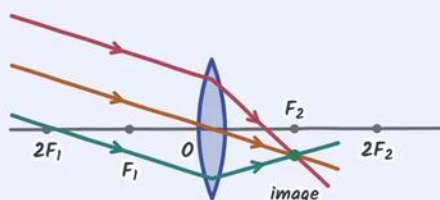




converging and diverging, one formula for both, and the sign convention that makes it work

The two kinds of lens

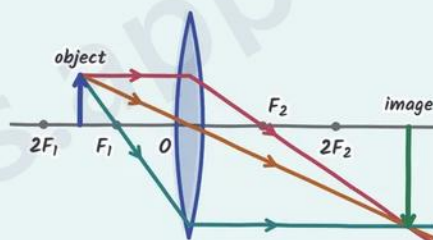
- a **convex lens** is thicker in the middle and **converges** parallel rays to a point
- a **concave lens** is thinner in the middle and **diverges** them, so they only appear to come from a point
- the **principal focus F** is where parallel rays meet, or seem to meet, after passing through
- the **focal length f** is the distance from the **optical centre** to that focus
- a lens has **two foci**, one on each side, since light may arrive from either direction
- the **centre of curvature** is at $2F$, and it is the point that fixes the special image positions



parallel rays through a convex lens really meet at one point in the focal plane through F_2 , so that image is real; a concave lens instead spreads them, and only their backward extensions meet

The three rays that locate an image

- a ray arriving **parallel to the principal axis** leaves through the focus on the far side
- a ray passing through the **optical centre** goes **straight on undeviated**, which is usually the easiest one to draw
- a ray passing through the **focus on the near side** leaves parallel to the axis
- any two of the three** are enough to fix the image, and the third is a check
- where the rays **actually meet**, the image is **real** and can be caught on a screen
- where only their **backward extensions** meet, the image is **virtual** and cannot be projected



object between F_1 and $2F_1$ (here $1.5f$): the parallel ray (pink), the ray through F_1 (teal) and the ray through O (orange) all meet beyond $2F_2$, where a screen would catch a real, inverted, larger image

The formulas, and the sign convention

the lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

magnification from distances $m = \frac{v}{u}$

magnification from sizes $m = \frac{h_i}{h_o}$

power of a lens, f in metres $P = \frac{1}{f}$

lenses in contact, powers add $P = P_1 + P_2$

distances are measured from the optical centre, with the incoming light travelling in the positive direction. The object distance u is therefore always negative, which is the detail that makes the whole formula behave

