RAFT IDEAS

Topics: Light, Color, Filters, Waves

Materials List

- ✓ RAFT polarizing filter material (with adhesive backing or tape), 17½ cm x 15 cm (7" x 6")
- ✓ Die-cut a foldable box (with opposing window openings) or cut with scissors
- ✓ Light blocking file folder material, or equal, to die cut
- ✓ Envelopes, 2
- ✓ Marble or aluminum foil (marble-sized) ball
- ✓ Scissors
- ✓ Paper cutter would be helpful
- ✓ Permanent marker

This activity can be used to teach:
Next Generation Science:

- Senses (Life Science, Grade 4, 1-2; Middle School, 1-8)
- Light reflects from objects, enters the eye, allows objects to be seen (Grade 4, Physical Science 4-2),
- Waves are reflected, absorbed/ transmitted (Middle School, Physical Science 4-2)
- Science/Engineering Pract. (Grades 3-12)

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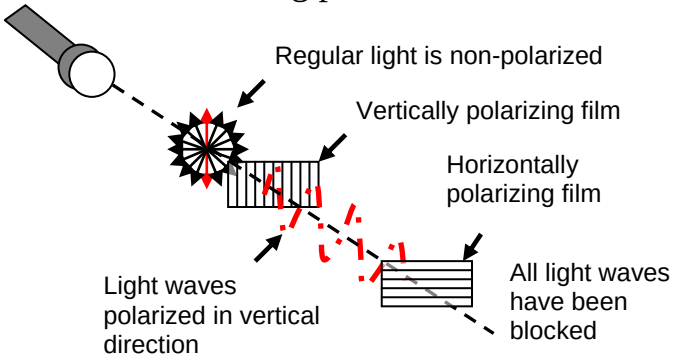
Breaking Through Barriers

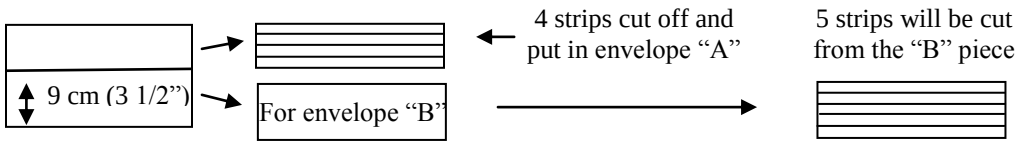
A cool illusion using polarized filter material.



Explore polarized light using polarizing filter material. The displays of many common electronic devices are covered with a polarizing filter to cut glare.

Assembly (Steps 1 to 12 are done by the teacher before doing the activity)
The RAFT polarizing filter material has thin protective coverings on **both** sides. In some of the steps one (and **only one**!) of the protective coverings is removed.

1. On top of the protective covering on the side **without the price sticker** draw roughly parallel lines from top to bottom using a permanent marker. Space the lines about 1 cm (3/8") apart. The lines do not need to be neatly drawn.
2. On the side of the material **with the price sticker** draw a line, parallel to and 9 cm (3 ½") from a longest side, as shown.
3. Starting from the side nearest the drawn line use a paper cutter or scissors to cut 4 (**and only 4!**) 1.6 cm (5/8") wide strips parallel to the single drawn line as shown.
4. Remove the **unmarked** protective covering from one side of each of the 4 strips.
5. Put the 4 strips into an envelope labeled "A".
6. Place the remaining large section of filter material in an envelope labeled "B".
7. From each of the 4 strips in envelope "A" material cut 10 sections 1.7 cm (11/16") long. Scissors will be needed to make the last cut on each strip as a paper cutter's finger guard would prevent cutting the last narrow section.



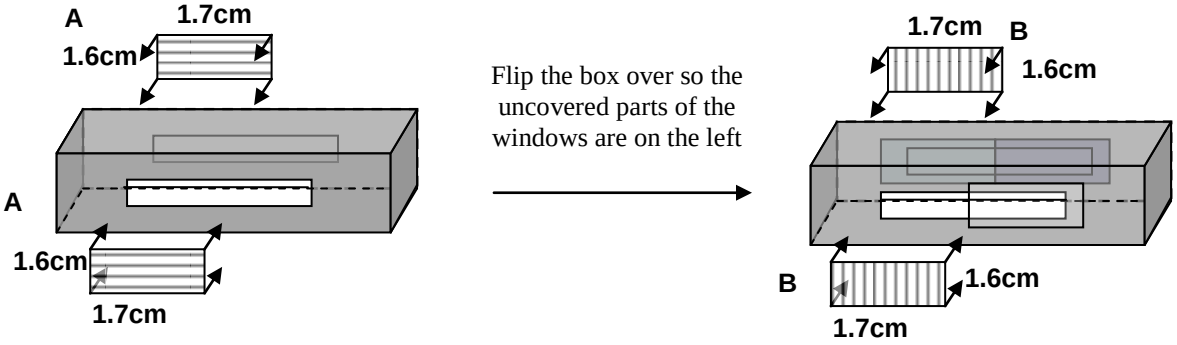
8. Put the 40 cut pieces from the "A" strips back into the "A" envelope.
9. Remove the polarizing filter material from envelope "B" and removed the **unmarked** protective covering. Cut the rectangle into 5 strips that are 1.7 cm (11/16") wide. Then cut each strip to make 8 pieces 1.6 cm (5/8") long.
10. Put all 40 cut pieces into the envelope labeled "B". Save the uncut section to use to cut out additional sections, if needed.
11. Die cut 20 boxes with opposing windows from dark file folder material.
12. Cut aluminum foil into 20 squares roughly 7.5 cm (3") on a side.

The following assembly steps are done with the students:

1. Fold the die-cut box along the dotted lines or creases and assemble the box so that the darkest side of the material will be on the interior of the box.
2. Give each student 1 section from the "A" envelope.

Written by Gus Liu (RAFT)

3. Students place the section over the left half of a "window" oriented so the marked lines are running **parallel** to the long edges of the box. See the illustrations below.
4. Have students remove the marked covering and attach to the box in the same orientation as in step 3.
5. Give each student a second piece from the "A" envelope.
6. Students flip over the box so the uncovered window is facing the student and the attached section is on the left side in the back. Repeat steps 3 and 4 checking that light can past through both filters before attaching.



7. Give each student a section from the "B" envelope and repeat the steps 3 to 4 except the orientation of the marked lines must be **perpendicular** to the long box edges. Give a 2nd "B" section for the other window. Check that light can past through both filters before removing the protective covering and attaching.
8. Give each student a cut section of aluminum foil to crumple into a ball and then put into the box.

To Do and Notice (Warning – do not look at the Sun through the polarizing material!)

1. Hold the box level and look through the window. What is observed?
2. Tilt the box back and forth and watch the foil ball roll inside the box. What is observed?

The Science Behind the Activity

A polarizing filter is often modeled by imagining a rope running between the stakes in a picket fence. The fence (the filter) only allows waves going up and down, in line with the gap in the fence, to pass through. Waves made by shaking the rope side to side would be blocked by the stakes in the fence. While the model is correct, to an extent, the rope/fence model would appear to indicate that only a small fraction of the light waves, only a wave going exactly up and down, will pass through the filter, while the other 99+% of the light is blocked. That is clearly not the case as a polarizing filter seems to only slightly dim the image seen through the filter material.

A light wave can be thought of as having an up and down component and a sideways component that when added together create the specific orientation of the light wave. A light wave with only a sideways component would be fully blocked by the polarizing filter (the "fence") that is oriented to allow only up and down light waves to pass. The filter will absorb the light waves traveling sideways. For all of the other possible orientations of the light waves the sideways orientation would still be blocked, but the up and down component of each wave would be able to pass through the filter.

When two polarizing filters are overlapped and the polarizing orientation of one is oriented 90° to the other, one section allows only the sideways component (for example) of the light waves to past through while the second filter blocks the sideways components. The result is that, effectively, no light can pass through the area where the polarizing filters are overlapped. No polarizing filter material can absorb (or block) 100% of the light passing through the material. A small fraction of light having the "filtered" orientation will still be able to pass through. The RAFT polarizing filter material, even with the protective covering over the adhesive left in place, absorbs enough of the light to demonstrate the polarizing effect.

Web Resources (Visit www.raft.net/raft-idea?isid=561 for more resources!)

- Teacher information & activities – http://www.arborsci.com/CoolStuff/New_CoolStuff_Articles/cool28.aspx
- Interactive animations & more, for students – http://www.colorado.edu/physics/2000/polarization/index.html