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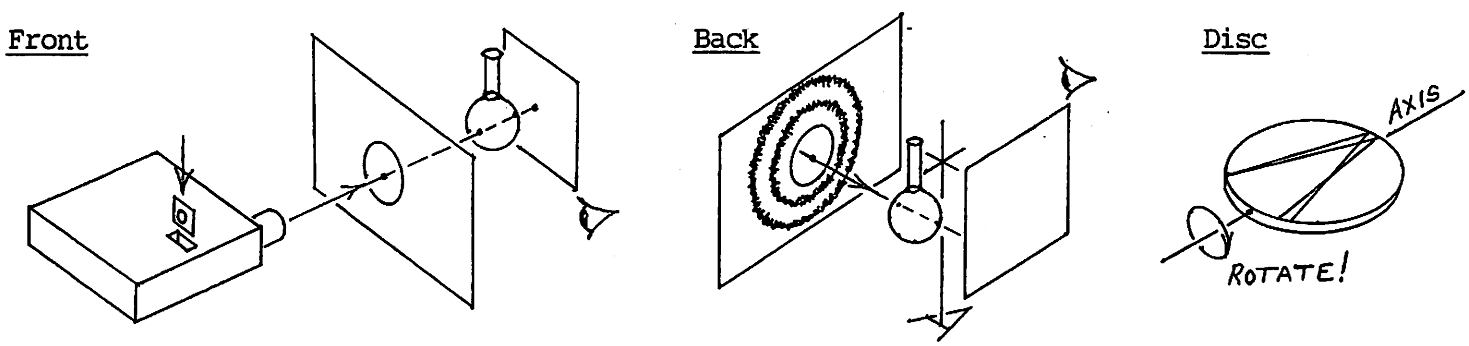
The rainbow - dispersion via refraction, internal reflection, and further refraction. We humans have been fascinated by rainbows for thousands of years. It is one of nature's grandest, non-threatening spectacles whose appearance and disappearance have stirred artists, poets, and composers for centuries. We commonly see it in the spray of a garden hose, a fountain, and a waterfall on a sunny day but only from certain angles. By chance, we see it on the outer edge or "curtain" of a late afternoon (4-6 PM?) rainstorm that has just passed, the sun has reemerged, and we happen to be standing in the right place. In otherwords, rainbows are a bit complex; certain conditions must exist before they emerge. It would require the brilliant Isaac Newton to provide us with the first complete explanation. Now we can, by illustration and demonstration, explain and see a rainbow recreated in the classroom. (Newton would be proud!) This topic should be addressed near, or at, the end of the study of light when dispersion, refraction, internal reflection, etc. are well understood. See the accompanying sheet of illustrations to be shown and discussed. The diagram below illustrates the apparatus set up for an actual "one-raindrop" rainbow(s). The "raindrop" will be the water-filled, 500 ml flask, and the slide projector will provide the "sunlight". Make up a cardboard screen and a metal slide, and you will have an interesting classroom "rainbow" for years to come, one well worth the effort!

Diagram:



Materials: slide projector, metal slide, large, one-hole cardboard screen, 500 ml round bottom (boiler) flask, light shield, ring stands(s), flask clamp, right angle clamp, etc.

Preparation: (a) Make up a 2" x 2" metal slide with a 5/8" dia. aperature in the center to narrow the beam.

(b) Make up a 40" wide x 28" high, white cardboard screen with a 5 3/4" dia. hole in the center. Glue two 22" x 28" pieces of posterboard together, and cut the hole with a box cutter on a scrap piece of corrugated cardboard.

(c) Fill the flask to the bottom of the neck with clean water and stopper it to stop evaporation. (I store my flask permanently sealed where it won't freeze. Thus, I avoid waterspots on the inside of the flask.)

(d) You need to provide a light shield, painted flat black or made from black posterboard, so students are not blinded by the projector's extra light. You decide the size of the shield needed.

(e) Spacing. Start with the projector and the light shield about 43" apart. With the metal slide in place, focus the beam on the shield, and insert the flask about 3/4" in front of the shield. Insert the one-hole screen about 30" from the projector's lens and center the hole around the beam. (Refocus the beam on the edge of the hole.) Move the screen back and forth a little to find the best concentric circles (bows) on the screen. Refocus again if necessary. You should have two sets of circles or bows, the primary (outer and bright) and secondary (inner and dimmer). You will notice the need for a darkened room; the bows are not terribly bright. Students will need to gather around for a better view. However, it is still nice to see the real phenomenon.

Explanation (Presentation): (a) First, the sheet of illustrations. You decide if you want to make copies for each student, an OHP transparency, or both. Fig. 1 is straight forward. At this point, you might make up a large disc (8" dia.) from white cardboard with the rays drawn on both sides that can be rotated around an axis to show the reason for the concentric circles (bows) to be seen later in the demo. See Diagram. Especially note the exit of the violet and red rays, that can't be seen by one eye at the same time; you have to move your head up or down to see the other.

(b) In Fig. 2 you can see why the sun must be behind you, its light coming over your shoulder. Note also the low angle, like the sun in late afternoon (4-6 pm) in the west while you are looking eastward at the edge (curtain) of the storm just past. Note the position of the red rays above the violet rays. IN Fig. 1 they are reversed. Why? Actually, both Figs. are correct. Note the slope of the rays in Fig. 1 and Fig. 2; the reds match, and the violets match.

(c) Fig. 3 explains why Figs. 1 and 2 are correct and match up. You can't see red and violet from the same raindrop. Red must be coming from a higher drop and violet from a lower (separate) drop. The remaining colors (orange→blue) must be coming from additional drops in between. With millions of droplets in the "curtain" of the passing storm (still raining east of you), there is enough light to make all of the colors of the bow.

(d) With the apparatus properly aligned, spaced, and focused ahead of time, turn on the projector and view the screen from the "flask" (back) side. The "sunlight" has passed through the hole in the screen, passed into the "droplet", reflected, and passed back out to head back and hit the screen. Note that on the outer, primary bow, the outer color is red, as you would expect. Interestingly, the inner, secondary bow's outer color is blue, the reverse of the primary due to the extra reflections going on inside of the "droplet" (flask); the reflections get complicated. Nevertheless, you have witnessed "one-raindrop" rainbows in the classroom!

(e) A bonus. If you look at the light shield behind the flask, it is lit up by the light passing through the flask. (Most of the light entering the flask goes on through and is not part of the rainbow-making.) Move the shield until a fine, bright point of light is found. You have just located the focal point of the flask acting as a convex, water lens. And it is three-dimensional! A mist (smoke?) of somekind will show it clearly.

Finally, it is a nice demo to end with as you complete the unit on light. It reviews important concepts and puts them together to display and explain one of nature's great gifts. Neat!

Physics for High School by Kelly and Miner (Ginn, 1967), p. 509 & 510.

"The rainbow."

Fig. 1

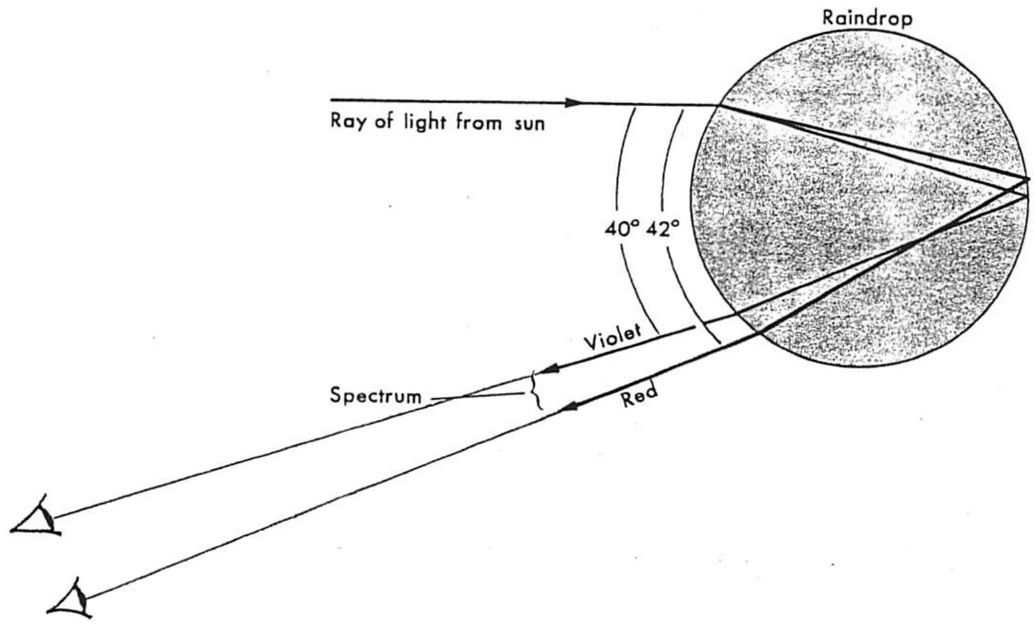
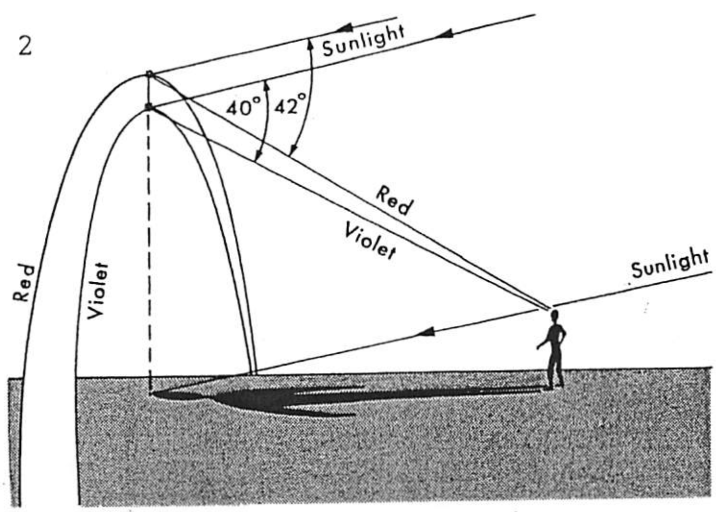


Fig. 2



The arch of a rainbow appears to be centered on a line from you to the shadow of your head.

Fig. 3