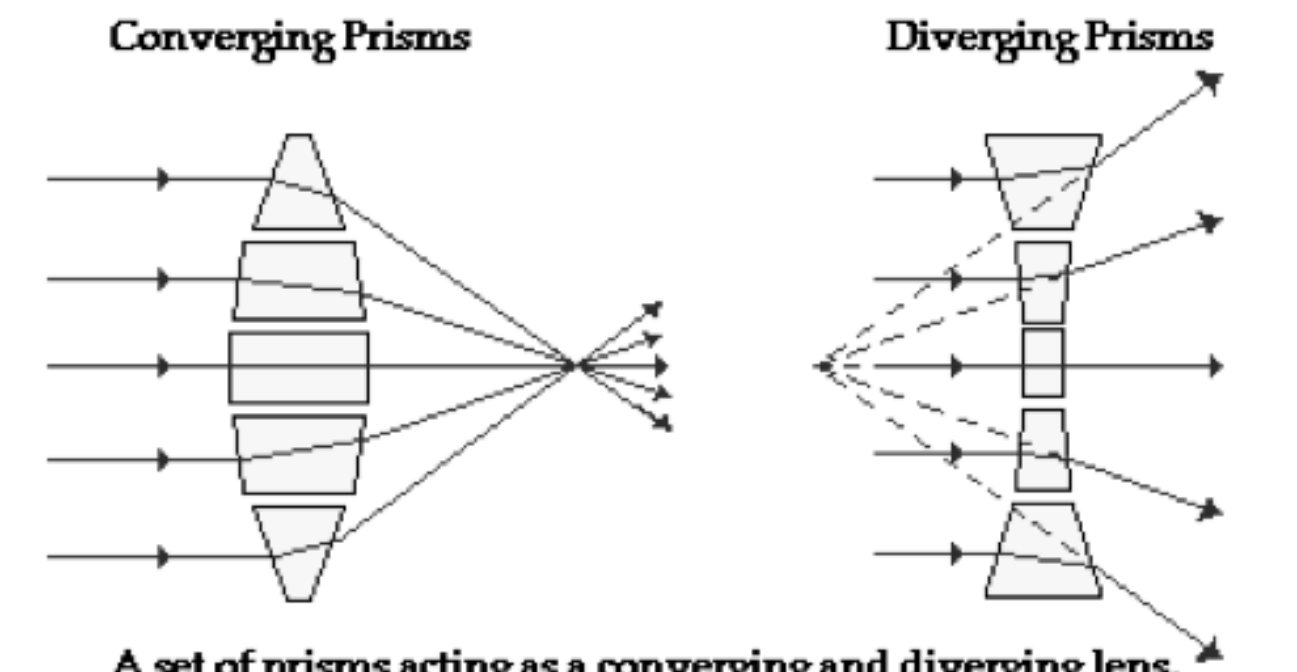
Lenses

Lesson 4

Anatomy of a Lens

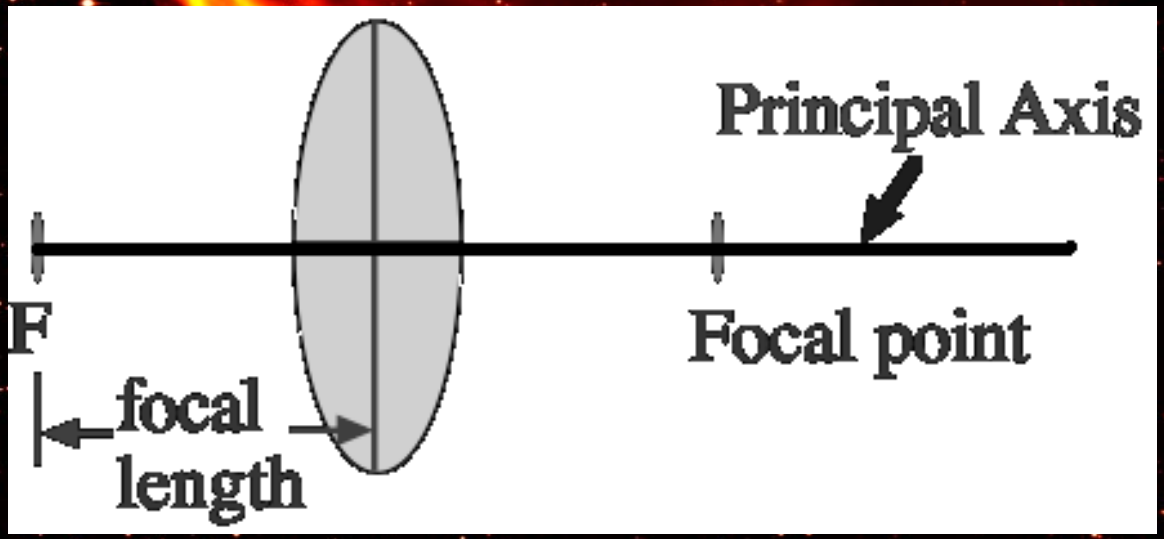
- Transparent material is capable of causing parallel rays to either converge or diverge depending upon its shape.



A set of prisms acting as a converging and diverging lens.

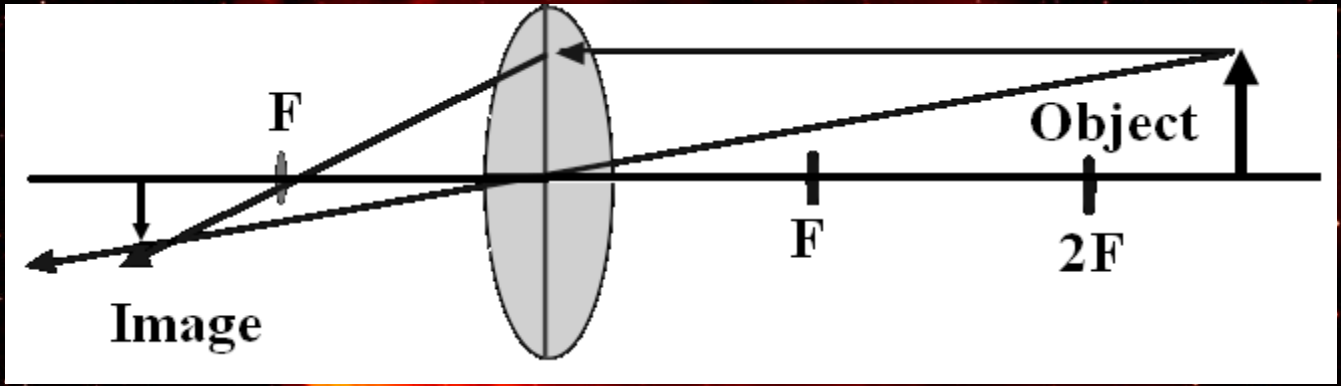
Double Convex Lenses

- A double convex lens will cause light rays that approach parallel to the principal axis to converge to a point called the focal point.
- The distance between the central axis and the focal point is known as the focal length.



Case 1

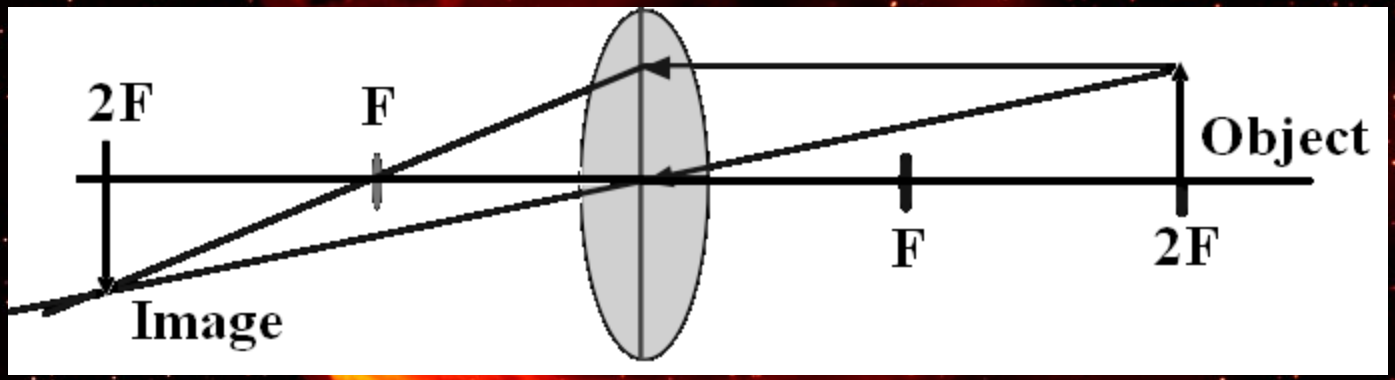
- **Object is located beyond 2F**



- The image is inverted, smaller, real and closer to the lens than the object.

Case 2

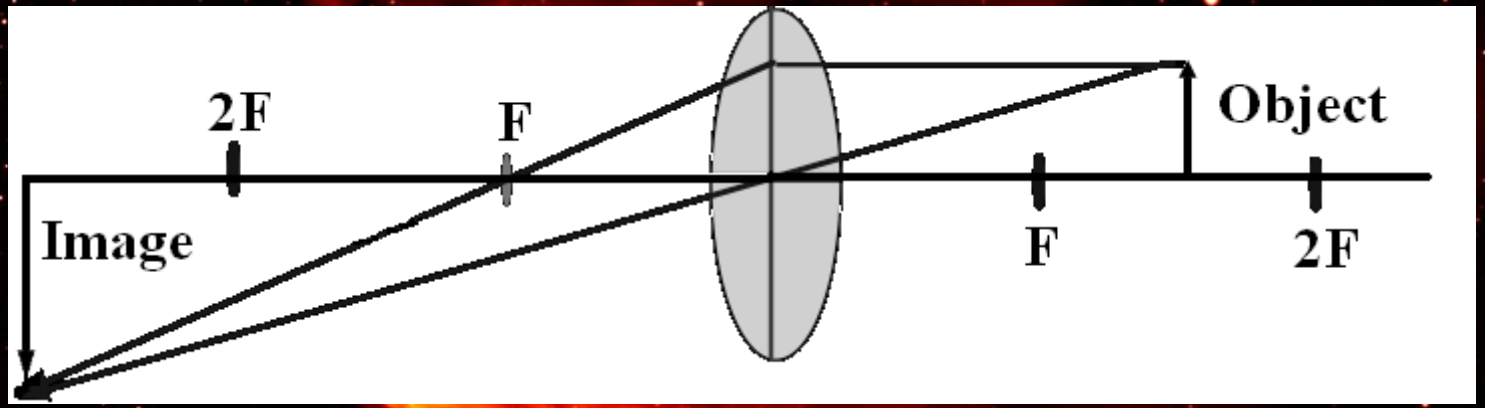
- Object located at 2F



- The image is inverted, same size, real and same distance from the lens as the object is

Case 3

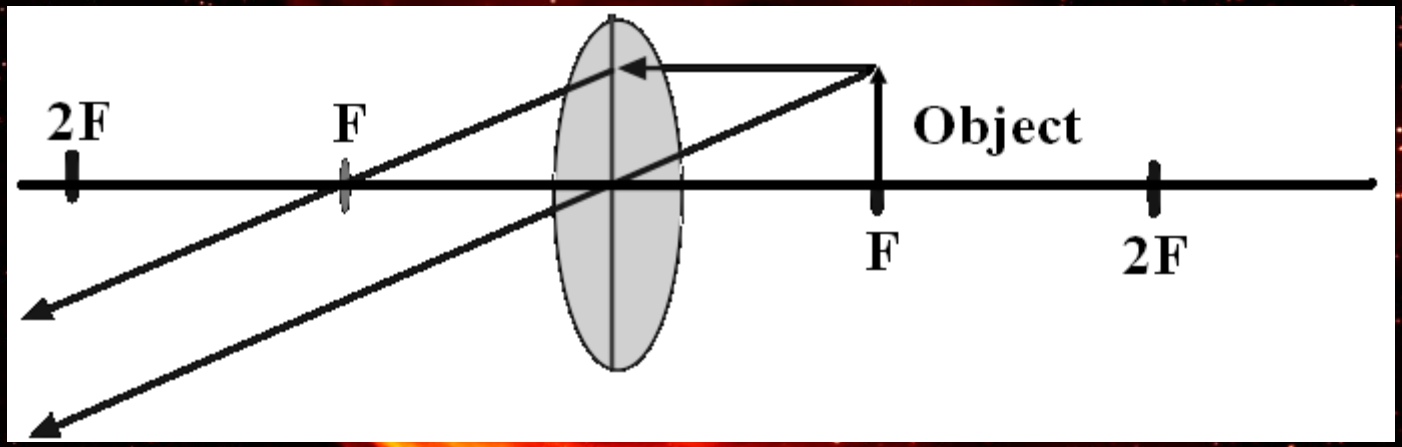
- Object between F and 2F



- The image is inverted, larger, real and further away than the object is from the lens.

Case 4

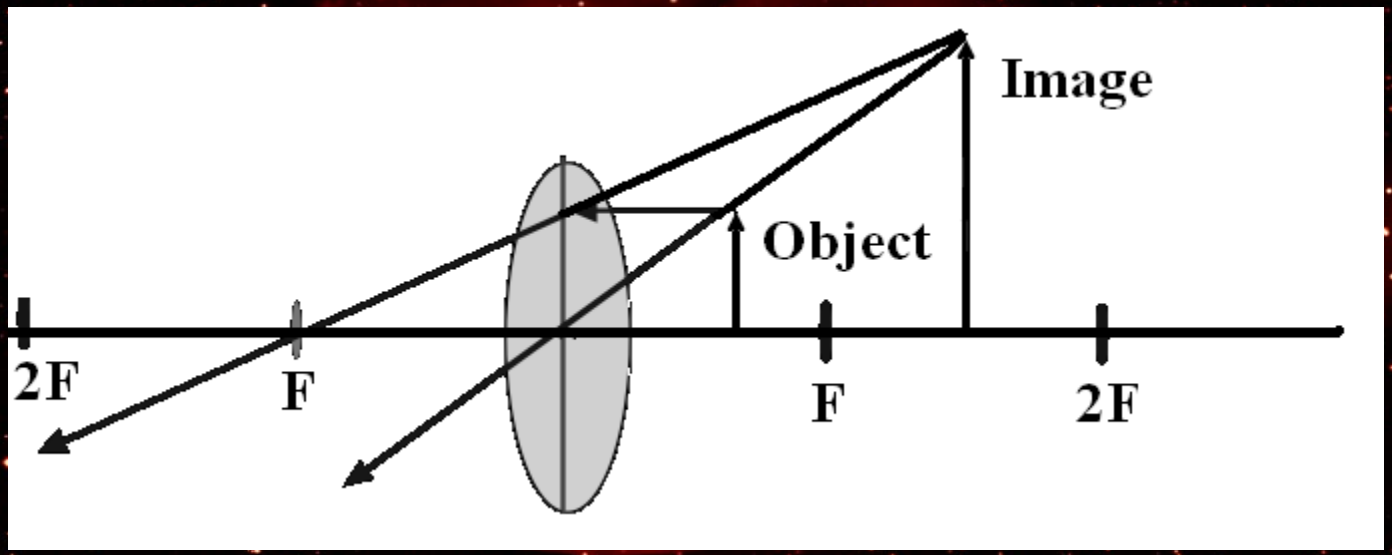
- Object at F



- Refracted rays are parallel so no image is formed.

Case 5

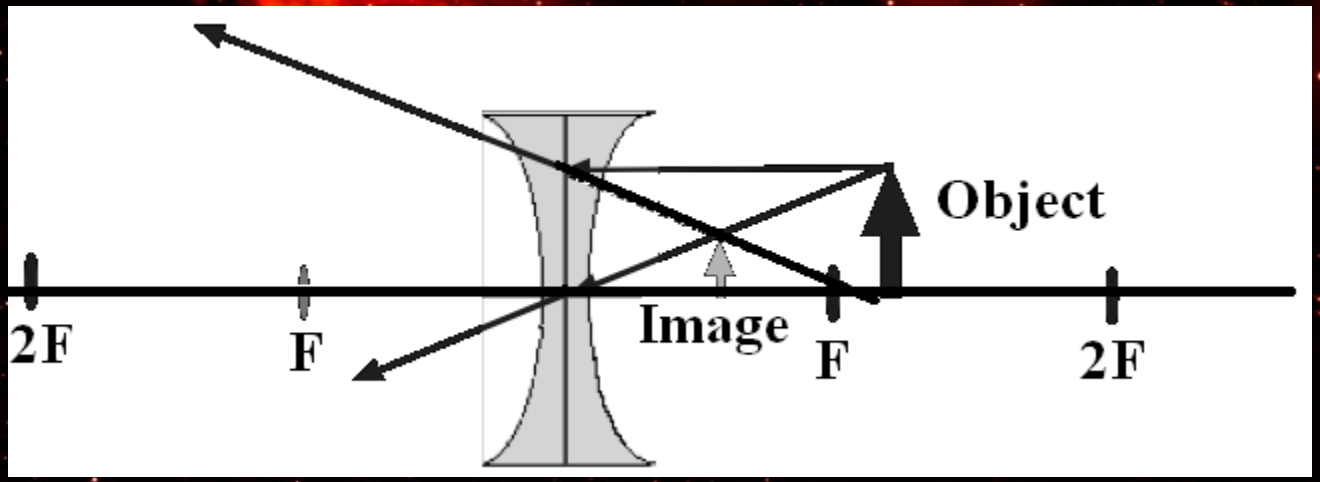
- Object between F and the lens



- The image is erect , larger and on the same side of the lens as the object (virtual).

Case 6 - diverging lens

- The ray from the object to the lens parallel to the axis is bent outward as if it had started from the first focal point.



- Image is erect, smaller, virtual and between object and lens.

Lens Formulas

- Formulas are the same as for mirrors:

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

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

Example

- A 4.0-cm tall light bulb is placed a distance of 45.7 cm from a double convex lens having a focal length of 15.2 cm. Determine the image distance and the image size.

Sign conventions

- f is + if the lens is a double convex lens (converging lens)
- f is - if the lens is a double concave lens (diverging lens)
- d_i is + if the image is a real image and located on the opposite side of the lens.
- d_i is - if the image is a virtual image and located on the object's side of the lens.
- h_i is + if the image is an upright image (and therefore, also virtual)
- h_i is - if the image an inverted image (and therefore, also real)

Solution

- The image will be inverted, 1.99-cm tall and located 22.8 cm from the lens. The results of this calculation agree with the principles discussed earlier in this lesson. In this case, the object is located *beyond the center of curvature (which* would be two focal lengths from the lens), and the image is located between the center of curvature and the focal point.
- The negative values for image height indicate that the image is an inverted image. In the case of the image height, a negative value always indicates an inverted image