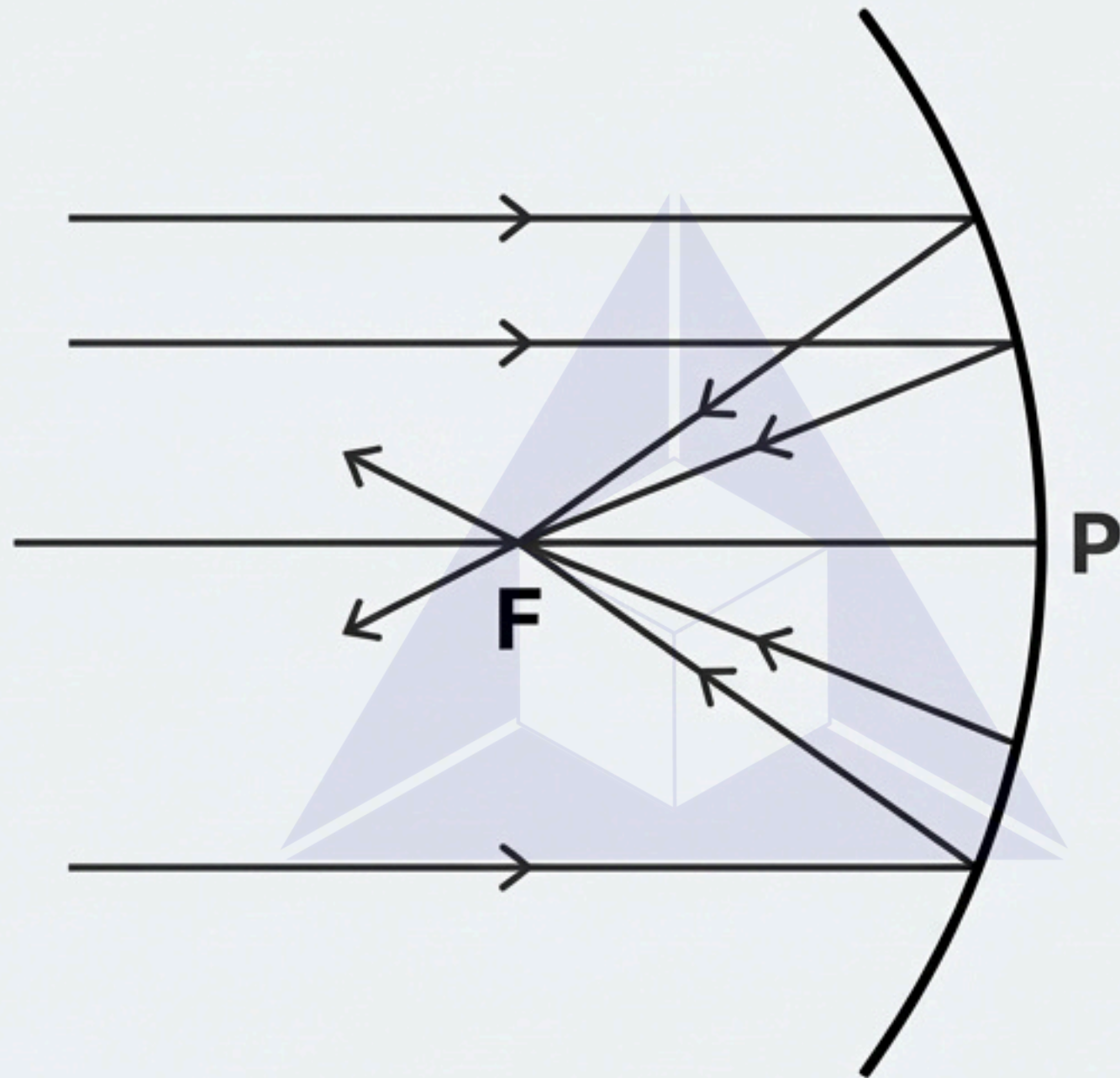




Focal Length of Spherical Mirrors

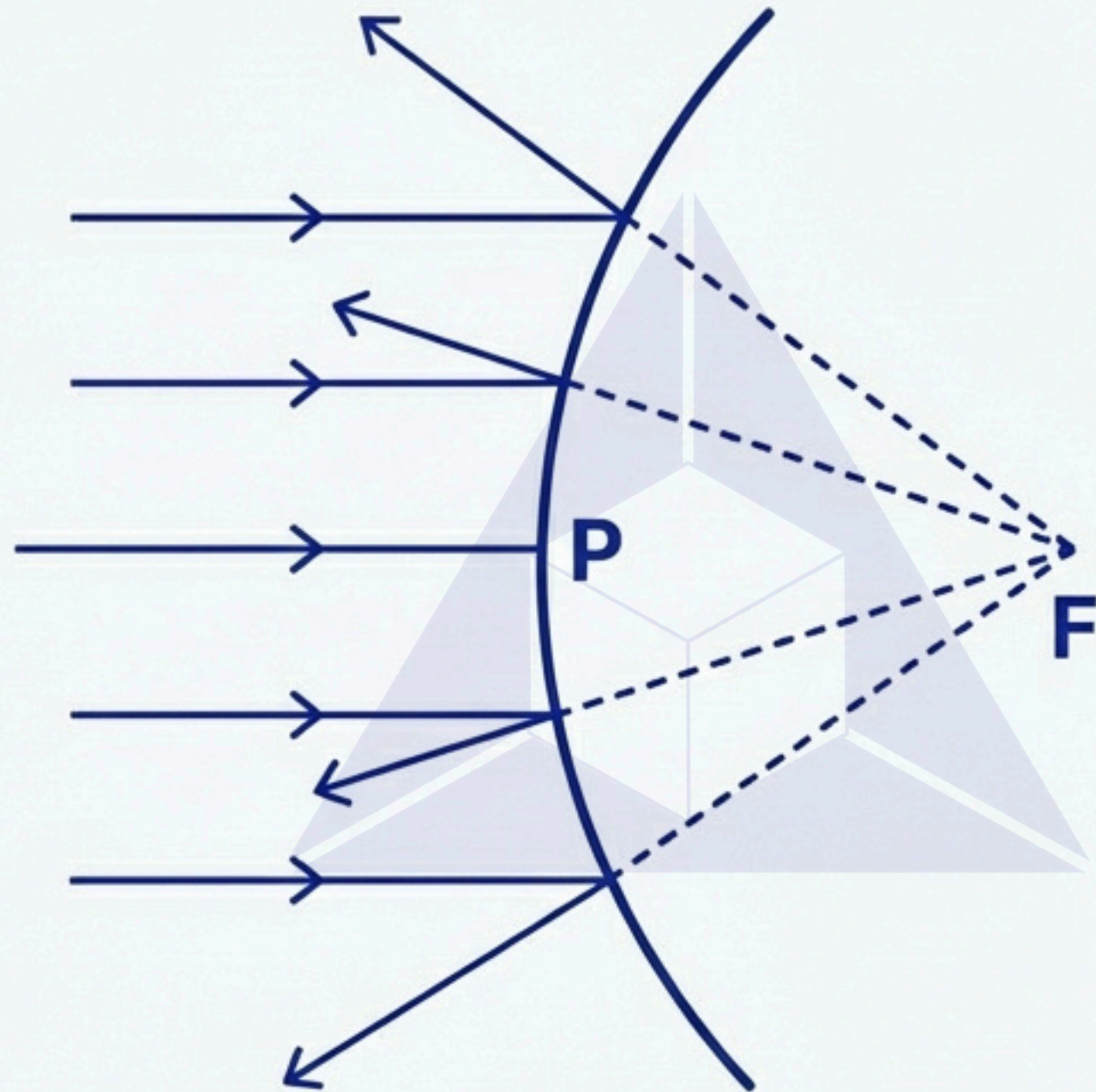
Understanding paraxial rays, the focal plane, and the geometry of $f = R/2$.



The Real Focus (Concave Mirrors)

When a parallel beam of light is incident on a concave mirror, the reflected rays physically converge at a specific point on the **principal axis**. This point **F** is the principal focus.

PARAXIAL ASSUMPTION We assume all incident rays are paraxial—they strike close to the pole P and make small angles with the principal axis.



The Virtual Focus (Convex Mirrors)

For a convex mirror, the reflected rays do not physically meet. Instead, they appear to diverge from a specific point F behind the mirror.

APPARENT DIVERGENCE

Because the light rays only appear to originate from F when traced backward, the principal focus of a convex mirror is virtual.



**You've Learned the Theory.
Let's Test Them Now.**

$$E=mc^2$$



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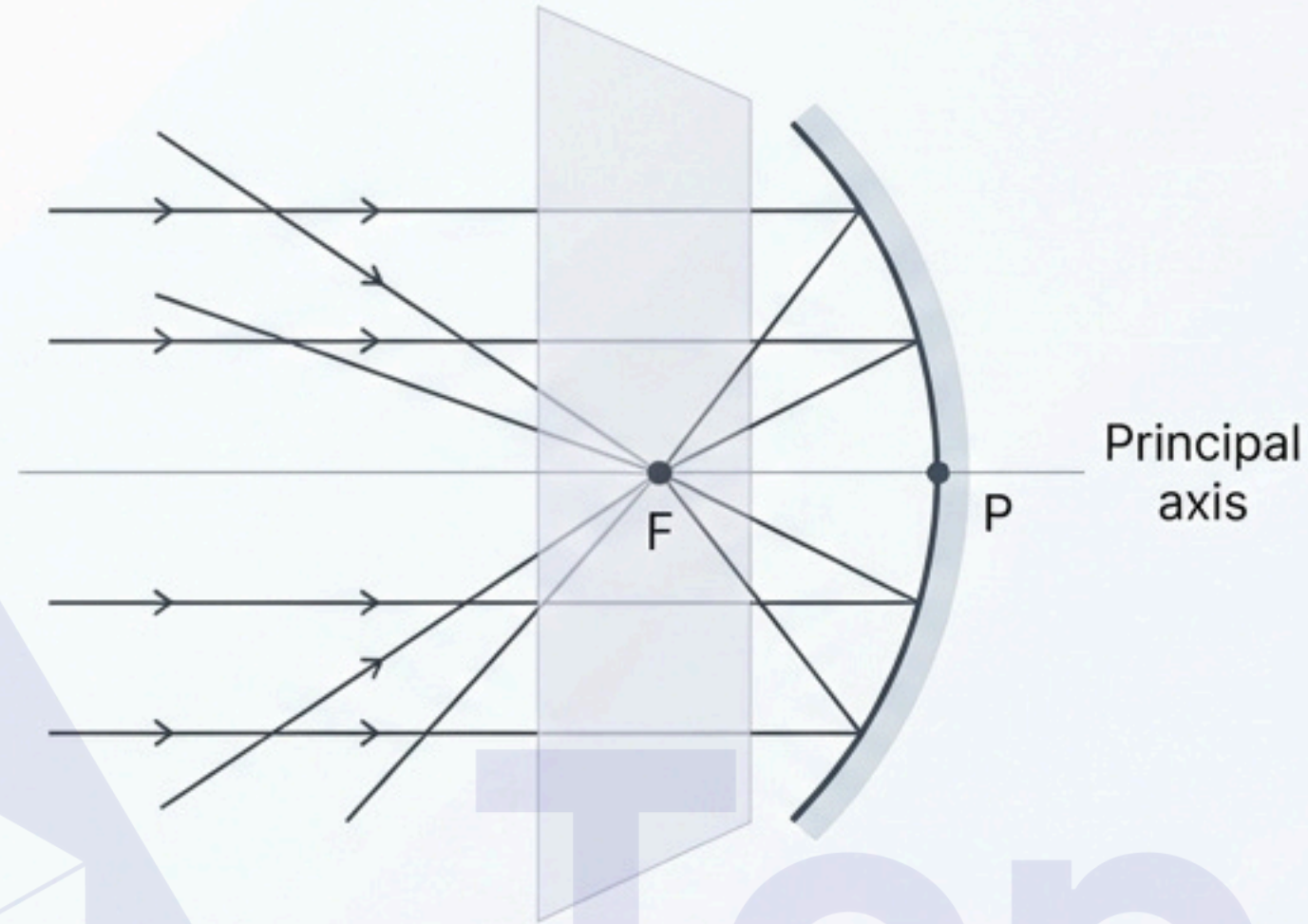


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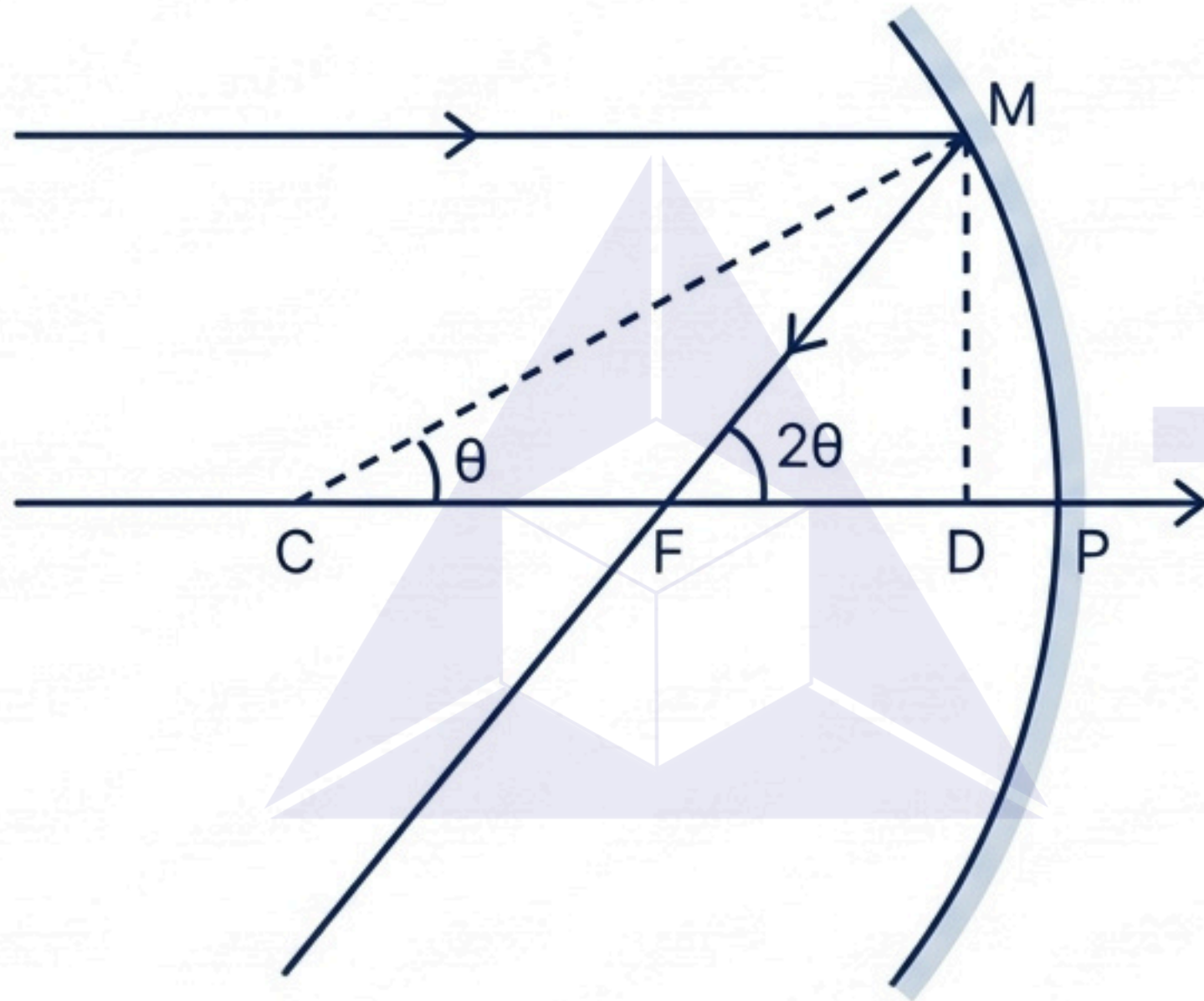




The Focal Plane Concept

If a parallel paraxial beam strikes the mirror at an angle to the principal axis, the rays will not converge exactly on the axis.

They converge at a point on a plane that passes through the principal focus F and is normal (perpendicular) to the principal axis. This 2D surface is the focal plane.



Step 1: Trigonometric Setup

$$\tan \theta = \frac{MD}{CD}$$

$$\tan 2\theta = \frac{MD}{FD}$$

Step 2: Small-Angle Approximation CRITICAL ASSUMPTION

For paraxial rays, θ is small. Therefore, $\tan \theta \approx \theta$ and $\tan 2\theta \approx 2\theta$.

Step 3: Substitution

$$\frac{MD}{FD} = 2 \times \frac{MD}{CD} \Rightarrow FD = \frac{CD}{2}$$

Step 4: The Limit

As $\theta \rightarrow 0$, point D approaches pole P.
Therefore, $FD \approx f$ and $CD \approx R$.

FOCAL LENGTH OF A SPHERICAL MIRROR



$$f = R / 2$$

f = focal length, R = radius of curvature.

Paraxial Assumption

The $f = R/2$ rule is only valid for paraxial rays (rays close to the pole making small angles).

Nature of Focus

Concave mirrors possess a real focus (convergence); convex mirrors possess a virtual focus (divergence).

Focal Plane

Off-axis parallel rays converge on a plane perpendicular to the principal axis passing through F .



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