

RAFT IDEAS

Topics: Color mixing, Light, Electromagnetic Spectrum

Materials List

- ✓ White card stock
- ✓ Magenta, Cyan, and Yellow colored film transparencies or laminated thermal printer film
- ✓ Adhesive tape
- ✓ White surface
- ✓ Bright light source (a light table or overhead projector work well)
- ✓ Marble
- ✓ Bottle cap
- ✓ A die cut that can cut 1/3 pie shaped sections would speed assembly

This activity can be used to teach:

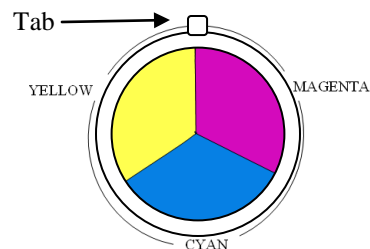
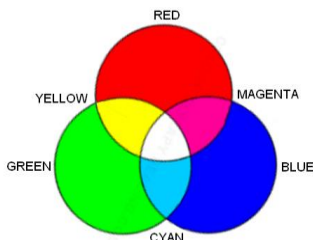
Next Generation Science Standards:

- Light and vision (Grade 1, Physical Science 4-3; Grade 4, Physical Science 4-2)
- Waves: Amplitude, wavelength, energy (Grade 4, Physical Science 4-1)
- Waves are reflected, absorbed, or transmitted (Middle School, Physical Science 4-2);



The Light Color Wheel

Cool Combinations with Colors Of Light



Construct a simple device that allows students to combine the colors of light, creating a multitude of colors across the visible color spectrum.

Assembly

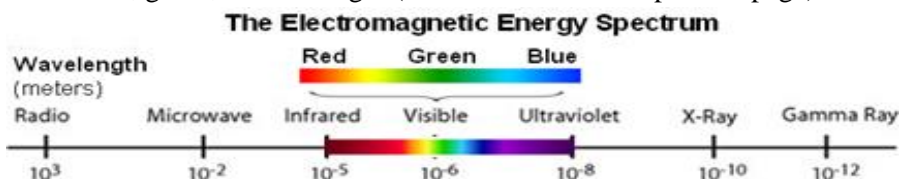
1. Cut 8 circular rings out of white card stock having a 10 cm (4") outer diameter and a 1 cm (3/8") width.
2. From each of the 3 colored transparencies cut 4 sets of 1/3 pie shapes having a 10 cm (4") diameter. Use an appropriate die cut, if available, to speed assembly.
3. Align the 3 colored pie segments (Magenta, Cyan, and Yellow) to form a full "pie" and use adhesive tape to adhere the segments to a circular ring. Sandwich the segments by adding another ring and attach the rings together.
4. Repeat the above 3 steps to create 3 more color wheels. Add a small tab of tape to each color wheel as shown above.

To Do and Notice

1. To enhance the colors to be produced place a color wheel over a white surface and/or use a bright light source (light table or overhead projector). Observe the Cyan, Magenta, and Yellow colors which are subtractive colors.
2. Place a second color wheel on top of first one, with all 3 colors aligned to each other and the first tab at 12 o'clock position. Next rotate the second color wheel 60° (tab at 4 o'clock) relative to the first one using the tab. Observe the 3 new color combinations: violet, green, and orange.
3. Place 2 more color wheels on top to make a stack of 4 color wheels, with colors aligned and all 4 tabs at 12 o'clock position. Using the tabs, rotate the 2nd color wheel 30° (2nd tab at 1 o'clock position) relative to the 1st, then the 3rd wheel 30° relative to the 2nd one (3rd tab at 2 o'clock), and finally the 4th wheel 30° relative to the 3rd one (4th tab at 3 o'clock). Observe the additional color combinations: yellow-orange, red-orange, red-violet, blue violet, blue-green, and yellow-green.

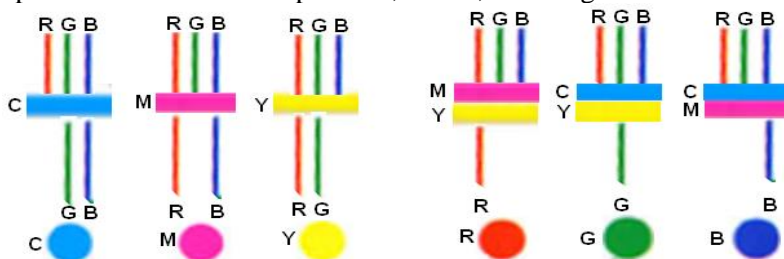
The Science Behind the Activity

The human eye can detect only a small portion of the electromagnetic energy spectrum. Visible wavelengths, as seen in the colors of the rainbow, range from 700 to 400 nm (nanometers). Millions of colors are possible by mixing the primary colors of light in various combinations or by subtracting colors from light such as white light. When all the various colors are seen together, we perceive the combination as white light. We will also perceive the color white when we are shown an overlapping pattern of red, green, and blue light (as illustrated at the top of the page).



The color of light is detected by the roughly 6 to 7 million cones in the human eye. Each cone contains one of three pigments that are each sensitive to a different, but overlapping, range of reddish, greenish or bluish wavelengths. The brain processes the information from the receptors and creates a mental image of a color that is related to the wavelengths of the light entering the eye. If more than one visible wavelength enters the eye, the color perceived by the brain is formed from the combined responses of the 3 types of receptors in the eye's retina. For example, if red and green light enter the eye, the resulting color produced in the brain is yellow, the color halfway between red and green in the spectrum. When wavelengths from both ends of the light spectrum (i.e., red and blue light) are detected at the same time the brain constructs a new color, magenta, to bridge the gap. Actually, magenta is a color that does not have an associated wavelength as do the others colors of the light spectrum. It exists only in the brain. Red, green and blue are the primary colors of white light. When equal amounts of red, green and blue light are combined, or added together, they produce white light. This is called "Color By Addition" and it is a direct way to prove that all of these three colors do indeed come from white light. Computer monitors, television, and theatrical lighting are some examples of where additive primary colors are used. (Red, Blue, and Yellow are the traditional primary colors of the painter's pallet.)

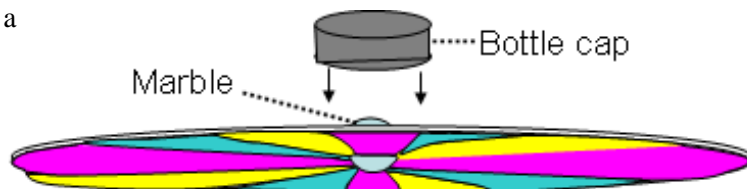
Colored film with cyan, magenta, or yellow pigments absorbs or subtracts certain portions of white light while allowing other portions to pass through to the viewer. This is called "Color By Subtraction". The predominant or primary colors of light are red, green, and blue. These 3 colors can be used as labels to divide the visible spectrum into 3 sections to help better understand how subtractive filters affect light as illustrated below. The R, G, and B letters together represent the full visible spectrum, that is, white light.



- Cyan colored film subtracts red while allowing green and blue light through which we see as cyan
- Magenta colored film subtracts green while allowing red and blue light through which we see as magenta.
- Yellow colored film subtracts blue while allowing red and green light through which we see as yellow
- Magenta and yellow colored films subtract green and blue allowing only red light through
- Cyan and yellow colored films subtract red and blue allowing only green light through
- Magenta and cyan colored films subtract red and green allowing only blue light through

Taking it Further

Cut the 3 colored films each into 4 1/12th pie segments. Attach the edges of red, yellow, and blue film segments in sequence with adhesive tape to a clear CD until a full circle is formed. (Packs of recordable CD's and DVD's often include a clear protective "CD") Place a marble into the center hole of the CD and use hot glue to secure the marble in place. Place a bottle cap on top of the CD, as shown below, and hot glue the cap to the CD. Allow the hot glue to cool. Rotate the bottle cap quickly with the fingers. When the CD is rotated at a sufficiently high rate of speed the colors will appear to disappear. On top of a light table, the spinning CD of the colored film segments will appear colorless and transparent. Why does this happen?



Web Resources (Visit www.raft.net/raft-idea?isid=595 for more resources!)

- **Black & White Makes Color** - www.raft.net/ideas/Black%20and%20White%20Makes%20Color.pdf
- Additive and subtractive primary colors - www.rgbworld.com/color.php
- Magenta, absence from color spectrum - www.biotele.com/magenta.html
- Investigate how light and color interact - exploratorium.edu/snacks/cymk/index.html
- Newton's prism experiment - micro.magnet.fsu.edu/primer/java/scienceopticsu/newton/index.html