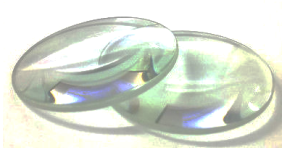
Thin lenses

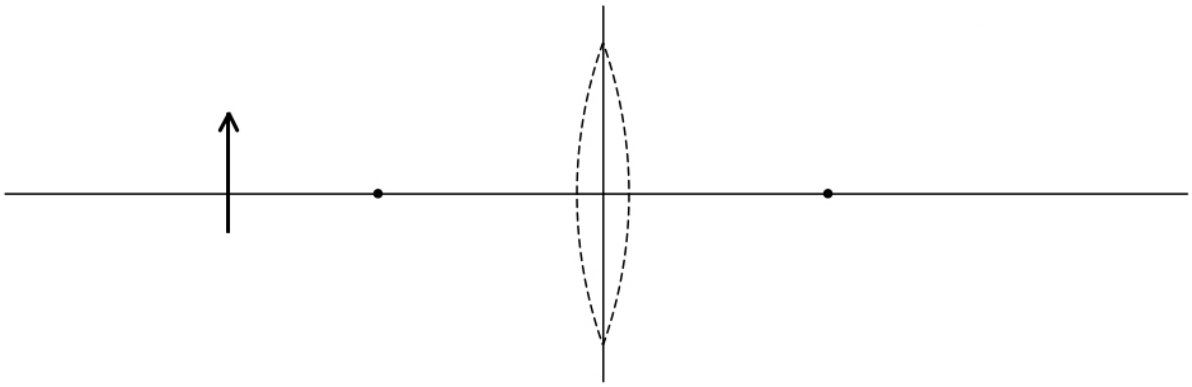
Converging lenses (convex lenses)



A converging lens is a flat round piece of transparent material (usually glass), which is thicker in the middle than at the rim. The light rays passing through a converging lense are bent inward, that is, they converge.

Label the following concepts in the picture below:

Center of the lens: Point at the middle of the lens.
Principal axis: Horizontal line passing through the center of the lens
Center line: Vertical line passing through the center of the lens
Focal point F (black round dots): Point where incident parallel light rays converge after passing through the lens (there are two!)
Focal length *f*: Distance from the center of the lens to its focal point



Tasks:

a) Place the light ray box onto the table and look at it from above. On the side where the parallel light beam exits the box, insert the plate with four slits. Direct the four light rays onto the lens, parallel to the principal axis, in such a way that the principal axis is located between the two middle light rays.

The four parallel light rays are refracted by the lens. After passing through the lens, the refracted light rays intersect in one point. Mark this point on the paper and label it as **F**. This is the focal point. Measure the distance of the focal point from the center of the lens (focal length *f*):

$f =$

Direct the four parallel light rays from the other side onto the lens, mark the focal point and label it as **F**. Measure the focal length:

$f =$

What do you notice?

.....

b) Substitute the slit plate of four slits by the one with one slit. Direct the light ray onto the lens, in such a way that it is travelling parallel to the principal axis (but not along the axis). Observe its path as it exits the lens. Complete the following sentence:

A light ray entering a converging lens parallel to its principal axis continues, when exiting the lens,

.....

Draw the path of the light ray in the picture on page 1.

c) Direct the light ray obliquely onto the lens, in such a way that it first passes through the focal point and then strikes the lens. Observe its path as it exits the lens. Complete the following sentence:

A light ray passing through the focal point of a converging lens before entering it continues, when exiting the lens,

.....

Draw the path of the light ray in the picture on page 1.

d) Direct the light ray obliquely onto the lens, in such a way that it passes through the center of the lens. Observe its path as it exits the lens. Complete the following sentence:

A light ray passing through the center of a converging lens continues, when exiting the lens,

.....

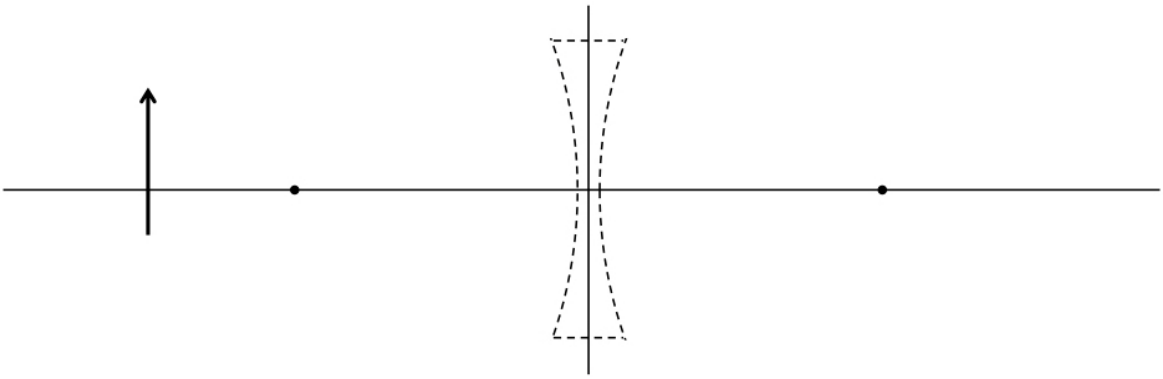
Draw the path of the light ray in the picture on page 1.

Diverging lenses (concave lenses)

A diverging lens is a flat round piece of transparent material (usually glass), which is thinner in the middle than at the rim. The light rays passing through a diverging lense are bent outward, that is, they diverge.

Label the following concepts in the picture below:

Center of the lens: Point at the middle of the lens.
Principal axis: Horizontal line passing through the center of the lens
Center line: Vertical line passing through the center of the lens
Virtual focal point Z (black round dots): Incident parallel light rays diverge after passing through the lens. The virtual focal point is the point where they seem to come from.
Negative focal length –*f*: Distance from the center of the lens to its virtual focal point



Tasks:

a) Place the light ray box onto the table and look at it from above. On the side where the parallel light beam exits the box, insert the plate with four slits. Direct the four light rays onto the lens, parallel to the principal axis, in such a way that the principal axis is located between the two middle light rays.

The four parallel light rays are refracted by the lens. After passing through the lens, the refracted light rays seem to be coming from one single point. Trace the light rays with a ruler and trace them back to the common point where they seem to be coming from. Mark this point on the paper and label it as **Z**. This is the virtual focal point. Measure the distance of the virtual focal point from the center of the lens (negative focal length *f*):

$$f = -$$

Direct the four parallel light rays from the other side onto the lens, mark the virtual focal point and label it as **Z**. Measure the (negative) focal length:

$$f = -$$

What do you notice?

.....

b) Substitute the slit plate containing four slits by the one with one slit. Direct the light ray onto the lens, in such a way that it is travelling parallel to the principal axis (but not along the axis). Observe its path as it exits the lens. Complete the following sentence:

A light ray entering a diverging lens parallel to its principal axis continues, when exiting the lens,

.....

Draw the path of the light ray in the picture on page 3.

c) Direct the light ray obliquely onto the lens, in such a way that it aims at the virtual focal point on the other side of the lens. Observe its path as it exits the lens. Complete the following sentence:

A light ray aiming at the virtual focal point on the other side of a diverging lens continues, when exiting the lens,

.....

Draw the path of the light ray in the picture on page 3.

d) Direct the light ray obliquely onto the lens, in such a way that it passes through the center of the lens. Observe its path as it exits the lens. Complete the following sentence:

A light ray passing through the center of a diverging lens continues, when exiting the lens,

.....

Draw the path of the light ray in the picture on page 3.

Note: The rules for ray tracing found here only apply to *thin lenses*. Lenses have two surfaces and the light is refracted twice as it passes through the lens. In a thin lens however, we can pretend that the light rays are bent only once, at the center line of the lens.