Derivation of Lens Formula

Convex Lens

A convex lens is thicker at the centre and thinner at the edges. It converges parallel rays of light to a single point (focus).

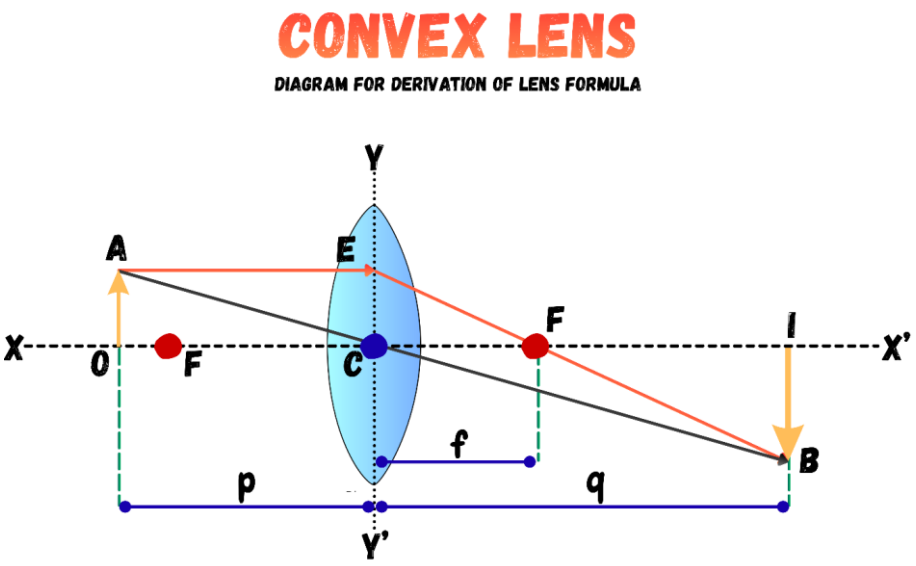
How is an Image Formed?

The location of the image can be determined following these steps:

- A ray parallel to the principal axis ($\overrightarrow{AE}$) passes through the focus after refraction
- A ray ($\overrightarrow{AB}$) passing through the optical centre (C) goes straight
- These rays meet to form a real, inverted image (in most cases)

Note

These are also the 3 core steps you need to remember for your examinations.



Convex Lens Formula

To find the image location by lens equation, consider the relationship between object distance (p), image distance (q), and focal length (f).

Note

The image in most of the cases is

- *Real*
- *Inverted*

Derivation of Lens Formula (Convex Lens)

Consider an object $\overrightarrow{OA}$ placed in front of a convex lens and the image $\overrightarrow{IB}$ formed on the other side as shown.

- Optical Centre = C

Derivation of Lens Formula

- Object Distance = p
- Image Distance = q
- Focal Length = f

Step 1: Use Similar Triangles

From the ray diagram:

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

So,

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

Step 2: Another Pair of Similar Triangles

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

So,

$$\frac{IB}{CE} = \frac{IF}{CF} \quad \text{... (2)}$$

But

$$CE = OA$$

Therefore:

$$\frac{IB}{OA} = \frac{IF}{CF} \quad \text{... (3)}$$

Step 3: Equate Equations

From (1) and (3):

$$\frac{IC}{OC} = \frac{IF}{CF} \quad \text{... (4)}$$

Step 4: Substitute Values

We know:

- $OC = p$
- $IC = q$
- $CF = f$
- $IF = IC - CF = q - f$

So:

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

Step 5: Simplify

Multiply both sides by 'pf':

$$qf = qp - pf$$

Derivation of Lens Formula

Rearrange:

$$pf + qf = pq$$

Divide by 'pqf':

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

This is the lens formula for a convex lens.