

COLOR

THE VISIBLE SPECTRUM:

The range of electromagnetic radiation that is visible to the human eye is called the visible spectrum, or "visible light". Some colors discernable by humans are not contained in the visible spectrum; these are created by mixing two or more different wavelengths. Colors consisting of only one wavelength are referred to as "pure" colors. The degree of purity is called "saturation" or "chroma".

The colors of the visible spectrum are violet, blue, green, yellow, orange, and red. Because light travels in waves, it has both **frequency** (the number of waves that pass a given point in space during a specific time interval) and **wavelength** (the distance between any two corresponding points on successive waves). It's not crucial for you, as a designer, to know the frequency and wavelength of each color, but we're going to tell you anyway:



COLOR	FREQUENCY	WAVELENGTH
Violet	668–789 THz	380–450 nm
Blue	606–668 THz	450–495 nm
Green	526–606 THz	495–570 nm
Yellow	508–526 THz	570–590 nm
Orange	484–508 THz	590–620 nm
Red	400–484 THz	620–750 nm

Image courtesy of Wikipedia Commons

Note that frequency and wavelength are inversely proportional. The higher a color's frequency, the shorter will be its wavelength.

COLOR MIXING:

There are two ways to mix colors in lighting:

- **Additive mixing** happens when two or more differently-colored lights are aimed at the same surface.
- **Subtractive mixing** happens when a single light source shines through differently-colored filters. Each filter allows certain colors to pass while blocking or absorbing other colors.

In additive mixing, **primary colors** are those three colors which, when aimed at the same place at the same intensity, theoretically form white light ("theoretically", because in practice, this is limited by the imperfections of color filters and light sources). These colors are red, green, and blue.

The **secondary** colors in additive mixing are those colors which can be created by evenly mixing two primaries. These colors are:

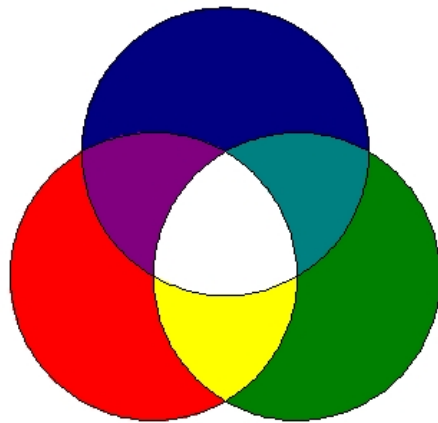
- Cyan (blue and green)
- Magenta (blue and red)
- Amber (red and green. Really.)

Televisions and computer monitors create colors by using additive mixing. For example:

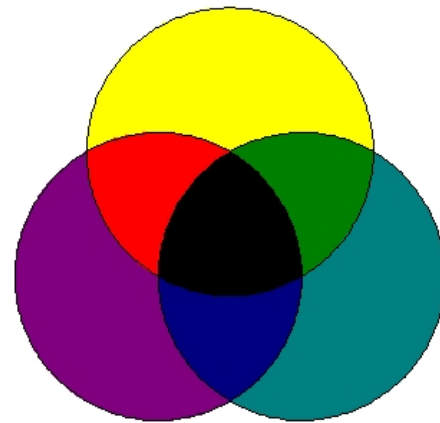
This sentence is 100% red.

This sentence is 100% green.

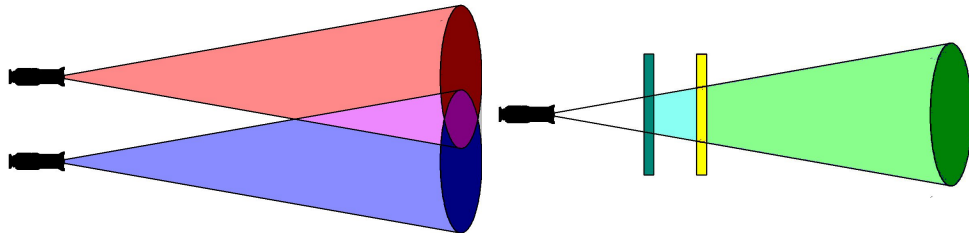
This sentence is 50% red and 50% green (See? I told you).



Additive Mixing



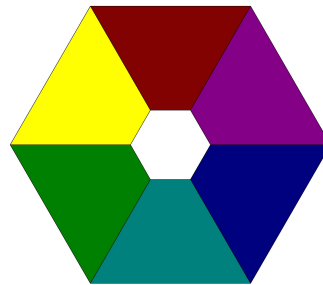
Subtractive Mixing



In subtractive mixing, the primary colors are those which can be created by evenly mixing two secondaries, as shown in the drawing above. In the example on the right, a white light is altered by inserting a cyan filter, which absorbs the red part of the spectrum and passes (or "transmits") blue and green light. The resulting cyan light is then passed through a yellow filter. This filter absorbs blue light, but transmits any red or green that may be present. Since there *is* no red (because we've already blocked it with the cyan filter) all that is transmitted is green.

Subtractive mixing is often found in automated fixtures. The act of inserting a color filter in front of a light is a very simple form of subtractive mixing.

Complementary colors are those colors directly across from each other on the color wheel:



For example: yellow and blue are complementary to each other, as are green and magenta. As you can see, the complementary of any primary color is the secondary color formed by mixing the two remaining primaries.

Complementary colors, when combined additively on a neutral surface, form (in theory) white light.

Complementary colors, when used adjacently, reinforce each other; each makes the other appear to be more vibrant.

This is yellow text against a green background

See how the blue background makes the yellow seem more vivid?

One of the most difficult problems faced by young designers is choosing color. The various manufacturers' swatchbooks (usually available free from dealers or from the manufacturers) offer literally thousands of possibilities.

How to choose? K.C. Hooper of Apollo Design Technology, a leading manufacturer of theatrical color media, offered these guidelines:

CHOOSING COLOR:

There are many factors to choosing color for your show, and as you look through your swatchbook, you will realize that there are many, many options to choose from. This section will cover the various concepts of choosing the best colors for your show.

Notice that I did not say the "*right*" color. Lighting design being an art form, we, as artists, are free to choose whatever color we feel will work for the effect or look that we are trying to create. Explore color and absorb the different elements of what it does for a scene, a dance piece, or a song.

The psychology of color is a wide ranging subject that many folks have written about. A quick Google search of the subject will bring up a large list of articles on the topic. One that I have found informative is [Color Psychology: How Colors Impact Moods, Feelings, and Behaviors](#), by Kendra Van Wagner.

Some obvious emotions connected with color are:

- Red = "anger," "danger," "evil."
- Green = "jealousy," "illness," "good luck."
- Blue = "tranquility," "coolness."

You, as a lighting design student, should sit down with a color swatchbook, put each color in front of a light fixture, and think about what each color means to you emotionally. You will call upon this process in the future when designing.

Seeing color is something that the designer will always practice. You may see a painting, scene, or museum exhibit and note that it has an emotional feeling. Analyze what is causing these emotions. Is it the colors, light angle, dimness or brightness? File that thought and use it down the road.

Many years ago, I saw a movie called *Cat People*. The movie itself was terrible and forgettable but the opening credits were done with green lettering on an orange sand background. As a designer, I remembered how vivid the lettering was and thought that it might be something that I could use down the road in a lighting design. Several years later, I was designing lights for a dance piece loosely based on the book, *Dune*. I remembered the effect from the movie and worked with the green/orange concept and creating the design based on that metamer (in this context, "mixing of two colors"). As an artist, you must use the variety of colors available to you to add to your visual tool kit.

SCRIPT ANALYSIS:

The lighting designer for a play can search for color clues in the script. The playwright often paints a clear picture of what he or she thinks the show should look like when the lights come up or the curtain opens. After going over the script, meet with the director and discuss his or her vision of the show. Ask the scenic designer and costume designer

These are some of the major manufacturers of theatrical color media:

- [Apollo Design Technology](#) -- Apollo was K.C.'s employer, and has the most amusing names for its colors.
- [GAM Products](#)
- [Lee Filters](#)
- [Rosco Labs](#)

A very good discussion of the emotional impact of color can be found here:

[Color Theory for Designers, Part 1: The Meaning of Color](#)

Jeff reminds you that the color wheel shown in the above link is subtractive, for mixing paint, not additive, for mixing light.

**"WHITE"
LIGHT ISN'T
WHITE –
COLOR
TEMPERATURE:**

"White" light exists mostly in theory; at any given time, the light we think of as "white" is actually somewhere between a pale yellow and a pale blue. This range is referred to as "color temperature". It can best be demonstrated by setting the "white balance" on a digital camera to "daylight" and taking a picture under incandescent light. The resulting image will be slightly yellow, because incandescent light is yellower – has a lower color temperature – than does daylight. Likewise, setting the white balance to "tungsten" and shooting a scene lit by daylight will yield a photo that is slightly bluish, since daylight has a higher color temperature than does tungsten light.



For this photograph, the white balance was set to "daylight" (or "outdoor").



For this photograph, the white balance was set to "tungsten" (or "indoor").

Color temperature is measured in "degrees Kelvin," abbreviated as "K." As mentioned above, the bluer a light is, the higher its color temperature will be. Below is a table of approximate color temperatures for common light sources:

Light Source	Color Temperature
Overcast Daylight	6500° K
Typical Daylight	5500°–6000° K
Theatre Lighting / Photofloods	3050°–3400° K
Standard Incandescent Theatre Lighting	3000° K
Household Incandescent Light Bulb	2700°–3300° K
Limelight	2400° K
Gaslight	2200° K
Sun at Sunrise or Sunset	2000°–3000° K
Candle Flame	1850° K
Match Flame	1700° K

So what does this mean? From what are these numbers derived? The temperature is referenced to that of a standard "black body" – a block of carbon which, when heated to specific temperatures, emits light of specific colors.

The Kelvin scale (named after British physicist William Kelvin) is a variation of the Centigrade/Celsius scale, except that rather than its being keyed to the freezing point of water, it is based on "absolute zero". If you subtract 273 from a Kelvin temperature, you will have its Celsius equivalent.

You may be thinking that none of the colors above looks like "white".... and you're right. First of all, they are merely approximations and not, as such, accurate. Secondly – and more important – the eye (or, more accurately, the brain) adapts. We tend to automatically "white balance" ourselves to the dominant light source in our environment at any given time. If, for example, you spend a significant amount of time outdoors during the daylight hours and then go into your house or apartment, the interior lighting may look yellowish for several hours, until your brain "white balances" to its new environment. This is something you should remember, by the way, when you're writing the first few cues of your show.