ARBOR SCIENTIFIC
TOOLS THAT TEACH.

Color Filters 33-0190

Your kit includes:
Six color filters cut into 8" x 10" sheets...

1 Blue	1 Green	1 Yellow
1 Red	1 Magenta	1 Cyan

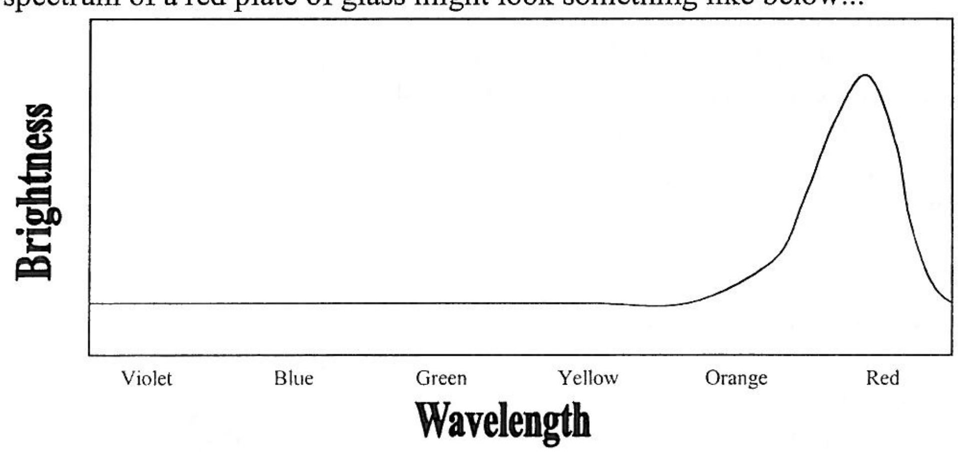
Background on Color

"To the physicist, the colors of things are not in the substances of the things themselves. Color is in the eye of the beholder and is provoked by the frequencies of light emitted or reflected by things. We see red in a rose when light of certain frequencies reaches our eyes. Other frequencies will provoke the sensation of other colors. Whether or not these frequencies of light are actually perceived as colors depends on the eye-brain system." (Hewitt, 411)

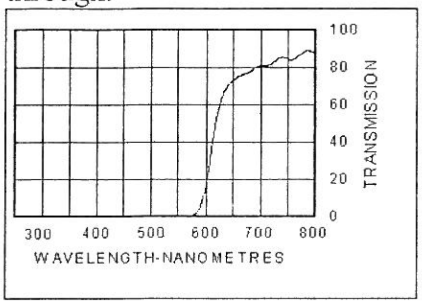
The above quote illustrates two points: (1) color is a subjective excitement in the eye that tells the brain what frequency of light is hitting it. The eye is only sensitive to a narrow band of frequencies known as visible light. And, if the eye or brain receives more than one frequency at a time, they will often interpret this as only one color. (2) We perceive an object's color to be our eye/brain response to the light that is either created or reflected. Reflected light can have its spectrum changed by the object it reflects off of because most materials absorb some frequencies and reflect the rest. If an object absorbs most visible frequencies and reflects red, for example, the material appears red. If a material reflects all of the light shined on it, it will have the same color as the initial light source. If it absorbs all light, it will appear black.

Colored Filters

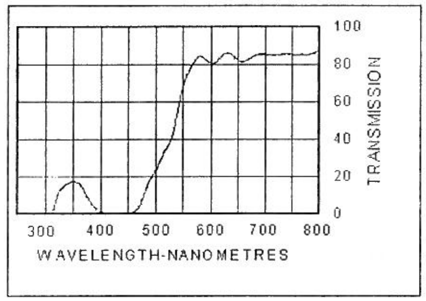
The color of a transparent object depends on the color of the light it transmits. A red piece of glass appears red because it absorbs all the colors that compose white light, except red, which it transmits. The material in the glass that selectively absorbs colored light is known as a pigment. (Hewitt, 414) The transmittance of an object can be shown with a wavelength spectrum graph. Such a graph shows the amplitude, or brightness, of the light of each wavelength that is transmitted. So the wavelength spectrum of a red plate of glass might look something like below...



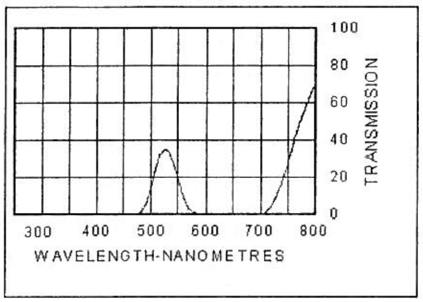
Notice that the transmitted light is brightest near the red part of the spectrum. The rest of the wavelengths have low brightness. Here are the transmittance spectrums of the 6 color filters included in the kit. They refer to wavelength in nanometers. But, rather than using brightness or amplitude, the graphs refer to the transmission, or the percentage of the original brightness that was allowed to pass through.



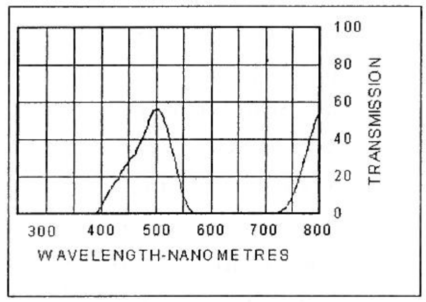
Red



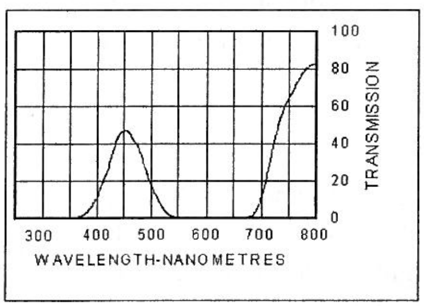
Yellow



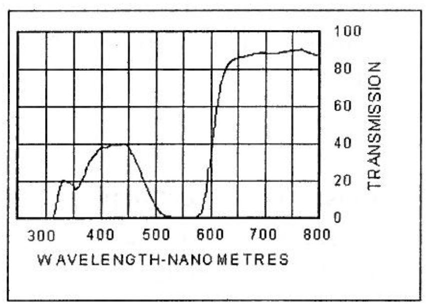
Green



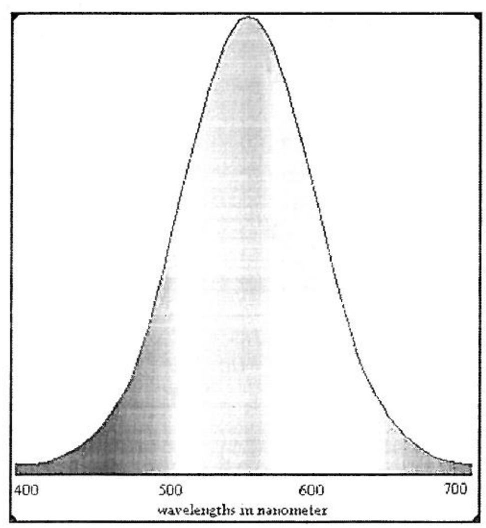
Cyan



Blue



Magenta



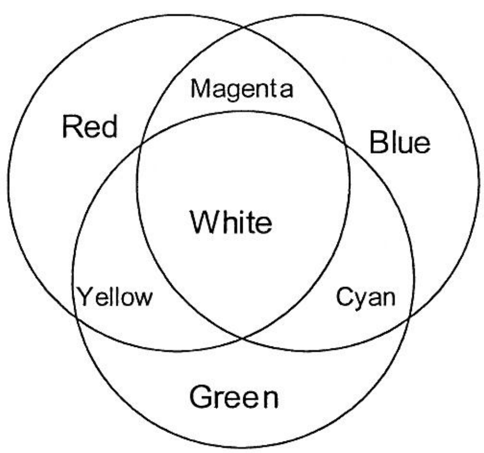
Notice that there aren't pure peaks at red, blue, green, etc. Rather, what our eyes perceive as color is often made up of several different frequencies. All of the filters let in high wavelength light, but our eyes are only sensitive to up to about 700 nm. The graph to the right shows the relative eye sensitivity of a *standard observer*. (http://home.wanadoo.nl/paulschils/05.01.html). Notice that humans are more sensitive to green and yellow light than any other. A conjecture can be made by pointing out that humans evolved in a natural setting of green foliage. Sensitivity to green was much more important than sensitivity to red or blue. This relative sensitivity plays a big part in how we perceive colors. So not only does our eye-brain mechanism assign single colors to light made up of multiple wavelengths, but it is more sensitive to some of those wavelengths than it is others. All of this adds up to a very confusing time for scientists *and* artists.

Color Addition and Subtraction

Every artist knows that if you mix red, green, and blue paint, the result will be an ugly brown color. Red and green paint certainly do not combine to make yellow as red and green light do. This is the difference between color addition and subtraction. When light shines on blue paint, for example, the paint reflects mostly blue light, but also violet and green; it absorbs red, orange, and yellow light. Yellow paint reflects mostly yellow light, but also red, orange, and green; it absorbs blue and violet light. When blue and yellow paints are mixed, then between them they absorb all the colors except green. The only color they reflect is green. This is called color by subtraction. So when you cast lights on the stage at a school play, you use the rules of color addition to produce various colors. But if you mix paint, you use the rules of color subtraction. (Hewitt, 419)

Activities:

1. Cut a corner of each filter off and make a slide that can fit into a slide projector. If you don't have a slide mount, try using heavy paper or gray board.
2. Place one color slide in a projector and another in a separate projector. Turn the lights out and shine the colors on the wall. Have your students predict what the result will be when you add the two colors together. Then just maneuver the projectors so that the colors overlap enough to see the resultant color. Start by adding pairs of primary colors.
3. Then, with a third projector, add all three primary colors together to get white light. Compare to the chart below.



4. Show the complementary colors by adding a primary with its complement. Can your students explain this with the help of the chart? (yellow = red + green, so blue + yellow = blue + red + green = white)
5. If your projector does not have a brightness gauge, you may be able to hook it up to a variac, or dimmer switch. Then you can experiment with increasing or decreasing the brightness of one, two, or three of the colors. Just about every color we perceive can by made in this way just like a television set.
6. Subtract color from the projector light source by placing one, then two, and then three filters in front of the source. Use three secondary colors first.

7. Try shining colored light onto colored objects, like sheets of construction paper or student art. Very powerful demonstrations consist of images with definitive colors that everyone is familiar with (i.e., red hearts with piercing black arrows, green money.) Keep the real color of the image or paper secret by only showing it in the colored light. Have your students try to figure out what color it really is. Or, by knowing what color the sheet is, have them try to guess what color light is shining on it. If you really want to freak them out, try eating food like fruit and vegetables bathed in colored light. Does it have an effect on the taste!
8. Place a holographic diffraction grating in your slide projector. Create a slit on the stage of the projector by placing two pieces of cardboard or two file folders about ¼″ apart to create a spectrum on the screen (you may have to adjust the slit.) Now place a red color filter in front of it and watch as it removes sections of the spectrum leaving its own absorption spectra. Try it with other filters. Do the resulting spectra match the transmission charts? How are they the same and how are they different?
9. Photocopy the transmission charts onto clear plastic sheets. Cut them each out and place them on slide mounts with their perspective colors so that when projected they show up on the wall surrounded by the color they define. Then try adding the colors *and* the charts. Line the graphs up so that you get one graph with all of the peaks surrounded by the resultant color.
10. Have your students put on diffraction grating glasses (see Rainbow Glasses below). View a light bulb with them on (lower wattage, diffuse bulbs work best so that students don't focus on the very bright center of the light.) While they are analyzing the spectrum given off by the bulb, hold a color filter in front of it. They should see sections of the spectrum simply disappear. Compare the colors left over to the transmission charts.

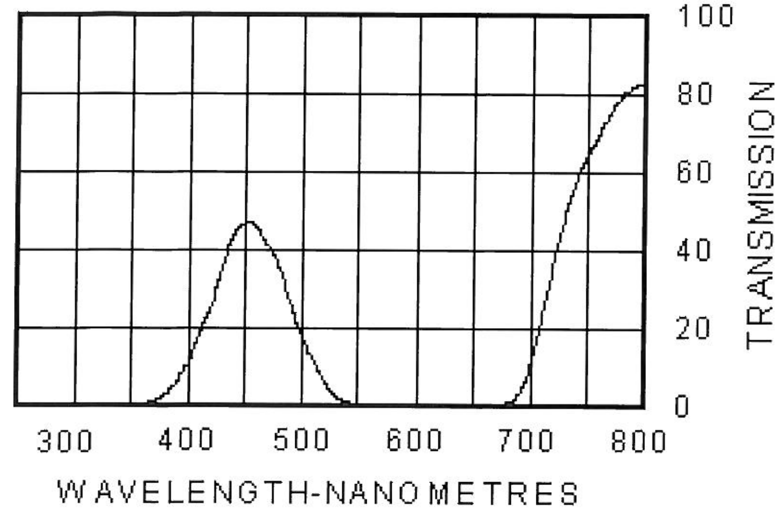
Related Products

- The **Light Box & Optical Set** allows students to perform hands on color and color mixing, plus light ray reflection and refraction. P2-9561
- Try our diffraction grating glasses, or **Rainbow Glasses**, to see the spectrums of colored and white light. P3-6300
- Our **3-D Glasses** take advantage of our eye/brain color system to make two dimensional art appear 3-D! Use it to study color, light and our brain's color and depth perception. P3-6100
- The **Holographic Diffraction Grating** creates the clearest rainbow you'll ever see! It is able to split any light source up into it's spectrum (with 750 lines per mm.) 33-0980

Bibliography

Conceptual Physics: The High School Physics Program. Paul G. Hewitt. Addison-Wesley Publishing Company, Inc. 1992

Arbor Scientific
P.O. Box 2750
Ann Arbor, MI 48106-2750
1-800-367-6695
www.arborsci.com

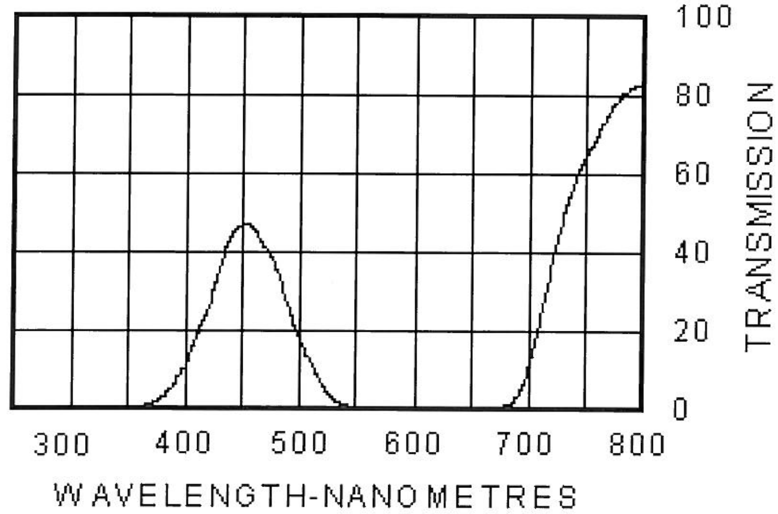


LEE Filter

*(HT)** 119
DARK BLUE

(Y=3.1%)

**(HT Version Optiona*

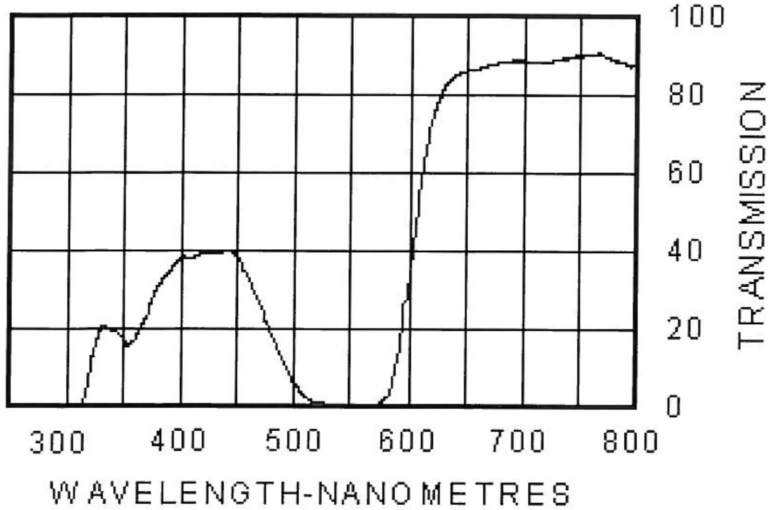


LEE Filter

*(HT)** 119
DARK BLUE

(Y=3.1%)

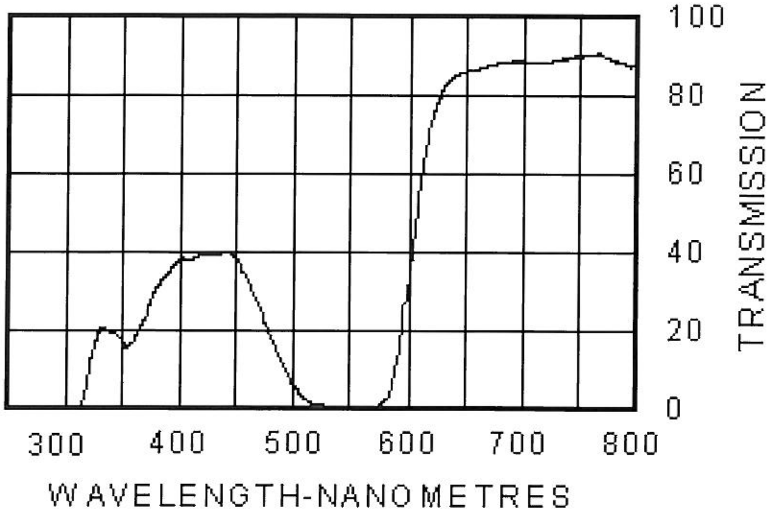
**(HT Version Optiona*



LEE Filters

128
BRIGHT PINK

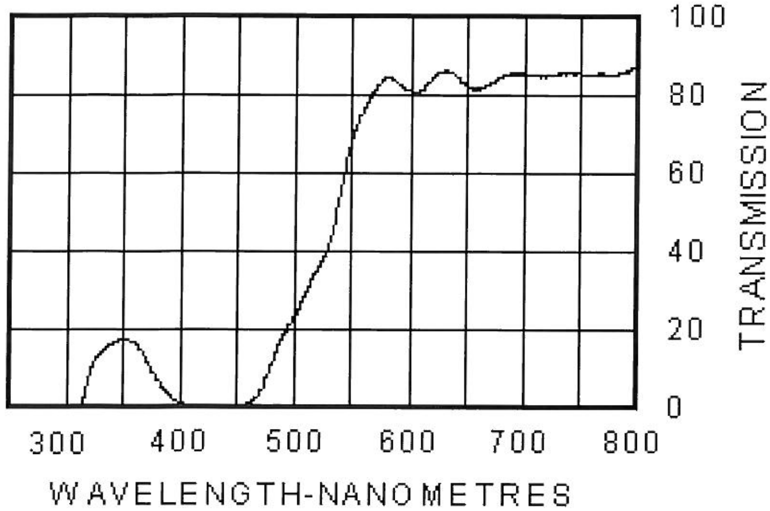
(Y=13.7%)



LEE Filters

128
BRIGHT PINK

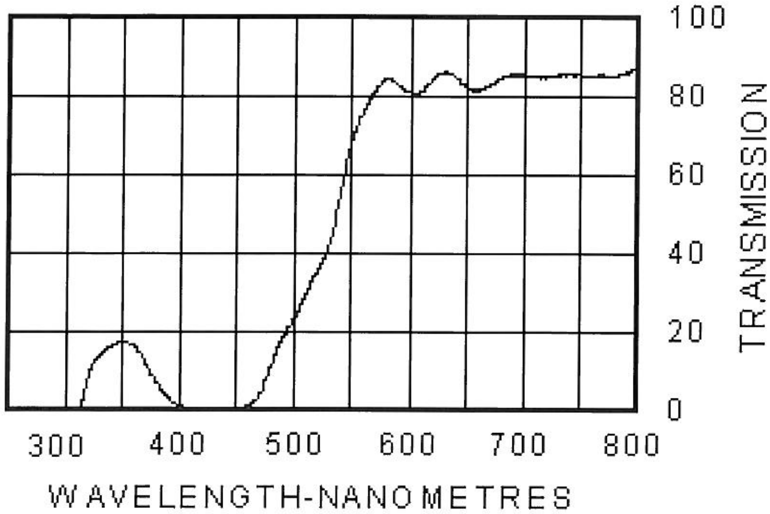
(Y=13.7%)



LEE Filters

104
DEEP AMBER

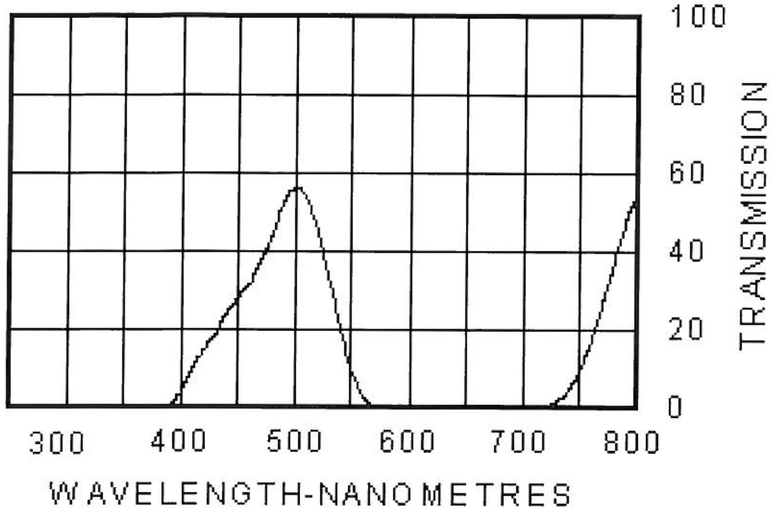
(Y=63.9%)



LEE Filters

104
DEEP AMBER

(Y=63.9%)

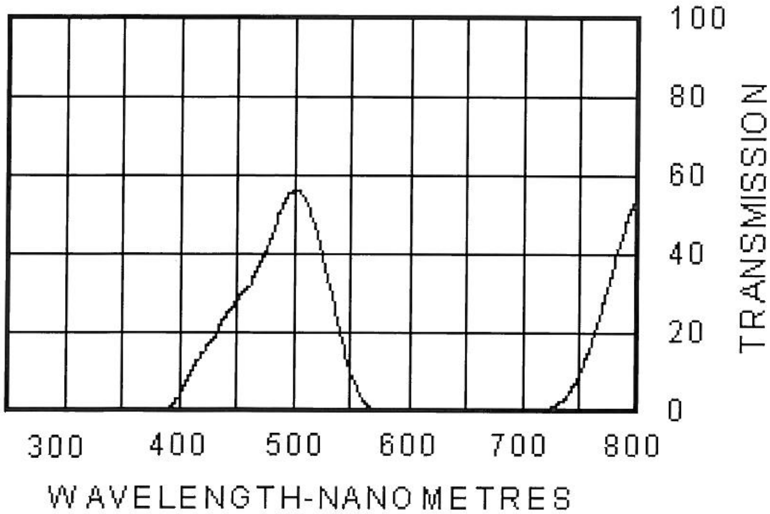


LEE Filter

(HT) * 116
MEDIUM
BLUE - GREE

(Y=16.5%)

**(HT Version Optiona*

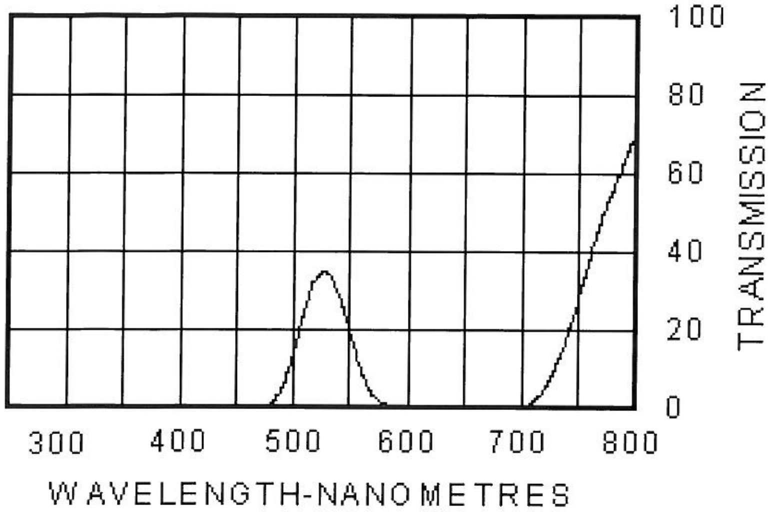


LEE Filter

(HT) * 116
MEDIUM
BLUE - GREE

(Y=16.5%)

**(HT Version Optiona*

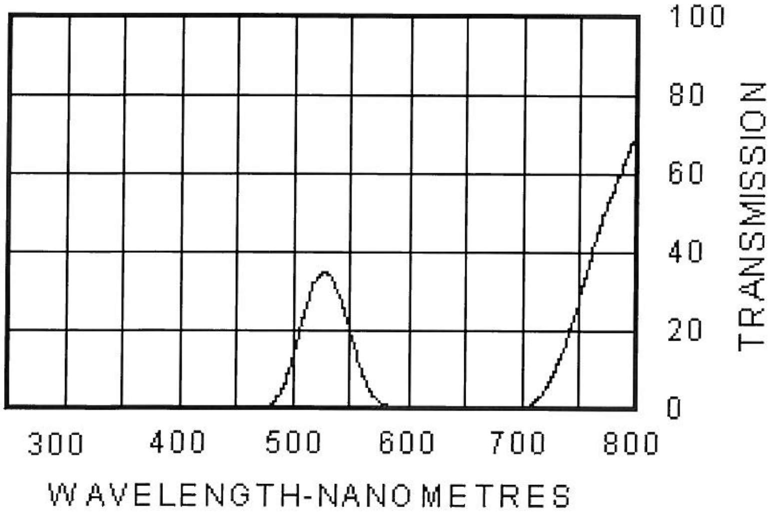


LEE Filter

*(HT)** 139
PRIMARY GRE

(Y=11.9%)

*(HT Version Optiona

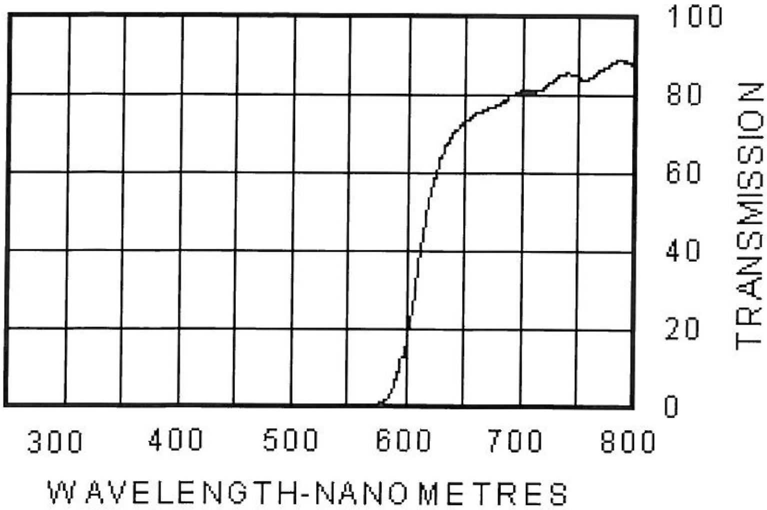


LEE Filter

*(HT)** 139
PRIMARY GRE

(Y=11.9%)

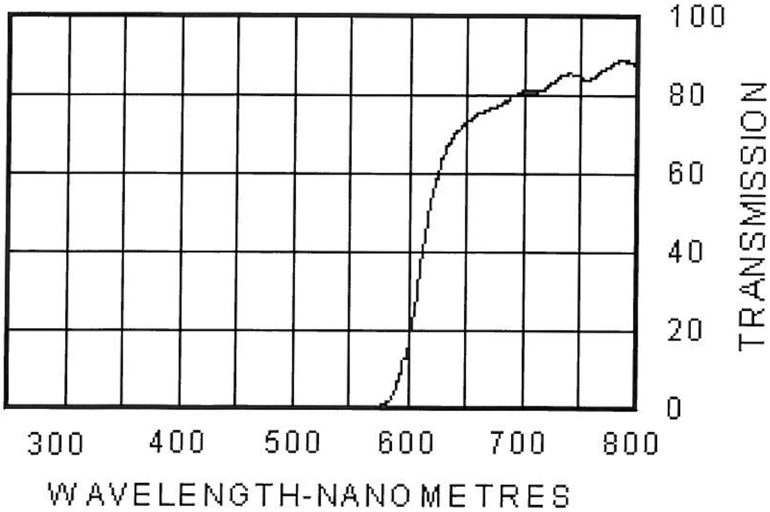
*(HT Version Optiona



LEE Filters

106
PRIMARY RE

(Y=9.3%)



LEE Filters

106
PRIMARY RE

(Y=9.3%)