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Light Travels Straight

Observation of Light Beams

Light beams from sources like the sun, torches, and vehicle headlights travel in narrow, concentrated streams. These beams help illuminate paths and guide vehicles safely.

Experiment with Pipes

Looking at a candle through a straight pipe allows the light rays to travel directly to the eye, making the candle visible. However, a bent pipe blocks the straight path of light, preventing the candle from being seen. This demonstrates that light travels in straight lines.

Rectilinear Propagation

The principle that light travels in straight lines is called rectilinear propagation. It explains why shadows have sharp edges and why we see objects only when light reaches our eyes

in straight paths.

Solved Examples

Practice Set

- **Level 1:** Why can't you see a candle flame through a bent pipe?
- **Level 2:** Explain how the straight pipe experiment demonstrates the rectilinear propagation of light.
- **Level 3:** A beam of light passes through a narrow slit and falls on a screen. Describe the path of light and explain why the beam remains narrow.

Answer Key

- **Level 1:** Because light travels in straight lines, the bent pipe blocks the direct path of light from the candle to the eye.
- **Level 2:** The straight pipe allows light rays to travel directly to the eye, showing that light moves in straight lines without bending.
- **Level 3:** The light travels straight through the slit, and since it cannot bend around edges significantly, the beam remains narrow on the screen.

Reflection of Light

Changing Light Direction

Light changes direction when it falls on shiny or polished surfaces like mirrors, water, or metal plates. This change in direction is called reflection.

Law of Reflection

The angle at which light hits a surface (angle of incidence) equals the angle at which it reflects off (angle of reflection). This law explains the behavior of reflected light rays.

Reflection in Water

Calm water surfaces act like mirrors, reflecting images of trees, buildings, and the sky. The reflected image appears reversed due to the law of reflection.

Solved Examples

Practice Set

- **Level 1:** What happens to light when it falls on a mirror?
- **Level 2:** Explain why the image in a calm water surface appears reversed.
- **Level 3:** A ray of light strikes a plane mirror at an angle of 30°. What is the angle of reflection?

Answer Key

- **Level 1:** It reflects off the mirror, changing direction according to the law of reflection.
- **Level 2:** The image appears reversed because the angle of incidence equals the angle of reflection, causing the image to be laterally inverted.
- **Level 3:** The angle of reflection is 30°.

Plane Mirror Images

Image Formation

A plane mirror forms a virtual image that appears behind the mirror at the same distance as the object is in front. The image is erect and of the same size as the object.

Image Characteristics

The image is laterally inverted, meaning left and right are reversed. The image cannot be projected on a screen because it is virtual.

Image Distance

The distance of the image from the mirror equals the distance of the object from the mirror, expressed as $v = -u$, where v is image distance and u is object distance.

Solved Examples

Practice Set

- **Level 1:** Describe the image formed by a plane mirror.
- **Level 2:** Why does the image in a plane mirror appear reversed left to right?
- **Level 3:** An object is placed 20 cm in front of a plane mirror. Where is the image located?

Answer Key

- **Level 1:** The image is virtual, erect, of the same size, and located behind the mirror at the same distance as the object.
- **Level 2:** Because the mirror reverses the front-back direction, the left and right sides appear swapped in the image.
- **Level 3:** The image is located 20 cm behind the mirror.

Spherical Mirrors

Concave and Convex Mirrors

Spherical mirrors are parts of a sphere. A concave mirror has a reflecting surface curved inward, while a convex mirror has a reflecting surface curved outward.

Image Formation by Concave Mirrors

Concave mirrors can form real or virtual images depending on the object's position. Real images are inverted and can be projected on a screen; virtual images are erect and magnified.

Image Formation by Convex Mirrors

Convex mirrors always form virtual, erect, and diminished images. They provide a wider field of view and are used as rear-view mirrors in vehicles.

Mirror Formula

The mirror formula relates focal length (f), object distance (u), and image distance (v):

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

Solved Examples

Practice Set

- **Level 1:** What type of image does a convex mirror form?
- **Level 2:** Explain why concave mirrors are used in headlights of vehicles.

- **Level 3:** An object is placed 30 cm from a concave mirror with focal length 15 cm. Calculate the image distance.

Answer Key

- **Level 1:** A convex mirror forms a virtual, erect, and smaller image.
- **Level 2:** Concave mirrors focus light into a beam, making headlights brighter and more directed.
- **Level 3:** Using mirror formula: $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$, $\frac{1}{15} = \frac{1}{v} + \frac{1}{-30}$, so $\frac{1}{v} = \frac{1}{15} + \frac{1}{30} = \frac{3}{30}$, thus $v = 10$ cm (real image in front of mirror).

Lens Images

Convex and Concave Lenses

Convex lenses are thicker in the middle and converge light rays, forming real or virtual images depending on object distance. Concave lenses are thinner in the middle and diverge light rays, forming virtual, erect, and diminished images.

Image Formation by Convex Lenses

When the object is beyond the focal length, convex lenses form real, inverted images. When the object is within the focal length, the image is virtual, erect, and magnified.

Image Formation by Concave Lenses

Concave lenses always form virtual, erect, and smaller images regardless of object position.

Lens Formula

The lens formula relates focal length (f), object distance (u), and image distance (v):

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Solved Examples

Practice Set

- **Level 1:** Describe the image formed by a concave lens.
- **Level 2:** What type of image does a convex lens form when the object is placed between the lens and its focal point?
- **Level 3:** An object is placed 30 cm from a convex lens with focal length 20 cm. Calculate the image distance.

Answer Key

- **Level 1:** A concave lens forms a virtual, erect, and smaller image.
- **Level 2:** The image is virtual, erect, and magnified.
- **Level 3:** Using lens formula: $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$, $\frac{1}{20} = \frac{1}{v} - \frac{1}{-30}$, so $\frac{1}{v} = \frac{1}{20} - \frac{1}{30} = \frac{1}{60}$, thus $v = 60$ cm (real image on opposite side).

Sunlight Colours

Rainbow Formation

Rainbows form when sunlight passes through water droplets, undergoing refraction, reflection, and dispersion, splitting white light into seven colors: red, orange, yellow, green, blue, indigo, and violet.

White Light Composition

White sunlight is a mixture of these seven colors. This is demonstrated by splitting light with a prism and recombining colors using Newton's disc.

Dispersion and Refraction

Different colors bend by different amounts when passing through mediums like glass, causing the separation of colors in rainbows and prisms.

Solved Examples

Practice Set

- **Level 1:** How many colors are there in a rainbow?
- **Level 2:** Explain why a rainbow appears as an arc in the sky.
- **Level 3:** Describe how a prism splits white light into different colors.

Answer Key

- **Level 1:** Seven colors: red, orange, yellow, green, blue, indigo, violet.
- **Level 2:** The rainbow is a circular arc because light is refracted and reflected inside water droplets at specific angles, forming a circle centered opposite the sun.
- **Level 3:** A prism refracts light; different colors bend by different amounts due to varying wavelengths, separating white light into its component colors.

Quick Reference Table

Common Mistakes and Misconceptions

Glossary