

A Colorful Lab in a Bag

In this lab you will explore color and color mixing. You will investigate the white light spectrum and examine ways in which color can be combined. One process of mixing color, called additive mixing, involves light. Subtractive mixing deals with the combining of pigments such as dyes, inks, and paints. As you will learn, each process follows a distinct set of rules.

Your “lab in a bag” contains a pair of diffraction glasses, six colored filters, squares of black cardboard, red, green, yellow, and blue colored stickers, and a box of crayons. You will also need your newly constructed ping pong ball color mixer.

I. The White Light Spectrum

1. Human hearing is amazing. When listening to a concert or a conversation, we are able to hear individual instruments or individual conversations. Unlike the ear, the eye is not able to detect all the hues that make up a perceived color. For this we must turn to a prism or diffraction grating.

a. Look at a white light source, such as an incandescent bulb, through the diffraction glasses. List the colors you see. This array of colors is known as the *white light spectrum*.

b. In the space below, use crayons or colored markers to recreate what you saw through the glasses. You need only sketch one segment of the pattern since the diffraction glasses you are using produce spectra in many directions.

c. In this activity a device known as a diffraction grating is used to analyze light, that is, break light up into its component colors. Describe other ways in which the colors that comprise white light often reveal themselves.

II. Additive Color Mixing

1. The Ping Pong Ball Color Mixer – Overlapping Color in Space

In the above activity, white light was separated into its component colors. What happens when the various colors found in the white light spectrum are recombined?

In this portion of the laboratory, you will explore a process known as additive color mixing. The ping-pong ball color mixer will be used to assist your investigation.

- a. Energize your ping-pong ball color mixer by inserting the batteries.

- b. Observe the ping-pong ball as the colors are sequentially projected on the top of the ping ball change. Notice that only three basic colors appear as projected spots on the surface of the ball. These colors are known as the additive primaries. What are these colors?

- c. Notice that the entire ball takes on the color of the projected spot. That is, if the spot on the top is red, the entire ball appears red. What happens when two colors are projected simultaneously? Observe the overall color of the ball and see if you can complete the following “color equations.”

red light + blue light = _____

red light + green light = _____

blue light + green light = _____

red light + blue light + green light = _____

- d. How might other colors be produced using just the three additive primaries?

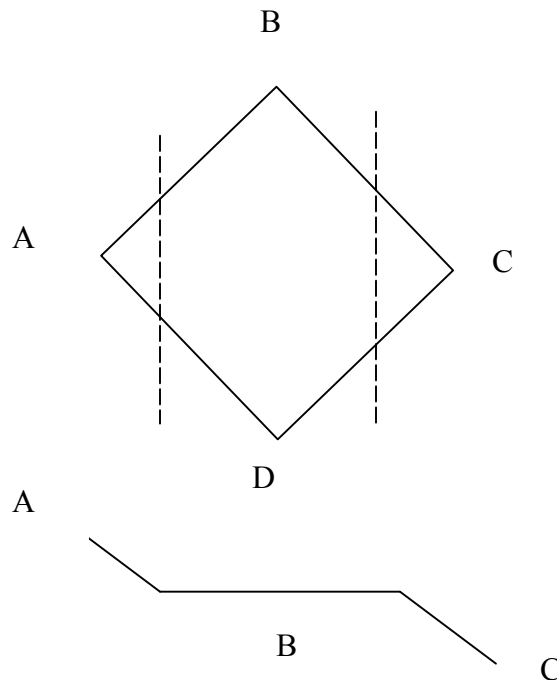
Assume other equipment is available to you.

2. The Color Mixing Turbine – Overlapping Color in Time

In the previous activity, colored lights were projected on a screen (the ball). These overlapping colors were optically mixed by the eye/brain system to produce the sensation of magenta, yellow, and cyan. When all three primary colors were combined, white light was perceived.

Due to a phenomenon known as persistence of vision, our retina retains an image for a short time after the source of light has come and gone. Thus it is possible to combine colors by presenting them to the eye in rapid succession. If for example, a flash of red light impinges on the retina, the sensitive cones that are activated by the light continue sending signals to the brain for a fraction of a second. If a source of green light strikes the retina within this time, the brain will perceive yellow. Follow the steps outlined below to experience this phenomenon for yourself.

a. Bend two corners of one of the black cardboard squares as shown in the figure below.



- b. Attach a green sticker to one side of the card and a red sticker to the other. Make certain that the two stickers have overlapping areas.
- c. Gently hold the card by corners B and D using two fingers. By blowing on the concave blade, the cardboard can be made to spin. The alternating colors act as flashing red and green lights, the combination of which produces the sensation of yellow.
- d. Experiment with the other stickers provided. Record your results below.

red sticker/green sticker yields _____

red sticker/blue sticker yields _____

blue sticker/yellow sticker yields _____

Are your results consistent with what you observed with the ping-pong ball color mixer?

3. Partitive Mixing - Mixing as a Result of Proximity

When two daps of color are placed sufficiently close together, the eye can't separate them. When the mixing occurs within in the eye it is often referred to as parititive mixing. An example of partitive mixing is a close by as your television.

a. Turn on your television or computer monitor. Place a drop of water on the screen. List the colors you observe when you view the screen through the droplet.

b. How do you suppose virtually all the colors of the spectrum are created on the screen?

c. Partitive color mixing was used by the 19th century pointillist painters. Using small dashes of color, these artists relied on the eye's inability to resolve closely spaced objects to imbue their paintings with brilliant color. The archetypical pointillist painting is Sunday Afternoon on the Isle Grand Jatte by Seurat located at the Institute of Chicago.

III. Subtractive Color Mixing

1. The Effect of Colored Filters on Light

- a. You will need your diffraction glasses, six colored filters (red, green, blue, magenta, cyan and yellow), and a source of white light. An ordinary incandescent lamp works well; a compact fluorescent source is even better.
- b. In a darkened room, view the lamp through the diffraction glasses. You will probably see spectra in many locations surrounding the source. You only pay attention to one of these in this activity.
- c. While wearing the diffraction glasses, close one eye and slowly slide the red filter over the lens covering the open eye. Describe what you observe. In the space below, sketch and label the colors that you see with the red filter in place.
- d. Repeat step (c) using the green, blue, magenta, yellow, and cyan filters in turn. Sketch and label all six observations in the space below.

2. Mixing Colors by Subtraction

Note: The diffraction glasses are not to be used in this activity. Only the six colored filters will be needed.

a. Hold a green and cyan filter together so that light from the lamp passes through both filters before entering the eye. Carefully observe the color(s) that are visible through both filters. Repeat this procedure with the combinations of filters listed below.

green filter + cyan filter = _____

green filter + yellow filter = _____

green filter + magenta filter = _____

red filter + cyan filter = _____

red filter + yellow filter = _____

red filter + magenta filter = _____

blue filter + cyan filter = _____

blue filter + yellow filter = _____

blue filter + magenta filter = _____

red filter + green filter = _____

red filter + blue filter = _____

green filter + blue filter = _____

b. Your observations in part (a) may now be used to deduce the transmission characteristics of cyan, yellow, and magenta filters. In terms of red, blue, and green, list the colors that are transmitted by each of the following filters.

primary color(s) transmitted by a cyan filter =

primary color(s) transmitted by a yellow filter =

primary color(s) transmitted by a magenta filter =

primary color(s) transmitted by a layer of
cyan, yellow, and magenta filters =

Cyan, yellow, and magenta are called the “subtractive primaries.” A cyan filter may be thought of as a “minus red” filter because it absorbs red light. What color does a yellow filter absorb? A magenta filter?

c. Colored filters, watercolors, dyes, and paints all selectively absorb certain colors. Cyan, yellow, and magenta are thought of as the subtractive primaries because in the proper combinations they may be used to produce virtually any color in the spectrum. For this reason, cyan, yellow, and magenta are used in painting and color printing.

Examine the flaps on the printed material provided. There you see cyan, yellow, and magenta “test dots” indicating the colors used in printing. These colors are clearly visible on a color inkjet cartridge.