)

1. A small telescope has objective f_0 = 144 cm and eyepiece f_e = 6 cm. Its magnifying power in normal adjustment is —
   (A) 24
   (B) 150
   (C) 864
   (D) 6
2. For a simple microscope, the maximum magnifying power (image at 25 cm) for f = 5 cm is —
   (A) 5
   (B) 6
   (C) 30
   (D) 0.2
3. A myopic person whose far point is 100 cm needs lenses of power —
   (A) +1.0 D
   (B) −1.0 D
   (C) +0.5 D
   (D) −2.0 D
4. Astigmatism is corrected by a —
   (A) convex lens
   (B) concave lens
   (C) cylindrical lens
   (D) bifocal lens

5. A compound microscope with objective f = 8 mm and eyepiece f = 2.5 cm, object at 9 mm from the objective, has the lenses separated by about —

(A) 7.2 cm

(B) 2.27 cm

(C) 9.47 cm

(D) 15 cm

1 Mark Questions

1. Define the near point and far point of a normal human eye.

2. State the formula for the magnifying power of a simple microscope with the final image at the near point.

3. Write the expression for the magnifying power of an astronomical telescope in normal adjustment.

2 Mark Questions

1. A telescope has objective f_0 = 144 cm and eyepiece f_e = 6 cm. Find its magnifying power and the separation between the lenses.

2. Explain the correction of myopia and hypermetropia with suitable lenses.

3. A person with normal near point 25 cm uses a magnifying glass of focal length 5 cm. Find the closest and farthest object distances for clear reading and the corresponding magnifications.

3 Mark Questions

1. Draw a labelled ray diagram of a compound microscope and derive an expression for its magnifying power with the final image at infinity.

2. A giant telescope has an objective of focal length 15 m and an eyepiece of focal length 1.0 cm. Find the angular magnification and, for the moon of actual diameter 3.48×10^6 m at a distance 3.8×10^8 m, the diameter of the image formed by the objective.

Some Natural Phenomena Due to Sunlight

MCQ Questions (choose the correct option)

1. The primary rainbow has —

(A) red on the outer edge

(B) violet on the outer edge

(C) all colours mixed

(D) no violet colour

2. The secondary rainbow is —

(A) brighter than the primary

(B) formed without dispersion

(C) fainter with reversed colours

(D) formed by reflection only

3. The sky appears blue because —

(A) scattering of blue light by air molecules is strongest

(B) refraction in the atmosphere

(C) water vapour absorbs red

(D) total reflection

4. The minimum number of refractions inside a drop for a primary rainbow is —

(A) one

(B) two

(C) three

(D) zero

1 Mark Questions

1. Name the optical phenomenon responsible for the formation of a rainbow.
2. Why is the sky blue?
3. In which order do the colours appear in the primary rainbow?

2 Mark Questions

1. Using refraction and total internal reflection inside a water drop, explain the formation of a primary rainbow.
2. Why does the red colour appear on the outer edge of the primary rainbow?

3 Mark Questions

1. Explain with a diagram the formation of the primary rainbow and the physical reason for the order of colours.
2. Why is the secondary rainbow fainter and how are its colours arranged?