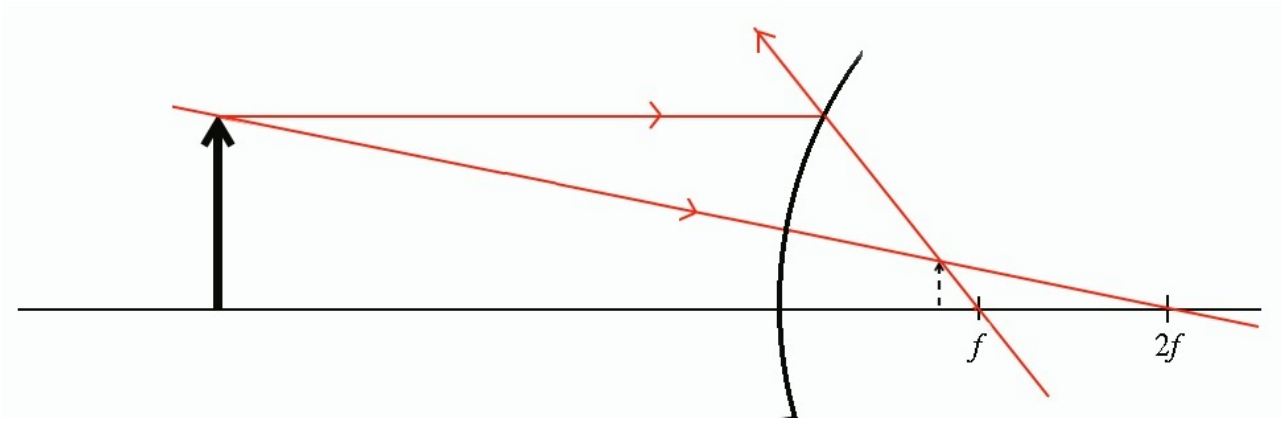
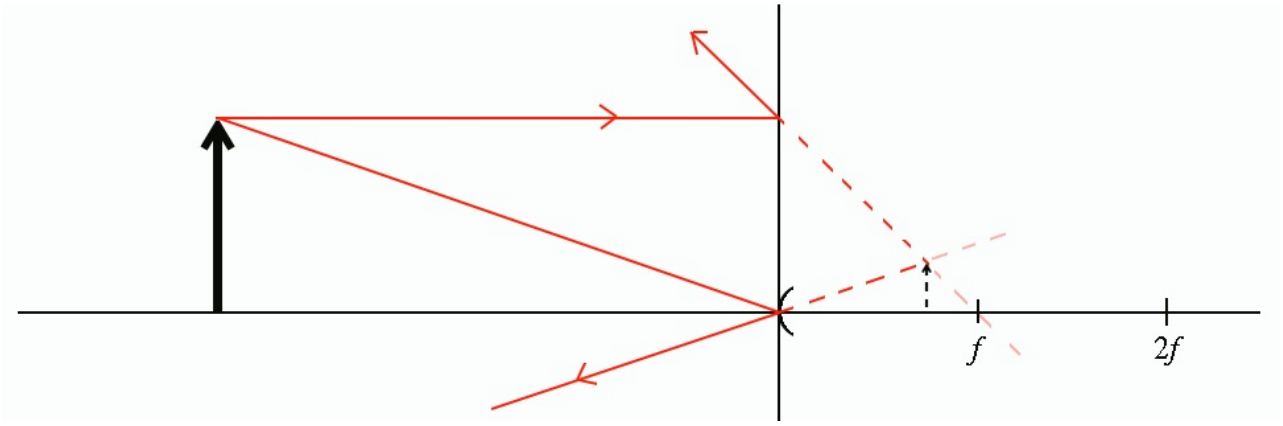
More ray diagrams

Shannon and Ian Jacobs

I had words with my Dad as I was rushing to draw 20 ray diagrams for an online math teacher in the ten minutes before class started. I'd been tired and hadn't done the diagrams for a concave lens and a concave mirror when I should have. I asked him if I was doing them right and he said, "*That's not how to do them*!" He meant … *there's an easier way* … but I was stressed and shouted back that my teacher wants them done this way and she's young and it's a modern method: *for which I have to say sorry*.



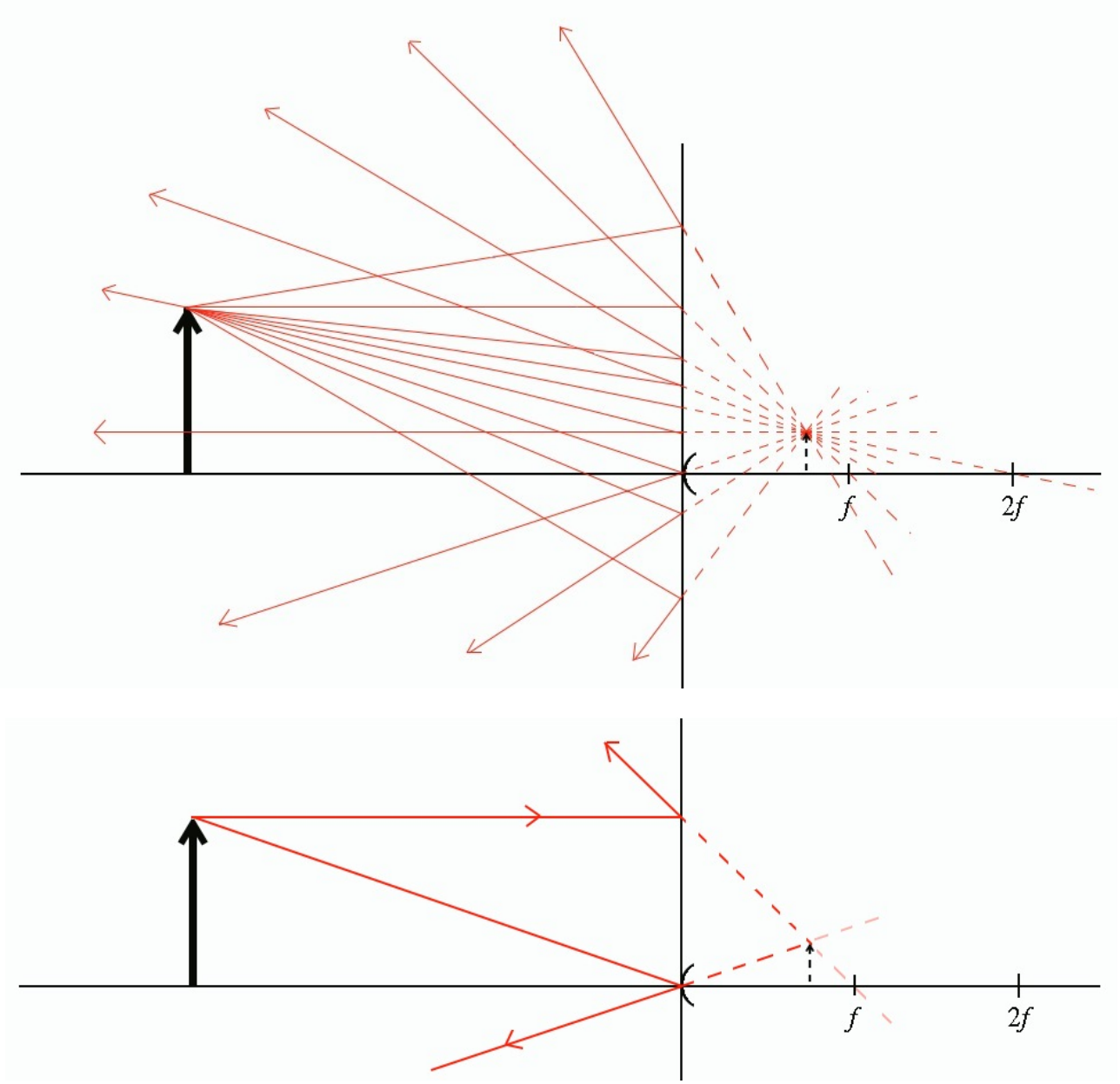
My diagram … a circular mirror and two rays. The ray parallel to the axis is reflected as though it came from the focal point. The teacher's ray, **the one I was told to draw towards 2*f***, is like that. The small virtual image is where the lines behind the mirror cross.



Dad's diagram … a line for the mirror and a ray to the centre.

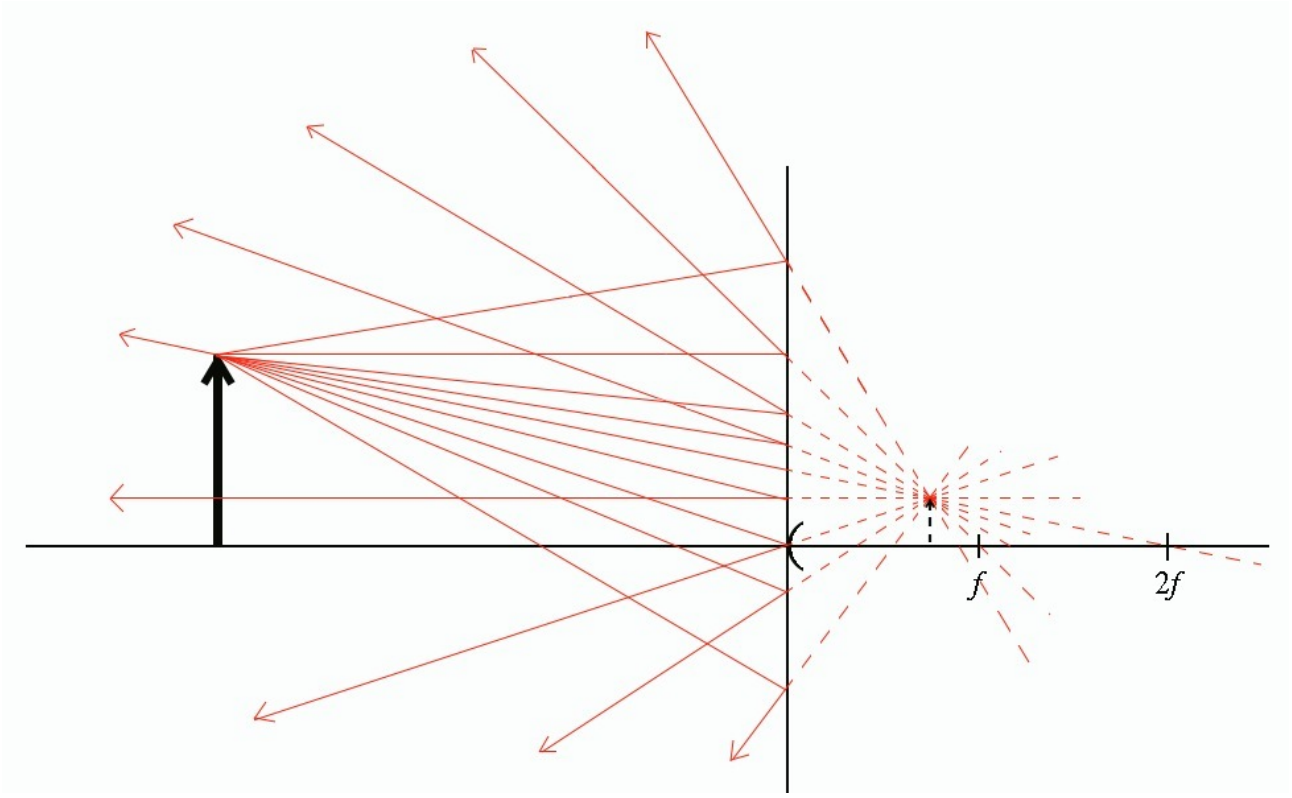
Who is right?

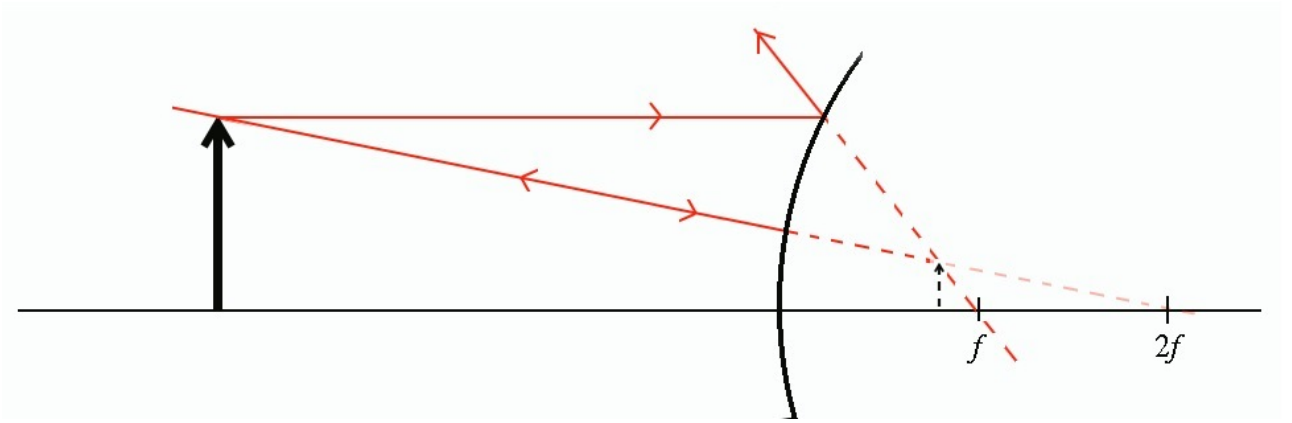
If we knew how to draw the object and image we could draw many rays from the tip of the object that reflect and appear to come from the tip of the image. So we have rays changing direction only once for lenses we draw a lens or mirror as a vertical line with a shape symbol on the axis.



Dad's rays. The reflections of these two rays appear to come from the tip of the image. One reflects as though it came from *f* and the other reflects at the same angle to the axis. *We know exactly what these two rays will do and can use them to find the tip of the image*.

My teacher's rays

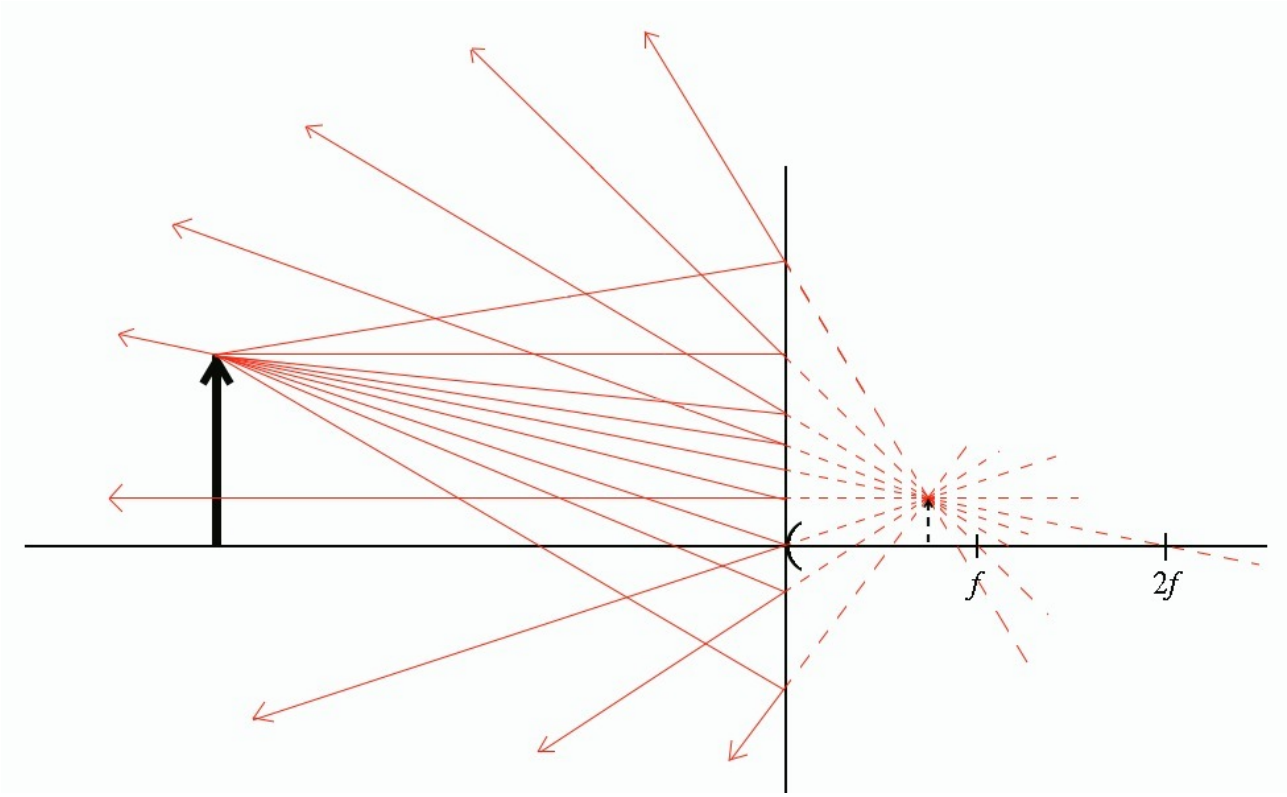




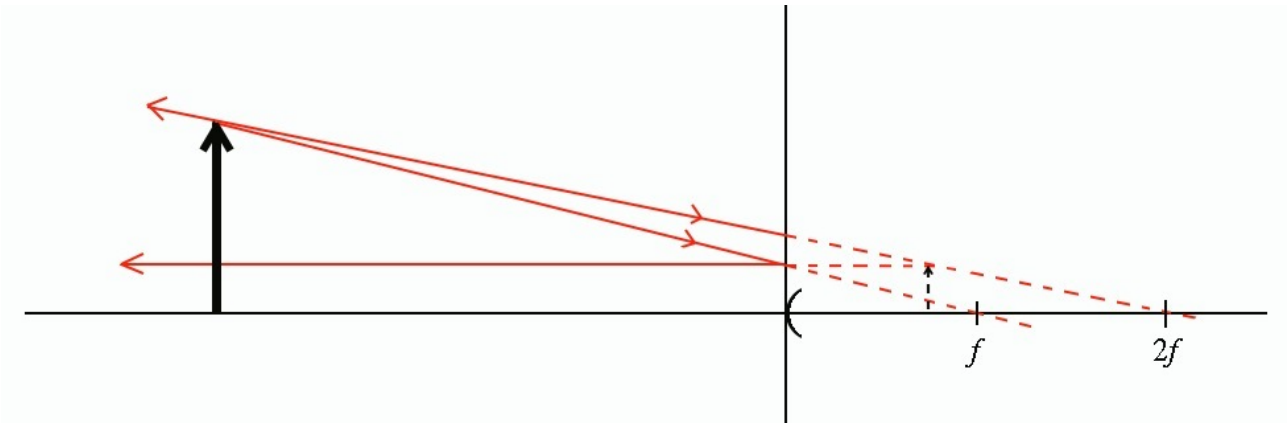
The point 2*f* is the centre of curvature of the mirror. The ray on a line towards 2*f* meets the mirror at right angles and reflects back along the same path. *We know exactly what these two rays will do and can use them to find the tip of the image*. The method is correct, but with my diagram the predicted image position has moved a little towards *f* and the image has shrunk very slightly.

Ray diagrams are drawn for "thin" spherical mirrors and lenses. My curved mirror is not thin, which has disturbed the diagram.

Are there other rays we could use?



There is one more …

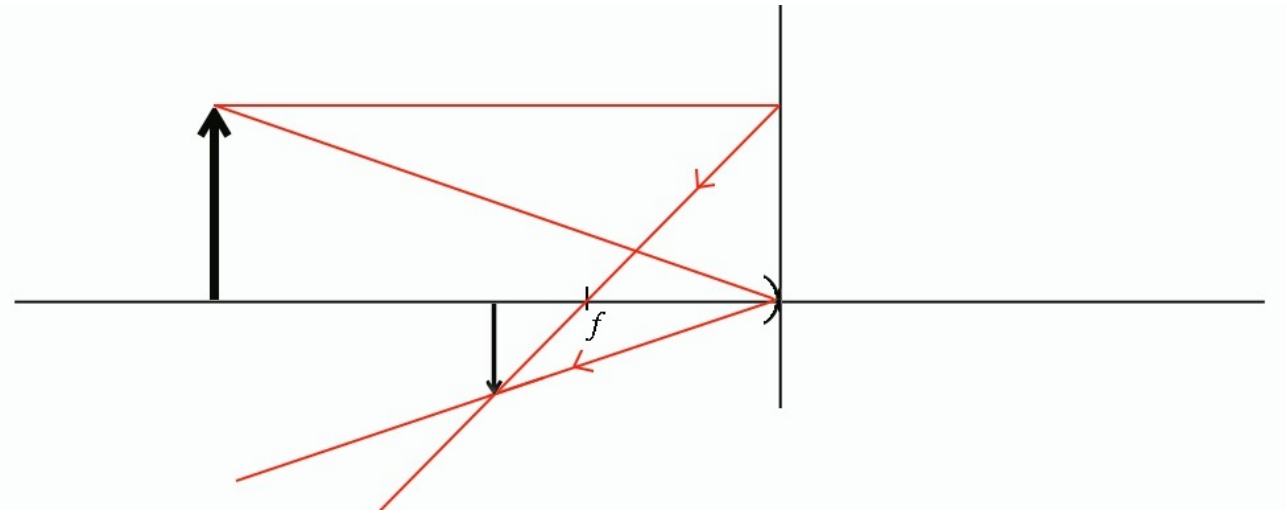


Because arrows on a ray can be reversed to show it going the other way, the ray directed towards the focal point of the mirror must be reflected parallel to the axis. *We know exactly what these two rays will do and can use them to find the tip of the image*.

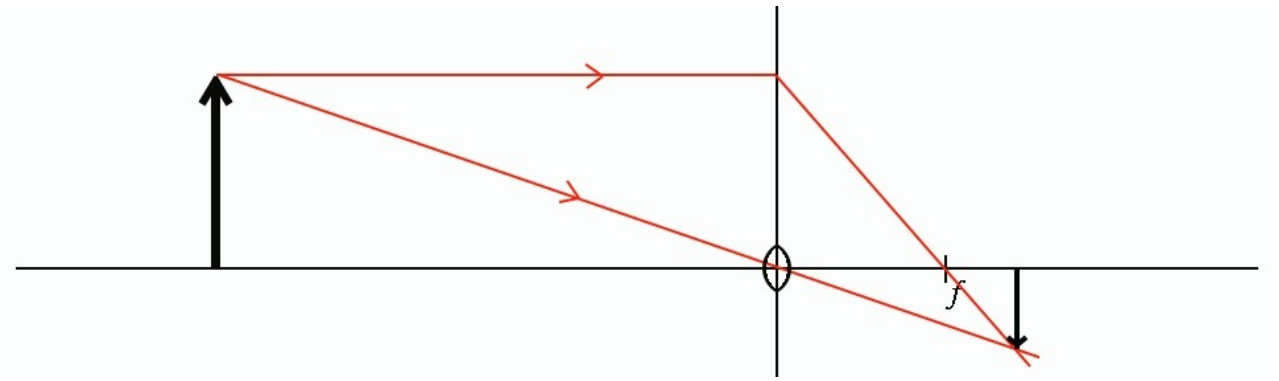
We can use any two of these four possible rays to find the image. It's now a matter of judgement as to which pair is preferred. No one is *wrong* here … but Dad's pair does require less thought to use.

A ray parallel to the axis and a ray to the centre for all concave mirrors and any convex and concave lens gives a simple diagram.

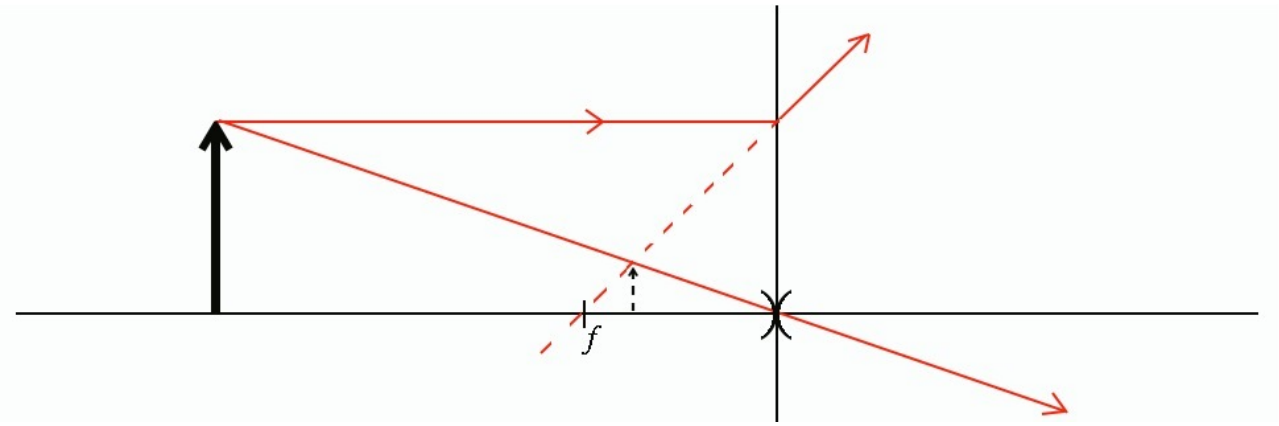
Concave mirror



Convex lens



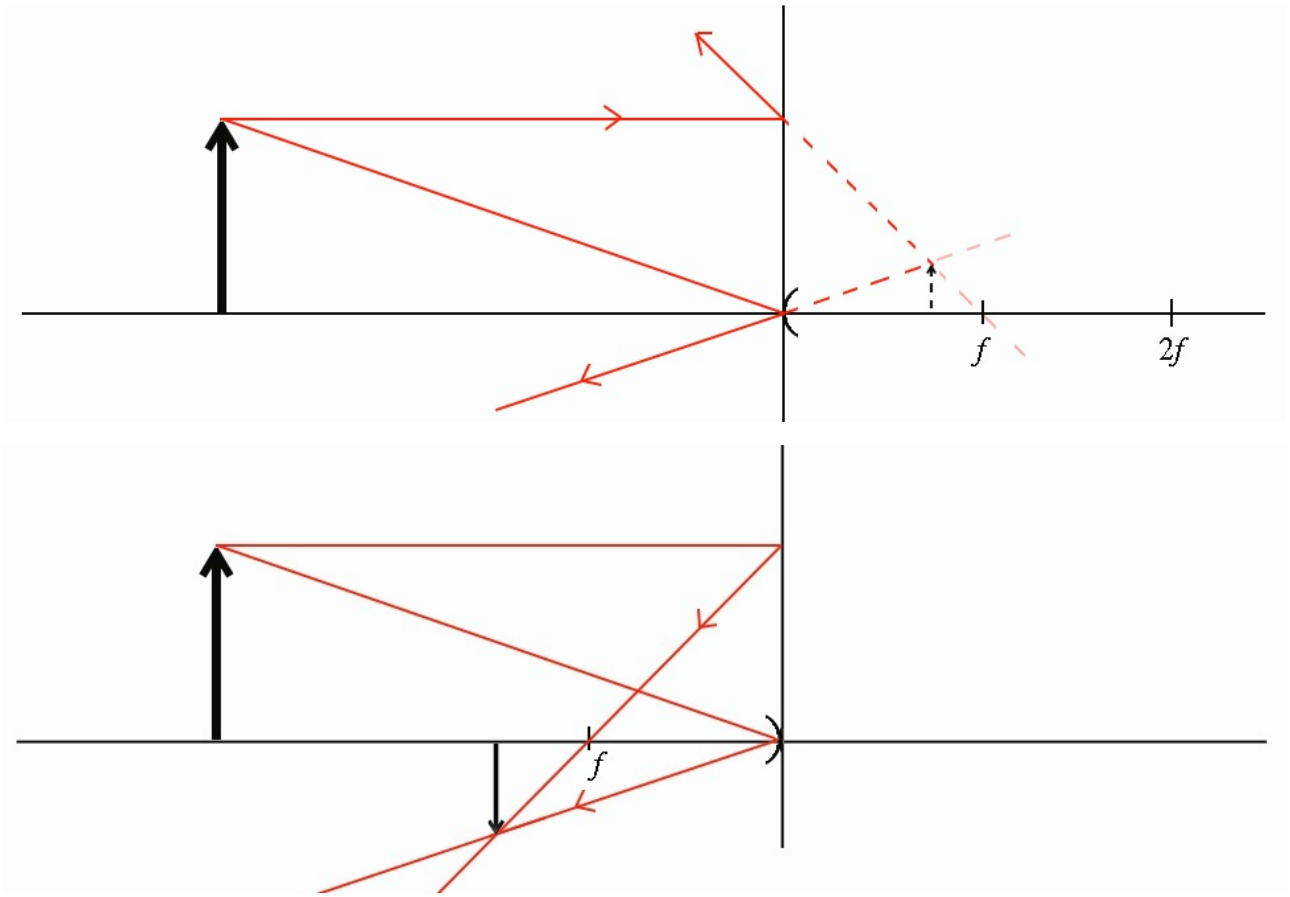
Concave lens



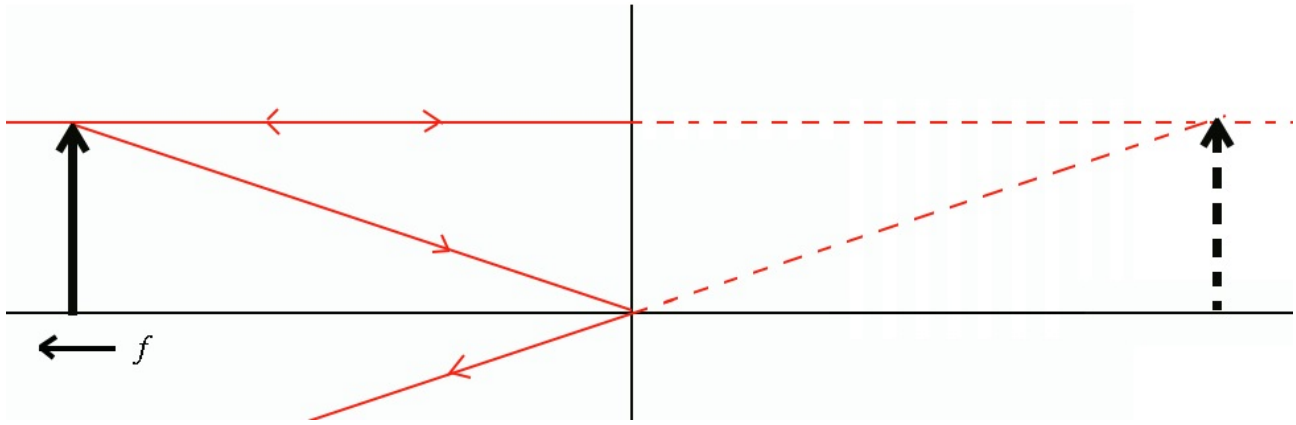
This simple method is recommended …

The image in a plane mirror

Look at diagrams for two mirrors, convex (above) and concave (below).



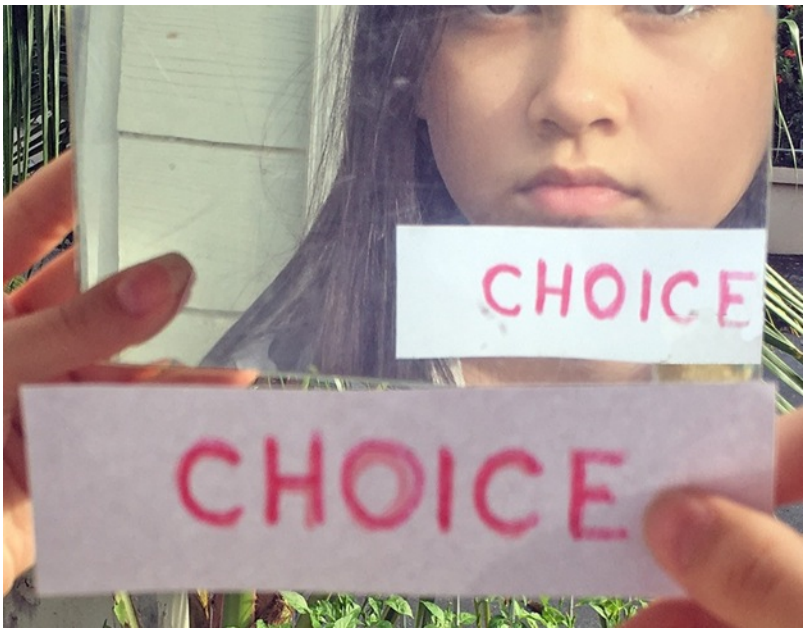
If the focal length of either mirror tends to infinity the mirror becomes flat. The ray to the centre is unaltered, and the second reflected ray (from the incident ray parallel to the axis) rotates to also become parallel to the axis.



As *f* recedes the upright virtual image moves away from the mirror to become the same size as the object at an equal distance behind the mirror.

Lateral inversion

An image in a plane mirror is not rotated by 180º like the image in a convex lens. So why can't we read our own T-shirt slogan in a mirror?



The paper is inked on both sides. The back is presented to the mirror. We are reading the image of the back of the paper in the mirror.

Turning the paper over is interesting. Note that "CHOICE" is a word written with carefully selected symmetrical capital letters