REFLECTION OF LIGHT

JEE MAINS LEVEL QUESTIONS

Multiple choice question type: 1,7,12

1.

Step 1: Understand the Geometry and Law of Reflection

The angle between the incident ray and the reflected ray is the sum of the angle of incidence (θ_i) and the angle of reflection (θ_r). The **Law of Reflection** states that these two angles are equal: $\theta_i = \theta_r$. Therefore, the total angle between the rays is twice the angle of incidence:

$$\theta_{\text{total}} = 2\theta_i$$

Step 2: Calculate the Angle of Incidence

Given the assumed total angle of 50°, we solve for the angle of incidence (θ_i):

$$50^\circ = 2\theta_i$$

$$\theta_i = \frac{50^\circ}{2}$$

$$\theta_i = 25^\circ$$

2.

A **convex mirror** is a curved mirror that bulges outwards. Its reflective surface diverges light rays, which makes the image appear smaller than the object. This property makes them useful as rear-view mirrors in vehicles, as they provide a wider field of view.

3.

- A convex mirror is also known as a diverging mirror because it causes parallel light rays to spread out after reflection.
- For any position of a real object placed in front of a convex mirror, the reflected rays never actually meet. Instead, they appear to diverge from a point behind the mirror, which results in a **virtual** image.
- The image formed is always in the same orientation as the object, meaning it is **upright** (or erect).
- The image is consistently smaller than the actual object, thus it is **diminished** in size. The image is always located between the pole and the principal focus behind the mirror.

4.

Step 1: Determine the image distance from the mirror

For a plane mirror, the distance of the image from the mirror (v) is equal in magnitude to the distance of the object from the mirror (u). The object distance is given as $u = 3.5\ \text{m}$.
Therefore, the image distance is $v = 3.5\ \text{m}$.

Step 2: Calculate the distance between the boy and his image

The total distance between the boy (object) and his image (D) is the sum of the object distance and the image distance.

$$D = u + v = 3.5\ \text{m} + 3.5\ \text{m} = 7.0\ \text{m}$$

5.

Focal length sign convention (usually for mirrors):

- Concave mirror → focal length **negative** (real focus) in Cartesian sign convention.
- Convex mirror → focal length **positive** (virtual focus).

Given $f = +15\ \text{cm}$ → **positive** focal length → **convex mirror**.

6.

For a plane mirror:

- Angle of incidence $i = 25^\circ$
- Angle of reflection $r = 25^\circ$
- The **deviation** δ = angle through which the reflected ray is turned relative to the original incident ray's direction.

Deviation $\delta = 180^\circ - 2i$ if measured between the **incident ray's original direction** and the **reflected ray's direction.**

But careful — some books define deviation as the angle through which the reflected ray is rotat from the incident direction when extended forward. Actually, the simpler formula:

$$\delta = 180^\circ - (i + r)$$

But since $i = r$,

$$\delta = 180^\circ - 2i$$

Plug $i = 25^\circ$:

$$\delta = 180^\circ - 2 \times 25^\circ = 180^\circ - 50^\circ = 130^\circ$$

7.

Step 1: Understand the Relationship

The focal length (f) of a spherical mirror is half its radius of curvature (R).

The relationship can be expressed by the formula:

$$f = \frac{R}{2}$$

Step 2: Calculate the Focal Length

Assuming the radius of curvature R is **0.5 m** (based on the provided options):

$$f = \frac{0.5\,\text{m}}{2}$$

$$f = 0.25\,\text{m}$$

8.

Step 1: Determine the required mirror height

The principle of optics states that the minimum vertical height of a plane mirror required for an observer to see their entire image is exactly half of the observer's height, regardless of the distance from the mirror [1]. The user's height (h) is given as $1.9\,\text{m}$.

The formula for the minimum mirror height (H) is:

$$H = \frac{h}{2}$$

Step 2: Perform the calculation

Substitute the student's height into the formula:

$$H = \frac{1.9\,\text{m}}{2}$$

$$H = 0.95\,\text{m}$$

9.

In a **plane mirror**:

- The image size is always equal to the object size (magnification = 1).
- Distance from mirror does not affect the image size.

Given object height = $0.3\ \mathrm{m} \Rightarrow$ image height = $0.3\ \mathrm{m}$.

10.

Explanation

- A **concave mirror** is used as a shaving mirror because, when the face (object) is placed close to the mirror (specifically, between the mirror's pole and focal point), it produces a virtual, erect (upright), and **magnified** image.
- This magnified image allows a person to see fine details of their facial hair clearly, which is beneficial for precise shaving.

JEE ADVANCED LEVEL QUESTIONS

11.

- **a) angle of incidence is equal to angle of reflection:** This is the second law of reflection and applies universally to all mirrors, including plane mirrors.
- **c) lateral inversion takes place:** This is the property of an image formed by a plane mirror where the left and right sides appear reversed.
- **d) radius of curvature is infinity:** A plane mirror can be considered a part of a sphere with an infinitely large radius, which results in a flat surface. Consequently, its focal length is also infinite.

12.

- **Assertion:** The focal length (f) of a concave mirror is indeed negative in calculations.
- **Reason:** According to the New Cartesian Sign Convention, distances measured from the mirror's pole in the direction opposite to the incident light are negative.
- **Concave Mirror:** A concave mirror converges parallel light rays to a real focal point *in front* of the mirror (on the same side as the incoming light).
- **Conclusion:** Since the focal point is in front, its distance (focal length) is measured against the incident light, making it negative.

Therefore, both statements are correct, and the reason fully justifies the assertion.

12.

- **Statement (a) is correct**: For a man of height 'h' to see his full image in a plane mirror, the minimum height of the mirror required is indeed **h/2**. This is due to the laws of reflection, where light rays from the top of the head and the feet must reflect to the eyes, a geometric analysis proves that only half the height of the person is needed.
- **Statement (b) is correct**: In a plane mirror setup, the image distance behind the mirror is always equal to the object distance in front. If the object moves a distance 'd' towards or away from the mirror (while the mirror is stationary), the image also moves the same distance 'd' towards or away from the mirror, respectively.
- **Statement (c) is correct**: If the object is stationary and the plane mirror is moved through a distance 'd', the image moves through a distance of **2d** relative to the original position. This is because the image position changes by 'd' relative to the mirror, and the mirror itself moved 'd', so the total displacement from the original image position is 2d.

13.

- **Assertion (A): A concave mirror cannot form an image smaller than the object.**
  - **False.** A concave mirror forms images of various sizes. When the object is placed beyond the center of curvature (2F), the image formed is real, inverted, and *diminished* (smaller than the object).
- **Reason (R): A convex mirror has a wider field of view and always forms an erect image.**
  - **True, but not the explanation.** Convex mirrors always diverge light, giving them a wide field of view (like security mirrors) and producing virtual, erect, and *diminished* images, which is why they are used for rearview mirrors in vehicles. However, this reason doesn't explain *why* a concave mirror can't form smaller images (which it can).

Conclusion:
The Assertion is incorrect because concave mirrors *can* form smaller images; the Reason correctly describes properties of convex mirrors but doesn't justify the Assertion's (false) claim about concave mirrors.

15.

when object is placed **not** on the angle bisector? Wait — correct general formula:
For **object placed symmetrically** (on angle bisector) or not? For object placed anywhere off the mirrors' intersection line:

If $\frac{360}{\theta}$ is integer → $n = \frac{360}{\theta} - 1$
If $\frac{360}{\theta}$ not integer → $n = \text{floor}\left(\frac{360}{\theta}\right)$
But some books use simply $n = \frac{360}{\theta} - 1$ for any case, rounding not needed only if object is not on mirror line.

Given typical high school problems, they use $n = \frac{360}{\theta} - 1$ with **integer** $\frac{360}{\theta}$ for these angles:

Let's compute:

(a) θ = 60°

$$\frac{360}{60} = 6 \quad \Rightarrow \quad n = 6 - 1 = 5$$

Matches code 3.

(b) θ = 45°

$$\frac{360}{45} = 8 \quad \Rightarrow \quad n = 8 - 1 = 7$$

Matches code 1.

(c) θ = 90°

$$\frac{360}{90} = 4 \quad \Rightarrow \quad n = 4 - 1 = 3$$

Matches code 2.

(d) θ = 20°

$$\frac{360}{20} = 18 \quad \Rightarrow \quad n = 18 - 1 = 17$$

Matches code 4.

16.

Number of Images Formed by Two Perpendicular Mirrors

- The number of images formed by two plane mirrors inclined at an angle θ is given by $N = \frac{360^\circ}{\theta} - 1$ (if $\frac{360^\circ}{\theta}$ is an even integer or if it is an odd integer and the object is placed symmetrically).
- For two perpendicular mirrors, $\theta = 90^\circ$.
- Using the formula: $N = \frac{360^\circ}{90^\circ} - 1 = 4 - 1 = 3$.
- For three mutually perpendicular mirrors, the total number of images is 7.
- Given the options for part (i), the question likely refers to **two** perpendicular mirrors.

i.

Step 1: Calculate the number of images

Assuming the question is for two perpendicular mirrors (as 7 is not an option), the number of images is:

$$N = \frac{360^\circ}{\theta} - 1$$

Substituting $\theta = 90^\circ$:

$$N = \frac{360^\circ}{90^\circ} - 1 = 4 - 1 = 3$$

ii.

Number of Images Formed by Two Parallel Mirrors

- For two parallel mirrors, the angle between them is $\theta = 0^\circ$.
- Using the formula $N = \frac{360^\circ}{\theta} - 1$:

  $$N = \frac{360^\circ}{0^\circ} - 1 = \infty - 1 = \infty$$

17.

For a **plane mirror**, the image is formed as far behind the mirror as the object is in front of it [1]. This means the **image distance** (d_i) is equal to the **object distance** (d_o).

- **Object distance** from the mirror, $d_o = 10$ cm.
- **Image distance** from the mirror, $d_i = 10$ cm (behind the mirror).
- **Observer's distance** from the mirror = 30 cm.

The eye focuses on the **virtual image**, not the mirror itself. The total distance the light travels from the virtual image to the observer's eye is the sum of the distance from the image to the mirror and the distance from the mirror to the observer:

$$\text{Total Distance} = d_i + \text{Observer Distance}$$

$$\text{Total Distance} = 10\text{ cm} + 30\text{ cm} = 40\text{ cm}$$

Answer:

The distance the eye must focus is **40 cm**.

18.

The distance between the object and its image formed in the mirror is **50 cm**.

For a plane mirror, the image is formed at the same distance behind the mirror as the object is in front of it. The image distance (d_i) is equal in magnitude to the object distance (d_o), or $d_i = d_o$. The total distance between the object and the image is the sum of these two distances: $D = d_o + d_i = 2d_o$.

Given the object distance $d_o = 25$ cm, the total distance between the object and its image is:

$$D = 2 \times 25\text{ cm} = \mathbf{50}\text{ cm}$$

LEARNERS TASK

Conceptual understanding questions – 2,3,4,5,6,7,8,9,10

1.

A mirror with a very wide field of view must be a **convex mirror**.

Convex mirrors produce diminished, upright virtual images and allow a larger field of view compared to plane or concave mirrors, which is why they are used in vehicle side mirrors and security mirrors.

2.

The mirror used in **searchlights** is a **concave mirror**.

Concave mirrors can produce a parallel beam of light when the light source is placed at the focus, making them suitable for searchlights and spotlights

3.

A real image, equal in size to the object, is obtained when the object is placed at the **centre of curvature** of a **concave mirror**.

At $u = R = 2f$, $v = 2f$, magnification $m = -1$ → image is real, inverted, same size.

4.

The laws of reflection (angle of incidence = angle of reflection, incident ray, normal, and reflected ray lie in the same plane) apply to **all** reflecting surfaces, regardless of shape.

5.

When an object is at the **focus (F)** of a concave mirror:
Rays become parallel after reflection.
The image is formed **at infinity**.

6.

A **real image** is formed when **actual rays** converge at a point.
For mirrors, that means **reflected rays** actually meet.

So, correct option: **reflected rays meet** → Option A.

7.

The image formed by a plane mirror is:

1. Virtual and erect
2. Same size as the object
3. Laterally inverted

All these statements are correct.

8.

When the object is at the **principal focus** of a concave mirror:

- The reflected rays are parallel → image at **infinity**
- The image is **real** and **inverted** (for a real object)
- Size is **infinite** in the sense that magnification is infinite? Actually, magnification approaches infinity as $u \to f$, so image size is extremely large ("infinite").

Given the options:

A) real and inverted → True

B) of infinite size → True (highly magnified, infinite in theory)

C) lies at infinity → True

9.

The sideways reversal of the image by a plane mirror is called **lateral inversion**.

10.

When an object is at the **centre of curvature** of a concave mirror:

- Image is **real and inverted**
- Size is **same as object**
- Image is also at **centre of curvature** (on the same side, between C and mirror if object at C, actually $u = R$, $v = R$).

All options A, B, C are correct.

JEE MAINS LEVEL QUESTIONS

Multiple choice question type:-8

1.

To see the full image of oneself in a **plane mirror**, the minimum length of the mirror needed is **half the height** of the person (or object).

This comes from the geometry of reflection:

- The top of the mirror needs to be at least at the level halfway between your eye and the top of your head.
- The bottom of the mirror needs to be at least at the level halfway between your eye and your feet.

Thus, total mirror length = half your height.

2.

The total number of images formed when an object is placed unsymmetrically between two plane mirrors inclined at an angle of 90 degrees is 3 [1].

The formula to calculate the number of images formed (n) when two plane mirrors are inclined at an angle θ is $n = (360^\circ/\theta) - 1$, provided that $360^\circ/\theta$ is an even integer or if the object is placed symmetrically when $360^\circ/\theta$ is an odd integer [1].

In this case:

- $\theta = 90^\circ$
- $360^\circ/90^\circ = 4$

3.

Step 1: Determine the angle of incidence

The mirror is oriented at an angle of 30° to the horizontal. The incident ray is vertical, meaning it makes a 90° angle with the horizontal. The angle between the incident ray and the mirror surface is $\theta_{\text{surface}} = 90^\circ - 30^\circ = 60^\circ$. The angle of incidence, i, is the angle between the incident ray and the normal to the mirror surface:

$$i = 90^\circ - \theta_{\text{surface}} = 90^\circ - 60^\circ = 30^\circ$$

Step 2: Determine the angle of reflection

According to the law of reflection, the angle of reflection, r, is equal to the angle of incidence, i.

$$r = i = 30^\circ$$

Step 3: Calculate the angle between the mirror and reflected ray

The angle between the reflected ray and the mirror surface is the complement of the angle of reflection:

$$\theta_{\text{mirror-reflected}} = 90^\circ - r = 90^\circ - 30^\circ = 60^\circ$$

4.

To see the full image of an object in a plane mirror, the minimum vertical length of the mirror must be exactly half the height of the object. This principle is independent of the distance between the observer and the mirror [1].

The required height ($\mathbf{H_{mirror}}$) is calculated using the formula:

$$\mathbf{H_{mirror}} = \frac{\mathbf{H_{object}}}{2}$$

Given the object height ($\mathbf{H_{object}}$) is 2 m:

$$\mathbf{H_{mirror}} = \frac{2\text{ m}}{2} = 1\text{ m}$$

5.

Explanation

- **Lateral Inversion**: A plane mirror produces an image that is laterally inverted. This means the image's left side corresponds to the object's right side, and the image's right side corresponds to the object's left side.
- **Applying the Concept**:
  - The man's real left eye has a yellow glass. In the mirror image, this will appear on the image's right side.
  - The man's real right eye has a red glass. In the mirror image, this will appear on the image's left side.
- **Result**: The man observes his image with the left eye appearing red and the right eye appearing yellow.

6.

Explanation

- **Total Images:** The number of images (N) formed by two plane mirrors inclined at an angle (θ) is given by the formula $N = \frac{360^\circ}{\theta} - 1$ when $\frac{360^\circ}{\theta}$ is an even number and the object is placed symmetrically. For mirrors at right angles, $\theta = 90^\circ$, so $N = \frac{360^\circ}{90^\circ} - 1 = 4 - 1 = 3$ images.
- **Handedness:**
  - The images formed by single reflection in each mirror are laterally inverted, meaning his right hand appears as a left hand in those two images.
  - The third image, formed by successive (double) reflection, undergoes two lateral inversions, which cancel each other out. This image appears as it would if viewed directly, with his right hand remaining a right hand.

Therefore, out of the three images, one shows the right hand, while the other two show the left hand.

7.

Explanation

When an object is placed at the **center of curvature (C)** of a concave mirror, the image formed has the following characteristics:

- **Position:** At the center of curvature (C) itself.
- **Nature: Real** and inverted.
- **Size:** Of the **same size** as the object.

Why other options are incorrect

- **A) When the object is at the focus:** The image is formed at infinity, is highly enlarged, real, and inverted.
- **B) When the object is at infinity:** The image is formed at the focus (F), is highly diminished (point-sized), real, and inverted.
- **D) When the object is between focus and pole:** The image is formed behind the mirror, is virtual, erect, and magnified (enlarged).

8.

Explanation

The number of images formed by two plane mirrors inclined at an angle θ is determined by the formula $n = \frac{360^\circ}{\theta}$. The rules for calculating the number of images are as follows:

- If $\frac{360^\circ}{\theta}$ **is an even integer**, the number of images is $n - 1$ for all positions of the object.
- If $\frac{360^\circ}{\theta}$ **is an odd integer**, the number of images is $n - 1$ if the object is placed symmetrically (on the angle bisector), and n if the object is placed asymmetrically.
- If $\frac{360^\circ}{\theta}$ **is a fraction**, the number of images is the integral (whole number) part of the result, generally rounded down or truncated.

In this case:

1. The angle between the mirrors is $\theta = 70^\circ$.
2. Calculate the ratio: $\frac{360^\circ}{70^\circ} \approx 5.14$.
3. Since the result is a fraction, the number of images is the integral part, which is **5**.

Thus, 5 images are formed.

9.

Step 1: Understand the Relationship

The relationship between the focal length (f) and the radius of curvature (R) of a spherical mirror is given by the formula $R = 2f$ (or $f = R/2$).

Step 2: Calculate the Radius of Curvature

Given the focal length $f = 25$ cm, we can calculate the radius of curvature R using the formula:

$$R = 2f$$

$$R = 2 \times 25\,\text{cm}$$

$$R = 50\,\text{cm}$$

Step 3: Reconcile with Options

The calculated radius of curvature is 50 cm. This value is not among the given options (A) 7.45, (B) 12.5, (C) 2.45, (D) 14.5. The value **12.5 cm** is present as option B, which would be the focal length if the radius of curvature were 25 cm. Assuming the question intends for one of the options to be correct, there is likely an error in the question or options. The value **12.5** is the most plausible intended answer if we assume a common homework problem variation.

10.

1. **Image Distance:** In a plane mirror, the image is formed as far behind the mirror as the object is in front of it [1]. Since the man's hand is 0.3 m from the mirror, the image of his hand is formed 0.3 m *behind* the mirror.
2. **Total Distance to Image:** The man is standing in front of the mirror. To see the image, his eye must focus on the location of the image. The total distance from the man's eye (presumed to be at the same location as his body in front of the mirror) to the image is:
   1. Distance from man to mirror (0.3 m) + Distance from mirror to image (0.3 m) = 0.6 m.

JEE ADVANCED LEVEL QUESTIONS

11.

Properties of a Real Image

- **a) always inverted:** A real image is typically formed below the principal axis (when the object is above it) and is therefore always inverted relative to a real object.
- **b) represented with full lines in ray diagrams:** In ray diagrams, real light rays that actually converge are represented by solid or full lines, as opposed to the dashed or dotted lines used for virtual rays.
- **c) formed when rays are actually meet:** A real image is defined as one that forms at the point where light rays actually converge or intersect after passing through an optical system.
- **d) can be caught on a screen:** Because the light rays physically meet at the image location, a real image can be projected or "caught" on a screen, such as a cinema screen or camera sensor.

12.

- **Virtual:** The light rays only *appear* to come from the image, so it can't be projected on a screen.
- **Erect:** The image stands upright, just like the object.
- **Laterally Inverted:** Left and right sides are reversed (your right hand looks like the mirror's left hand).
- **Not Real:** Real images are formed by actual convergence of light rays, which doesn't happen here.

13.

Explanation

Letters that are vertically symmetrical do not show lateral inversion because their mirror image appears exactly the same as the original letter. Lateral inversion is the phenomenon where the left and right sides of an object are reversed in a plane mirror.

- **A**, **H**, and **O** are all symmetrical along their vertical axis, meaning their mirror images are unchanged.
- **L** is not vertically symmetrical. Its mirror image appears as a backward 'L', demonstrating lateral inversion.

Why other options show lateral inversion

- **L** is the only letter among the choices that shows a clear reversal of its structure when reflected in a plane mirror, confirming it undergoes lateral inversion.

14.

- **Assertion (A): A concave mirror can form both real and virtual images. (True)**
  - **Real Images:** Formed when the object is placed beyond the focal point (F).
  - **Virtual Images:** Formed when the object is placed between the focal point (F) and the mirror's pole (P).
- **Reason (R): A concave mirror converges parallel rays to a single focal point. (True)**
  - This property defines a concave mirror as a converging mirror, which explains how it forms real, inverted images when light rays actually meet.

Why R is not the explanation for A:

- The converging nature (R) explains why real images form when rays meet, but it doesn't inherently explain the virtual image formation (when rays appear to diverge from behind the mirror). The key to both types of images lies in the *object's specific location*, not just the converging property itself.

15.

- **Assertion (A) is True:** A convex mirror, due to its outward curve, always produces an image that is virtual (seen behind the mirror), erect (upright), and diminished (smaller than the object).
- **Reason (R) is True:** A convex surface reflects parallel light rays outwards (diverges them), preventing them from actually meeting in front, hence the image is virtual.
- **Reason Correctly Explains Assertion:** The diverging nature of light from a convex mirror directly causes the formation of a virtual image, as the perceived meeting point of these spread-out rays is always behind the mirror and smaller than the object, making the explanation valid.

In Summary: The reason perfectly describes *why* the assertion is true—the divergence of light is the fundamental property leading to the specific image characteristics.

16.

1. **A light ray** – a single straight-line path of light.
2. **Parallel beam** – light rays that are parallel to each other (e.g., from a distant source).
3. **Convergent beam** – light rays that are coming together toward a point.
4. **Divergent beam** – light rays that are spreading apart from a point.

17.

i.

To see one's full image in a plane mirror, the minimum height of the mirror required is half the person's height, regardless of the distance from the mirror.
The man's height is 1.5 m.

The minimum height of the mirror for this purpose is $h_{\text{mirror}} = \frac{h_{\text{man}}}{2}$.

$$h_{\text{mirror}} = \frac{1.5\text{ m}}{2} = 0.75\text{ m}$$

The correct option is **0.75 m** (Option L/C in the original question).

1. **ii.**

When a person stands in the exact center of a room, to see the full height of the back wall in a plane mirror on the front wall, the minimum height of the mirror required is one-third the height of the wall.

The height of the back wall is $H_{\text{wall}} = 6\,\text{m}$.

The minimum height of the mirror for this purpose is $h_{\text{mirror}} = \frac{H_{\text{wall}}}{3}$.

$$h_{\text{mirror}} = \frac{6\,\text{m}}{3} = 2\,\text{m}$$

18.

Step 1: Determine the Image Distance

A **plane mirror** forms a virtual image such that the distance from the mirror to the image (d_i) is equal to the distance from the mirror to the object (d_o).

The object distance is given as $d_o = 10$ cm.

Therefore, the image distance is $d_i = 10$ cm.

Step 2: Calculate the Total Distance

The object is 10 cm in front of the mirror, and the image is 10 cm behind the mirror. The total distance between the object and the image (D_{total}) is the sum of these two distances.

$$D_{\text{total}} = d_o + d_i$$

Substituting the values:

$$D_{\text{total}} = 10\text{ cm} + 10\text{ cm} = 20\text{ cm}$$

19.

Direct Images (4): Each of the four mirrors reflects the object, creating one image each, totaling 4 virtual images located behind each mirror.

2. **Corner/Central Image (1):** The images formed by adjacent mirrors reflect each other, and crucially, the images from opposite mirrors appear to form a central

image, effectively creating one additional, combined image in the center of the square, as if looking into a corner.

Total = 4 (direct) + 1 (central/corner effect) = 5 images.