

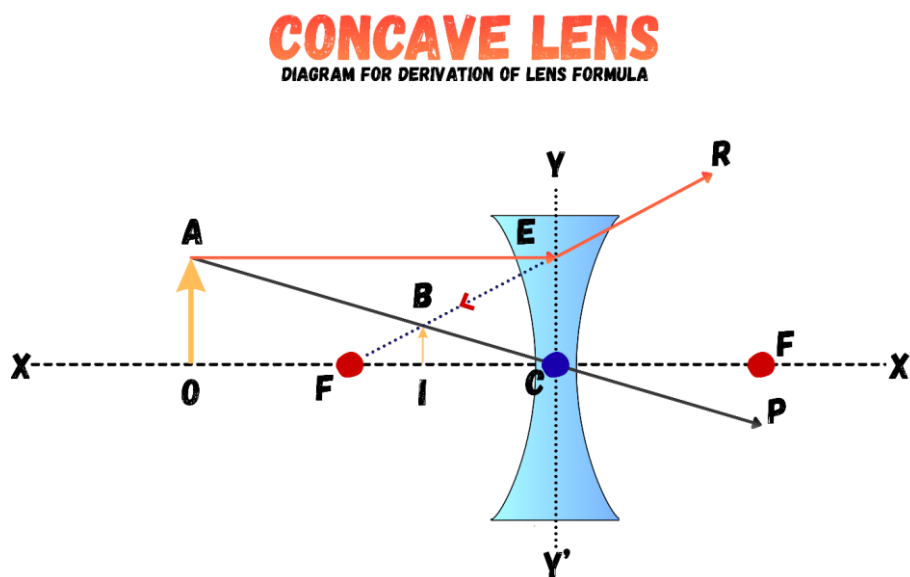
Derivation of Lens Formula

Concave Lens

A concave lens is thinner at the centre and thicker at the edges. It diverges light rays.

How is an Image Formed?

- A ray parallel to the principal axis (\overrightarrow{AE}) appears to come from the focus (\overrightarrow{FR}) after refraction.
- A ray (\overrightarrow{AP}) through the optical centre goes straight
- The rays do not actually meet, but appear to meet on the same side of the lens



Note

The image is always

- Virtual
- Upright
- Smaller (diminished)

Concave Lens Formula

A concave lens utilises the same lens formula as applied to the convex lens: Although the formula is the same, the difference comes from the sign convention:

Quantity	Convex Lens	Concave Lens
f	Positive	Negative
q	Positive (real image)	Negative (virtual image)

Derivation of Lens Formula

Derivation of Formula

Consider a concave lens as shown.

- Object \overline{OA} placed in front of the lens
- Image \overline{IB} is virtual, formed on the same side
- Rays diverge and appear to meet in front of the lens

Step 1: Similar Triangles

From the diagram:

- Triangle $\triangle OAC$ and $\triangle IBC$ are similar

So,

$$\frac{IB}{OA} = \frac{IC}{OC} \quad \dots(1)$$

Step 2: Second Pair of Triangles

Using extended rays:

- Triangle $\triangle EFC$ and $\triangle BFI$ are similar

So,

$$\frac{IB}{OA} = \frac{IF}{CF} \quad \dots(2)$$

Step 3: Equate

From (1) and (2):

$$\frac{IC}{OC} = \frac{IF}{CF} \quad \dots(3)$$

Step 4: Apply Geometry

Here:

- $OC = p$
- $IC = q$ (*virtual \rightarrow negative*)
- $CF = f$ (*negative for concave lens*)
- $IF = IC - CF = q - f$

So:

$$\frac{q}{p} = \frac{q - f}{f}$$

Step 5: Simplify

Multiply both sides by ' pf ':

$$qf = qp - pf$$

Rearrange:

Derivation of Lens Formula

$$pf + qf = pq$$

Divide by 'pqf':

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

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