

# Lenses

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## Refraction by lenses

A lens is a carefully ground or molded piece of transparent material that refracts light rays in such a way as to form an image. Lenses serve to refract light at each boundary.

### Refraction rules for **converging lenses**:

- Any incident ray traveling parallel to the principal axis of a converging lens will refract through the lens and travel through the focal point on the opposite side of the lens.
- Any incident ray traveling through the focal point on the way to the lens will refract through the lens and travel parallel to the principal axis.
- Any incident ray that travels straight through the optical centre of the lens will not refract and will pass straight through

### The Thin Lens approximation :

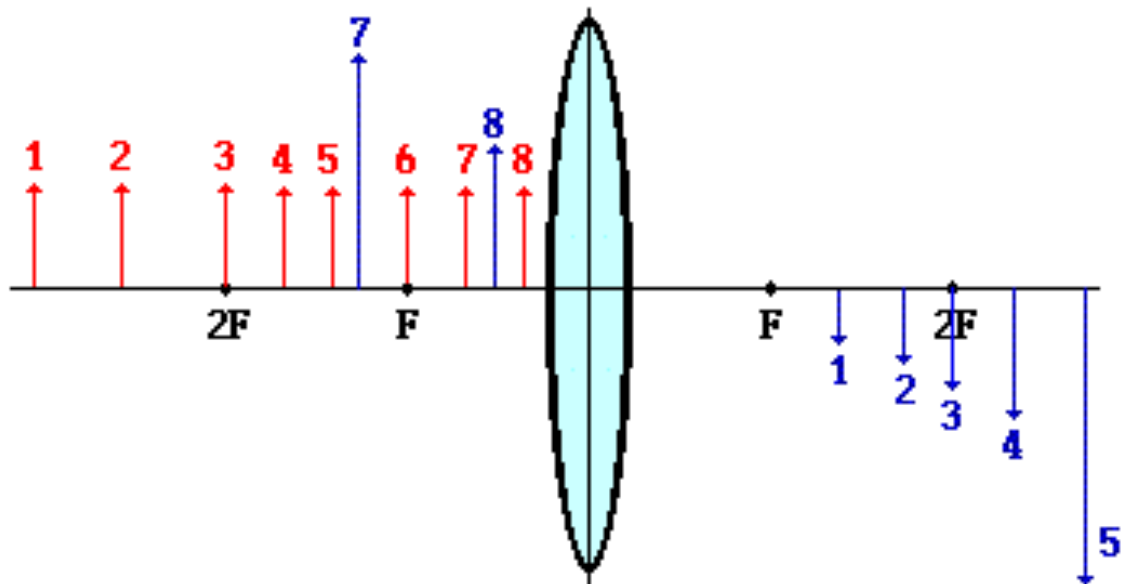
- Thickness of lens is negligible
- Refraction that occurs at the 2 surface of lenses can be added together. So the lens can be considered as a single surface along the vertical axis.
- To simplify the construction of ray diagrams, we will avoid refracting each light ray twice - upon entering and emerging from the lens.
- We will continue the incident ray to the vertical axis of the lens and refract the light at that point. For thin lenses, this simplification will produce the same result as if we were refracting the light twice.

### Refraction rules for **diverging lenses**

- Any incident ray traveling parallel to the principal axis of a diverging lens will refract through the lens and travel in line with the focal point (i.e., in a direction such that its extension will pass through the focal point).
- Any incident ray traveling towards the focal point on the way to the lens will refract through the lens and travel parallel to the principal axis.
- Any incident ray that travels straight through the optical centre of the lens will not refract and will pass straight through

## Converging lenses image cases

- 1 Object beyond  $2F$  → Image between  $2F$  and  $F$ 
  - a Real, inverted and diminished
- 2 Object at  $2F$  → Image at  $2F$ 
  - a Real, Inverted and same size
- 3 Object between  $2F$  and  $F$  → Image beyond  $2F$ 
  - a Real, inverted and magnified
- 4 Object at  $F$  → Image at infinity / image not formed
- 5 Object in front of  $F$  → Image behind object on same side
  - a Virtual, upri ght and magnified



**Each of the numbered objects (except #6) has an image with the corresponding number; its relative location, size, and orientation are shown.**