Comprehensive Study Notes

Class 10 Physics Chapter 1: Light - Reflection and Refraction

Based on the Latest Syllabus and Exam Pattern

1. Introduction to Light

Light is a form of electromagnetic radiation that causes the sensation of sight. It travels in straight lines (rectilinear propagation) and does not require a material medium to propagate.

- **Speed of light in vacuum:** $c = 3 \times 10^8$ m/s
- **Ray of light:** The straight-line path along which light travels.
- **Beam of light:** A bundle of light rays.

2. Reflection of Light

The phenomenon of bouncing back of light rays in the same medium upon striking a polished surface (like a mirror) is called reflection.

Laws of Reflection

1. The angle of incidence ($\angle i$) is always equal to the angle of reflection ($\angle r$). i.e., $\angle i = \angle r$.
2. The incident ray, the reflected ray, and the normal at the point of incidence, all lie in the same plane.

Spherical Mirrors

Mirrors whose reflecting surfaces are spherical are called spherical mirrors.

- **Concave Mirror:** The reflecting surface is curved inwards (faces the center of the sphere). It is a converging mirror.
- **Convex Mirror:** The reflecting surface is curved outwards. It is a diverging mirror.

Important Terms Related to Spherical Mirrors

- **Pole (P):** The center of the reflecting surface of a spherical mirror.
- **Center of Curvature (C):** The center of the hollow glass sphere of which the mirror is a part.

- **Radius of Curvature (R):** The radius of the hollow glass sphere.
- **Principal Axis:** The straight line passing through the pole and the center of curvature.
- **Principal Focus (F):** The point on the principal axis where light rays parallel to the principal axis converge (concave) or appear to diverge from (convex) after reflection.
- **Focal Length (f):** The distance between the pole and the principal focus. **Relation:** $R = 2f$

3. Image Formation by Spherical Mirrors

Image Formation by a Concave Mirror

Position of Object	Position of Image	Size of Image	Nature of Image
At infinity	At the focus F	Highly diminished, point-sized	Real and inverted
Beyond C	Between F and C	Diminished	Real and inverted
At C	At C	Same size	Real and inverted
Between C and F	Beyond C	Enlarged	Real and inverted
At F	At infinity	Highly enlarged	Real and inverted
Between P and F	Behind the mirror	Enlarged	Virtual and erect

Image Formation by a Convex Mirror

Position of Object	Position of Image	Size of Image	Nature
At infinity	At the focus F, behind mirror	Highly diminished, point-sized	Virtual
Between infinity and P	Between P and F, behind mirror	Diminished	Virtual

Uses of Spherical Mirrors

- **Concave Mirrors:** Used in torches, searchlights, vehicle headlights, shaving mirrors, and by dentists to see large images of teeth.
- **Convex Mirrors:** Used as rear-view (wing) mirrors in vehicles because they always give an erect image and have a wider field of view.

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4. Sign Convention for Reflection by Spherical Mirrors

The **New Cartesian Sign Convention** is used:

1. The object is always placed to the left of the mirror.
2. All distances parallel to the principal axis are measured from the pole (P) of the mirror.
3. Distances measured in the direction of incident light (right) are taken as positive (+), and those in the opposite direction (left) are taken as negative (-).
4. Heights measured upwards and perpendicular to the principal axis are taken as positive (+).
5. Heights measured downwards and perpendicular to the principal axis are taken as negative (-).

5. Mirror Formula and Magnification

Mirror Formula: The relationship between object distance (u), image distance (v), and focal length (f).

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

Linear Magnification (m): The ratio of the height of the image (h') to the height of the object (h).

$$m = \frac{h'}{h} = -\frac{v}{u}$$

Note: A negative sign in the value of magnification indicates that the image is real. A positive sign indicates that the image is virtual.

6. Refraction of Light

The bending of light when it passes obliquely from one transparent medium to another is called refraction.

- **Cause of Refraction:** The speed of light changes as it enters from one medium to another.
- **Optically Rarer Medium:** A medium in which the speed of light is more.
- **Optically Denser Medium:** A medium in which the speed of light is less.
- *Rule:* When light travels from a rarer to a denser medium, it bends **towards** the normal. When it travels from a denser to a rarer medium, it bends **away** from the normal.

Laws of Refraction

1. The incident ray, the refracted ray, and the normal to the interface of two transparent media at the point of incidence, all lie in the same plane.
2. **Snell's Law:** The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant, for the light of a given color and for the given pair of media.

$$\frac{\sin i}{\sin r} = \text{constant} = n_{21}$$

Refractive Index

- **Relative Refractive Index (n_{21}):** Refractive index of medium 2 with respect to medium 1.

$$n_{21} = \frac{\text{Speed of light in medium 1}(v_1)}{\text{Speed of light in medium 2}(v_2)}$$

- **Absolute Refractive Index (n_m):** Refractive index of a medium with respect to vacuum (or air).

$$n_m = \frac{\text{Speed of light in vacuum}(c)}{\text{Speed of light in the medium}(v)}$$

7. Spherical Lenses

A transparent material bound by two surfaces, of which one or both surfaces are spherical, forms a lens.

- **Convex Lens:** Thicker at the middle as compared to the edges. It is a converging lens.
- **Concave Lens:** Thicker at the edges as compared to the middle. It is a diverging lens.

Image Formation by a Convex Lens

Position of Object	Position of Image	Size of Image	Nature of Image
At infinity	At focus F_2	Highly diminished	Real and inverted
Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted
At $2F_1$	At $2F_2$	Same size	Real and inverted
Between F_1 and $2F_1$	Beyond $2F_2$	Enlarged	Real and inverted
At focus F_1	At infinity	Highly enlarged	Real and inverted
Between F_1 and Optical Center O	On the same side	Enlarged	Virtual and erect

Position of Object	Position of Image	Size of Image	Nature of Image
At infinity	At focus F_1	Highly diminished	Virtual and erect
Between infinity and O	Between F_1 and O	Diminished	Virtual and erect

Image Formation by a Concave Lens

8. Lens Formula and Magnification

Lens Formula:

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

Magnification (m):

$$m = \frac{h'}{h} = \frac{v}{u}$$

Note: For lenses, m is positive for virtual images and negative for real images.

9. Power of a Lens

The degree of convergence or divergence of light rays achieved by a lens is expressed in terms of its power. Power is the reciprocal of focal length (in meters).

$$P = \frac{1}{f \text{ (in meters)}}$$

- **SI Unit:** Diopter (D). 1 D = 1 m^{-1}.
- Power of a convex lens is positive (+), and power of a concave lens is negative (−).
- **Power of a combination of lenses:** If several lenses of powers $P_1, P_2, P_3 \ldots$ are placed in contact, the total power P is given by:

$$P = P_1 + P_2 + P_3 + \ldots$$

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