Light, Reflection, and Mirrors

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Rectilinear Propagation of Light

Light travels in straight lines through a uniform medium. This is called **rectilinear propagation** and is demonstrated by the fact that an opaque object placed in the path of light casts a sharp shadow.

Shadows

When an opaque object blocks a point source of light, a single dark shadow called an **umbra** forms, a region that receives no light.

When the source is extended (not a point), two shadow regions form:

- **Umbra:** region of complete shadow (no light from the source reaches it).
- **Penumbra:** region of partial shadow (some light from the source reaches it, but not all).

Diagram showing a large light source on the left and an opaque object in the centre, with the umbra (complete shadow) and penumbra (partial shadow) labelled in the cone of shadow on the right

Eclipses

The same geometry explains solar and lunar eclipses:

Solar eclipse: The Moon moves between the Sun and the Earth. In the umbra of the Moon's shadow, a total solar eclipse is observed. In the penumbra, a partial eclipse occurs.

Lunar eclipse: The Earth moves between the Sun and the Moon. The Moon enters Earth's shadow and appears dark.

The Pinhole Camera

A pinhole camera is a box with a tiny hole in one face and a translucent screen on the opposite face. Light from each point of the object passes through the hole in a straight line and forms an inverted image on the screen.

Diagram of a pinhole camera showing rays from a candle passing through a small hole and forming an inverted image on the opposite screen inside the box

Properties of the pinhole camera image:

- **Inverted** (upside down and laterally reversed).
- **Smaller than the object** if the camera is shorter than the object distance.
- **Dimmer** than a lens image (very little light passes through the pinhole).
- **Increasing the pinhole size** makes the image brighter but blurs it; decreasing it sharpens the image but dims it.

Laws of Reflection

When light reflects from any surface, two laws always hold:

- 1. The **angle of incidence** equals the **angle of reflection** (both measured from the normal to the surface at the point of incidence).
- 2. The incident ray, reflected ray, and normal all lie in the **same plane**.

<PlaneReflectionDiagram />

Images in a Plane Mirror

When an object is placed in front of a plane (flat) mirror, the image formed has the following properties:

Property	Description
Nature	Virtual (cannot be projected onto a screen)
Upright	Right-way up (erect)
Laterally inverted	Left and right appear swapped (e.g. text appears reversed)
Same size	Image size equals object size
Same distance	Image is as far behind the mirror as the object is in front of it

The image is behind the mirror because the eye traces reflected rays back as if they came from behind the mirror surface.

Plane mirror image location

An object is placed 12 cm in front of a plane mirror. The image is formed 12 cm **behind** the mirror surface. The total object-to-image distance is 24 cm.

If the object moves 3 cm closer (now 9 cm from the mirror), the image also moves 3 cm closer to the mirror's back surface, and the total separation becomes 18 cm.

The Periscope

A simple periscope uses two plane mirrors (or two right-angle prisms) set at 45° to the horizontal, one above the other. Light enters the top mirror, reflects downward, then reflects again at the bottom mirror to the observer's eye. Periscopes are used in submarines and trenches to see above obstacles.

📝 Exam Tip

Always measure angles of incidence and reflection from the **normal**, not from the mirror surface. A common error is measuring from the mirror itself, which gives the complement of the correct angle.

For plane mirror questions: the image is the same distance behind the mirror as the object is in front of it. State that the image is virtual, upright, laterally inverted, and the same size as the object.