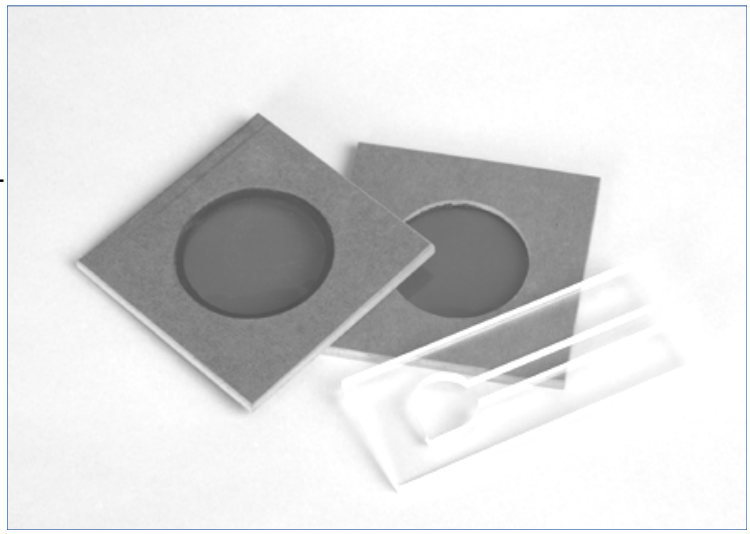
32613 Novel Crossed Polarizers



Purpose:

Polarizing material is usually supplied in square cut sheets with the axis of polarization aligned along one edge of the square. The material in this apparatus was die-cut in a circle and then mounted in a square frame. This provides some demonstration events that are at odds with the usual expectations of students who see this, at first, as a "... ho hum, been there, done that..." demonstration.

Required Accessories:

Overhead projector, or other light source
Polaroid® Sunglasses

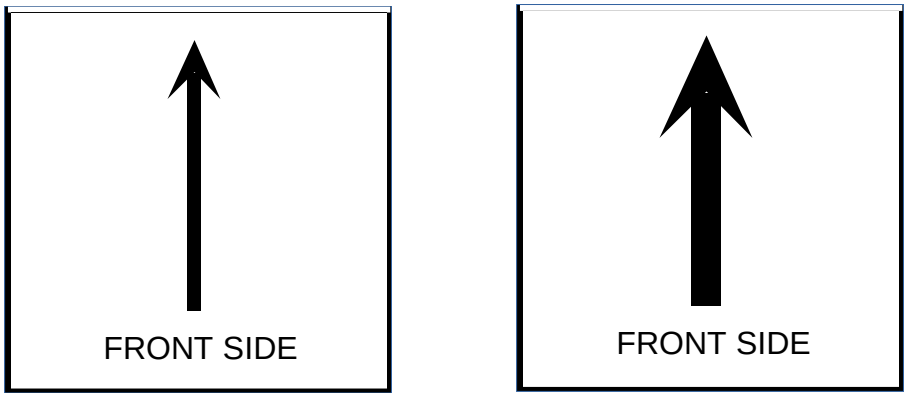
Background:

Of the four possible ways of polarizing light, this apparatus uses a dichroic material which first separates unpolarized light into two components and then absorbs most of one component. This property is attributable to long chain molecules in the material. Used in pairs, the mounted material in the first frame "polarizes" the light passing through it and the second frame of material "analyzes" it by allowing anything from a minimum to a maximum to pass through it. A 90 degree rotation of the analyzer will go from maximum to minimum transmission of the polarized light. At maximum, only about 20% of the incident light will pass through, so a bright enough source must be used for demonstration. An overhead projector is perhaps the best way to share the experience with a group, but individuals might use a light box, or a sky-lit window against which to view the behavior of the polarizing material.

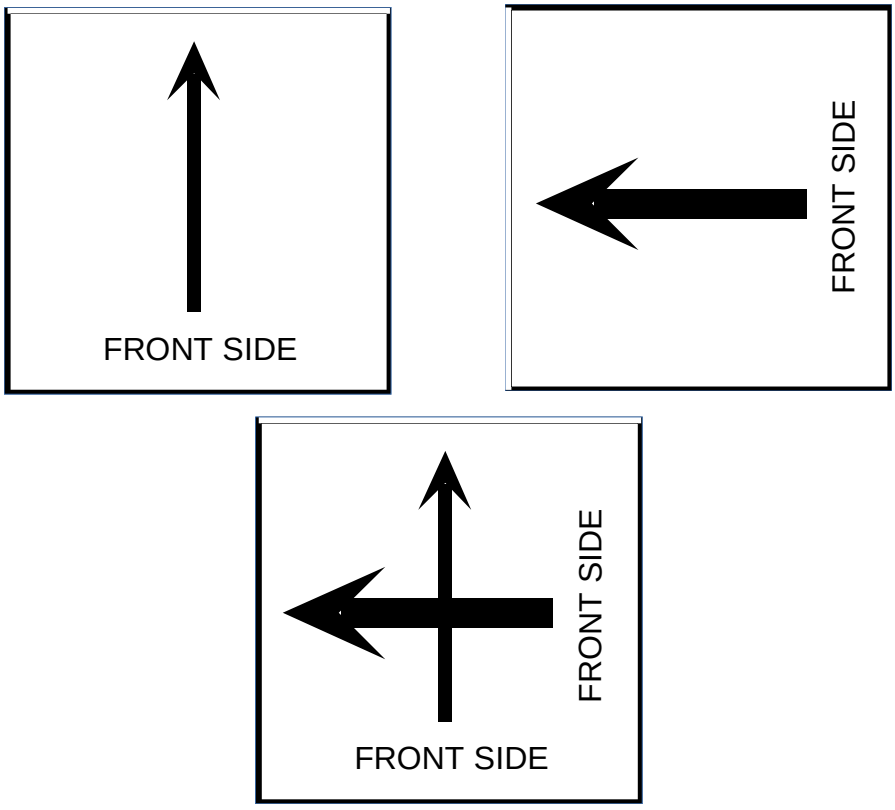
Non-Destructive Testing of certain materials is often accomplished by stressing samples of proposed structures between crossed polarizers. Sunglasses can be quickly tested to see if they are a polarizing type. While wearing the sunglasses in the normal way, look through one of the frames of this apparatus while rotating it. If the illumination changes every 90 degrees of rotation, then the sunglasses are a polarizing type and will be useful in a later activity using this apparatus.

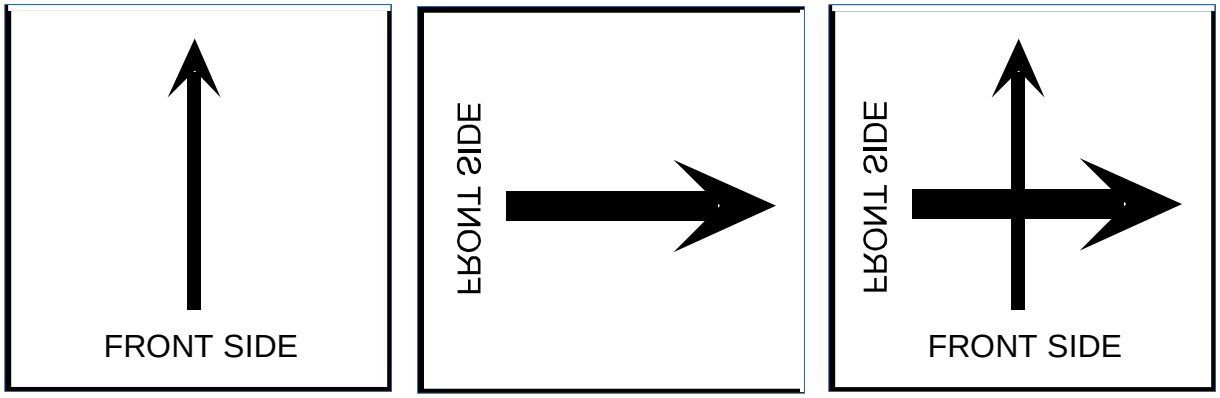
Initial Exploration:

The first thing to establish is the orientation for pieces of polarizing material for the maximum and the minimum transmission of light. Suppose the two pieces pictured here were superimposed without any rotation. One would expect that since the axis of polarization (indicated by the arrows) is the same, that light would be transmitted through the stacked pair at a maximum.



But, if either one were rotated by 90 degrees first, then the stack would transmit light at a minimum, as shown here.



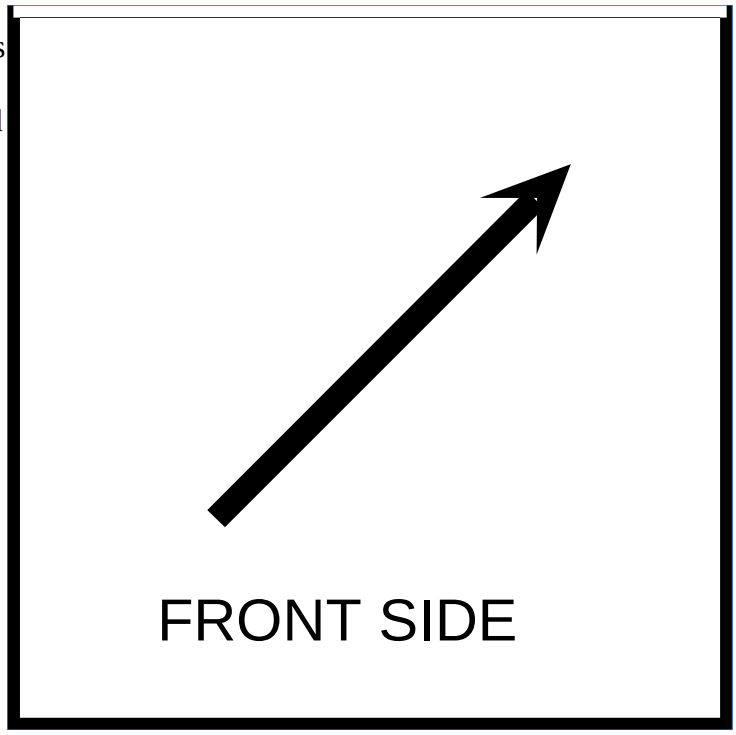


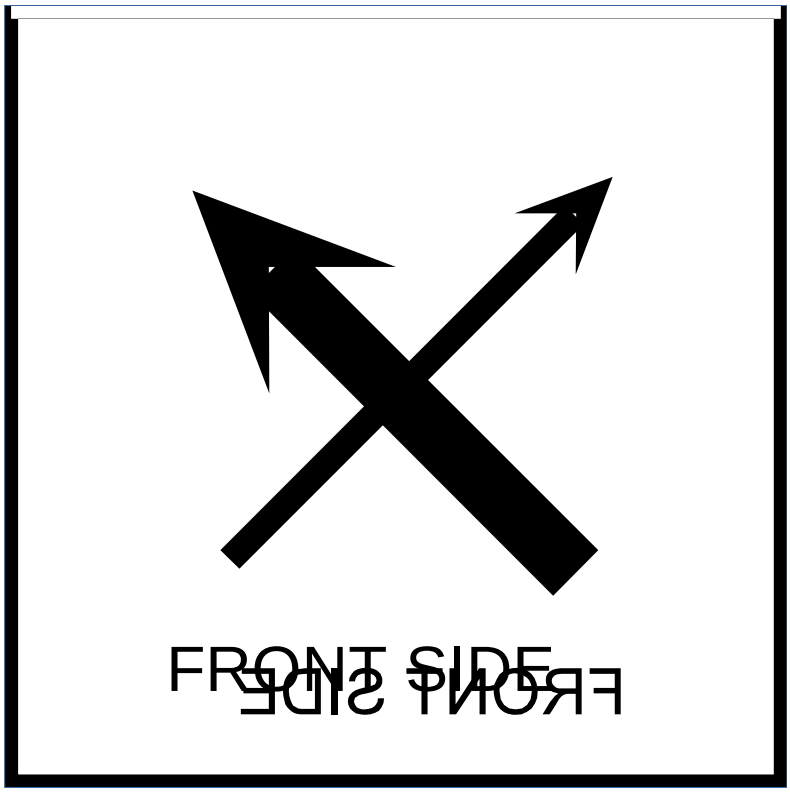
Now, if we flipped either one of them over and tried this, it would still give a minimum. Using the printing master on the last page, either paper copies or transparencies of the figures above can be made to confirm all these details. This is an important initial exploration and should be conducted BEFORE attempting any of these using the apparatus.

Exploring With Apparatus:

Now, try this with the frame mounted polarizing material included with these instructions. The frames obviously have a front and a back side, based on a careful look at the perimeter of the disk of polarizing material.

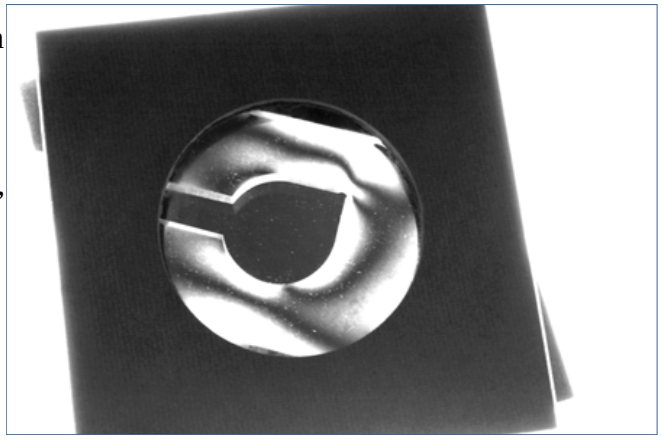
Choose, the side you want to be the FRONT side and search for the minimum and maximum transmission as before. So far, so good. But, now try flipping one of the frames over so the two frames are back to back or front to front and — something is different. When the frames are now matched up on the sides, the behavior is different. By slowly rotating one of the frames over the other, you should be able to get the idea that the axis of polarization is not aligned with the edge of the square frames. Perhaps it as aimed along a diagonal, but which diagonal?





Again, using the printing masters on the last page, make transparencies or study prints that can be cut apart and used to ponder the behavior of the frame mounted polarizing material. A real help in concluding this will be to use a pair of polarizing sunglasses as a reference. Reflections of sunlight off of water will be partially polarized horizontally (the vertical component being preferentially refracted and absorbed by the water). This gives a powerful clue as to the polarization axis of the sunglasses, since the wearer will want to minimize this glare off the water.

Studying Stress:



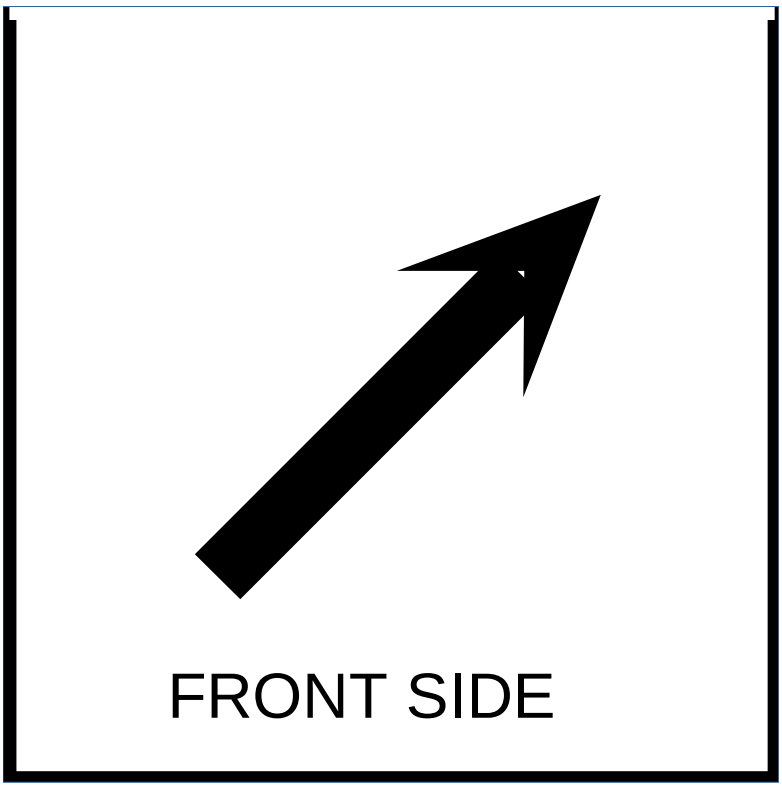
With the frames oriented to minimize the transmission of light, introduce the plastic sample between them. Projecting the ensuing demonstration on an overhead projector will enable a group to discover that when squeezing the “handles” of the sample gently together, a pattern of light and dark regions is projected, if the sample is made of an optically active material. In this case, each continuous light or dark region is experiencing the same strain. It is easy to see that these internal forces are quite concentrated at the sharp corner compared with the smooth circular region. Noticing this will help in the analysis of the other details seen in the pattern.

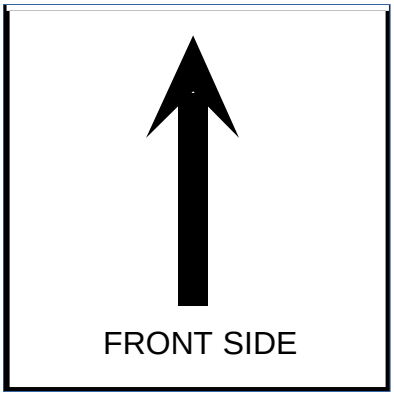
Other Things:

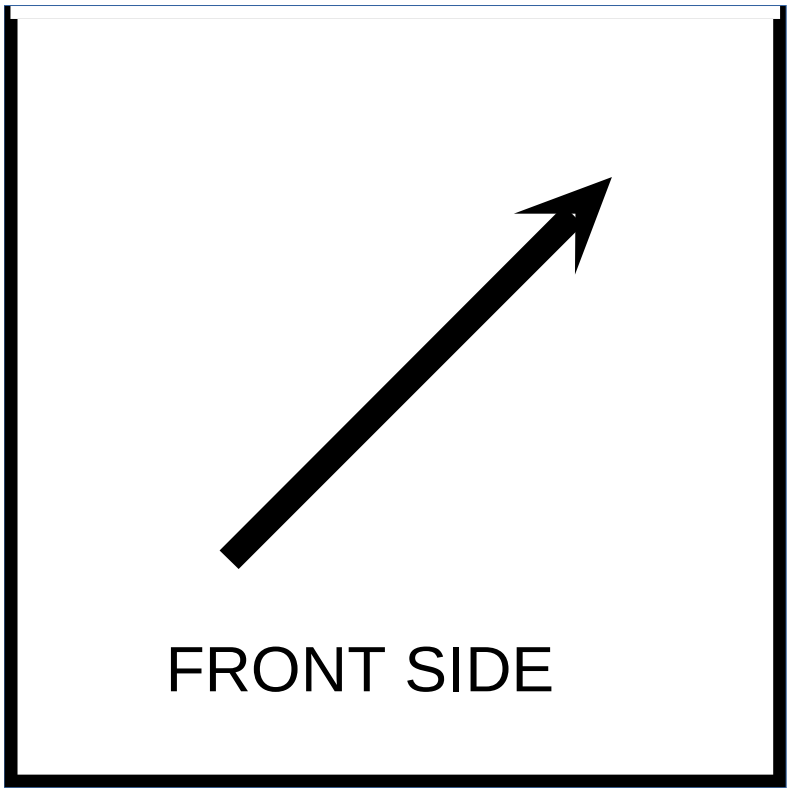
Between crossed polarizers, many other materials take on a new and informative presentation. Among these might be listed:
Mica, cellophane, and corn syrup.

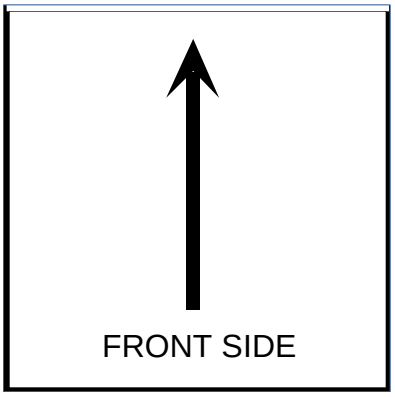
Time Allocation:

To prepare this product for an experimental trial should take less than ten minutes. Actual experiments will vary with needs of students and the method of instruction, but are easily concluded within one class period.






FRONT SIDE


FRONT SIDE