Step 4:
Optional: The optical properties of the goggles can be enhanced by blackening the three unused surfaces of the prisms. These are the two rough sides and the upper surface. Paint these with a black lacquer pen or something similar (not felt tip pen or "Sharpie"). This reduces stray light inside the prisms.

C. Fitting the prisms into the goggles
The mounting rings with the glued-in prisms are fitted to the goggles with two of the four provided threaded rings.

Step 5:
Open the visor of the goggles and fit the prisms from the inside so that the short sides of the prisms face the eyes when closing the visor.

Tip: If the little handles on the threaded rings are too long to go past the prism, you can file them down a bit.

Step 6:
Put the threaded rings on the mounting rings and tighten them to hold the prisms in place. If you want to adjust the prisms, you only have to loosen them a bit.

Step 7:
Optional: When you look through your goggles you might find that you notice some reflections overlaying the upside-down picture. These reflections originate from light entering the prisms through the first centimetre of their undersides (the parts exactly below the first half of the angled sides). If you cover this area with a narrow strip of black electrician's tape, the reflections vanish!

Tips for using the Reversing Goggles

Adjusting the prisms:
Put on the goggles and check that the horizontal alignment of the prisms is perfect. Rotate the prisms by small amounts until all straight lines of the objects you can see with both eyes are parallel. If horizontal lines are parallel, but appear at different heights, it is possible that the 90º angle of one prism isn't perfect, or that the goggles are slightly twisted. By bending the visor in the opposite direction you can mend this temporarily. For a more lasting fix, you can fit slips of paper between the mounting rings and the visor to adjust the angle.

Experimenting:
Important: The Reversing Goggles will affect your sense of balance!

Don't make any moves that could lead to a fall or possible injury. If you want to investigate the physiological effects of reversed vision you should wear the goggles for at least an hour. But be careful: a sensitive person can develop motion sickness when wearing the goggles for prolonged periods of time.

- **Up and down reversal:** The prisms are mounted with the underside facing up or down. Try out which possibility gives you the best field of view. Try for example to shake someone's hand, grab different objects, drink water from a glass, fill a glass with water, write something, or try walking around (with someone else guiding you).

- **Left-right reversal:** Turn the prisms 90º so that the rough sides face up and down. Try the same experiments again and find out how your spatial sense and the ability for spatial vision changes.

KLAUS HÜNIG

The Reversing Goggles

Kit for a pair of prism glasses, using total internal reflection.
Choice of upside down or left/right inversion.

- Lightproof, vented case
- Prism holder made from sturdy MDF
- High quality Dove prisms made from lightweight PMMA
- 35 x 20 mm picture size
- Prism visor can be raised
- Suitable for spectacle wearers

AstroMedia

Hands-on Science Series

AstroMedia Verlag
45731 Waltrop

© Klaus Hünig, Translation: Andreas Schröer
Made in Germany

Article-No. 829.UBR-E
4 260568 978296

What is vision? This question was already under discussion in ancient Greece. Later, from his work with optical lenses, Leonardo da Vinci discovered that the picture on the eye's retina is turned upside-down by 180 degrees. Of course that leads to the question how this upside-down picture can still enable us to see properly and experience our surroundings the right way up.
In 1896 the American George Stratton was the first to experiment with a one-eyed inverting prism over several days. These ground-breaking experiments to understand the optical sense have been continued by several scientists, the most important one being Ivor Kohler from Innsbruck in Austria.
Even today scientist are still investigating the effects of inverting glasses, as a quick internet search will show. The main result of these experiments would be the same with your new Reversing Goggles, although single prisms can only swap up and down, but do not swap left and right.
In the past, vision has been understood as some type of "mechanical" process, like analogue photography, or television. In recent years it has become clear that the camera-like process in the human eye is only turned into vision by complex activity in the brain itself.

This kit contains:

- 1 set of goggles with threaded rings to hold the prisms (two of the four rings are spares)
- 2 OptiMedia Dove Prisms
- 2 MDF mounting rings for the prisms
- A file

What you need for completion:

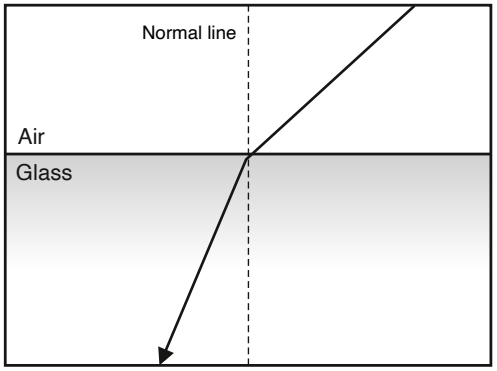
- A set square or something else to determine 90º angles
- Quick setting two-component glue (eg UHU Plus Schnellfest)
- Optional: a black lacquer pen to cover the inactive sides of the prisms (a normal felt pen doesn't work because of its lack of black pigments)
- Optional: some black electrician's tape to eliminate unwanted reflections

Assembly instructions

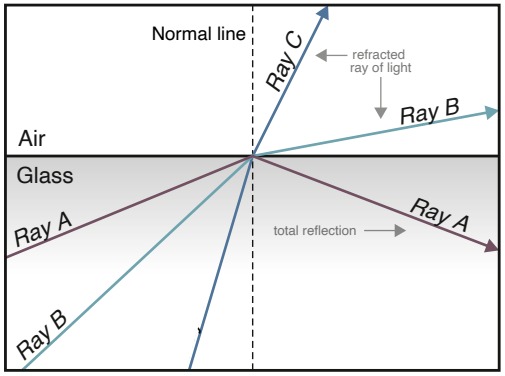
Please always read completely through each step before commencing.

A. Preparing the Dove prisms

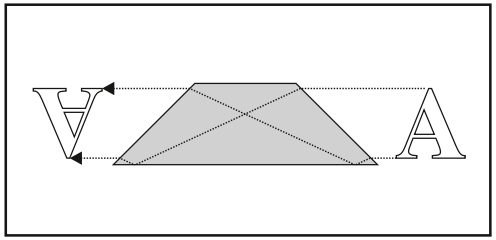
A Dove prism is a reflecting prism. It is used to reflect light, not to refract it. The reflection occurs on the largest surface of the prism. This phenomenon, which occurs even without a reflective coating of the surface, is called total internal reflection and can be explained by the law of refraction found by the dutchman Snellius in 1618: If a ray of light coming from an optically thin medium (air) hits an optically thicker medium (glass) it is refracted towards the normal line. In the opposite case it is refracted away from it.



Total reflection occurs inside the prism when the light hits the surface at a very small angle



(*Ray A*). Because of Snell's law the angle of reflection will then be greater than 90º and the light is therefore reflected back into the glass. This happens until it hits a surface at a sufficiently large angle, so it can leave the glass again.
Most prisms used for total internal reflection are equal-sided and right-angled.
Nevertheless the top part of these prisms is actually not needed. We are using Dove prisms which have the top bit cut off, which is the reason for its unusual shape. A picture that is projected into one of its sides is reflected on the underside of the prism and therefore appears upside-down on the other side:



Tip: The only optically important surfaces of the Dove prism are the underside and the two angled sides. Be careful not to touch these sides. Fingerprints can be carefully removed with a soft tissue and some soapy water. It is best if you only touch the two rough sides of the prism.

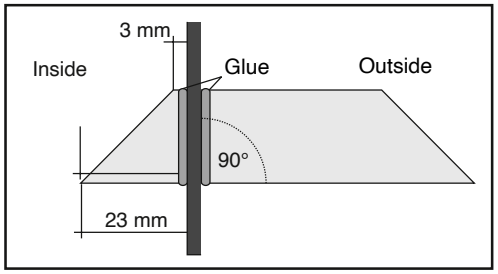
Step 1:
Careful: the edges of the prisms can be very sharp! Use the file to smooth over all edges to avoid any danger of cutting yourself.

B. Mounting the prisms

The black side of the mounting rings faces the eyes, the blue one faces outwards.

Step 2:
Push a prism from the blue side through the rectangular hole until it sticks out by 23mm on the inside (57mm on the outside). The upper surface should stick out about 3mm on the inside as well. Use set squares to check that the prisms are at right angles with the mounting rings.

Tip: The width of the prisms can vary slightly by tenths of a millimetre. If the mounting rings are too tight you can widen them slightly with the file. If the prisms are too loose, you can temporarily add slips of paper to stabilise them whilst applying the glue.



Step 3:
Apply glue only to the rough sides of the prisms and if you want to the upper surface. Do this on both sides of the mounting rings. **Make sure the underside stays free from any glue!** Put the prisms carefully on the edge of a table with the mounting rings hanging free while the glue sets. Check again that the right angle is as accurate as possible.