

PHYSICS • CLASS 12

CHAPTER 9

Ray Optics and Optical Instruments

CHAPTER NOTES



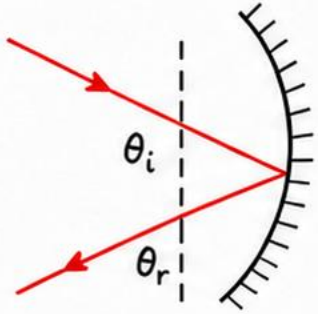
RAY OPTICS & OPTICAL INSTRUMENTS

Geometrical optics models light by directed rays when the relevant dimensions are much larger than the wavelength.

$$c = 299,792,458 \text{ m s}^{-1}$$

$$\text{visible light: } \lambda \approx 400\text{--}700 \text{ nm}$$

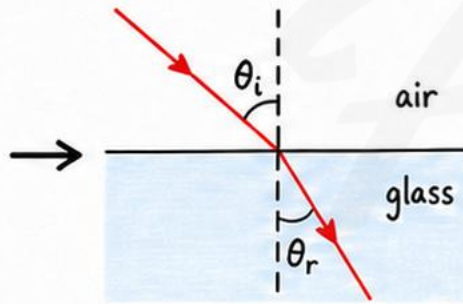
① REFLECTION



At a surface, the angle of reflection equals the angle of incidence.

$$\theta_r = \theta_i$$

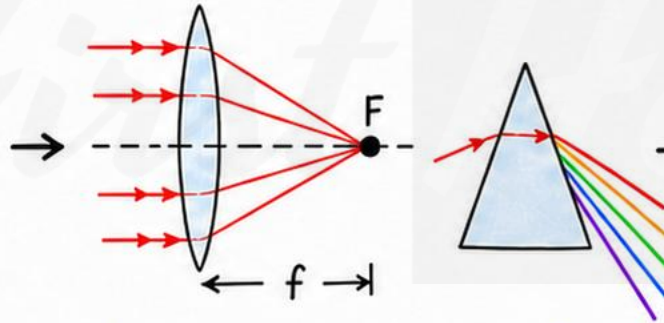
② REFRACTION



When light enters a denser medium, it bends toward the normal.

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

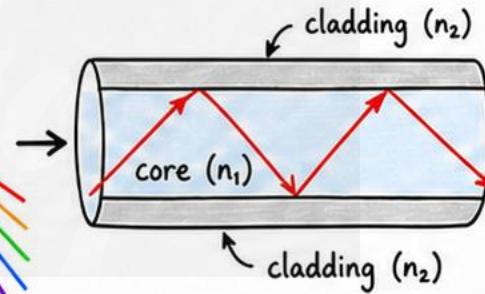
③ LENSES & PRISMS



Lenses can converge rays to a focus. Prisms disperse white light into its spectrum.

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

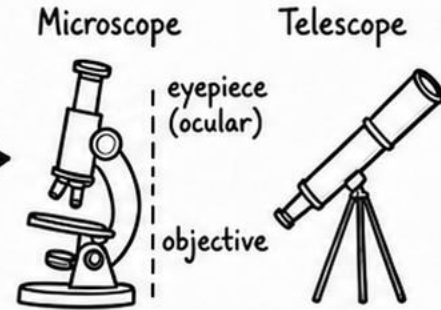
④ TOTAL INTERNAL REFLECTION



If light in a denser medium hits the boundary above the critical angle, it is totally reflected and stays guided.

$$\sin \theta_c = \frac{n_2}{n_1}, \quad n_1 > n_2$$

⑤ OPTICAL INSTRUMENTS



Instruments use lenses and mirrors to form magnified or distant images for the eye.

Rays track the direction of energy propagation. Wave effects become important near wavelength-scale features.

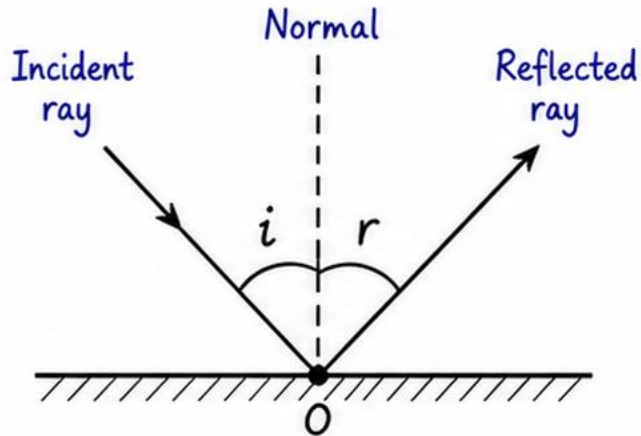
LAWS OF REFLECTION & SPHERICAL MIRROR GEOMETRY

LAWS OF REFLECTION

- ① The angle of incidence is equal to the angle of reflection.

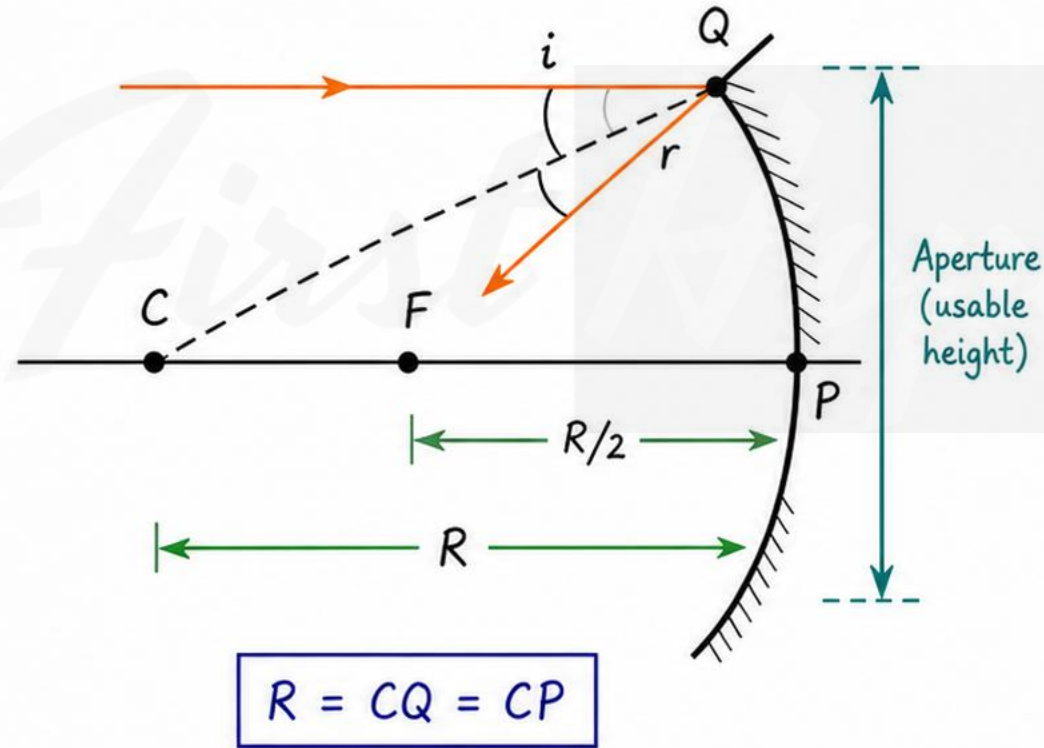
$$i = r$$

- ② The incident ray, reflected ray and the normal at the point of incidence lie in one plane.



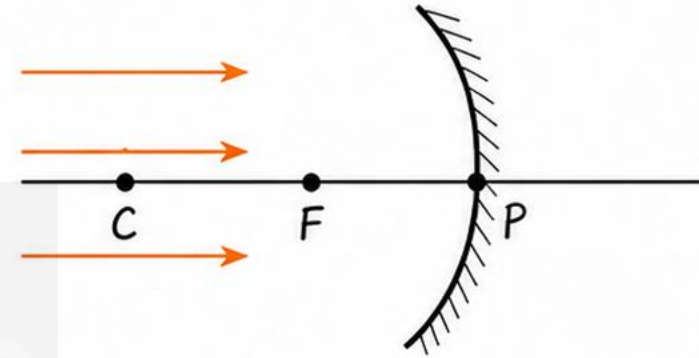
CONCAVE SPHERICAL MIRROR GEOMETRY

At every point of a spherical mirror, the local normal passes through C.

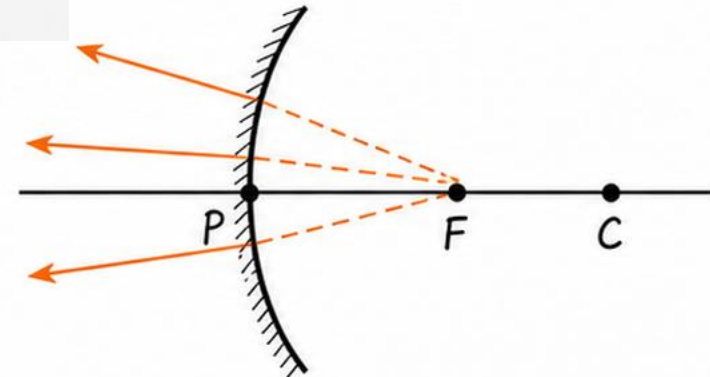


TYPES OF SPHERICAL MIRRORS

(a) CONCAVE (reflecting inner surface)

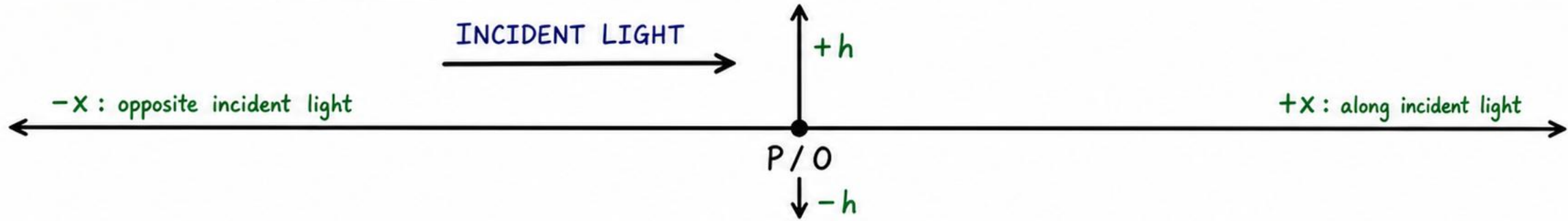


(b) CONVEX (reflecting outer surface)



Spherical-mirror formulae are paraxial: small aperture and rays close to the principal axis.

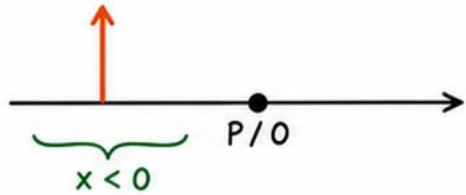
CARTESIAN SIGN CONVENTION



All longitudinal distances are measured from P or O. Heights above the principal axis are positive; below are negative.

1. REAL OBJECT

A real object is in front of the optical system (on the side from which light comes).

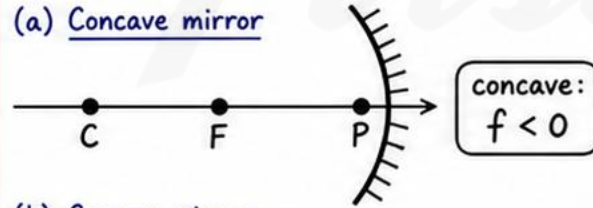


$$u < 0$$

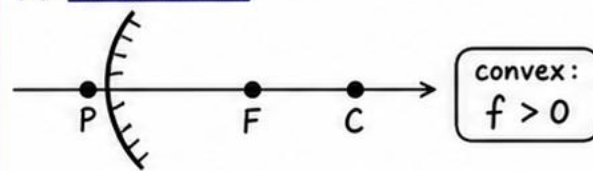
2. SPHERICAL MIRRORS

Incident light is left $\rightarrow$ right.

(a) Concave mirror



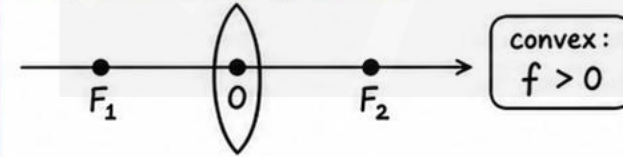
(b) Convex mirror



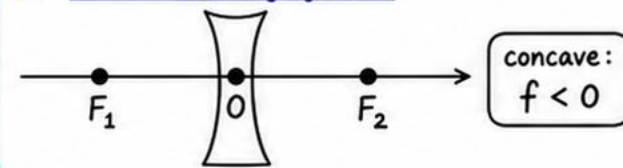
3. THIN LENSES

Incident light is left $\rightarrow$ right.

(a) Convex (converging) lens



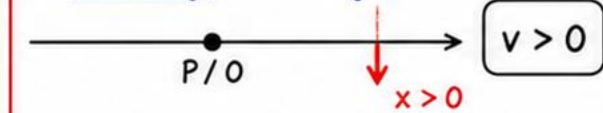
(b) Concave (diverging) lens



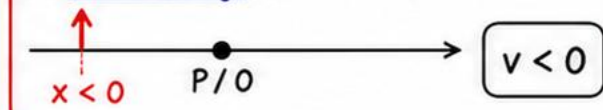
4. IMAGE COORDINATE

The sign of image distance (v) follows the coordinate (x) of the image, not the word real/virtual by itself.

(a) Real image (on the right)



(b) Virtual image (on the left)

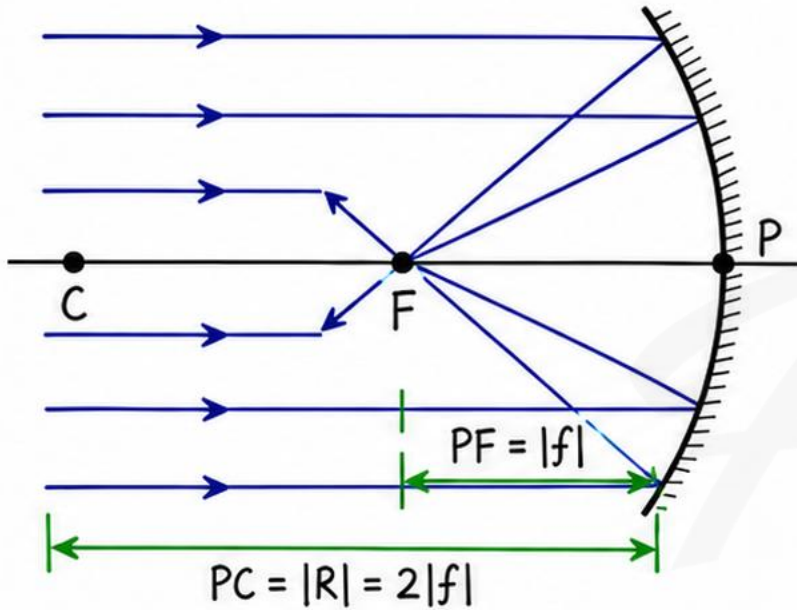


FORMULA REMINDER

For SPHERICAL MIRRORS: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$, $m = -\frac{v}{u}$ | For THIN LENSES: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, $m = \frac{v}{u}$

SPHERICAL MIRROR FOCUS & FOCAL PLANE

1) CONCAVE MIRROR (converging)

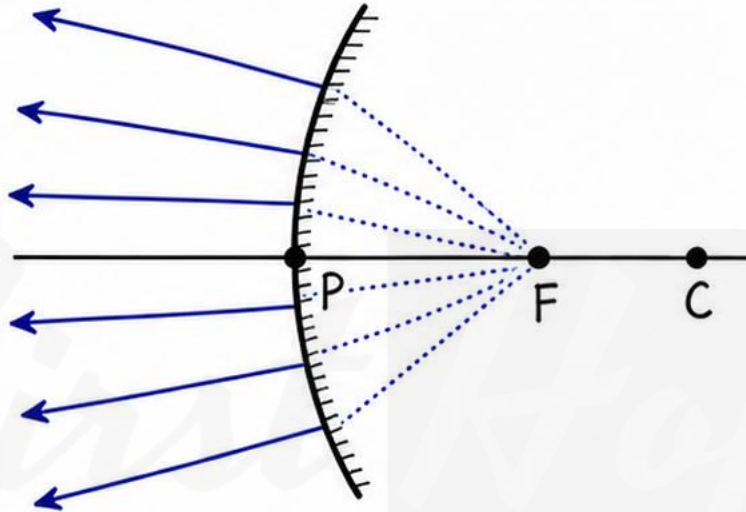


REAL PRINCIPAL FOCUS

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

signed; for this concave mirror $f < 0$, $R < 0$

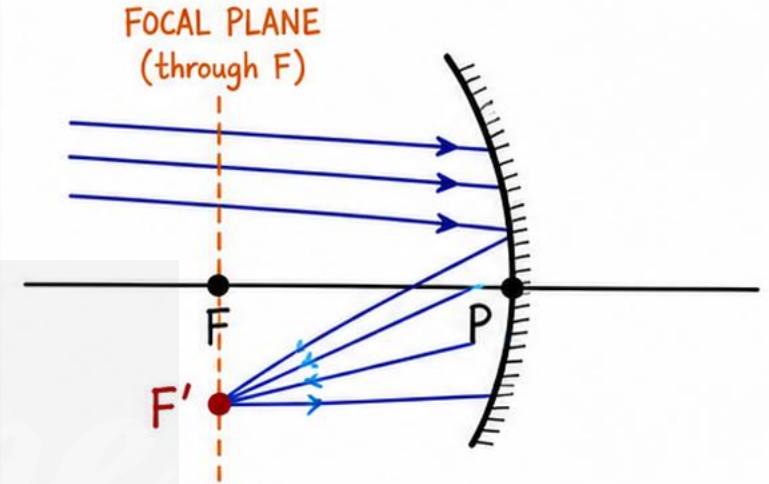
2) CONVEX MIRROR (diverging)



VIRTUAL PRINCIPAL FOCUS

$$f > 0, R > 0$$

3) FOCAL PLANE (off-axis rays)



- Parallel rays along the principal axis focus at F.
- Parallel rays at a small angle focus at a point on the focal plane.

Real focus: rays actually meet.

Virtual focus: only dotted backward extensions meet.

Paraxial result: $f = \frac{R}{2}$.

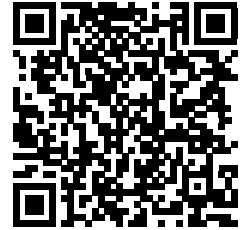


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