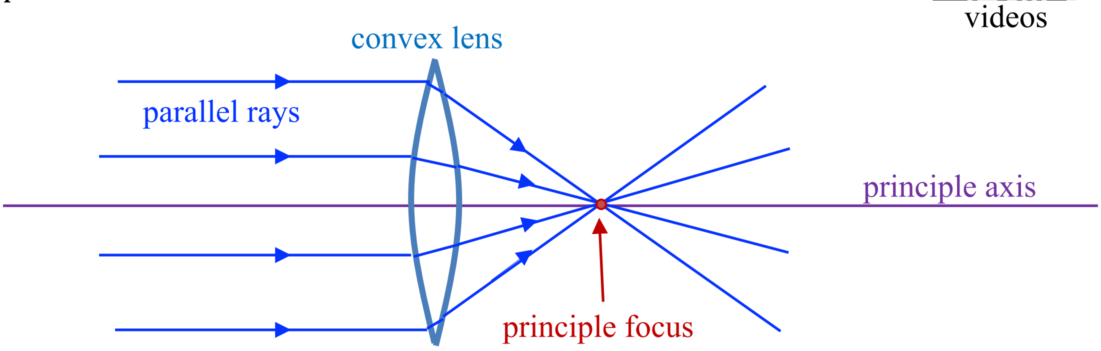
6.4.1 lenses

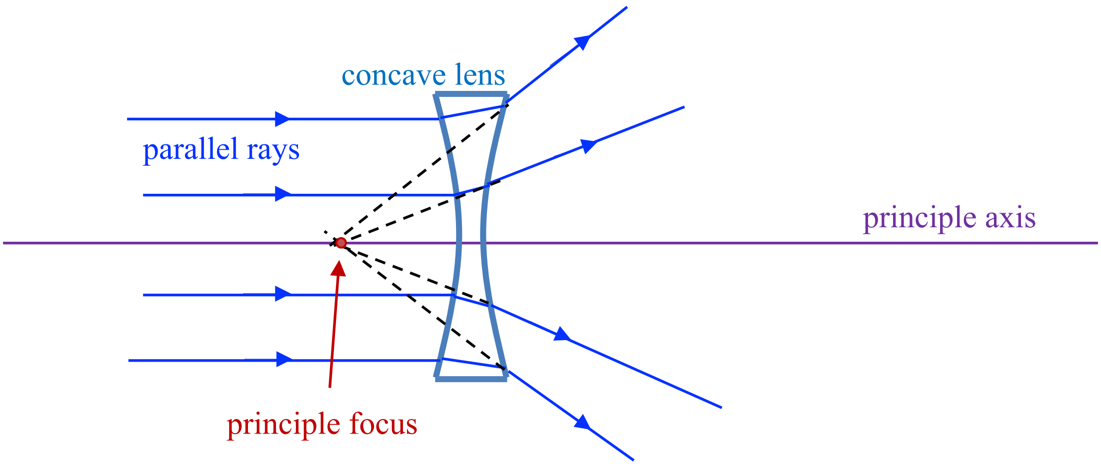
Lenses are shaped pieces of glass that refract light, producing images. There are two types of lens. The first, called a 'convex' or 'converging' lens, brings parallel rays of light together at a focal point.

videos



The 'principle axis' is a line that runs through the middle of the lens. The 'principle focus' is where rays parallel to the principle axes are brought to a focus.

The second, called a 'concave' or 'diverging' lens spreads out parallel rays of light.



Note that, for the concave lens, the principle focus is where the diverging rays appear to originate from. So, if you were looking from the right-hand side, the rays of light appear to be coming from this point. We use a dashed line to extrapolate back to this point.

When we draw ray diagram, we often use the following simplified diagrams to represent convex and concave lenses:

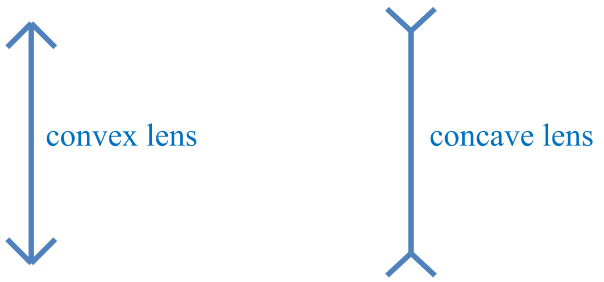
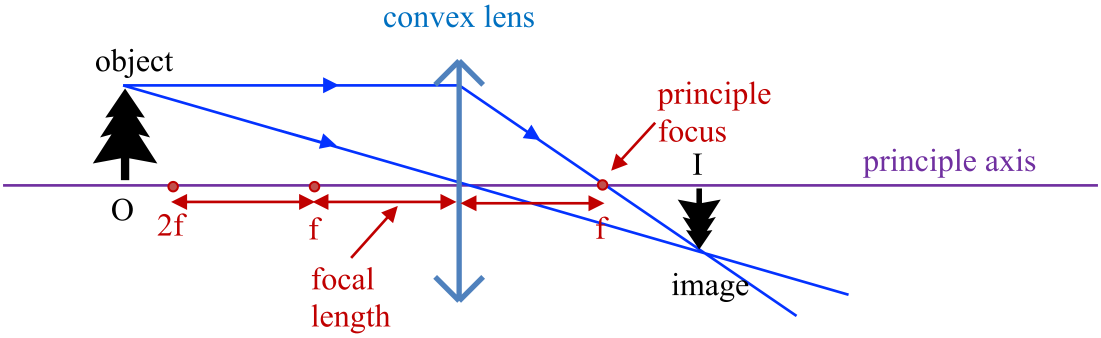


Image formation using a convex lens

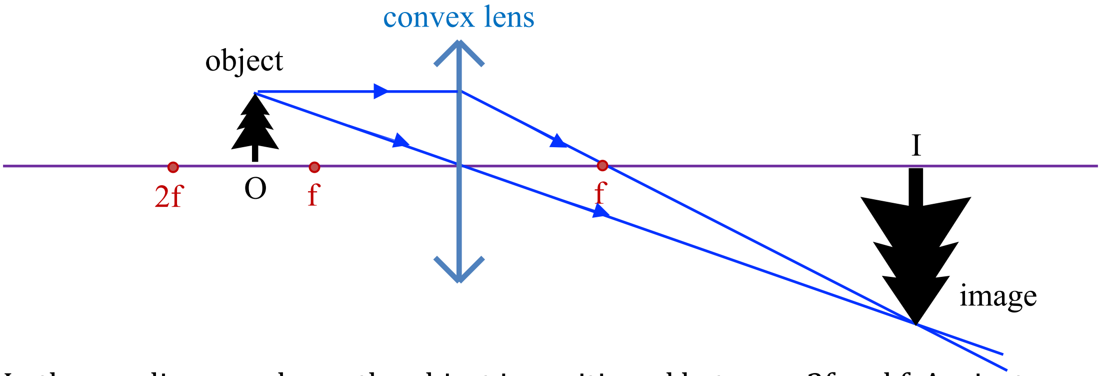
Consider an object (O) more than twice the focal length away from a convex lens. We are interested in where the image (I) is formed.



Rays of light from a point at the top of the object (the tree, in this case) pass through the lens and are brought to a focus where the rays cross each other. Where the rays are brought to a focus is where an image of the top of the tree will form. We only need two rays to show where the focus point is. The first ray passes directly through the centre of the lens without deflection. The second ray, travelling parallel to the principle axis is refracted and passes through the principle focus. We can see that the image is *inverted* (upside down), *diminished* (smaller than object), and *real*. 'Real' images are formed if rays are brought to a focus. Real images would form an image on a screen placed at the focus. We can work out the magnification M using the formula:

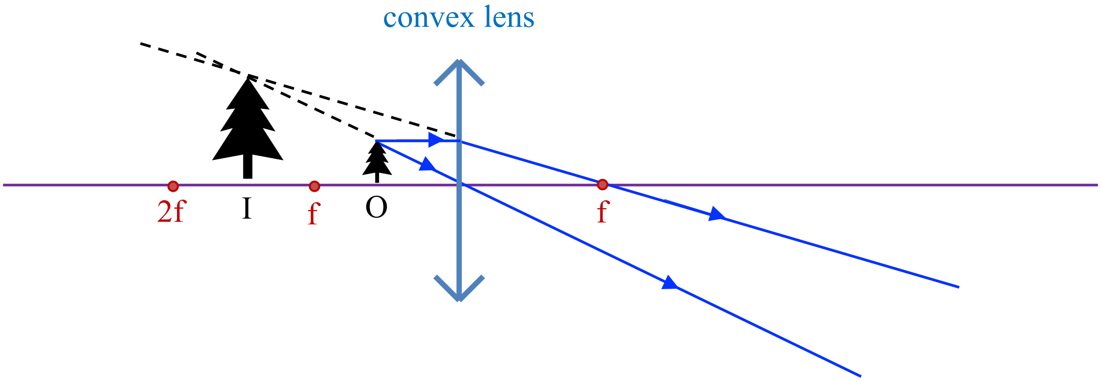
$$M = \frac{image\ height}{object\ height}$$

(1)✐Using the formula, calculate the magnification for the situation above. (Use a ruler to measure the heights.)



In the ray diagram above, the object is positioned between 2f and f. Again, two rays are drawn to locate where the image will form. The image is inverted, enlarged and real.

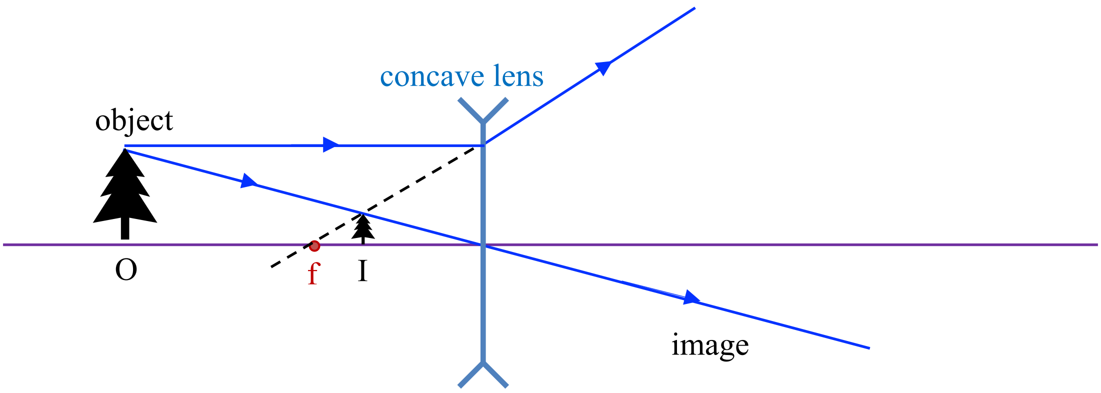
(2)✐Calculate the magnification for the situation above.



In this case, the object (O) is positioned between the lens and f. Again, two rays are required to find out the position of the image (I). The rays do not cross, but someone looking from the right-hand side would see the rays originating from a point on the left-hand side. Dashed lines are used to show where this point is. The image is upright, enlarged and virtual. A 'virtual' image is formed when rays do not cross.

(3)✐Calculate the magnification for the situation above.

Image formation using a concave lens



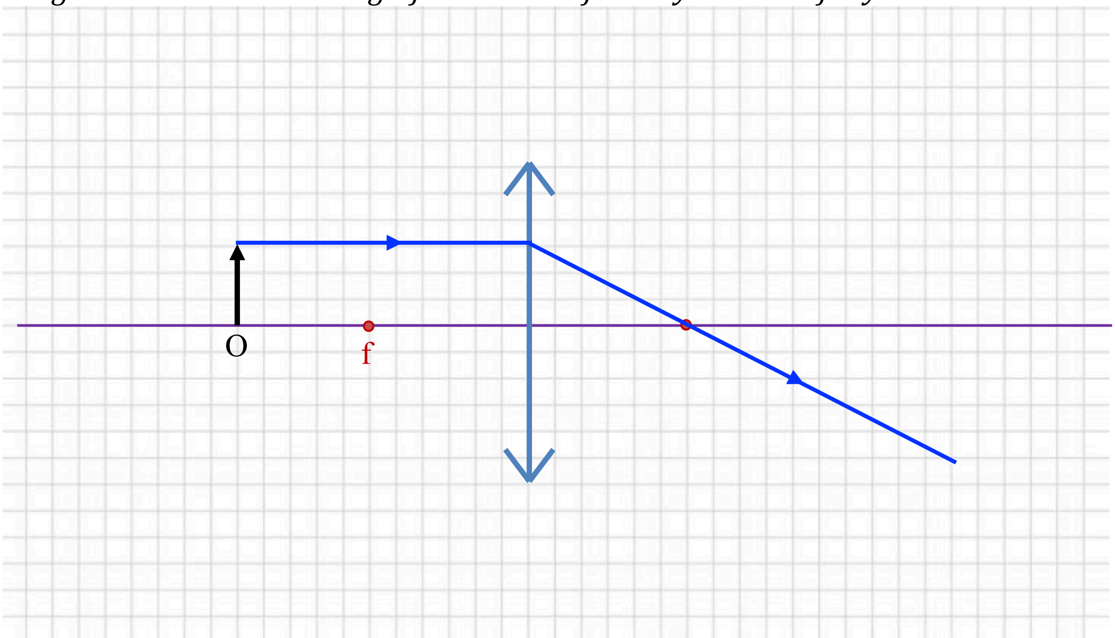
Images formed by a concave lens are always *upright*, *diminished* and *virtual*.

(4)✐How can you tell from the diagram that the image is diminished?

(5)✐How can you tell from the diagram that the image formed is virtual?

(6)✐What is the magnification for the situation above?

(7)✐Complete the ray diagram to show where the image is formed. Describe the image and calculate the magnification. The first ray is drawn for you.



(8)✐Complete the ray diagram to show where the image is formed. Describe the image and calculate the magnification. (Note: This is a concave lens.)