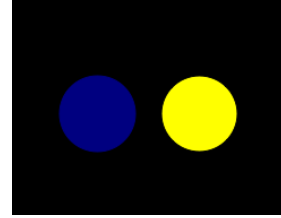


## Color and Polarization

### What do you think?

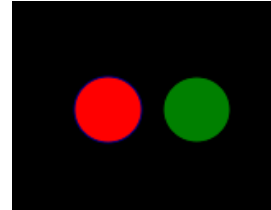
Imagine a darkened room with two projectors shining light on a screen. One shines blue light while the other shines yellow light.

- What color will be seen when these two colors overlap each other on the screen?
- Why do you think this is the case? What experiences have you had that helped you decide on the color?

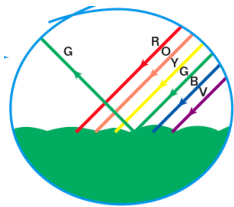


Suppose the colors are switched to red and green.

- What color will be seen when these two colors overlap each other on the screen?
- Why do you think this is the case? What experiences have you had that helped you decide on the color?



### Color



Why does a leaf appear green?  
Why does the umbrella appear red?

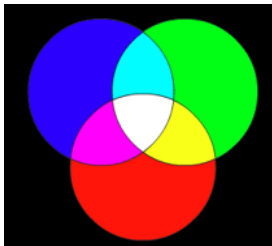
Objects appear a certain color because they absorb the other colors of the spectrum.

- The leaf absorbs all but green. The green gets reflected.
- The umbrella absorbs all but red. The red gets reflected.



### Color Addition

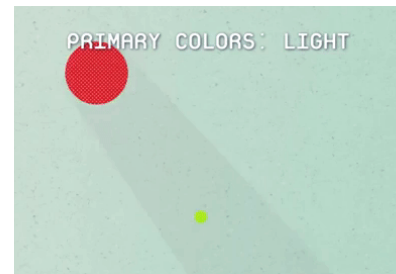
- White light is a mixture of all of the colors of the spectrum (ROYGBIV).
- The primary additive colors are **red**, **green**, and **blue**.
- Addition of these colors with differing intensities produces all other colors.
  - TVs use closely spaced red, green, and blue pixels



Red + green = yellow  
Red + blue = magenta  
Blue + green = cyan

Any two colors forming white are said to be complimentary colors.

- Yellow and blue
- Magenta and green
- Cyan and red



### Color Subtraction and Pigments

Another way to form different colors is by subtraction.

- Pigments and dyes absorb (or subtract) some colors and reflect (or transmit) others.
- Leaves subtract red and blue but reflect green.

The primary pigments for color subtraction are cyan, magenta, and yellow.

- Color printers use CYM cartridges. These have three colors of ink and mix them to produce all other colors.
- Yellow is a combination of red and green. A yellow pigment reflects both red and green *or* it removes blue.
- In other words, yellow pigments subtract/absorb blue light.
  - Similarly, cyan pigments subtract/absorb red light.

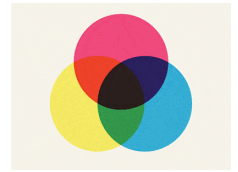
Therefore, if you mix yellow and cyan pigments, blue and red are both subtracted, and you see green reflected.

- Use subtraction to determine the color seen if you mix
  - o cyan and magenta
  - o yellow and magenta



Mixing all three pigments produces black.

Different quantities of cyan, magenta, and yellow can produce the “millions” of colors possible on printers.



### Discovery- Colors of Light

### Polarization of Light

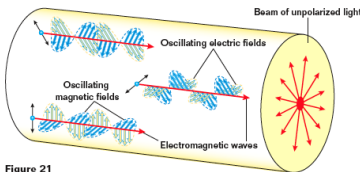


Figure 21  
Randomly oscillating electric fields produce unpolarized light.

Unpolarized light consists of light with the electric and magnetic fields vibrating in all directions.

Polarized light waves have fields vibrating in only one plane.

- In this case, the electric field is vertically polarized.

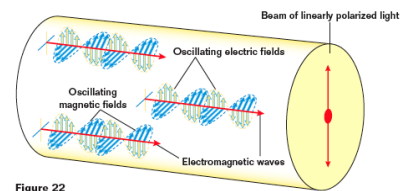
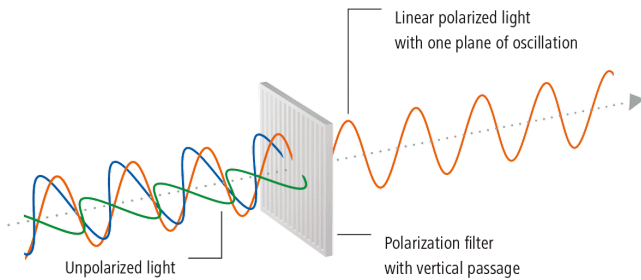
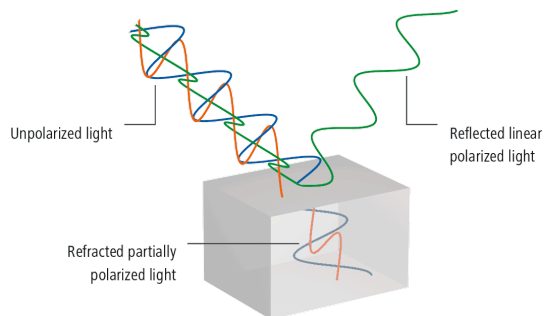
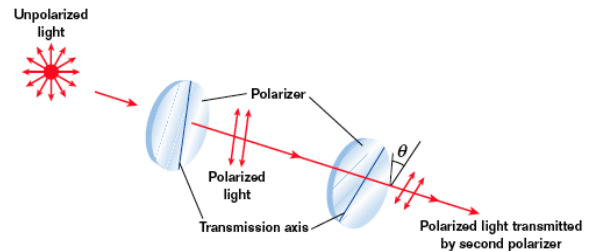


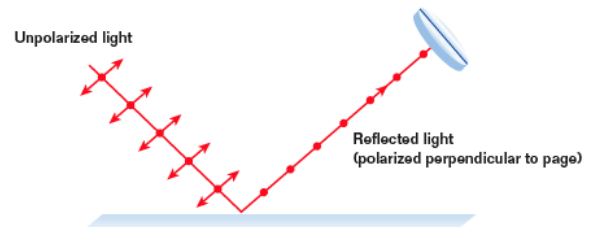
Figure 22  
Light waves with aligned electric fields are linearly polarized.



Polarizing filters only allow light with the electric field aligned with the transmission axis to pass through. Light that is not aligned does not pass through.



Light reflected off a shiny surface like water is polarized by the reflective process. **Reflected light is polarized horizontally.** This light can be blocked by aligning the transmission axis of sunglasses vertically.



Fishermen use polarized sunglasses to reduce the reflected glare from the water.