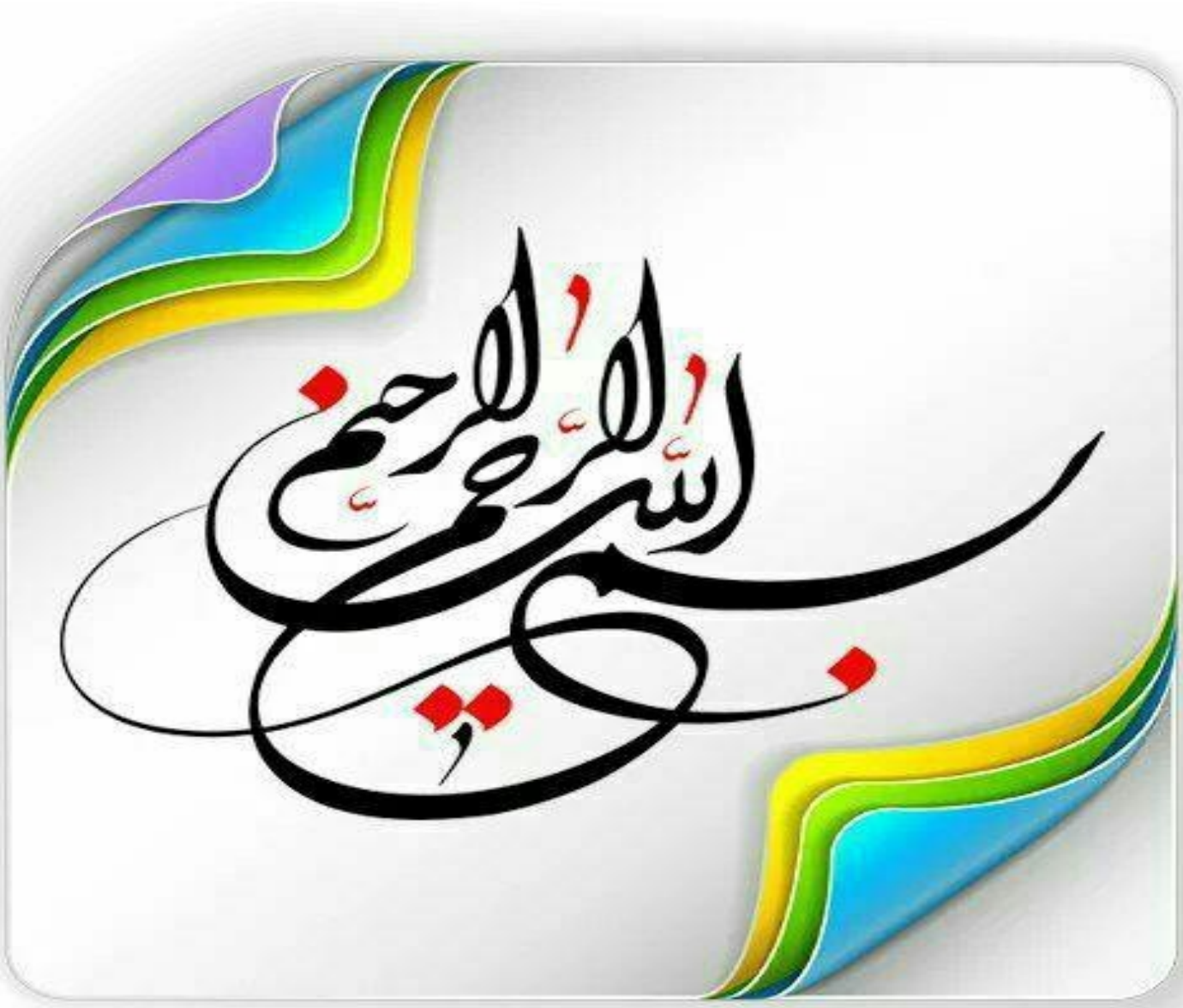

بسم الله الرحمن الرحيم

LENSES

Types of Lenses:

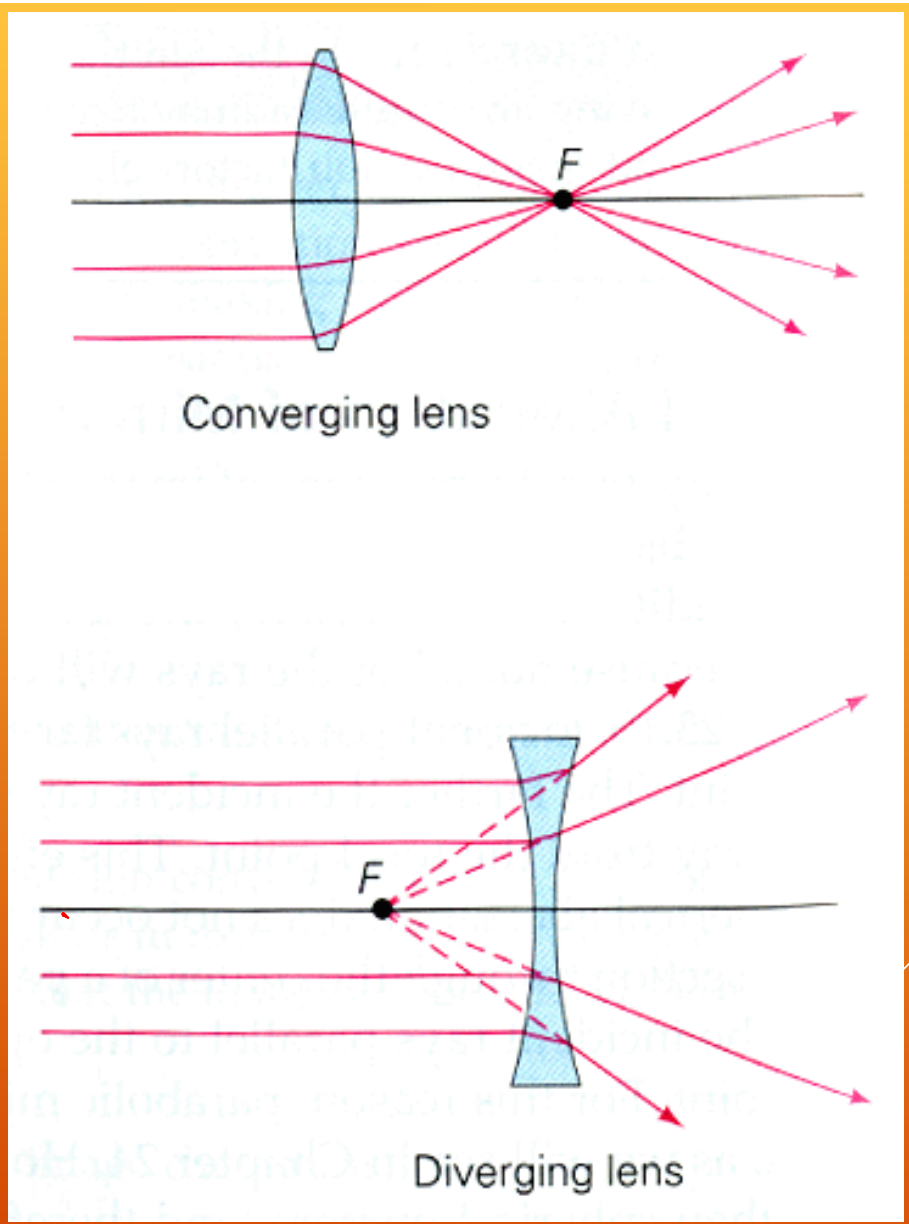
Convex and Concave Lenses

- A **lens** is a piece of transparent material, such as glass or plastic, that is used to focus light and form an image.

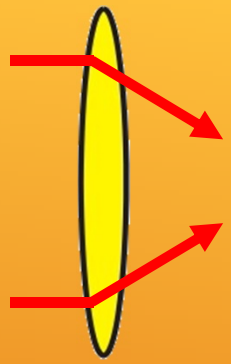
- Each of a lens's two faces might be either curved or flat.

Basic Types of Lenses

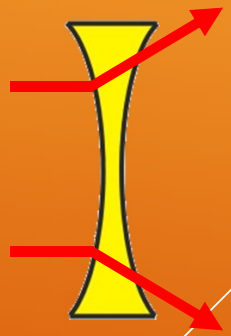
- Convex
- Concave



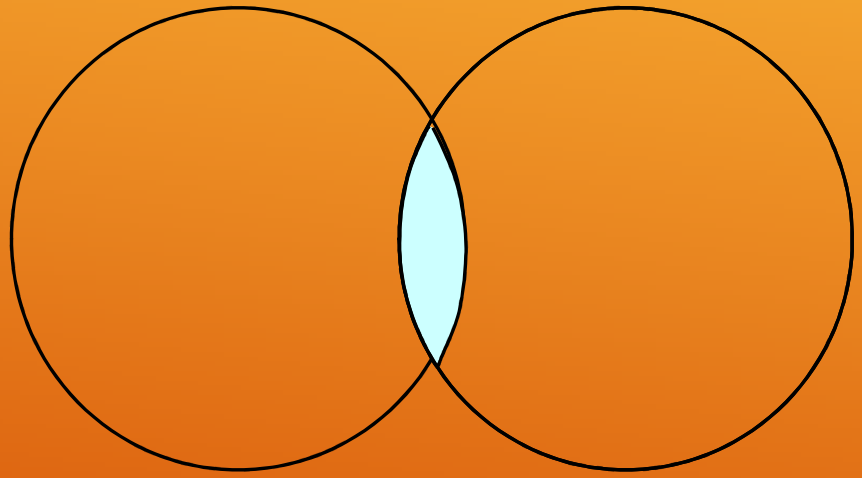
Convex lenses are thicker in the middle and thus they converge light rays.



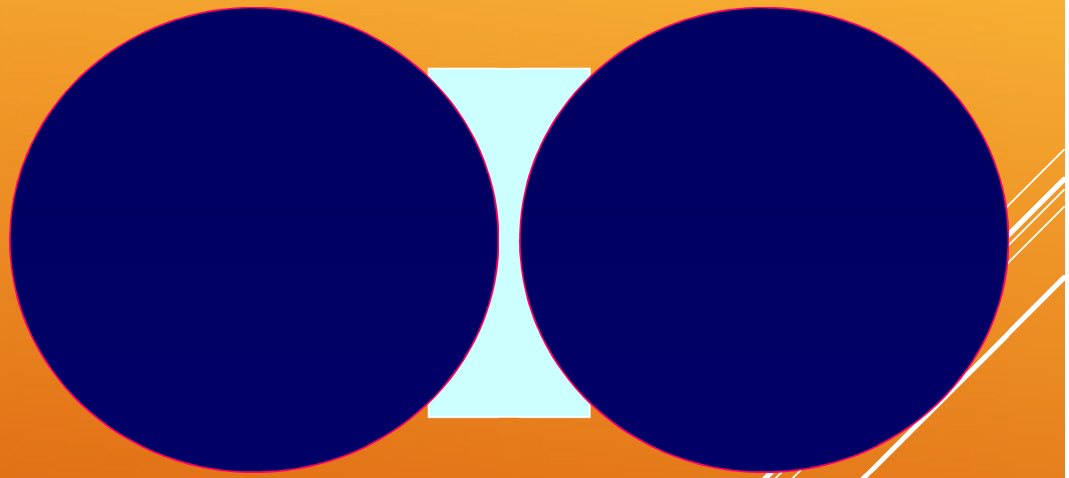
Concave lenses are thinner in the middle and thus they diverge light rays.



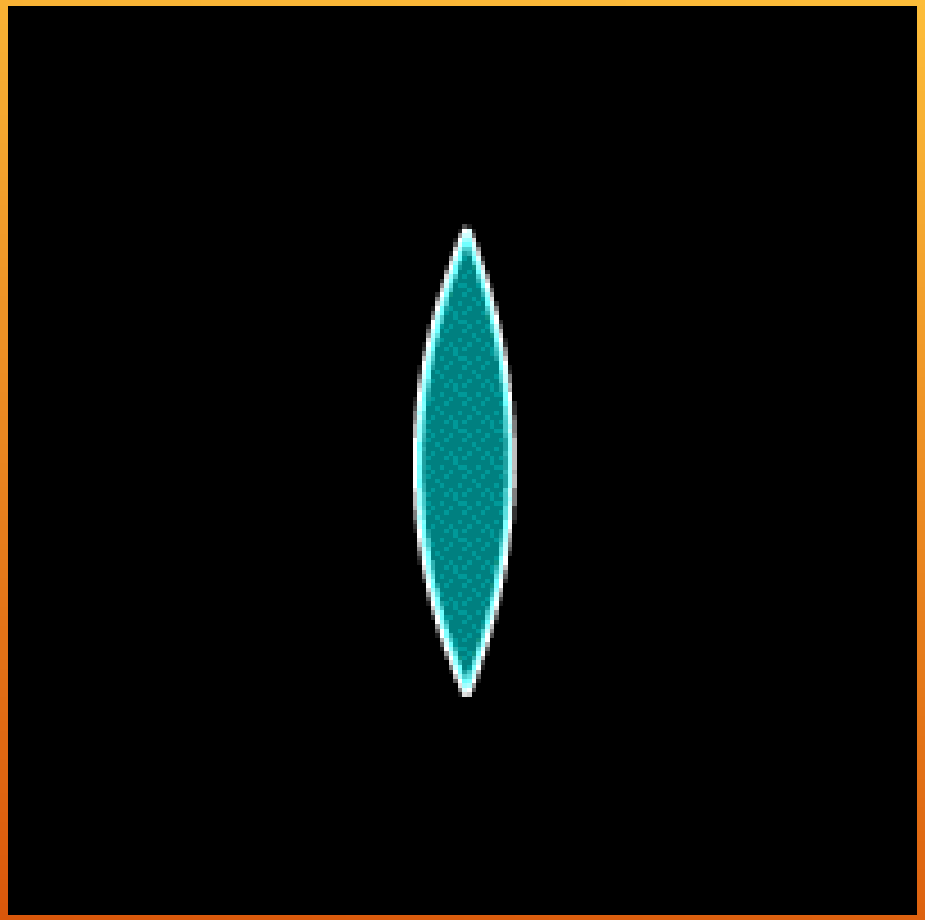
Thin spherical lenses



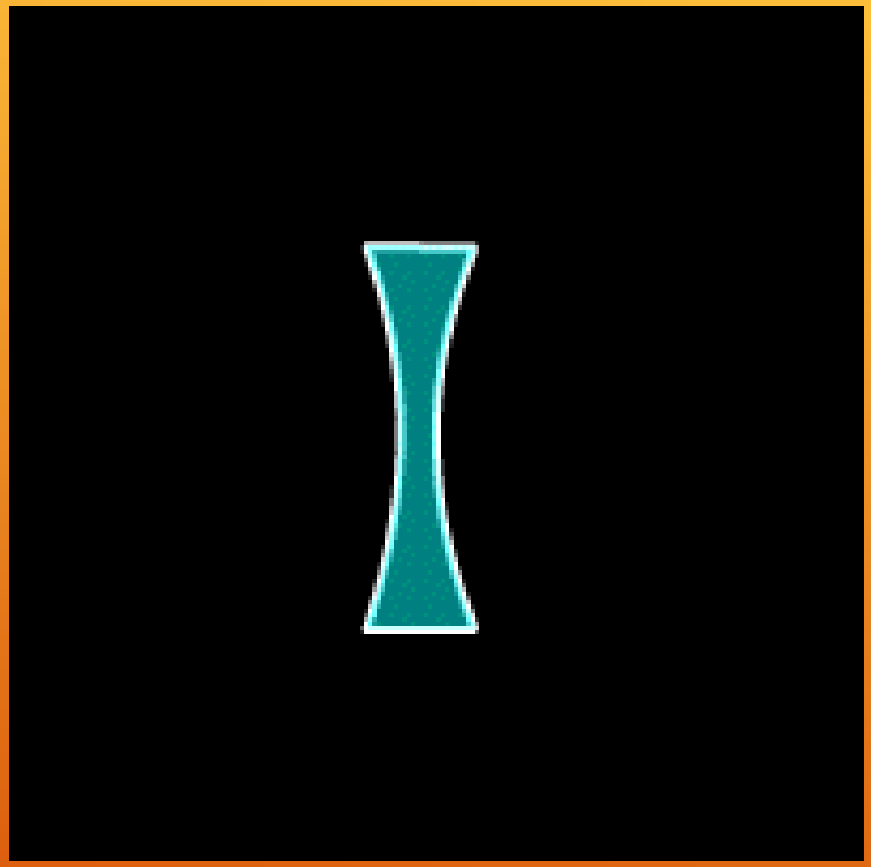
Convex Lens:
focal length (*f*) is positive



Concave Lens:
focal length (*f*) is negative

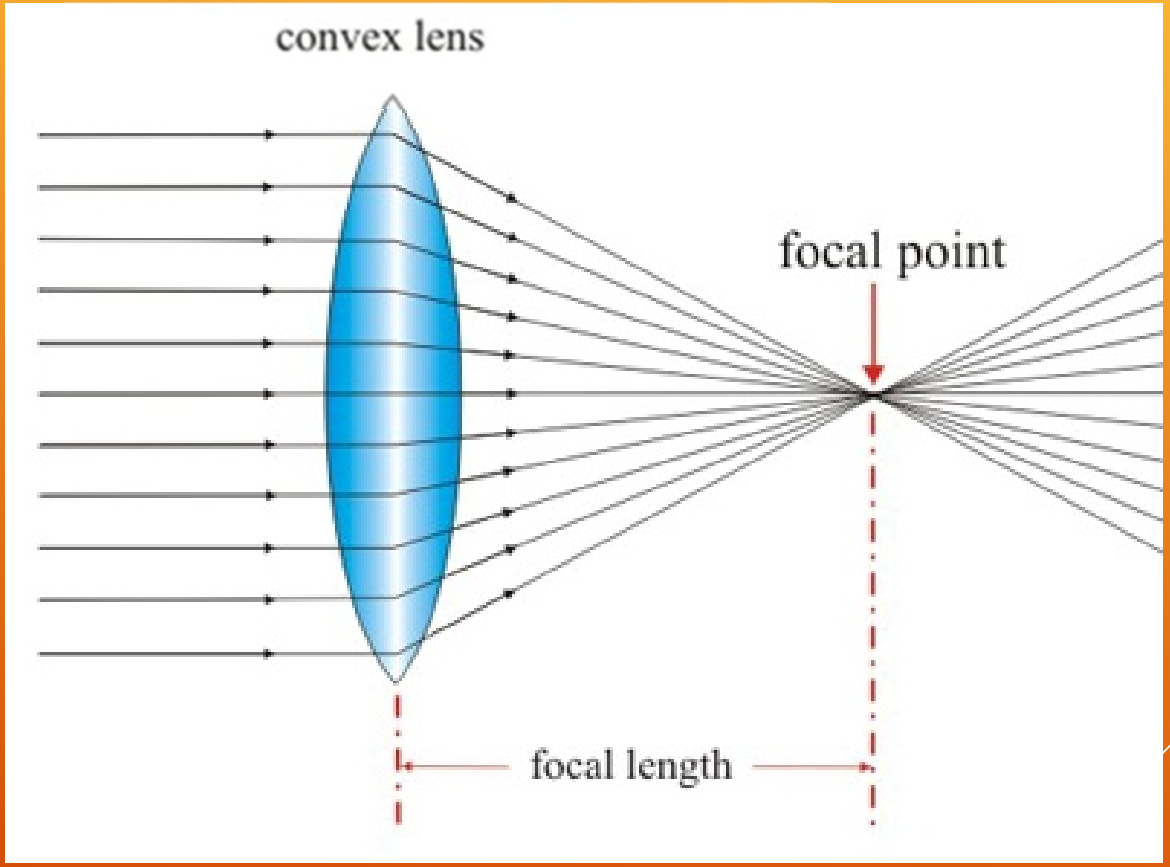


http://www.shokabo.co.jp/sp_e/optical/labo/lens/lens.htm



http://www.shokabo.co.jp/sp_e/optical/labo/lens/lens.htm

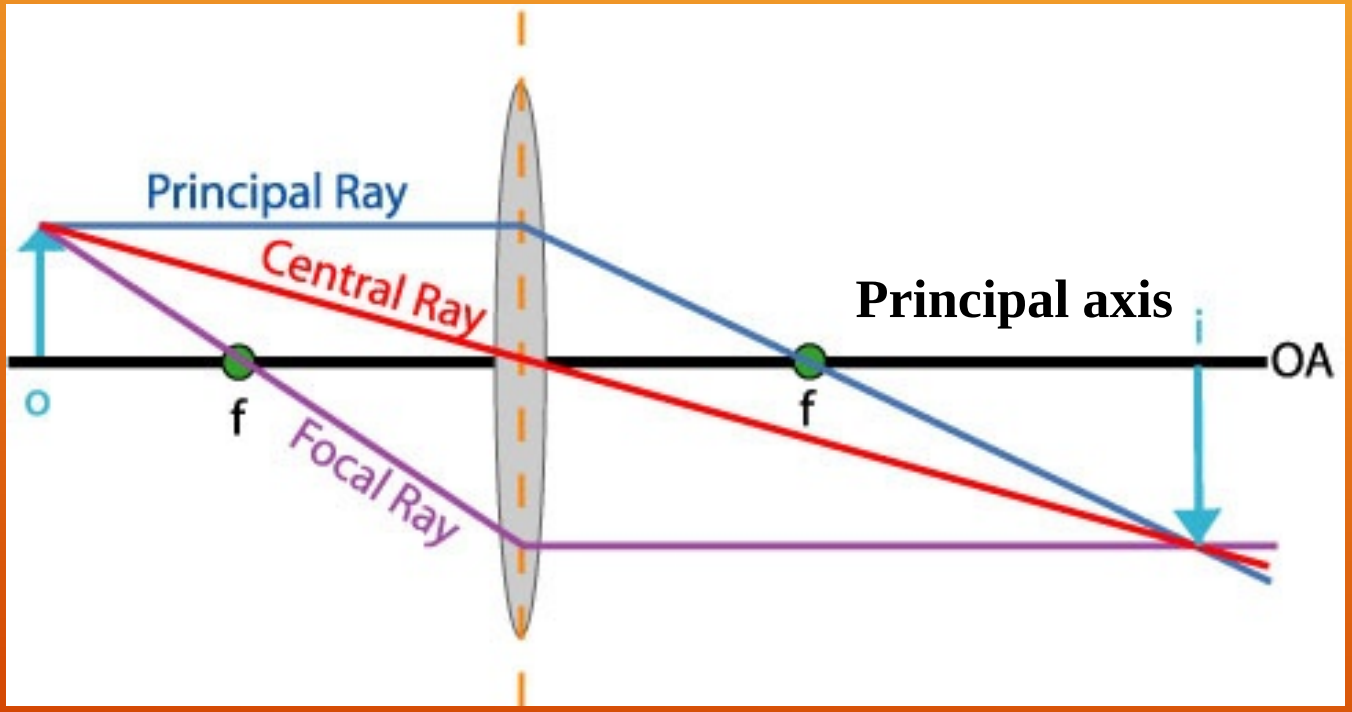
Convex lens



Ray diagram for convex lens

Rules for ray diagrams for convex lens

- A parallel ray refracts through the focal point.
- A ray through the center of the lens continues straight.
- A ray coming through the focal point, refracts parallel to the principal axis.



Lenses

Just as with concave mirrors, the characteristics of the image formed by a converging lens depend upon the location of the object.

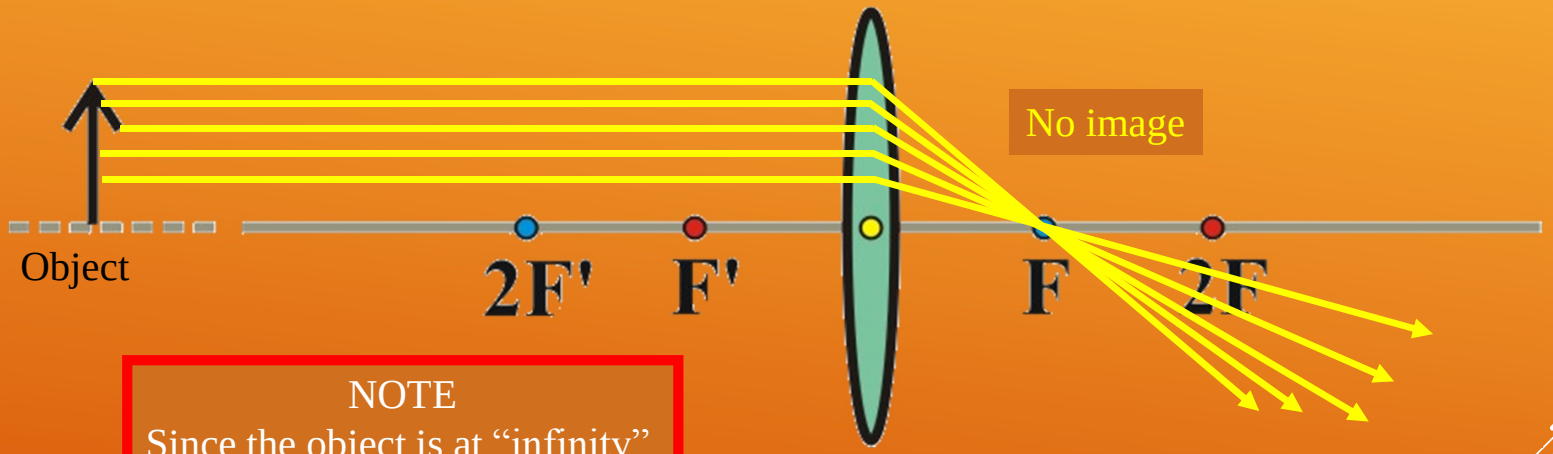
There are six "strategic" locations where an object may be placed. For each location, the image will be formed at a different place and with different characteristics. We will illustrate the six different locations and label them as **CASE-1** to **CASE-6**.

Case-1: Object at infinity
Case-2: Object just beyond 2 F’
Case-3: Object at 2F’
Case-4: Object between 2F’ and F’
Case-5: Object at F’
Case-6: Object within focal length (f)

Convex lens

CASE-1 : Object at "infinity"

Infinity simply means "far away".



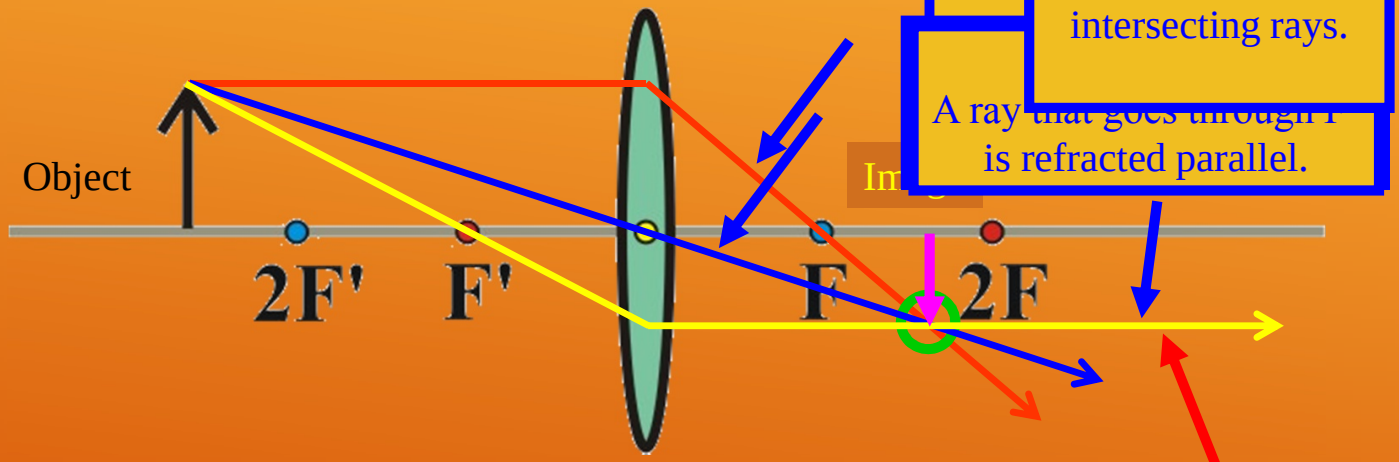
NOTE
Since the object is at "infinity", all rays arrive parallel.

No image formed (All rays pass through F)

Click

Convex lens

CASE-2: Object just beyond 2F'



NOTE
In order to establish an image point, all we need are two intersecting rays.

A ray that goes through F is refracted parallel.

This ray is extra in locating the image.

Image is real (formed by refracted rays)
Inverted (upside down)
Reduced (smaller than object)
Located between F and 2F

Convex lens

CASE-3 : Object at 2F’

Again:
In order to establish an image point, all we need are two intersecting rays.

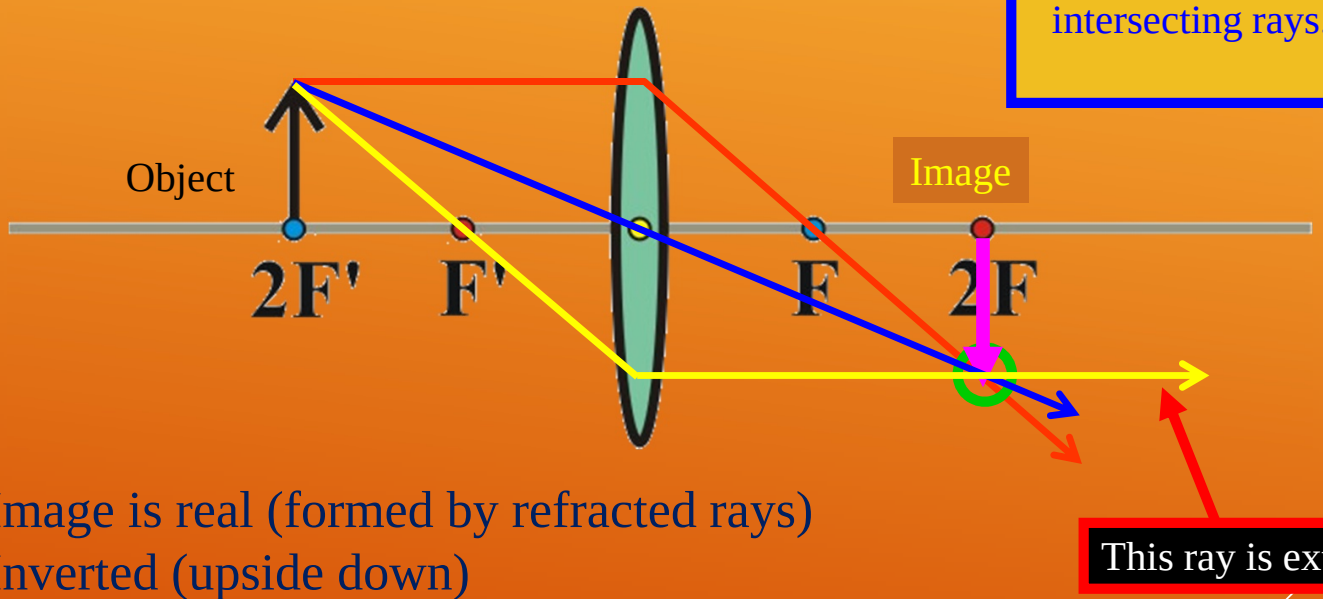
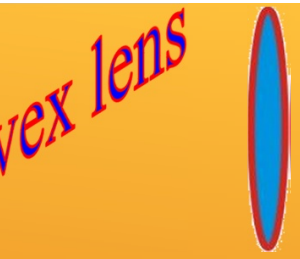


Image is real (formed by refracted rays)
Inverted (upside down)
Same size as object
Located at 2F

Convex lens



CASE-4: Object between 2F' and F'

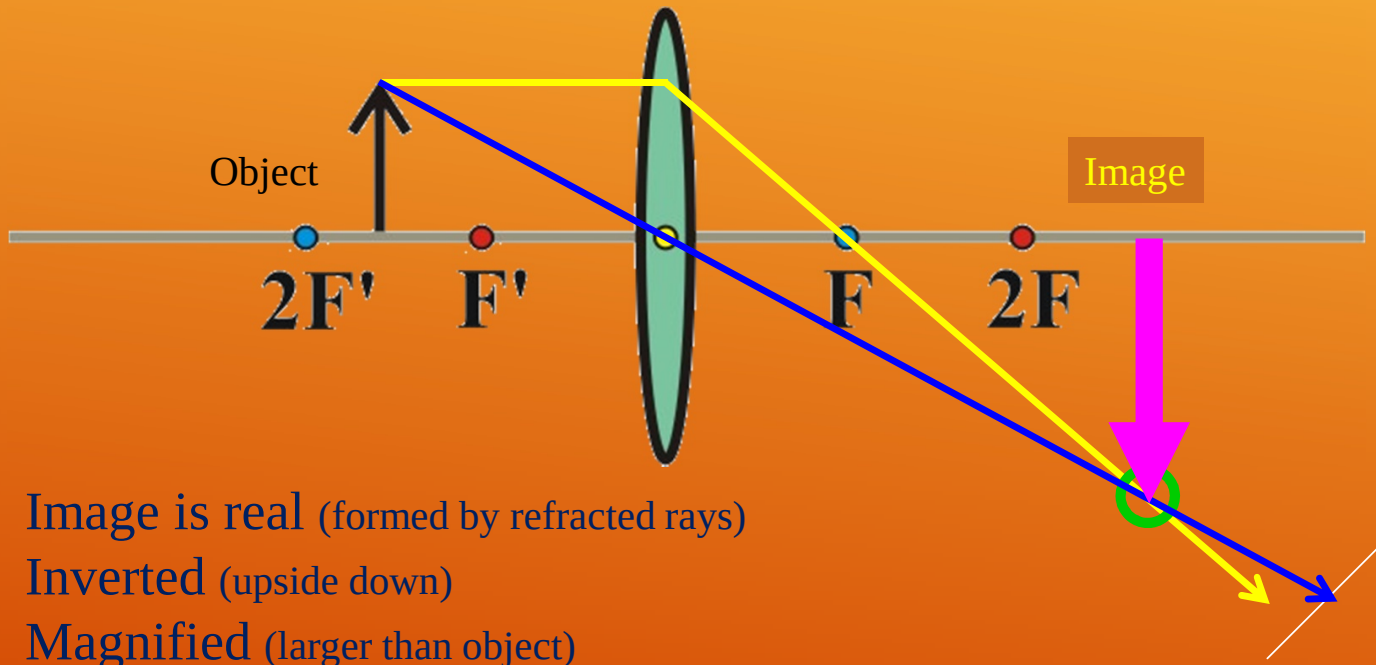
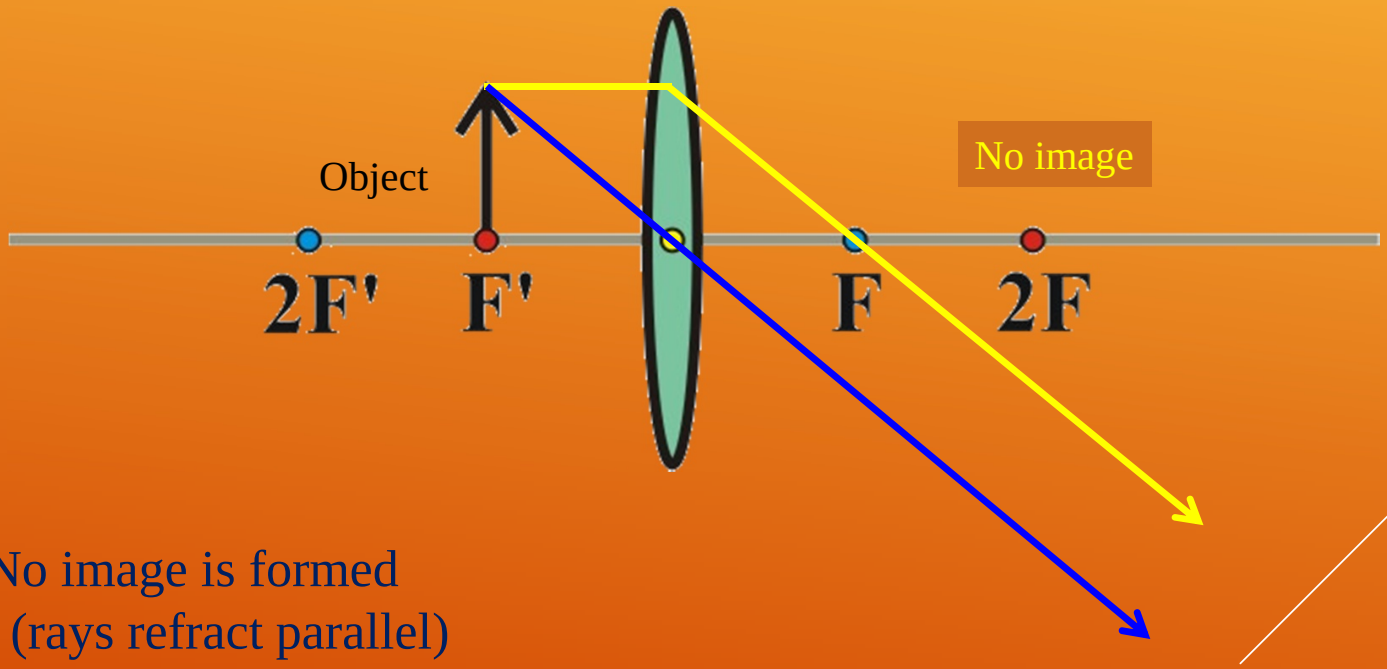


Image is real (formed by refracted rays)
Inverted (upside down)
Magnified (larger than object)
Located beyond 2F

Convex lens

CASE-5 : Object at F’



No image is formed
(rays refract parallel)

Convex lens

CASE-6: Object is within focal length

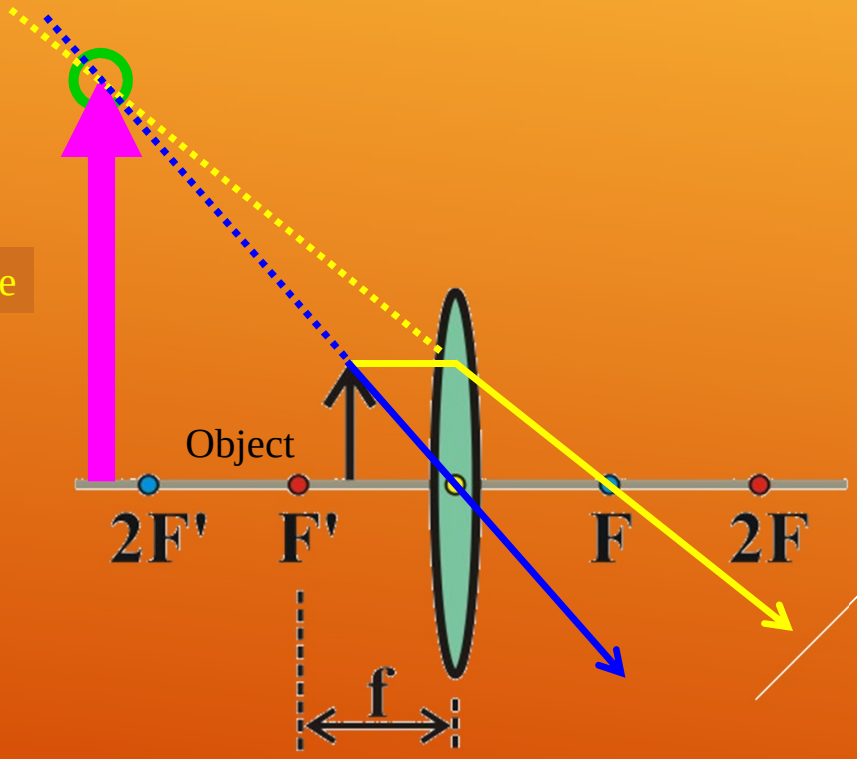


Image is virtual
(formed by extended rays)
Upright
Magnified
Located on same side as object

Summary for convex lens

When the object is:	Then the image is:
Beyond 2F	**Between 2F and F**
At 2F	**At 2F**
Between 2F and F	**Beyond 2F**
At F	**No image**
Between F and lens	**Virtual image**

Sign convention

d_o + object distance

d_i + real image, other side of lens

d_i - virtual image, same side as object

h_i + erect image

h_i - inverted image

f + converging lens (convex = converging)

f - diverging lens (concave = diverging)

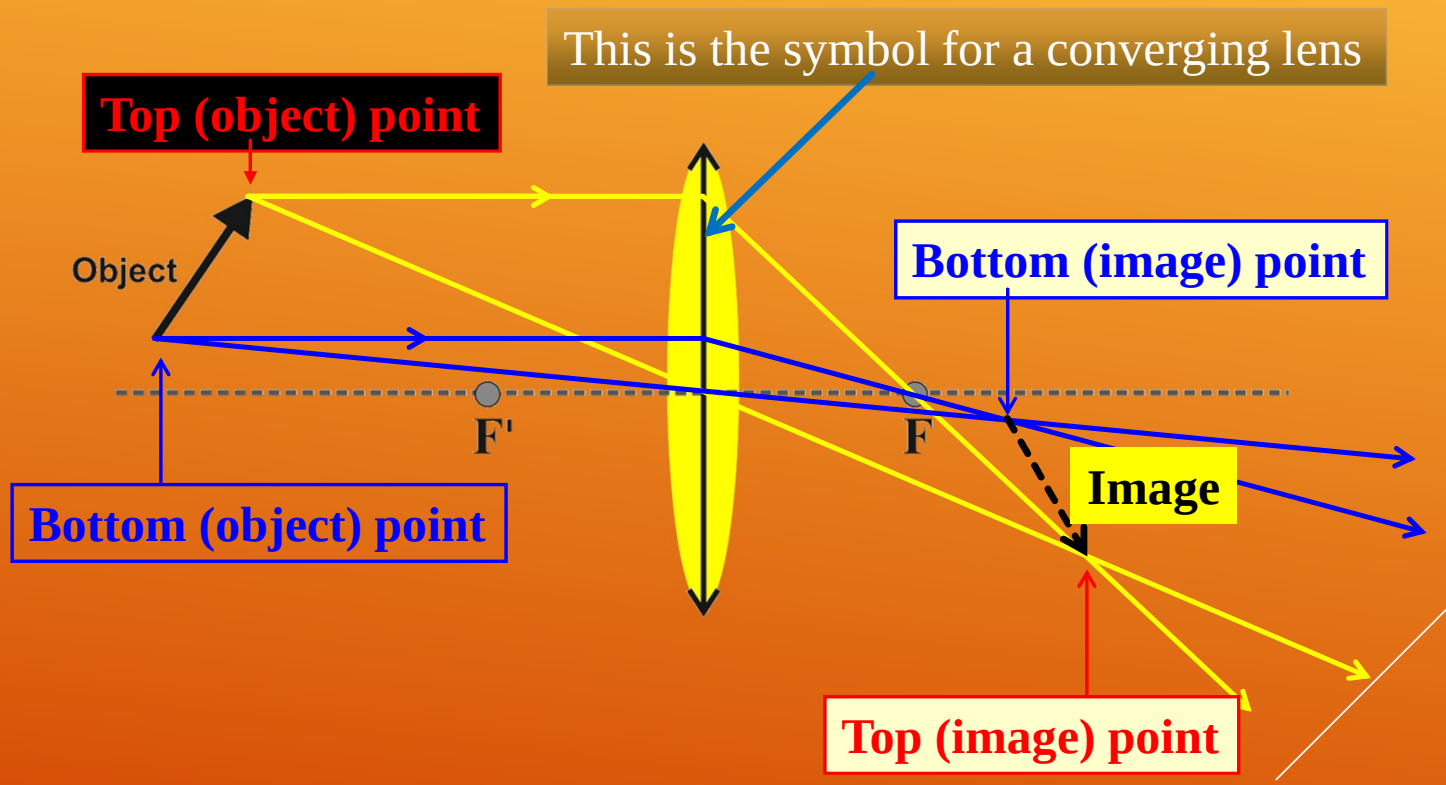
Lens equation

$$\frac{1}{d_o}+\frac{1}{d_i}=\frac{1}{f}$$

$$m=-\frac{d_i}{d_o}=\frac{h_i}{h_o}$$

$$d_i=\frac{f\cdot d_o}{d_o-f}$$

Physics **PRACTICE**



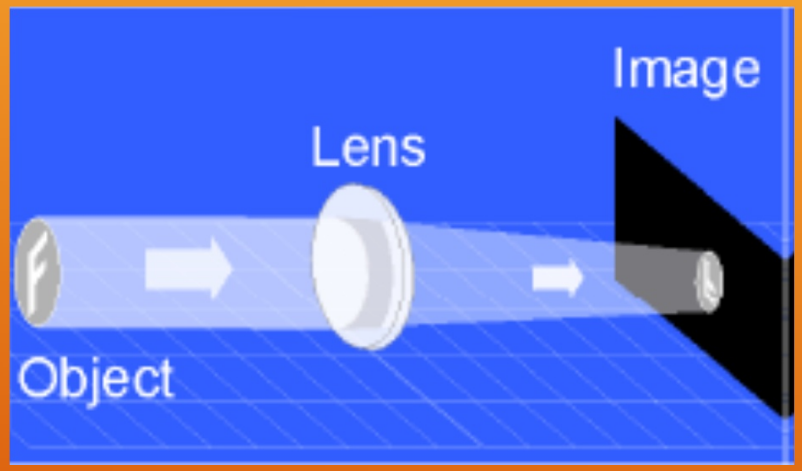
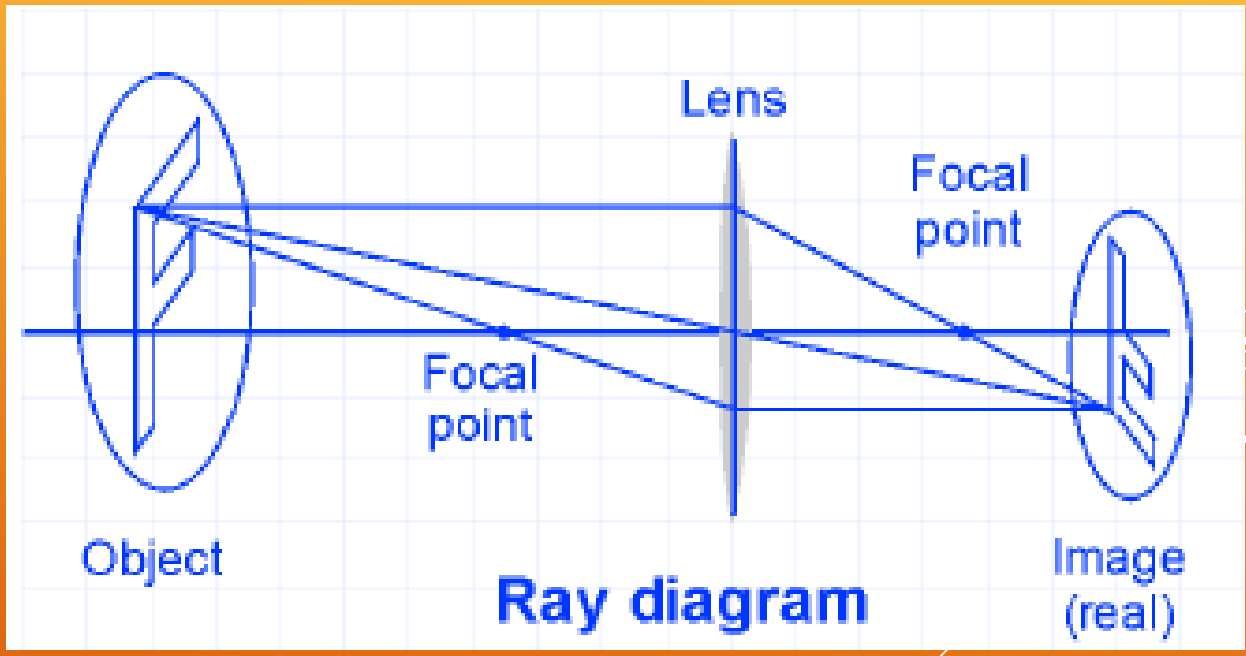
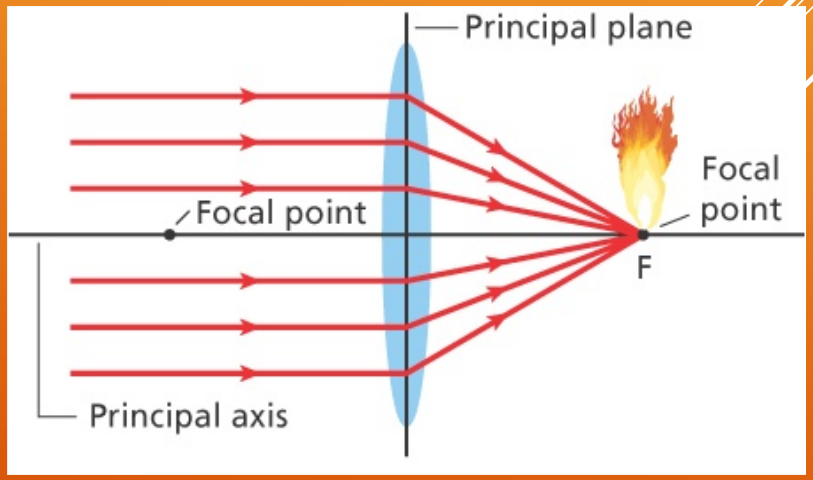


Image
Lens
Object


Lens
Focal point
Focal point
Object
Image (real)
Ray diagram

Convex Lenses and Real Images

- Paper can be ignited by producing a real image of the Sun on the paper.
- The rays of the Sun are almost exactly parallel when they reach Earth.
- After being refracted by the lens, the rays converge at the focal point, F, of the lens.



Concave lens

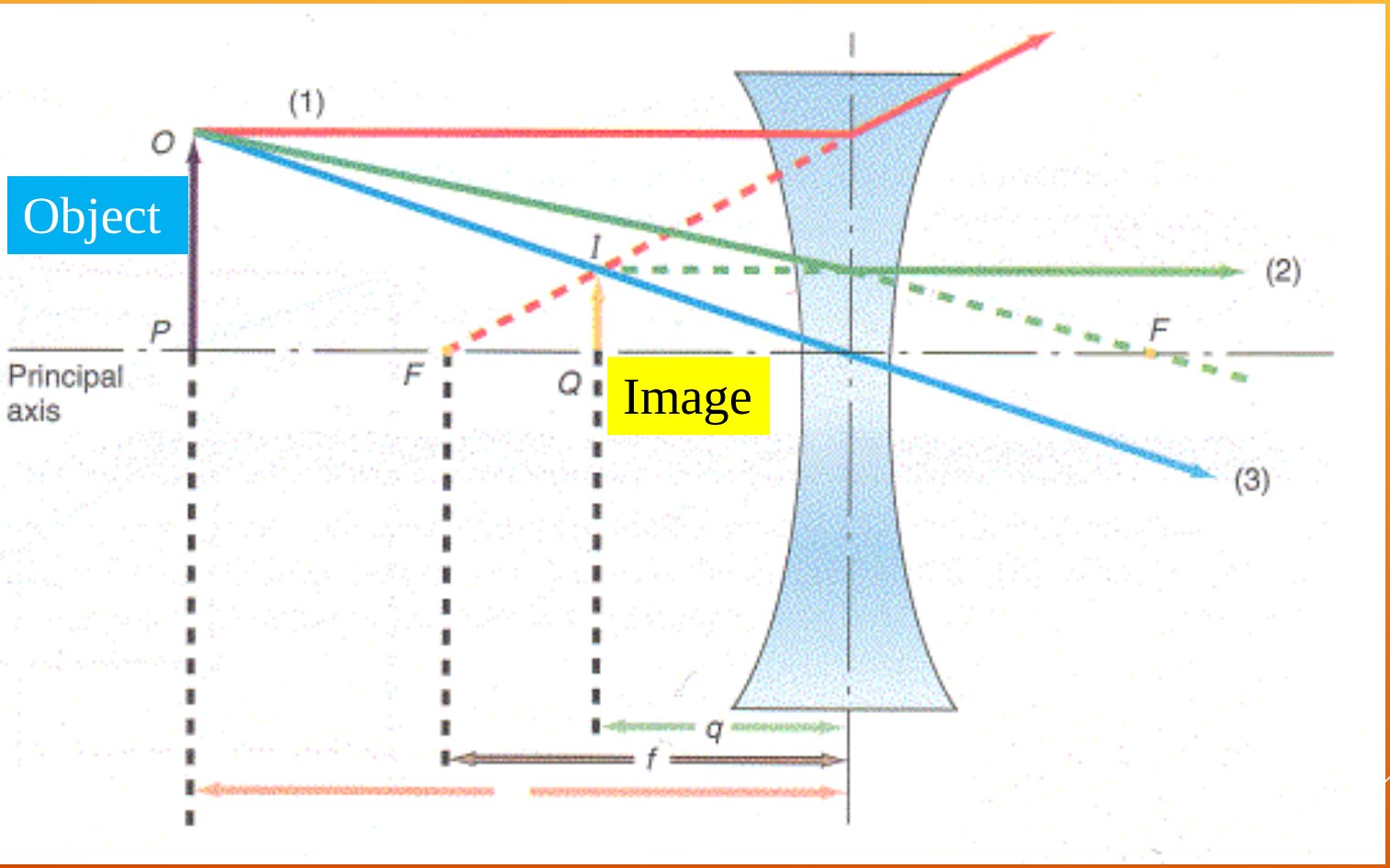


Image:

- Virtual,
- reduced,
- upright

- A lens can form a virtual image just as a mirror does.

- Rays from the same point on an object are bent by the lens so that they appear to come from a much larger object.