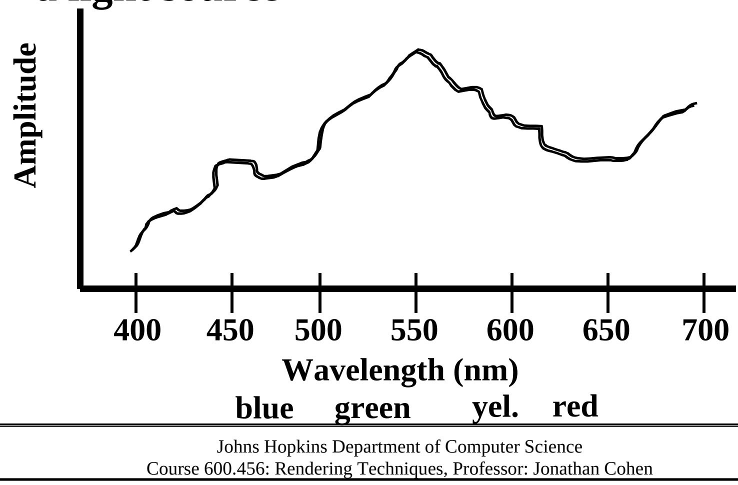
Light and Color

Frequency Spectrum

Spectrum describes frequency distribution of a light source



Definitions

Hue: quality that distinguishes one color family from another (i.e. red, yellow, green, blue, etc.)

Chroma: degree of color's departure from greyscale

Value/Lightness: quality distinguishing light from dark colors

More definitions

Achromatic light: literally light without chroma, or greyscale light

- fairly uniform frequency distribution

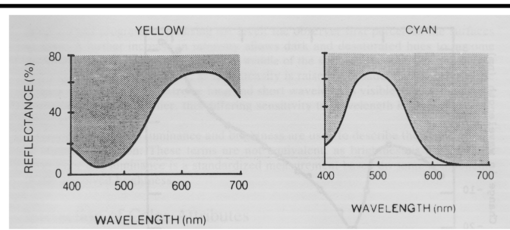
Monochromatic light: light which has all intensity near a single frequency

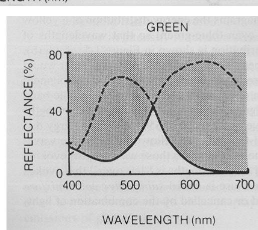
Color Mixture - Subtractive

Applies when mixing pigments and dyes

- **Each substance absorbs certain frequencies**
- **Combining substances absorbs the union of these frequencies**
- **Resulting reflected light is intersection of colors reflected by each**

Subtractive Mixture Example





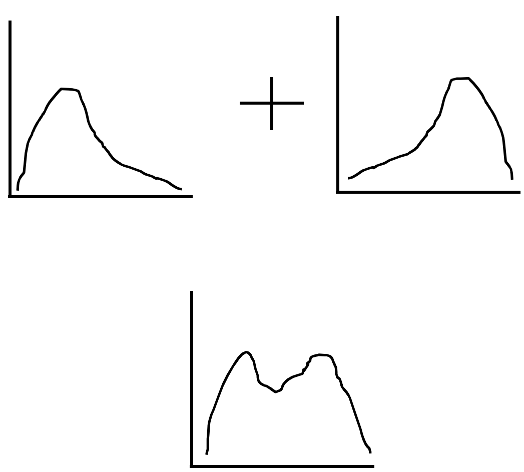
from Gerald Murch, "Color Displays and Color Science", in* Color and the Computer*, H. John Durrett, ed., page 10.

Color Mixture - Additive

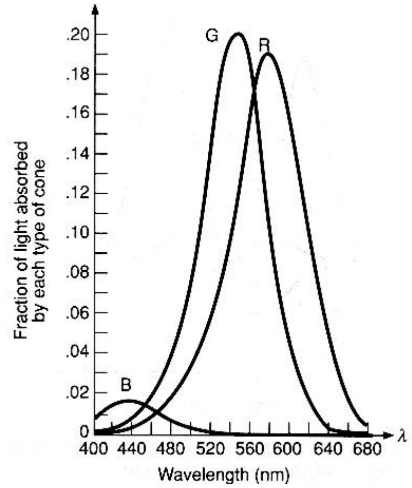
Applies to mixing of luminescent colors, such as color CRT and LCD displays, etc.

- **Color refers to actual frequency spectrum of light**
- **Combining lights adds their frequency spectra**

Additive Color Example



3 Types of retinal cones



***From Foley, vanDam, Feiner, and Hughes*, Computer Graphics: Principles and Practice, 2nd edition, page 577**

Efficient Color Computations in Computer Graphics

Represent frequency spectrum as discrete set of samples

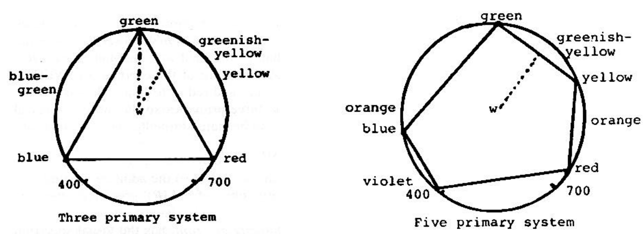
- **Typically 3 samples: red, green, and blue**
- **Monitors also use samples corresponding to different phosphors**
- **Eye also has 3 samples (types of cones)**

Does *not* imply that three samples for initial and intermediate produce accurate computations

Color Space Gamut

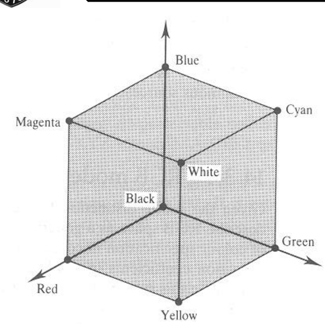
Color gamut: subspace of visible colors

No system of mixing colors from fixed number of primaries can represent all visible colors

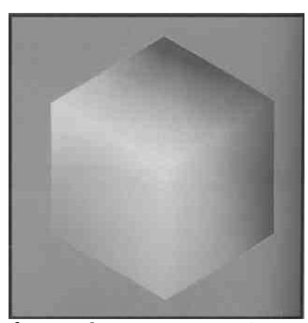


from Gerald Murch, "Color Displays and Color Science", in Color and the Computer, *H. John Durrett, ed., page 13.*

Color Spaces - RGB cube



From Alan Watt, 3D Computer Graphics*, 2nd edition, p. 416*

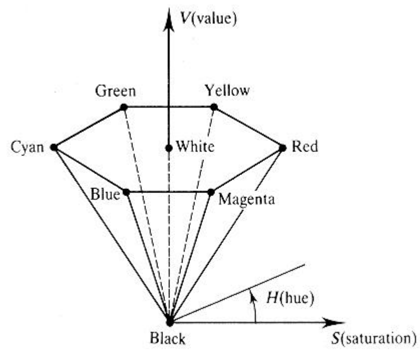


from Foley, vanDam, Feiner, and Hughes, Computer Graphics: Principles and Practice*, plate II.4*

Shortcomings:

- **perceptually non-linear**
- **non-intuitive for human specification**

Color Spaces - HSV hexacone



From Alan Watt, 3D Computer Graphics*, 2nd edition, p. 419*

Still not perceptually linear

Axes correspond to more intuitive perceptual qualities

- **Selection similar to artist color mixing**
- **choose hue of base pigment, add white, add black**

Derived from projections of RGB cube

HLS double hexacone

Similar to HSV hexacone

Pulls white to make the apex of upper cone

- **Gives white and black similar geometric representation**

L (lightness) is similar to V, but the primaries occur at L=0.5 (for HSV, V=1 for primaries)

CIE Color Space

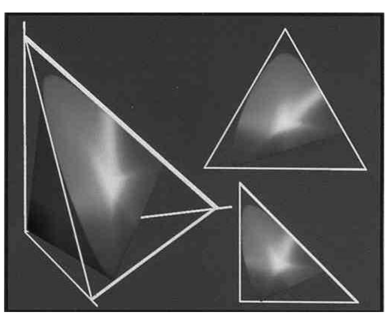
Employs 3 artificial primaries: X, Y, Z

- **Mathematical abstractions, not physically realizable**
- **Allow supersaturation**

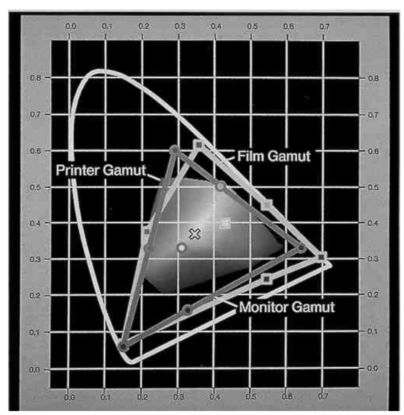
Larger than visible spectrum

Standard for representing colors and converting between spaces

CIE Space and Device Gamuts



Chromaticity Diagram



from Foley, vanDam, Feiner, and Hughes, Computer Graphics: Principles and Practice, *plates II.1 and II.2*

Gamma Correction

Exponential function converts from device-independent RGB space to device-dependent RGB

- **Gamma is exponent**
- **Every monitor is different**
- **Monitor color intensities are non-linear with respect to phosphor excitation levels**