Image inversion

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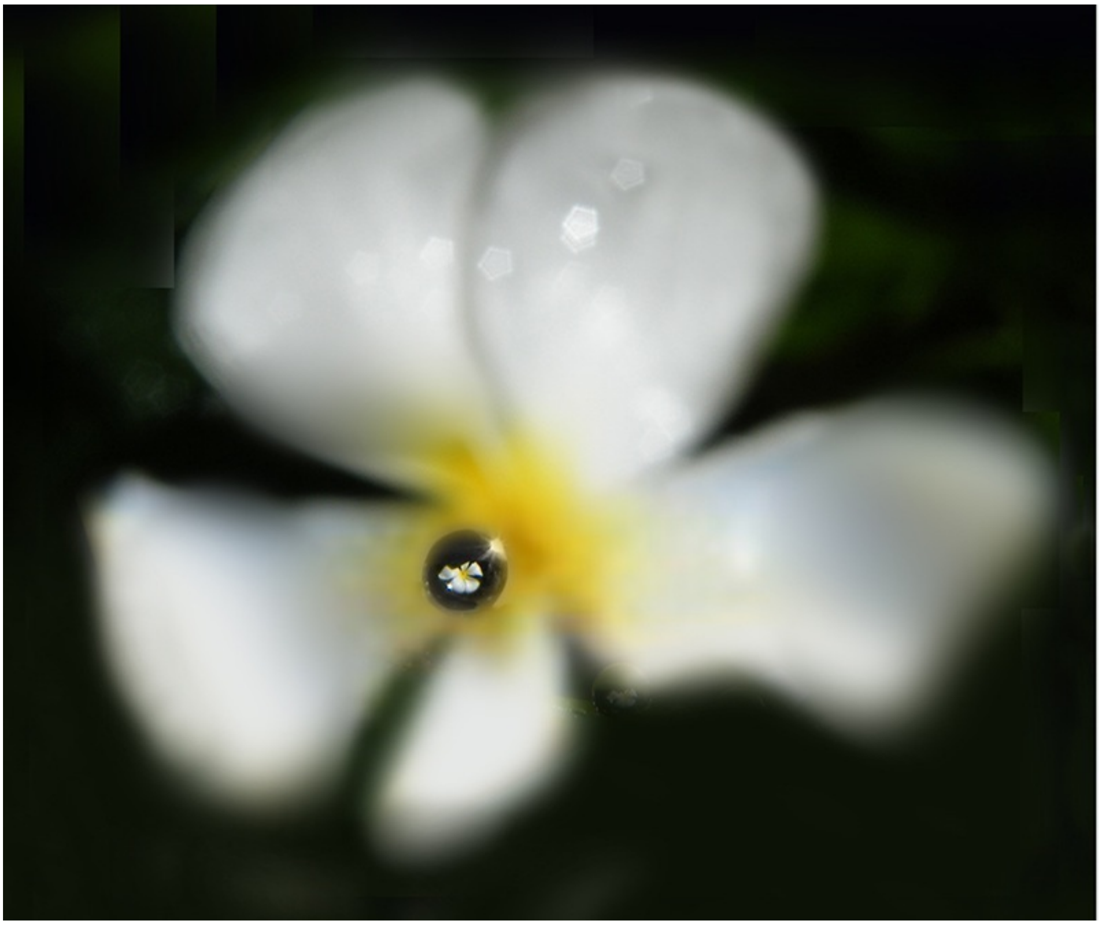
The image on the retina at the back of the eye is said to be upside down (physics texts all say “inverted”). The brain takes the raw image and makes it upright. The story is that if a person wears inverting glasses for a week the brain reinterprets the image and they see normally again. When they take off the glasses the next week is the same in reverse.

The cornea (front) of the human eye is a water lens much like a water drop on a leaf. The image below shows the inversion in a spherical water drop. The real image of the flower is upside down: the books have that part right.



The drop was on a leaf, which has been removed from the image to leave the drop appearing to float in the air as it would be in the space station.

The drop is small and you probably didn't notice something important. To make it easier to see we make the background flower smaller to compare the flower with the image in the drop. (Note: the image is not actually *in* the drop, but in the air outside the water surface on the near side.)

Look carefully at the image. The two wide petals above the centre of the flower are below the centre in the image - the image is upside down but it doesn't look right. Something else has happened.

The flower is not reflected in a horizontal line through its centre: it's *rotated* about the centre by half a turn (180°). The image has been *inverted by rotation* not by reflection. We find an obscure reference to this on the web in an answer to a question on QUORA.

https://www.quora.com › Can-lenses-turn-images-upside-...

Can lenses turn images upside down? - Quora

Jun 2, 2560 BE — To be clear, if a screen is placed in the focal plane of the **image** that is formed by a **convex lens**, the **image** projected onto the screen will be **rotated** 180 ...

The inversion of a real image formed by a convex lens is not the same thing as the *lateral inversion* (reflecting left for right) in a plane mirror.

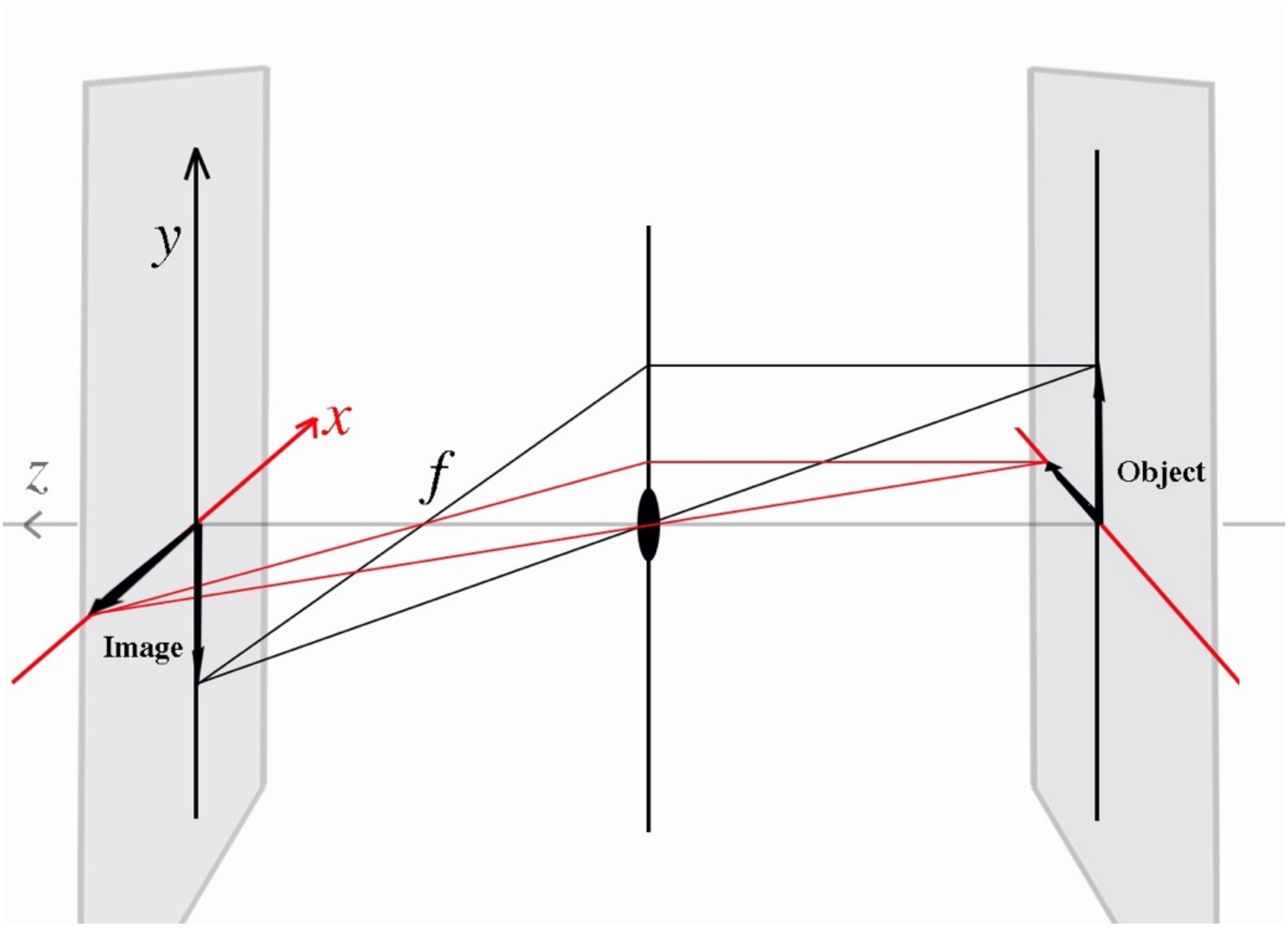
I look normal to myself in the mirror but I can't read my T-shirt. Maybe that explains why some people walk around with unbelievable things written on their shirts?

Note: to read a mirror image of print turn the page over and hold it up to the light. (If you get an exam question that asks for the reflection of a figure in a line AB that's easy. Hold that paper up to the light and look at it.

Textbooks and teachers that say the image made by a lens is "flipped" are thinking of simple ray diagrams that have the image drawn as a vertical arrow. Rotating that arrow 180º is the same as flipping it vertically. To notice that that is only half the story we need to draw a 3D ray diagram.

3D ray diagram in perspective

Ray diagrams are normally drawn with just two aves (horizontal and vertical). The ray diagrams in the articles on the microscope in this site are drawn that way to keep them as simple as possible. To understand more clearly what's happening we need to draw a ray diagram in three 3D.



Take a minute to study the digram. The *x* axis is horizontal, the *y* axis is vertical: object, lens and image are lined up along the *z* axis right to left.

Rays that are parallel to the *z* axis and pass through the focal point, and rays that pass through the centre of the lens, are drawn in black in the *y* plane and in red in the *x* plane. Both the vertical object arrow and the horizontal object arrow swap directions in the image. There are two reflections: one in the *x* axis and one in the *y* axis. It is shown in *Transformations 2* (Math index) that two such reflections are equivalent to one rotation of 180°. The image is rotated by 180° as expected.

To demonstrate the situation shown in the ray diagram above, we put two candles (long and short) on a table about two metres from a light coloured wall, held a large magnifying glass in front of us between the candles and the wall and turned out the lights.

Looking right at the burning candles, the short one was on the *far side*.

Looking left at the wall …

… the image was upside down and in 3D the short one was swapped to the *near side* on the wall. Because we looked *right* from the lens at the candles and looked *left* at the image on the wall when we take the photographs right and left (as above) the short one is on the left in both images.

To see the image of the burning candles rotated in a illustration as it is in 3D, we would need to make the wall translucent like paper and put he camera far to the left beyond the wall along the z axis. In that way the camera is not *turned* to look right and the left between shots and the image in the single photograph is *rotated*, not flipped.

There is another example that leads to similar confusion in the night sky. In the northern hemisphere a new crescent moon has the points of the crescent pointing left.

Imagine you are looking at the new moon in an English sky and fly south to cross the equator and arrive in New Zealand. As you cross the equator you have to *turn round* to look north to see the moon. Turning round, (changing your point of view), makes the points of the same new moon appear to point to the right in New Zealand. It's the same moon but appears to you to have been laterally inverted.

Where might this image of the crescent moon and venus in the evening sky been taken, England or NZ? An illustrated explanation is on the web.

http://www.primaryhomeworkhelp.co.uk/moon/hemispheres.html