Communicating Color

Courtesy of:
X-Rite Inc
4300 44 Street SE
Grand Rapids MI
(616) 803-2000

What is Color?

Munsell Color

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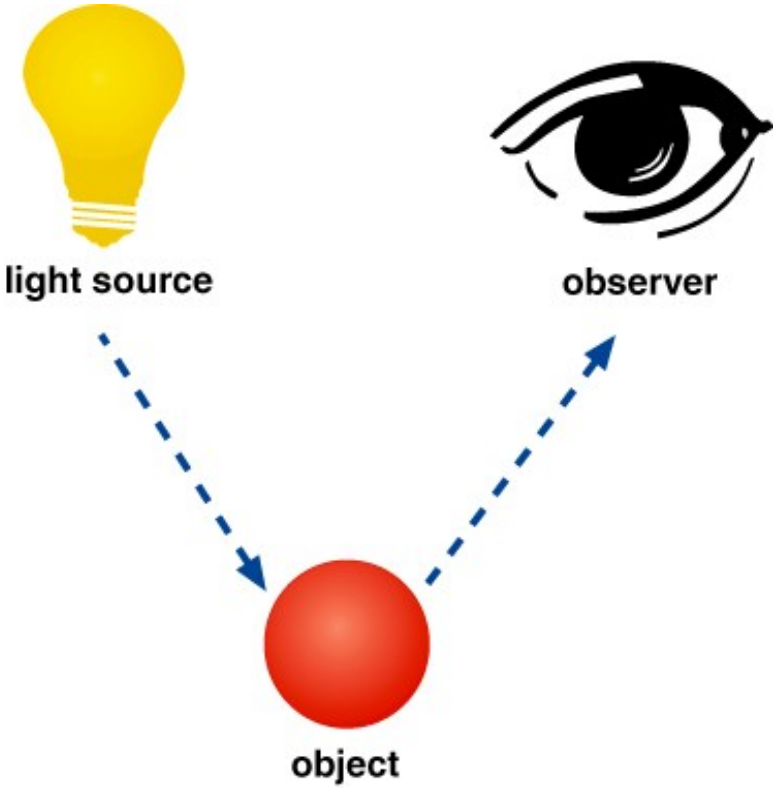
Color Perception

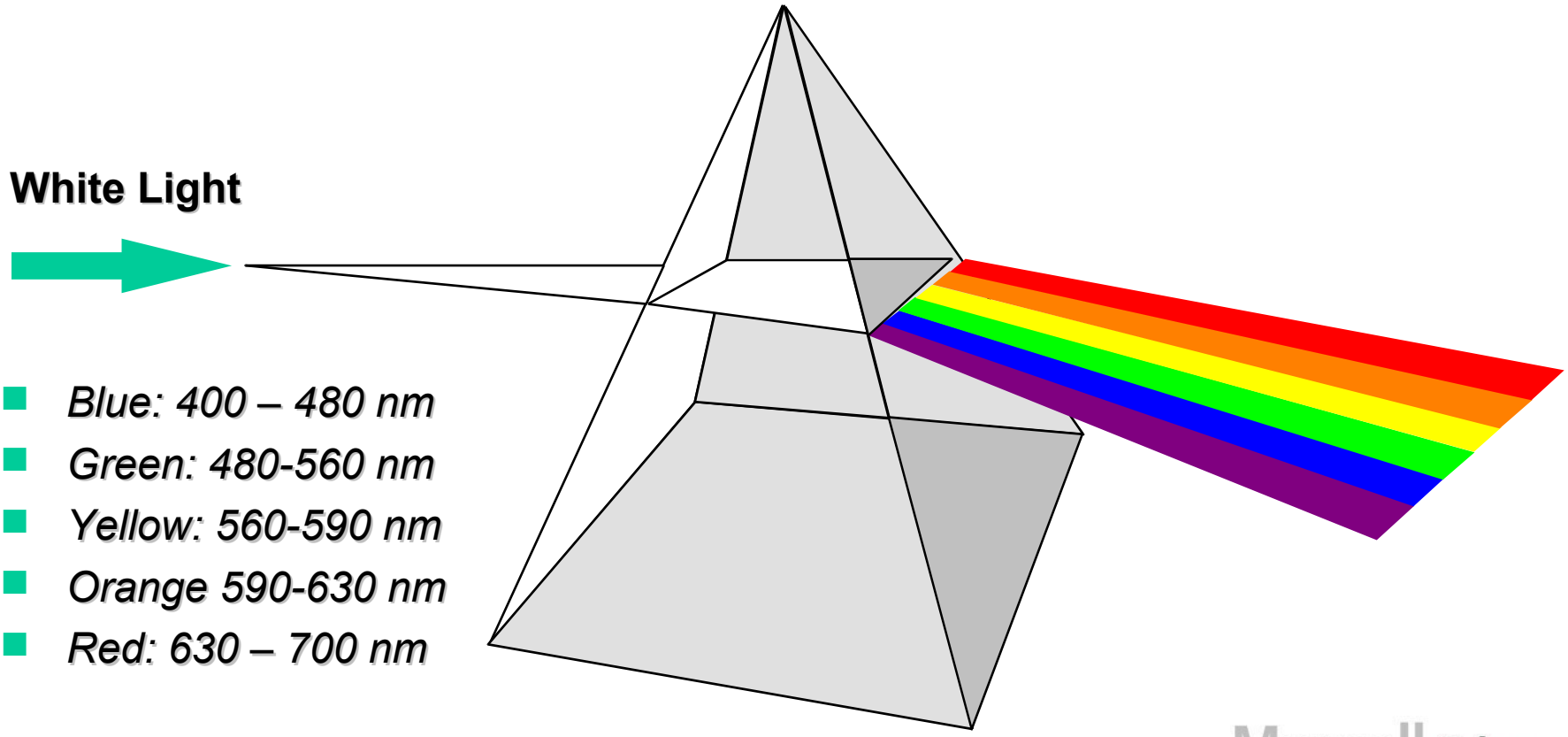


Observer Situation

What influences the perception of color?

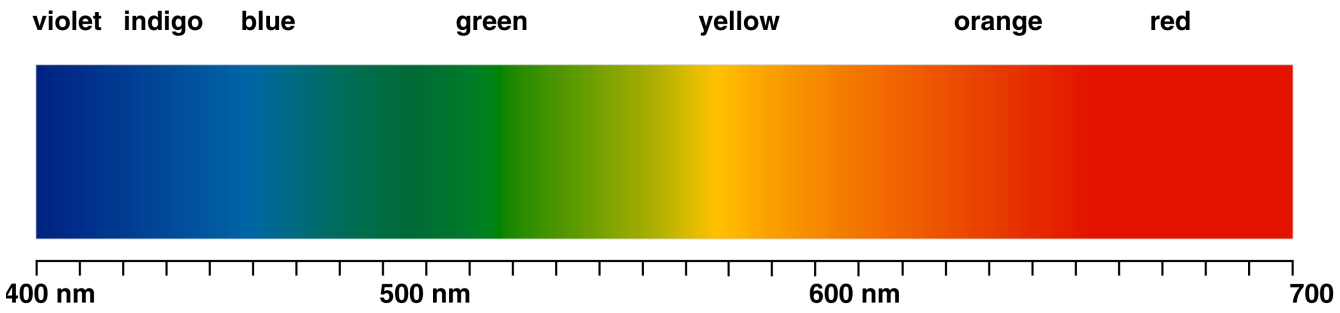
1. light source
2. object being viewed
3. observer (person)

Generation of the Spectrum



- *Blue: 400 – 480 nm*
- *Green: 480-560 nm*
- *Yellow: 560-590 nm*
- *Orange 590-630 nm*
- *Red: 630 – 700 nm*

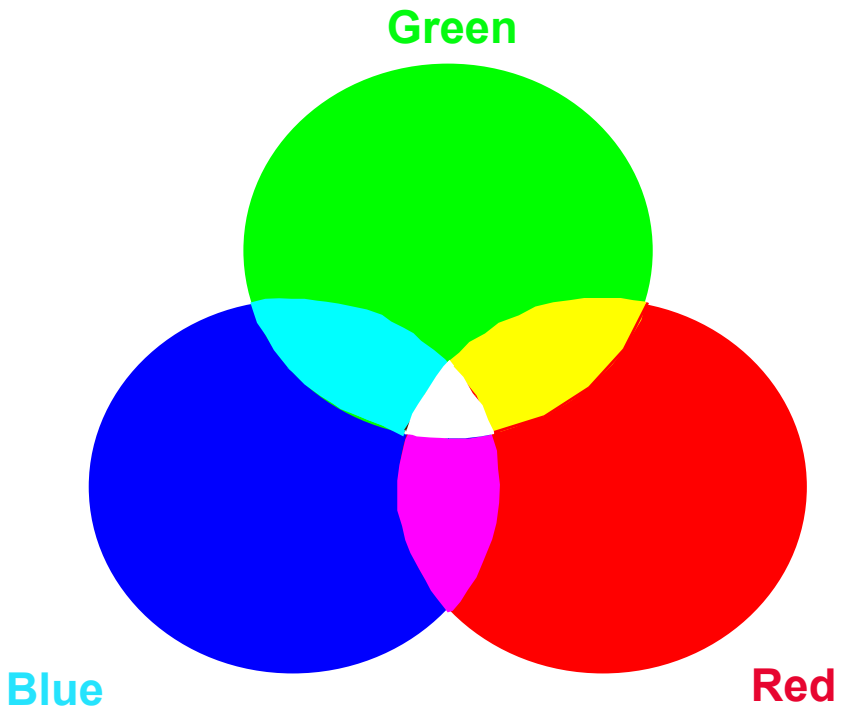
Electromagnetic Spectrum



Primary Colors “Additive Mixtures”

The additive mixture of **Red, Green** and **Blue** light help to build the final color you see. (Example: TV, Scanner, etc)

Red, Green and **Blue are Additive Primary Colors**

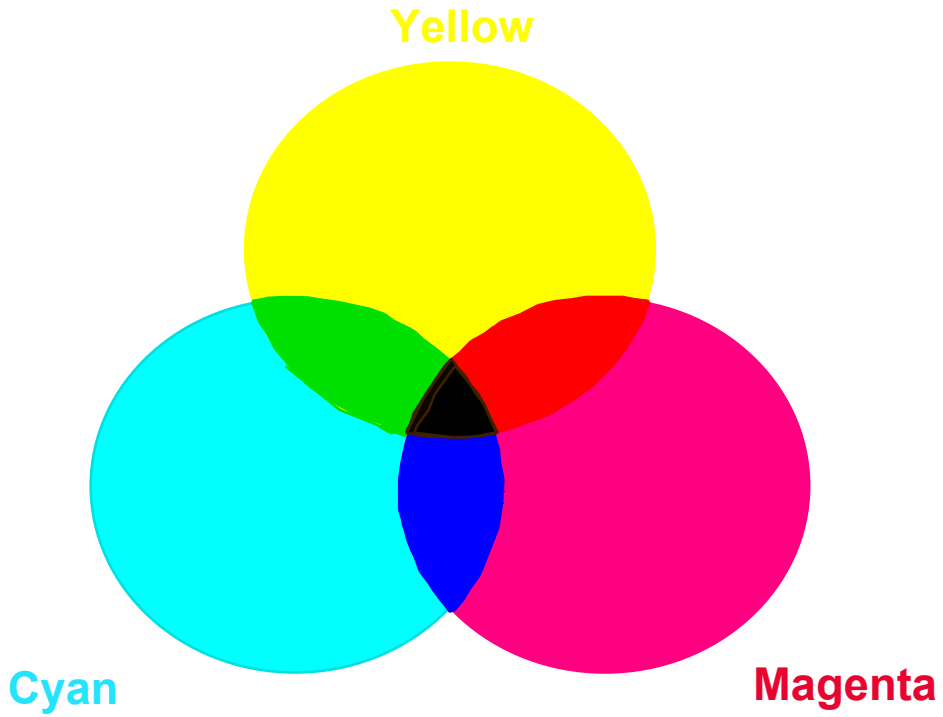


Primary Colors “Subtractive Mixtures”

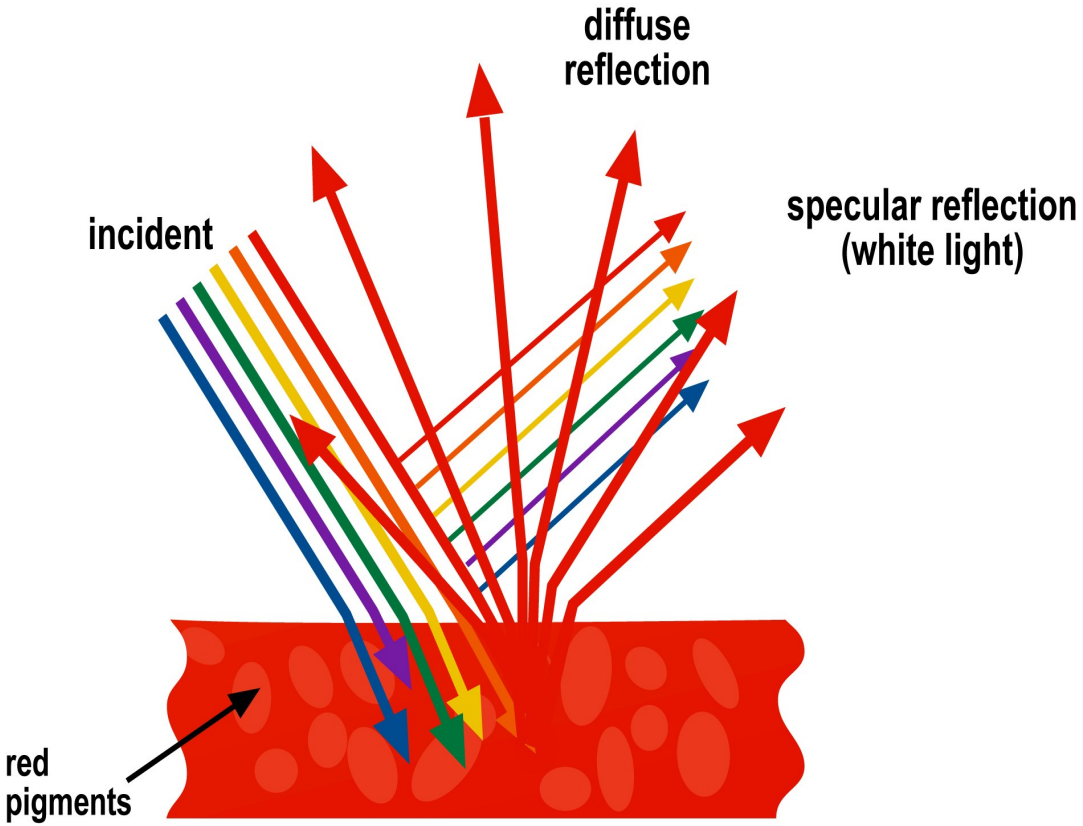
These build colors by subtracting or filtering from a white source of light with **Blue (Yellow)**, **Green (Magenta)**, and **Red (Cyan)** filters.

Color filters transmit only the light from the own color and **reflect or absorb** all other colors

Cyan, Magenta and **Yellow are Subtractive Primary Colors**



Opaque (non-metallic) Object



Common Light Sources

Daylight D65

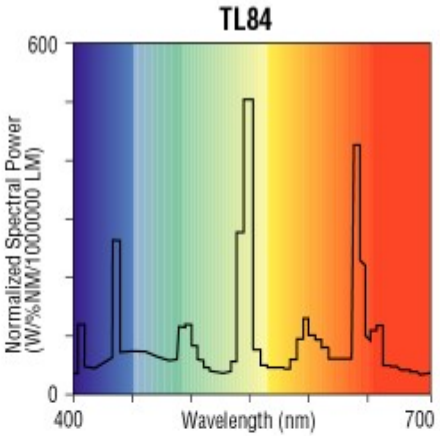
TL 84 Fluorescent

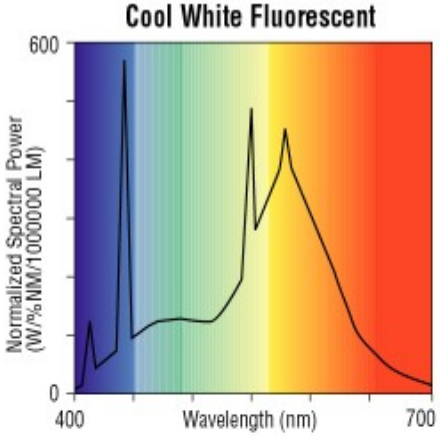
Cool White Fluorescent

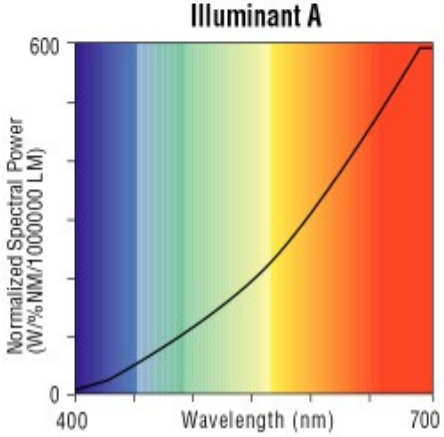
Illuminant A (Incandescent)

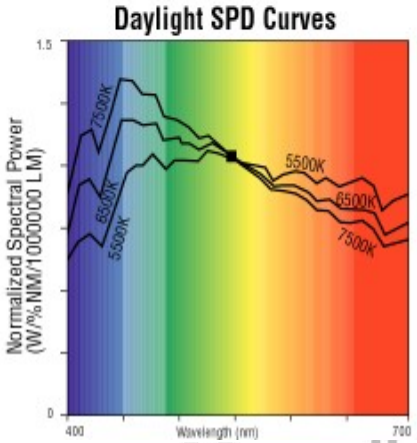
Light Source - Variation

Light source
SPD Curves









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Standard Illuminants

Illuminant	Description	Color Temperature
A	Incandescent	2856K
B	Noon Daylight	4874K
C	Average Daylight	6774K
D65	Average North Sky Daylight	6520K
D50	Graphic Arts viewing std	5150K
F2	Cool White Fluorescent	4150K
TL84	Narrow Band Fluorescent	4100K

Observer - Variation

- Visual Evaluation
  - Observers Color Vision
  - Observers Experience
- Instrumental Evaluation
  - Type of Instrument
  - Which illuminant and observer function used

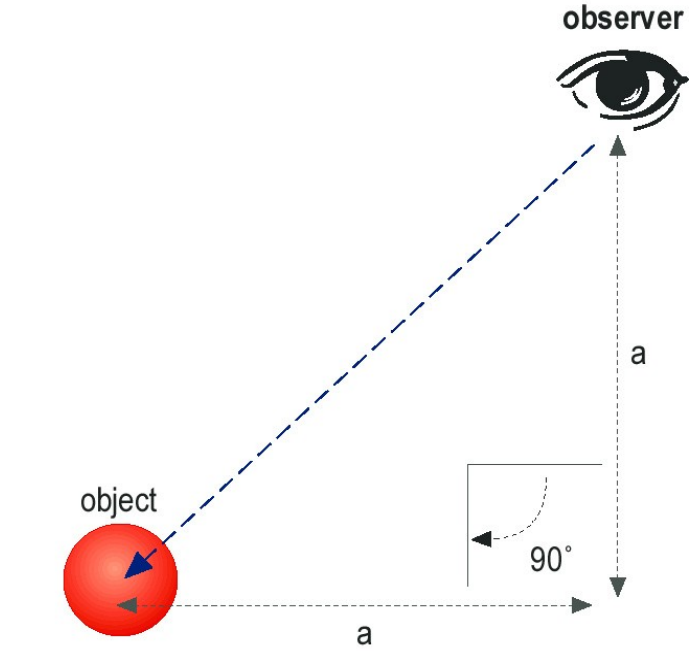
Facts About Color Vision

- 1 in every 12 males are color deficient.
- 1 in every 250 females are color deficient.
- The most common color deficiency is a partial green deficiency.
- Being color blind is rare; only 1 in 40,000. You would be missing all three receptors and called an “Achromat”.

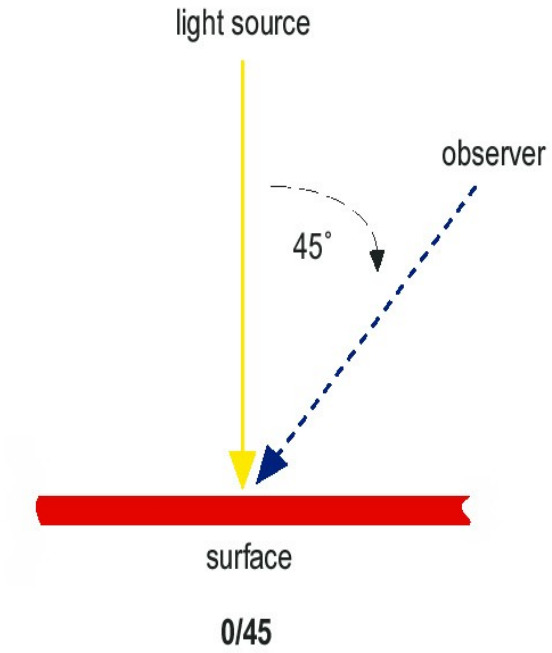
Things that effect our color vision

- Tiredness: time of day color is viewed.
- Age: causes discoloration of lens and cornea
- Stress: Hypertension (high blood pressure)
- Hunger: Color assessment is effected by hunger
- Medication: Viagra and Digitalis both effect blue color vision.
- Disease: Diabetes, Retina Pigmentosis and Cataracts effect color vision.
- UV: exposure to ultraviolet, can cause retina damage and yellowing of lens and cornea.

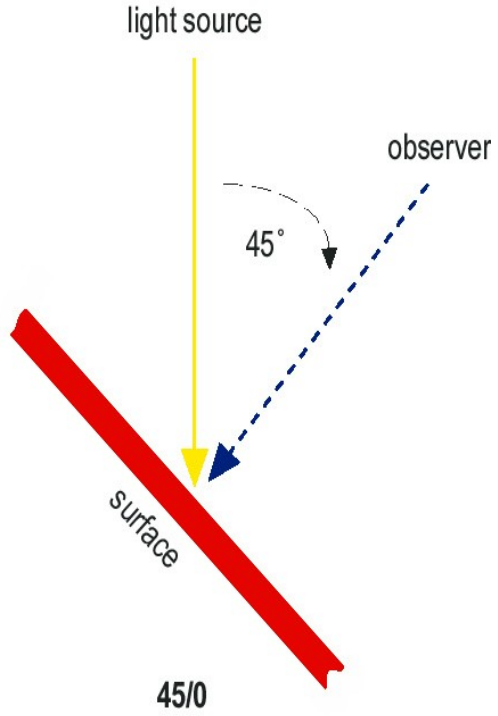
Correct Viewing Geometry 45 ^{0} ANGLE



Viewing Geometry



0/45



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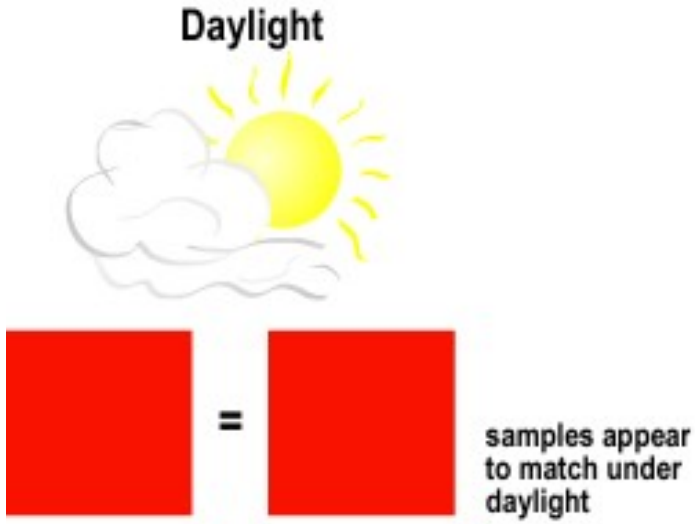
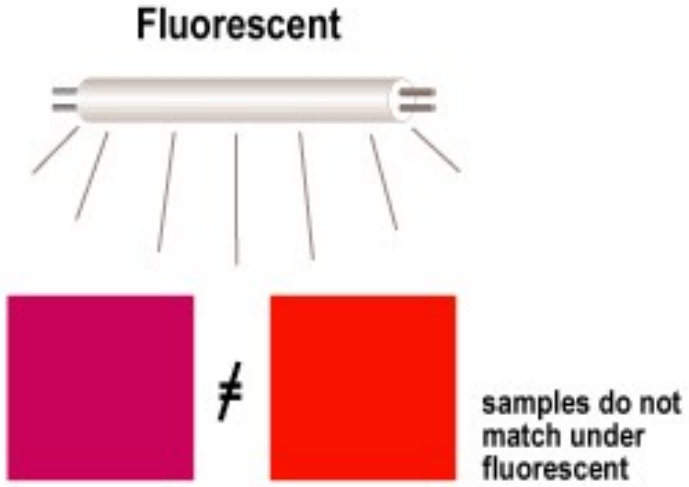
Metamerism

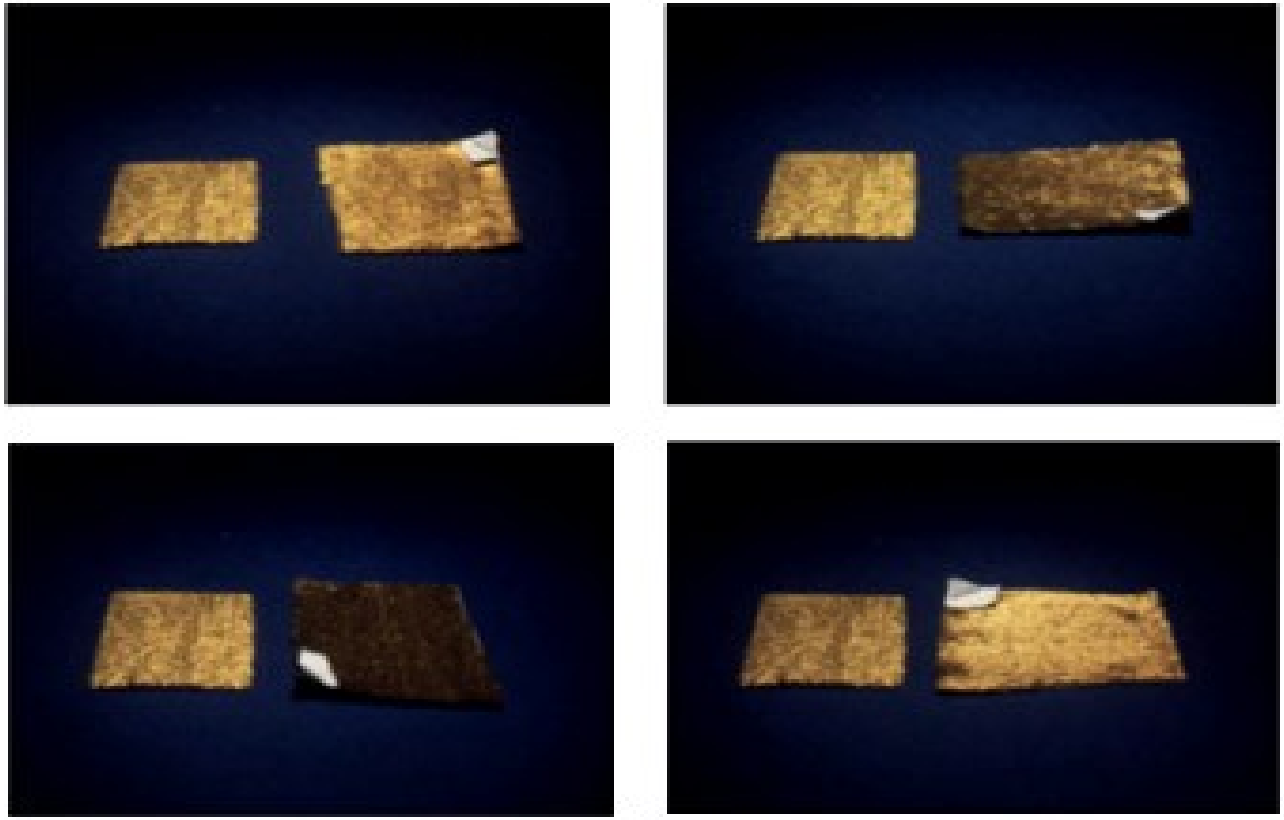

Daylight
=
samples appear to match under daylight


Fluorescent
≠
samples do not match under fluorescent

Gonioappearance (Geometric Metamerism)

- Samples that match at one angle of illumination, but do not match when the angle of illumination or viewing angle is changed.
- Often occurs with materials such as pile fabrics, satins, velvets, suedes, broadlooms, textured extruded plastics or Special Effect Paints (metallic, Pearlescent)

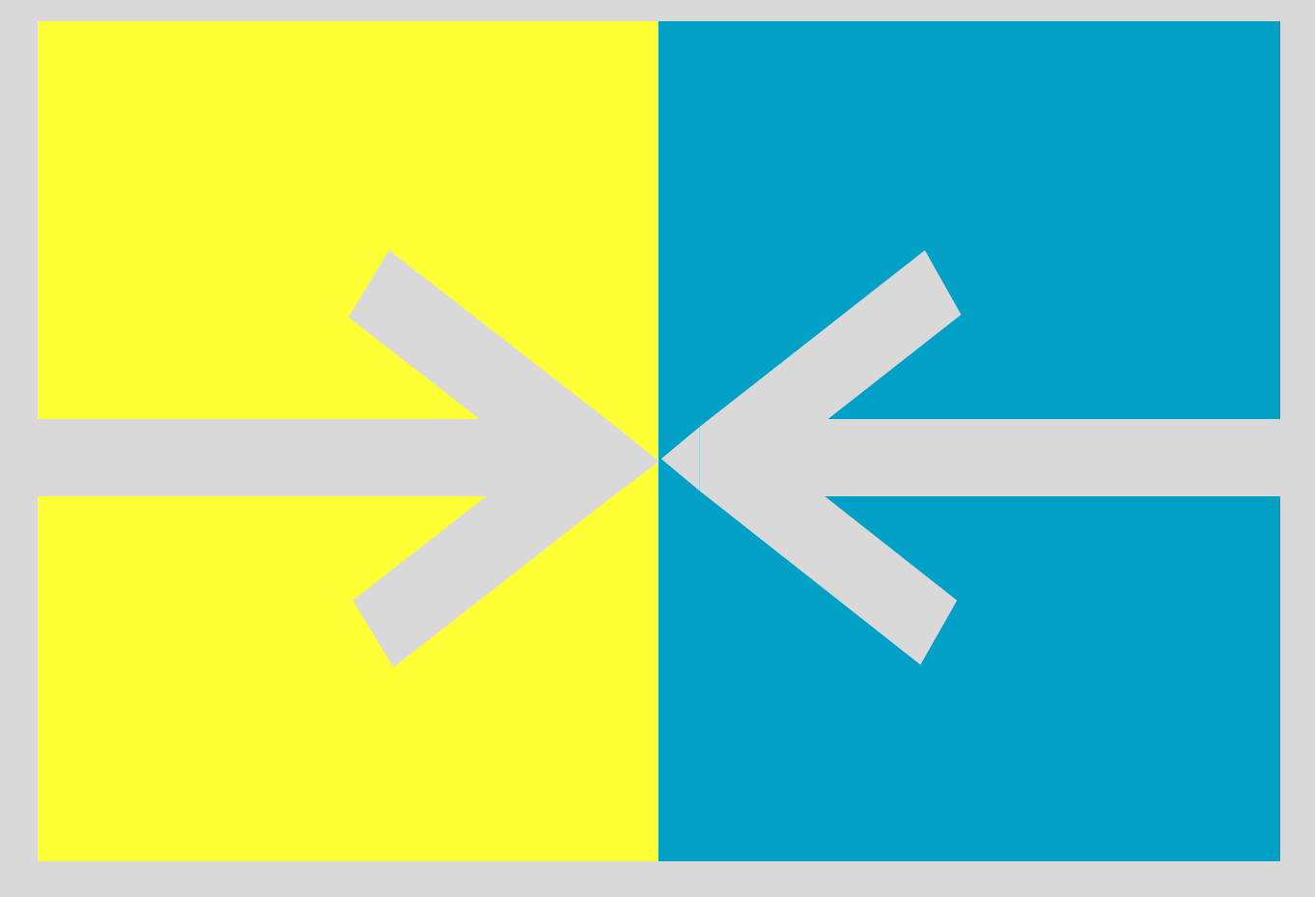
Gonioappearance



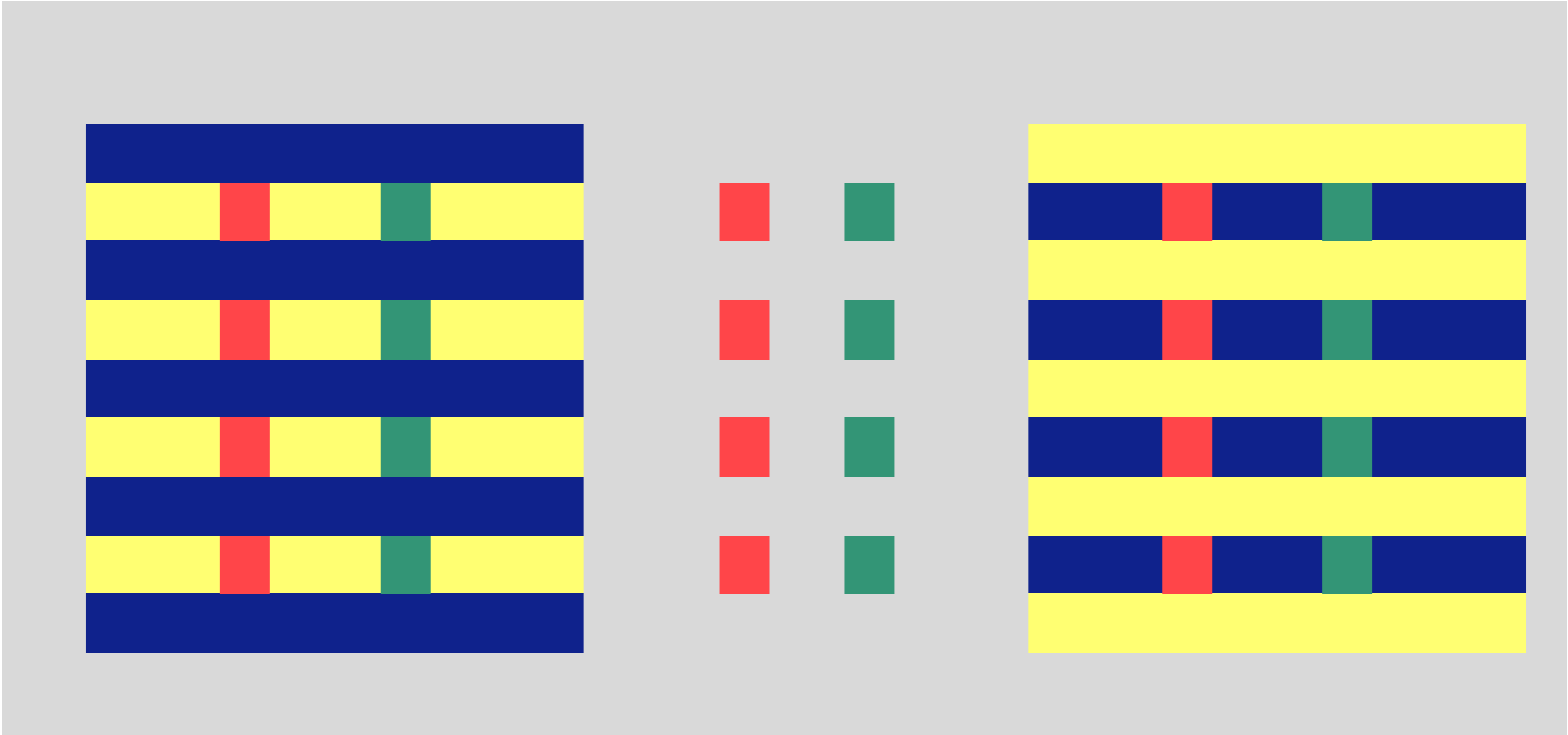
Observer Metamerism

- When samples appear to match to a group of observers, but do not match to an individual observer.
- This individual could have slightly inferior color vision.
- Color Vision and Discrimination (Munsell / Farnsworth) tests provide some insight into the differences between observers and the areas of color that presents difficulty for the observer to discriminate.

Simultaneous Contrast



Chameleon Effect



Light Source Selection

- Use established industry procedures or standards that specify specific light sources and viewing practices, (ASTM, AATCC).
- Choose light sources that do not hinder your ability to make good color decisions.
- Specify color temperature, SPD, CRI, CIE Assessment and lamp technology.
- Everyone must agree to use the same light sources and procedures.

Proper Technique

- Select the correct light source(s).
- Viewing booth should be kept clear of extra samples.
- Samples should be placed inside the light booth.
- Orient Standard and Sample in same direction, side by side, touching. Same size samples are best.
- Align standard and sample at 45^0 degree angle as standard viewing geometry.
- Limit the amount of ambient light flooding the viewing booth.
- Evaluator is should not be wearing brightly colored clothing.
- No tinted glasses.

Describe this Color.

Red

Red-Purple

Blue-Red

Cool Red

Roman Red

Wine Red

Two things that are definite when talking about color:

1) Rarely does anyone agree on color
2) Everyone can tell you when the color is wrong

Color Anarchy?

Color Order/Description System:

- Allows for the specification of a color as it relates to its place in color space.
- Allows for easy understanding of what the color is.
- Provides a controlled method for specifying colors.

They are several types of systems or languages

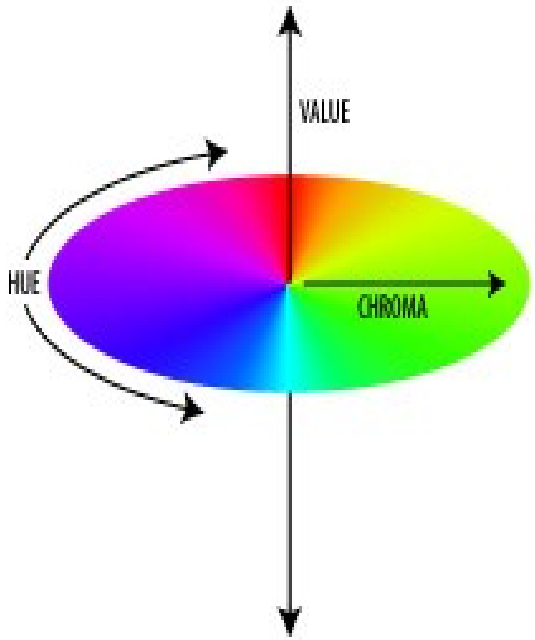
- Munsell
- Lab
- Lch
- XYZ

Essentially the perform the same task

Color systems or languages

- Provide means for communicating color effectively
- Similar to a map a providing an effective way to find a location

Munsell Color Order System



A system which shows the relationship among colors using three attributes:

- **hue,**
- **value**
- **chroma**

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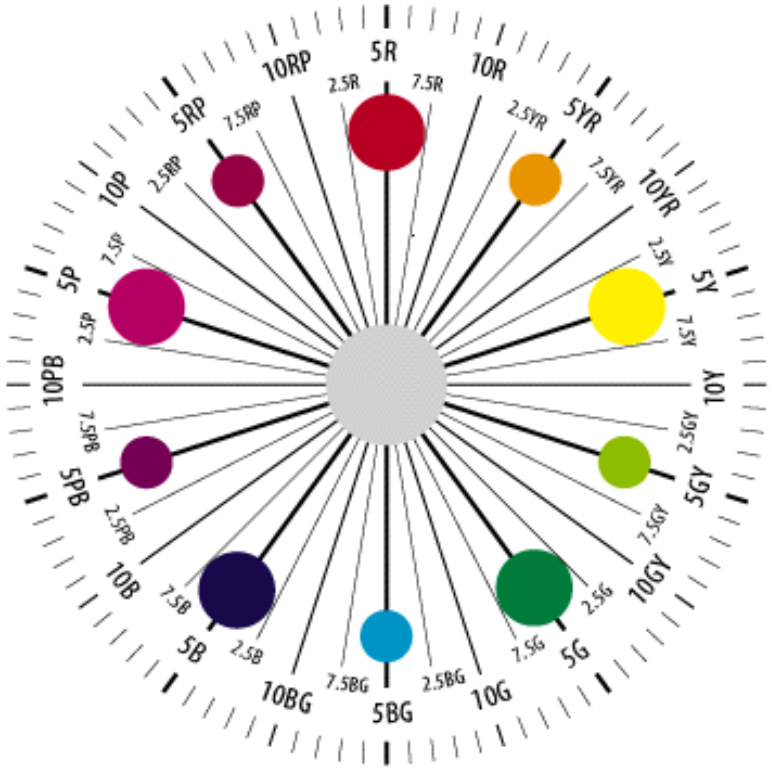
Hue



Hue is the color attribute by which we distinguish red from green, blue from yellow, and so forth.

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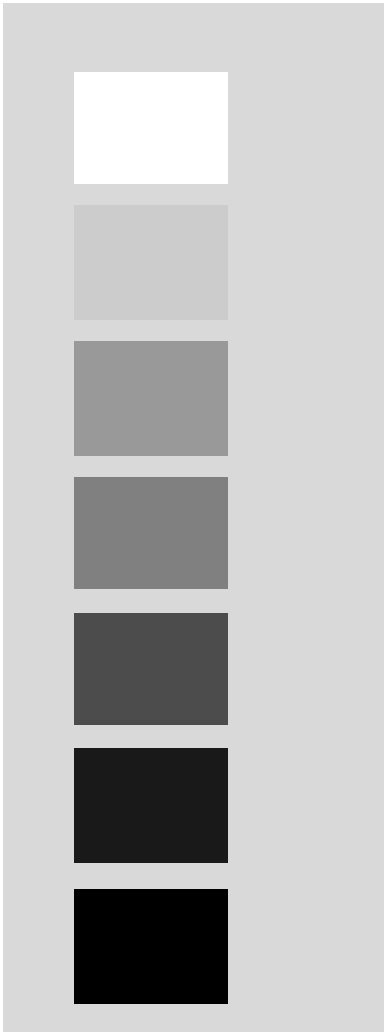
Value



Value indicates the lightness or darkenss of a color:

0 = pure black
10 = pure white

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Chroma

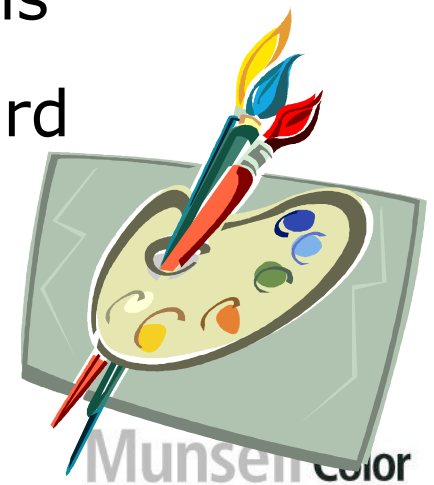
Weak Strong

Chroma is the degree of departure of color from the neutral color of the same value.

- Low chroma colors are called weak.
- High chroma colors are called strong.

How can a color standard be quantified and communicated?

- By defining ways to describe a color
- By defining the Illuminate to use
- By defining the Observer Conditions
- By using a controlled Color Standard



Color Measurement and Specification

- Communicating and achieving accurate color is a process which begins with measuring. Knowing the who, what, where and why we measure is critical to your success.

Sources of Visual Assessment Difference Human Observer

- Acuity, color discrimination
  - Use FM Test to assess observers' strengths and limitations
- Age, meds, mood, fatigue, etc
- Colored glasses or contacts?
- Colored apparel?
  - Best Practice: wear white or gray lab coat

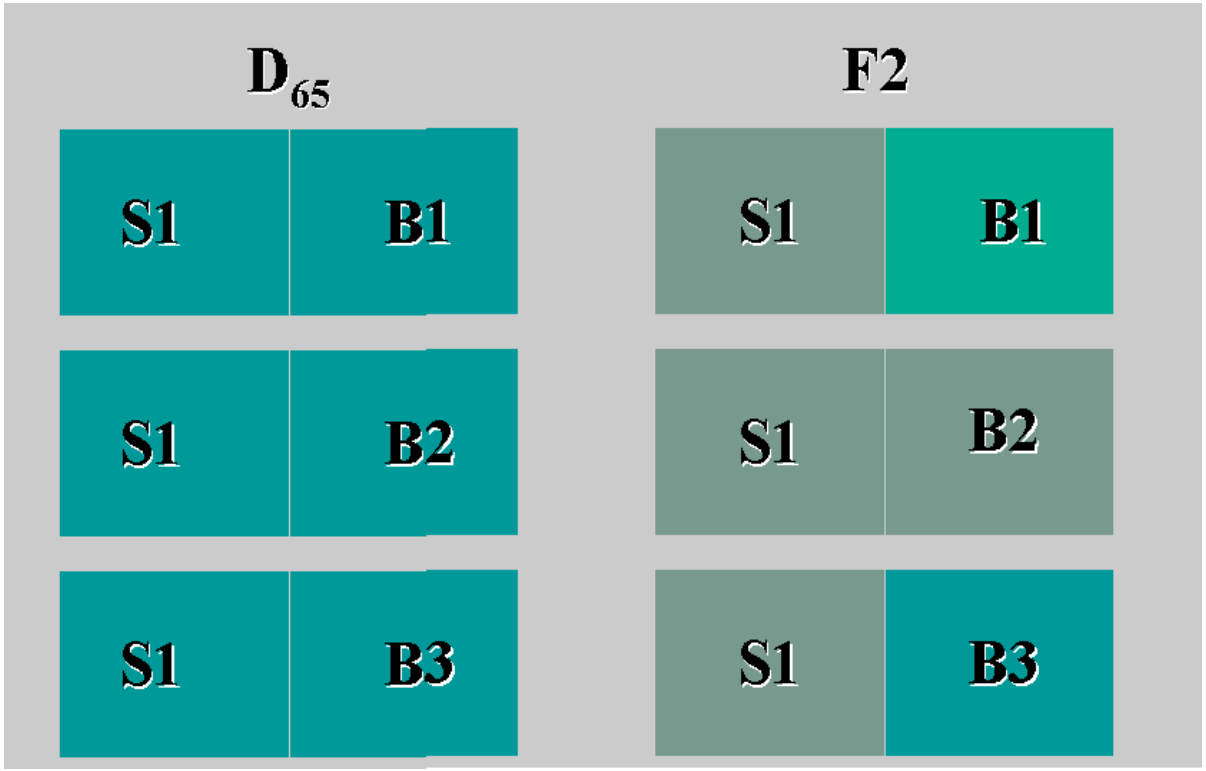
Keys to a Successful Color Program

- Use consistent, standard Best Practices
- Identify assessments which are “borderline”
  - Pass/fail judgment depends on business issues, in addition to color
- Rigorous visual program will correlate well with instrumental program
- Control the use of color standards

Best Practice for Physical Color Standards

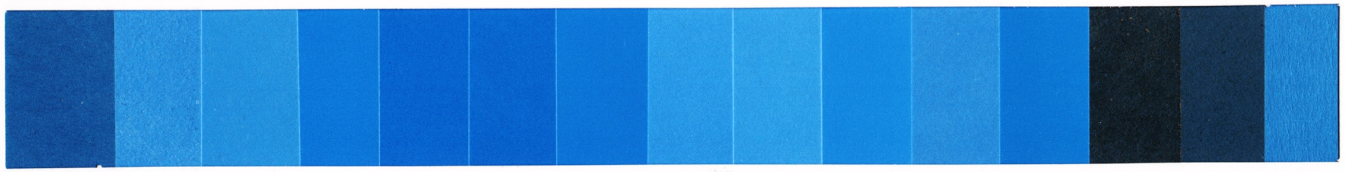
- Control your standards – do not let them travel!
- Create or select color constant standards whenever possible.
- Do not cut them into successively smaller pieces.
- Use consistent, controlled procedures for any critical viewing of color or color match.
- There will be changes over time and between different pieces.

Standards – Metamerism vs. Flare (Hinks)



Flint Ink CORPORATION

Color Quiz



Which swatches are printed with the same ink?

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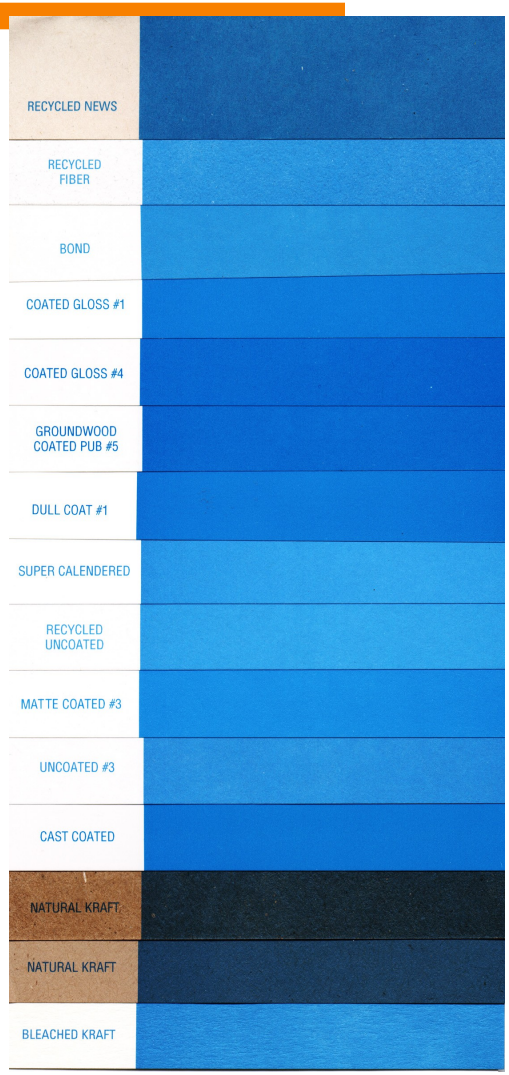
All Of Them!



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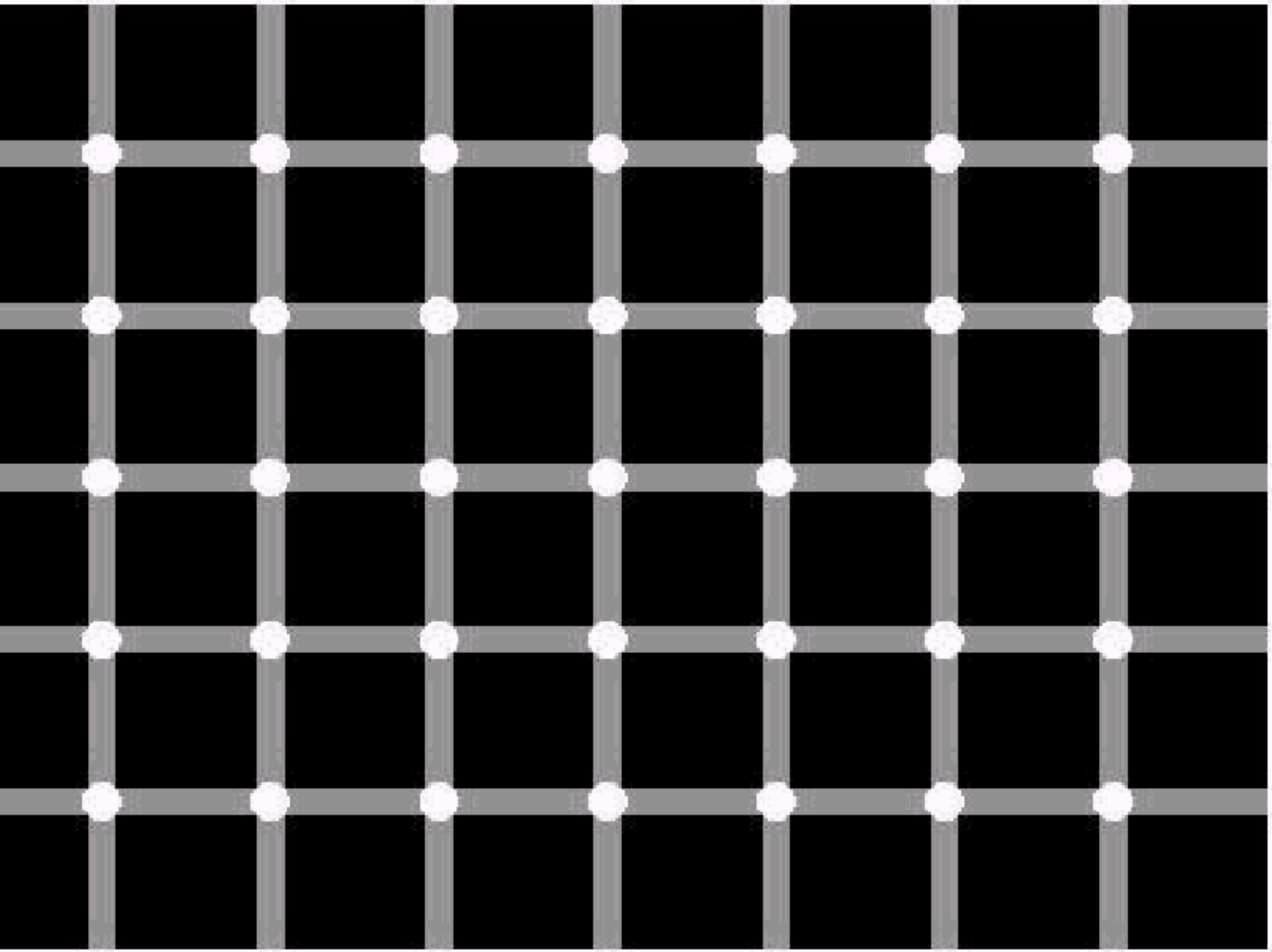
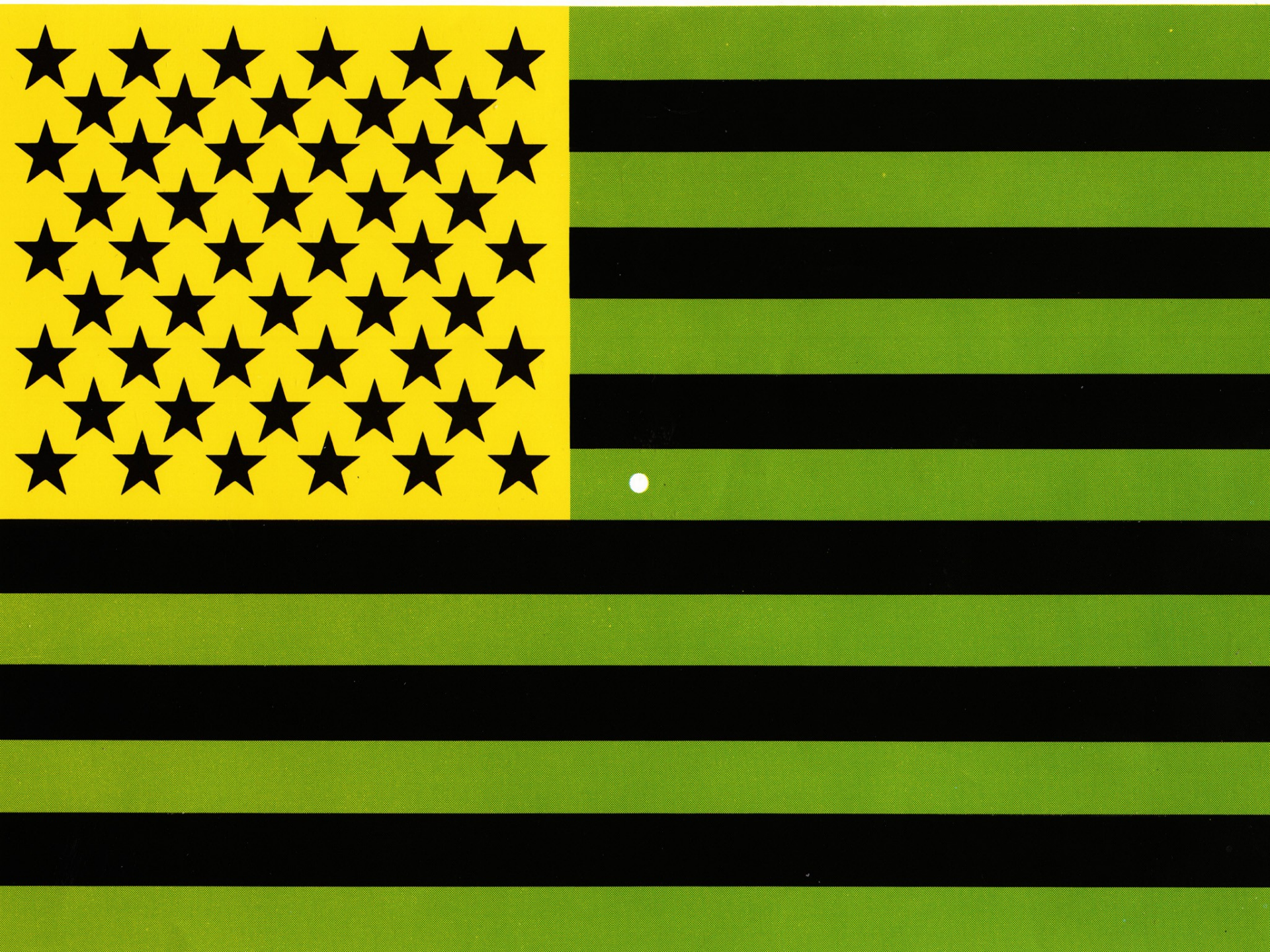
Why Do We Need Instruments?

- Communication of Color
- Limitations of the Human Eye



Limitations of the Human Eye

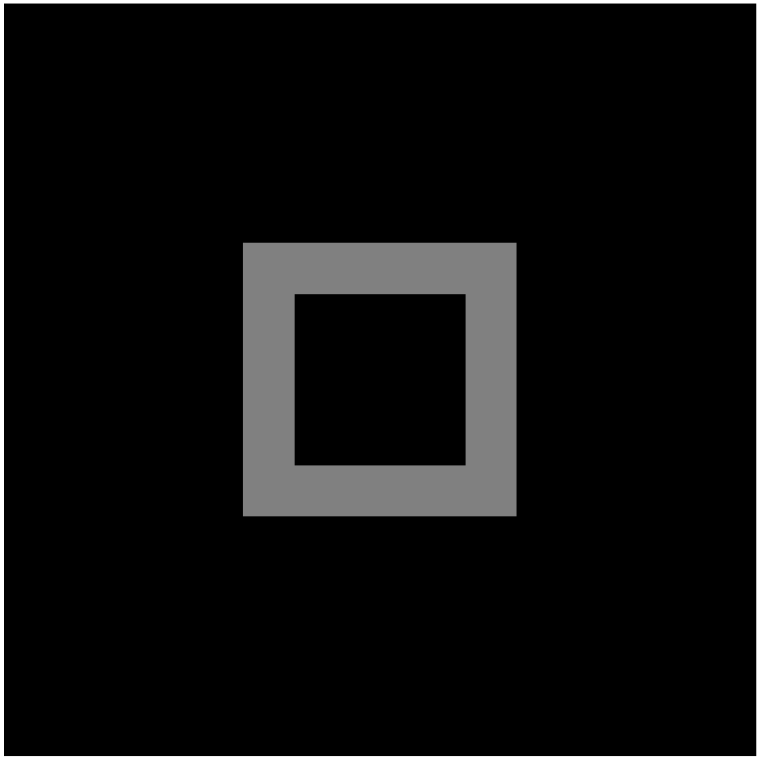
- Visual Phenomena

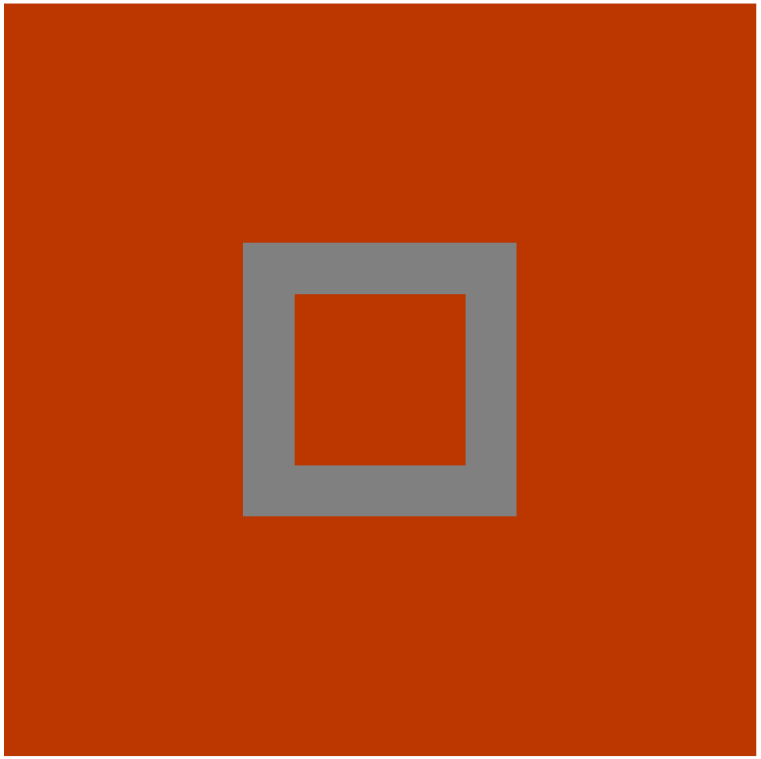


Limitations of the Human Eye

- Visual Phenomena
- Fatigue

Different Grays?





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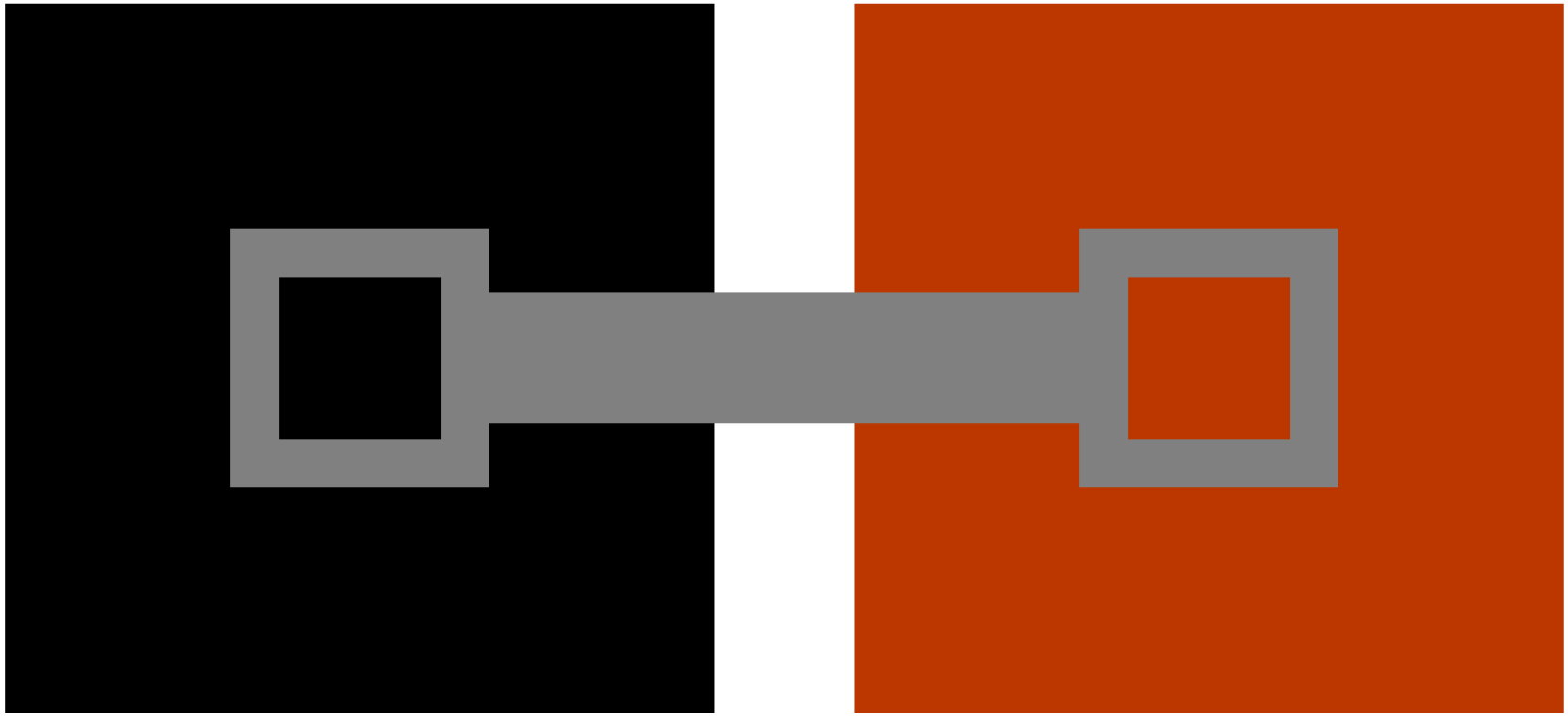
No, Same Gray!



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- Visual Phenomena
- Fatigue
- Surround Color

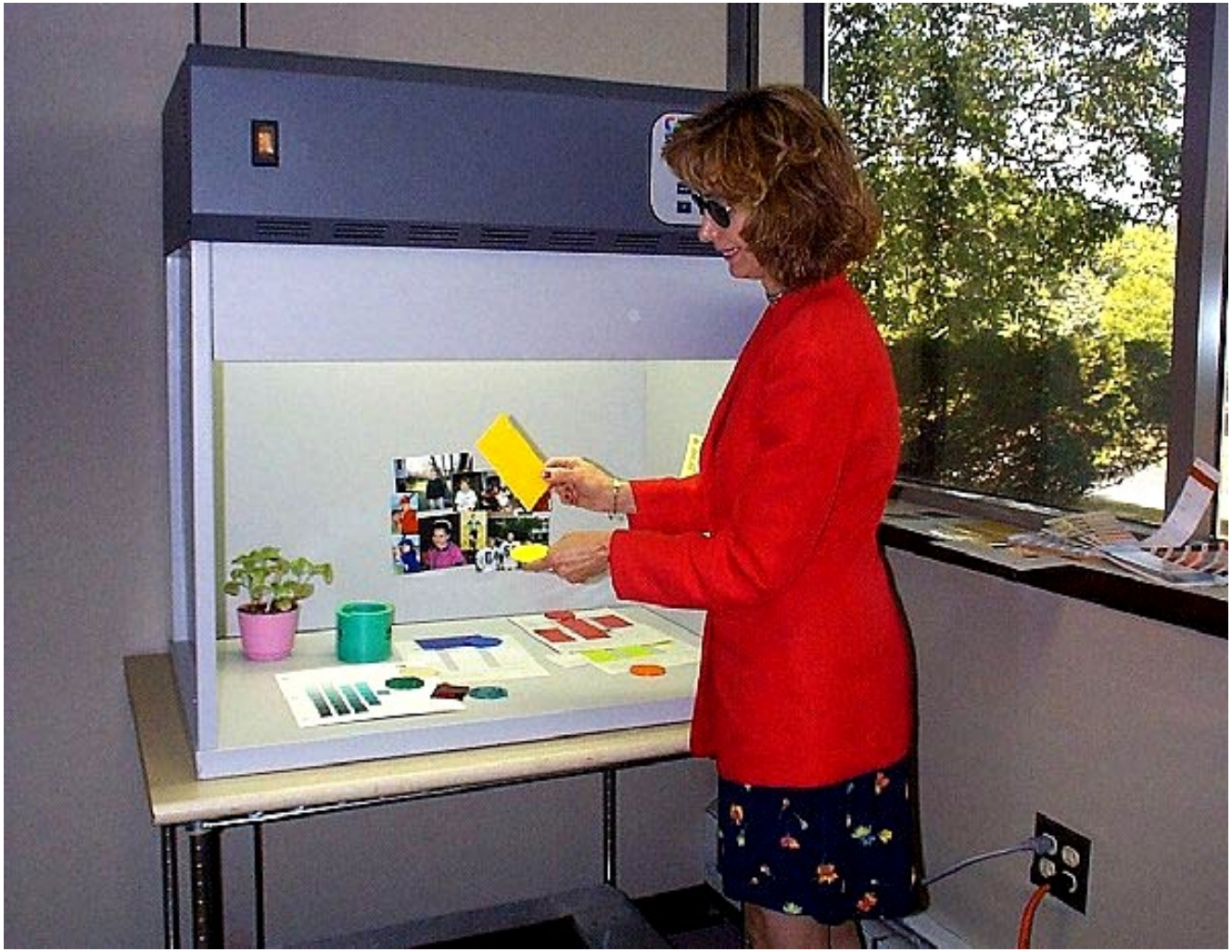
Limitations of the Human Eye

- Visual Phenomena
- Fatigue
- Surround Color
- No Memory

Limitations of the Human Eye

- Visual Phenomena
- Fatigue
- Surround Color
- No Memory
- Color Deficiency
- Recordabilty
- Age
- Viewing Conditions

What's Wrong with This Picture?



Munsell Color

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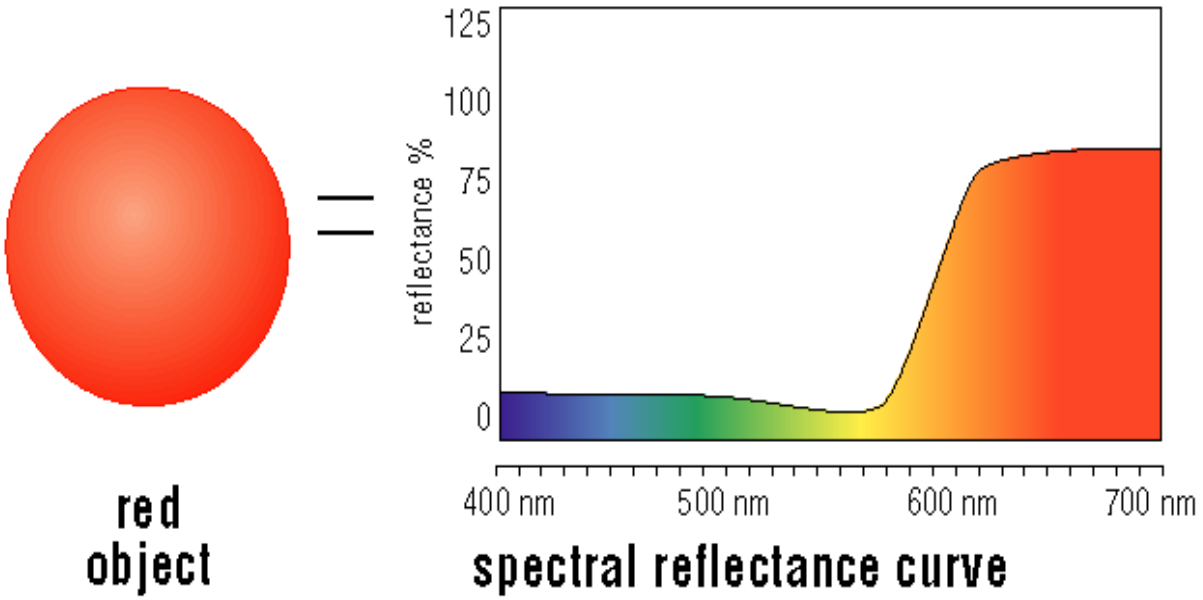
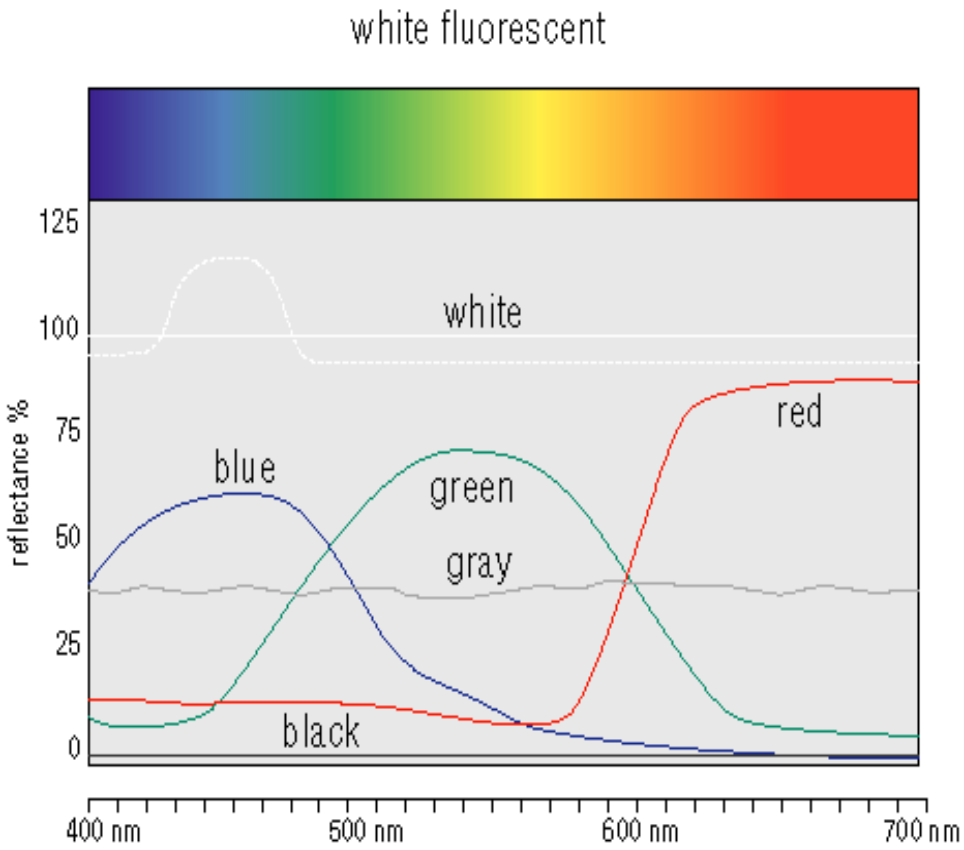
Instrumentally Quantifying Objects

- Spectral characteristics are specified by reflectance (or transmittance) as a function of wavelength
- Spectral data are measured with a spectrophotometer

Red Object



Spectral Reflectance Curves



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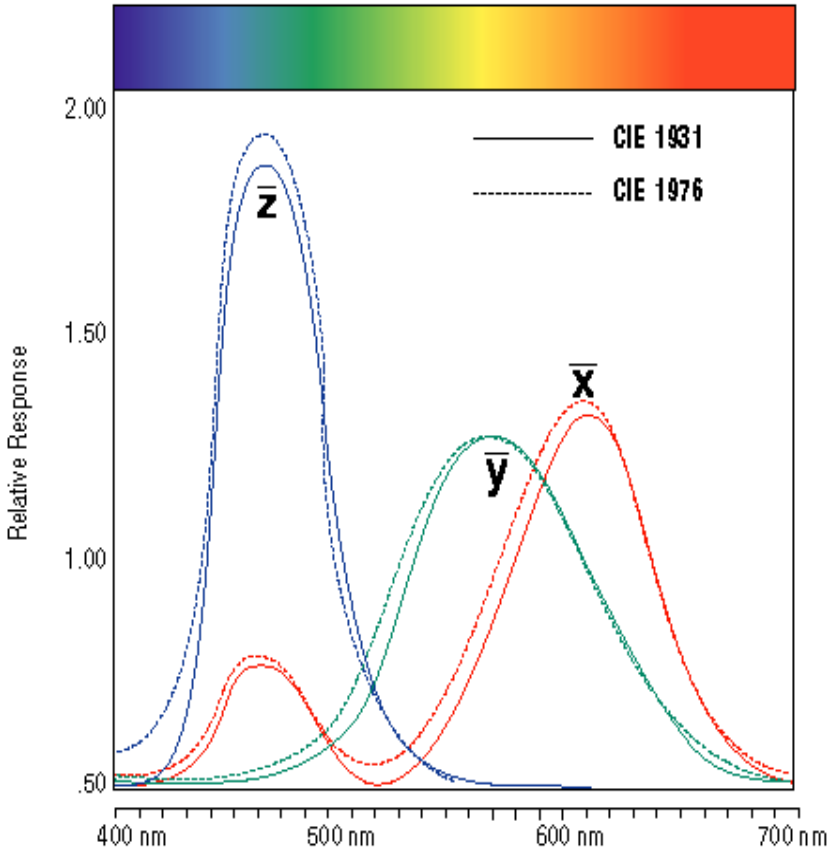
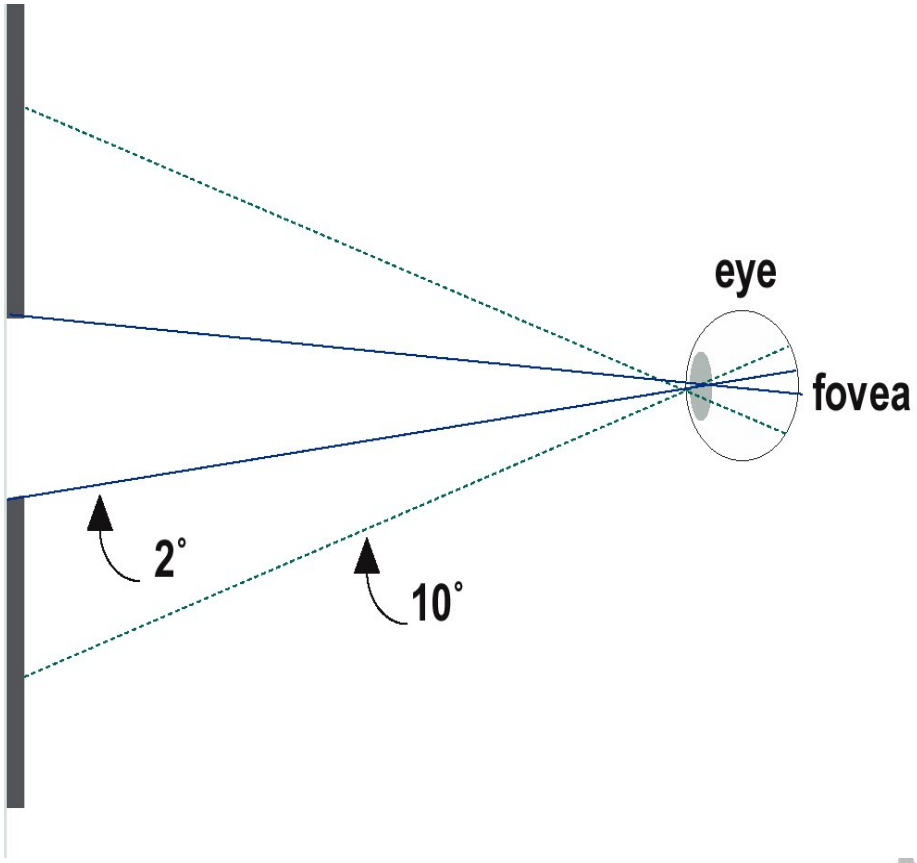
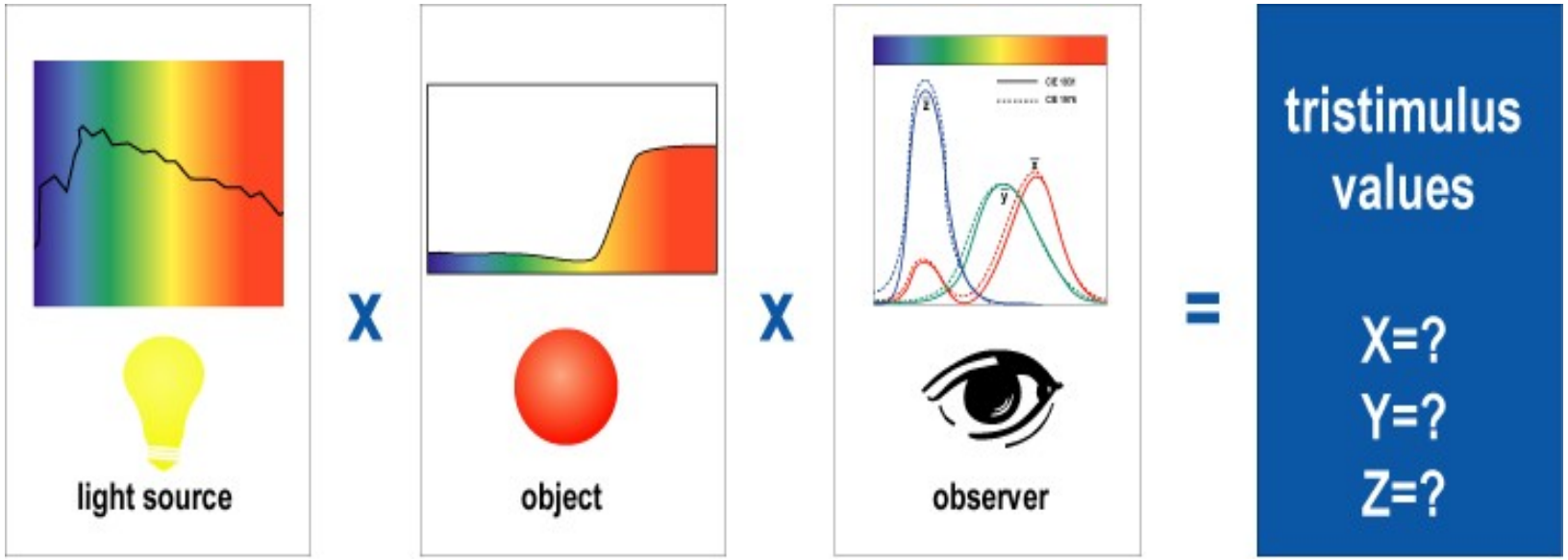
Standard Observer Responses



2º & 10º Standard Observer



Tristimulus Values – X, Y & Z



What Color Is This?

10° Observer, Illuminant D65

X = 18.34

Y = 11.19

Z = 6.68

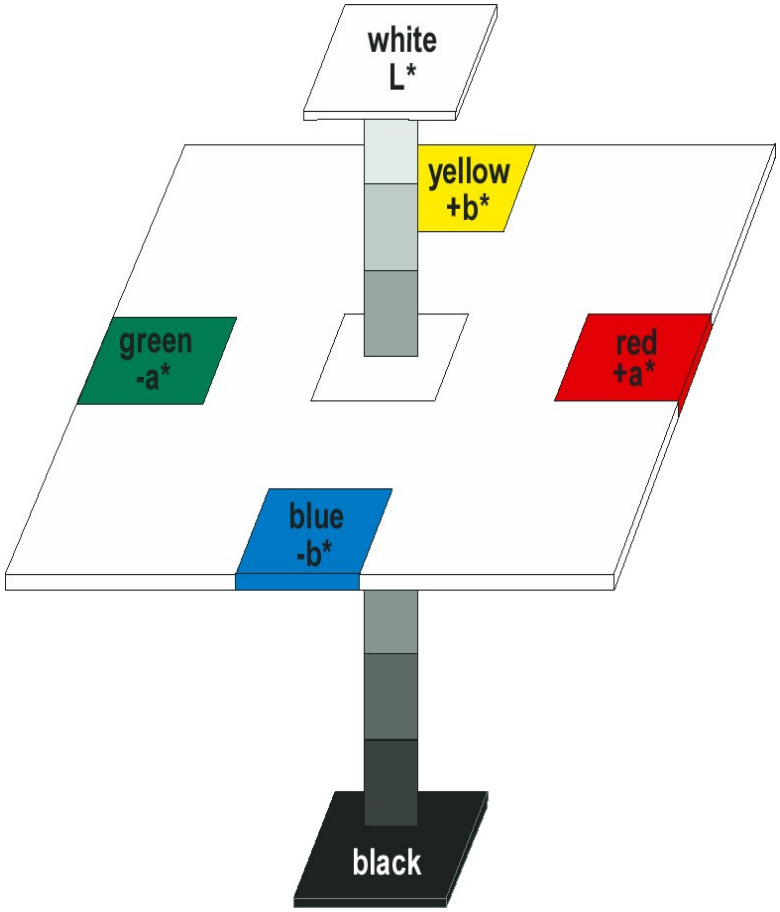
CIELab Values for a Red Object

- 10° Observer, Illuminant D65
- L*=39.90
- a*=48.04
- b*=17.18

CIELab Values for a Red Object D65 vs F2

- L* = 39.90 L* = 39.95
- a* = 48.04 a* = 37.77
- b* = 17.18 b* = 16.94

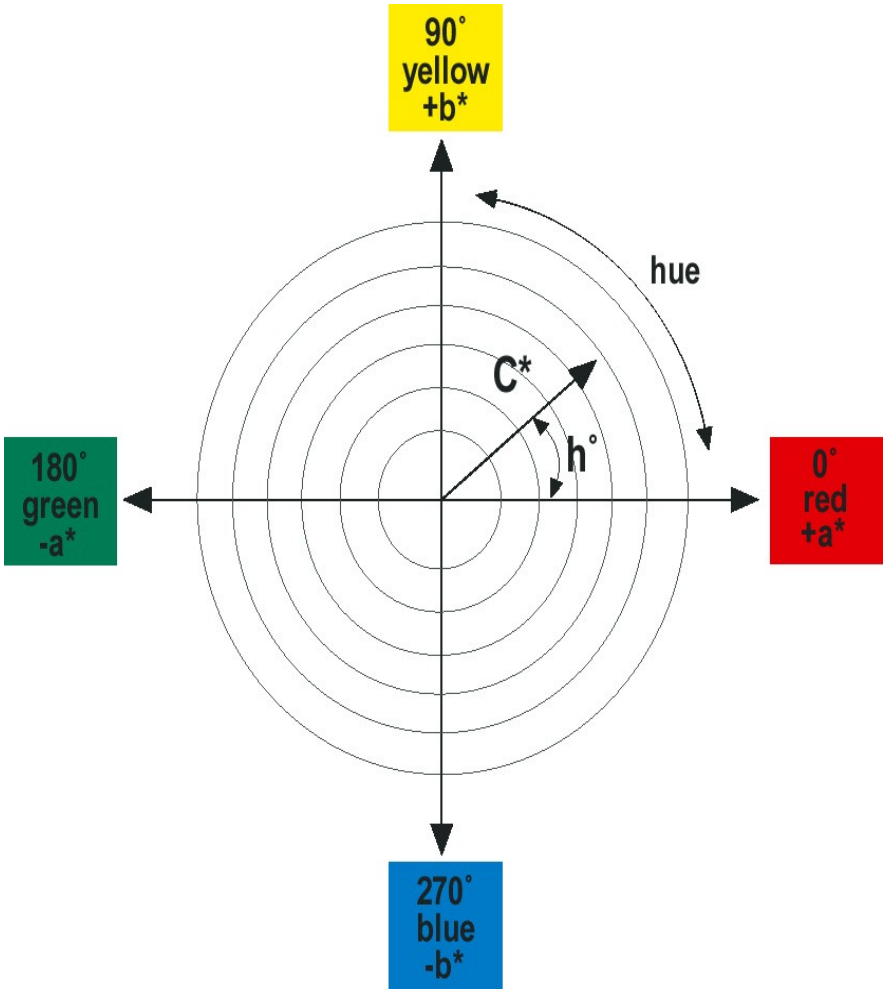
CIELab



CIELab

Example	L*	a*	b*
Pale Gray (nearly white)	83.70	-0.50	0.50
Medium Gray	59.60	0.00	0.50
Brilliant Red	43.70	37.10	18.70
Brilliant Yellow	83.30	1.90	77.00
Green	56.80	-30.00	15.40
Deep Blue	29.30	8.00	-17.90

CIELCh



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CIELch

Example	L*	C*	h*
Pale Gray (near ly white)	83.70	0.71	315.0º
Medium Gray	59.60	0.50	270.0º
Bril li ant Red	43.70	41.55	26.8º
Bril li ant Y ell ow	83.30	77.02	88.6º
Green	56.80	33.72	152.7º
Deep Blue	29.30	19.61	294.1º

In Conclusion

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