A WORKSHOP ON COLOR AND LIGHT
Presented by
Physics Department
University of Northern Colorado
and the UNC Seminar in Teaching Physics Class

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1. CORNER MIRROR

Most people think that mirrors transpose the left and right sides of images. Actually, it is precisely because they DO NOT that things look funny in a mirror. A mirror actually changes the front and back of the image. For example when you look into a mirror, the image faces you so you see your the face in the mirror rather than the back of your head. All other things are the same. It is possible to make a mirror that actually shows an image of what you actually look like to other people. It is simply constructed by placing three mirrors all at right angles to one another. However, if people look into such a mirror they will think things look strange since people are so used to looking into real mirrors.

2. FLYING

When we look into a regular mirror the image is not on the mirror but on the other side, equally far behind the mirror that the object is in front. This can give rise to some very interesting illusions. Try straddling a large vertical mirror. Then gradually lift your leg on the mirror side while standing on the other leg. To anyone in front of the mirror it will give the illusion that you are flying!!

3. NEW HEAD

This demonstration also makes use of the fact that images are as far behind the mirror as the object is in front. Have one student stand a few feet in front of a tall mirror that does not quite reach their head. Have a second student stand equally far behind the mirror. It is possible to observe some very interesting people this way. A girl with a football player's physique or a tough boy in a pretty dress.

4. IS WHITE WHITE?

Cut a rectangle about 1" by 2" from the center of a white index card. Hold this card in front of a second index card so that you can see the second card through the hole. If you turn one of the cards up or down, the two cards seem to change color. One gets whiter and one gets grayer as different amounts of light fall on them.

5. DISAPPEARING PENNY

This will demonstrate the principles of refraction and total internal reflection. Put a penny underneath a clear plastic tumbler. Show that the penny can be seen from the side even when a piece of cardboard covers the top of the tumbler. Then fill the tumbler with water to the very top and again cover the top with a piece of cardboard. The penny will have seemed to have disappeared. Explain that the light from the penny is being refracted as it enters the bottom of the tumbler. When it hits the side of the tumbler, it strikes at such an angle that it undergoes total internal reflection and can only exit the water at the top surface. This is really the principle of fiber optics. Light enters one end of the fiber and can only exit at the other end.

6. CYLINDRICAL LENSES

Why do letters printed in one color turn upside down while letters in another color do not? Try printing the following words on a sheet of paper. Print the normal letters in blue and the underlined letters in red.

BLUE + RED   DIOXIDE GLASS

If the cylindrical lens (pop bottle filled with water) is held close to the words, everything looks normal. However, when the cylindrical lens is held about 2 to 3 inches above the paper, the red letters turn upside down while the blue ones do not! Actually, the blue ones also turn upside down but because they are symmetrical they appear to read the same.

7. TYNDALL EFFECT

Different colors of light have different wavelengths. Red is long; Blue is short. (Actually they are all rather short, only about 5 ten thousandths of a millimeter, but red is longer than blue.) When encountering small objects, long wavelengths tend to bend around easiest while short wavelengths tend to reflect the easiest. When light travels through something with a number of small particles the red light tends to go on through but the blue light tends to be scattered to the side. Thus the sky is blue and the sun turns red at sunsets. This can be demonstrated using an overhead and a large beaker of water. As small amounts of coffee creamer are added to the beaker, the water in the beakers tends to become tinted blue and the light passing through to the wall becomes tinted red. Remember, pretty sunsets usually mean lots of pollution!

8. BUBBLES

Nearly everyone has played with bubbles and noticed the colors. The colors are produced as the water between the two surfaces of the bubble begins to settle to the bottom. As the thickness of the bubble changes at different places, light of different wavelengths (different colors) constructively interfere as they reflect from the inside and outside surfaces. Thus the color is an indication of the bubbles' thickness. The reflection of light from thin films is very important in the production of fine photography lenses.

9. GREEN, BLACK, AND ORANGE FLAG

Our eyes detect light when the light causes chemical reactions to occur in the cones of our eyes. Our eyes have three different kinds of cones to detect three different colors (RED, BLUE, GREEN). If you stare at a red picture for a few moments, the cones in our eyes that respond to red light are all actuated and it will take a short time before they are ready to detect red light again. If you then quickly look at a white background the red cones will not react but the blue and green detectors will and your brain will register a cyan color even though you are looking at a white background. The short time before the cones can again detect light after they have reacted is called persistence of vision. This also accounts for our seeing "moving pictures" even though they are just a series of still pictures projected on a screen.

10. SPINNING DISKS

Part A: Most students know that it is possible to mix colors to get other colors. However, most students (and teachers) do not really know the primary colors of light. If we are working with light the primary colors are RED, BLUE, and GREEN*. Combinations of these three colors can make all the other colors we see. If you hold a magnifying glass up to a color TV you will see only small dots of red, blue and green. By coloring a cardboard disk these three colors and spinning it quickly you can produce white which is the combination of all colors.

(*In art classes students usually do not work with colors of light but pigments of paint. Pigments absorb colors rather than emit colors. The primary pigments which can be mixed together to make other pigments are RED, BLUE, and YELLOW.)

Part B: Because of the way our eyes detect light we can trick them into thinking they are seeing colors. Because the persistence of vision is different for each of the three kinds of cones in our eyes, when we spin a black and white disk with different patterns we can begin to see some variation in color.

11. COLORED BULBS

It is possible to buy "party bulbs" from the grocery store in all three primary colors. If only one bulb projects light upon a white screen then you will only see that color and a black shadow. If you shine any two bulbs on a white screen then they will add together to produce a new color of light (red + blue = magenta, red + green = yellow, blue + green = cyan), black shadows and shadows of the original two colors. It is very interesting to shine all three colors on a white screen. They will produce white light with black shadows and shadows of the three complementary colors.

12. SOMEWHERE OVER THE BEAKERBOW

If a projector is aimed so that the beam just strikes the edge of a beaker full of water, a "beakerbow "can be formed. The light will internally reflect twice before leaving the beaker just like in a spherical raindrop. A number of properties of a rainbow can be studied in the classroom. Just like in a real rainbow the angle between the incident ray and the exiting ray is about 42 degrees. This indicates that the sun tends to always be at your back when you look at the top of the rainbow. Also, since, the angle between the incident ray and the red is slightly larger than the blue, when you look at a rainbow the red normally appears on top.

13. OVERHEAD SPECTROSCOPE

One way to make a rainbow is to use a prism but anyone who has tried it in the classroom knows that it is not easy. The other way is to use a diffraction grating. Diffraction gratings spread the different colors of light by different amounts. The longer the wavelength, the more the color spreads. The inexpensive "rainbow glasses" that you can buy in carnivals use diffraction gratings. By using an overhead projector and a diffraction grating, an excellent rainbow can be made in the classroom. Put the grating in front of the overhead projector lens and use two file folders to make a narrow slit on the stage of the projector. Two rainbows will be projected on the screen. To observe how different filters absorb different colors try putting filters over the slit and observe the projected rainbows.

14. ULTRAVIOLET BEADS

The light that we see is not the only kind of light that exists. Light that has a longer wavelength than red light is called infrared while light with a shorter wavelength than violet is called ultraviolet. Our eyes cannot detect these wavelengths but they can be detected by other means. Some photographic films are exposed by these wavelengths. It is the ultraviolet light in sunlight that gives people sunburns. The string of beads you have been given turns to different colors only when they are exposed to ultraviolet light. Indoors the beads are white but in the direct sunlight they turn colored.