



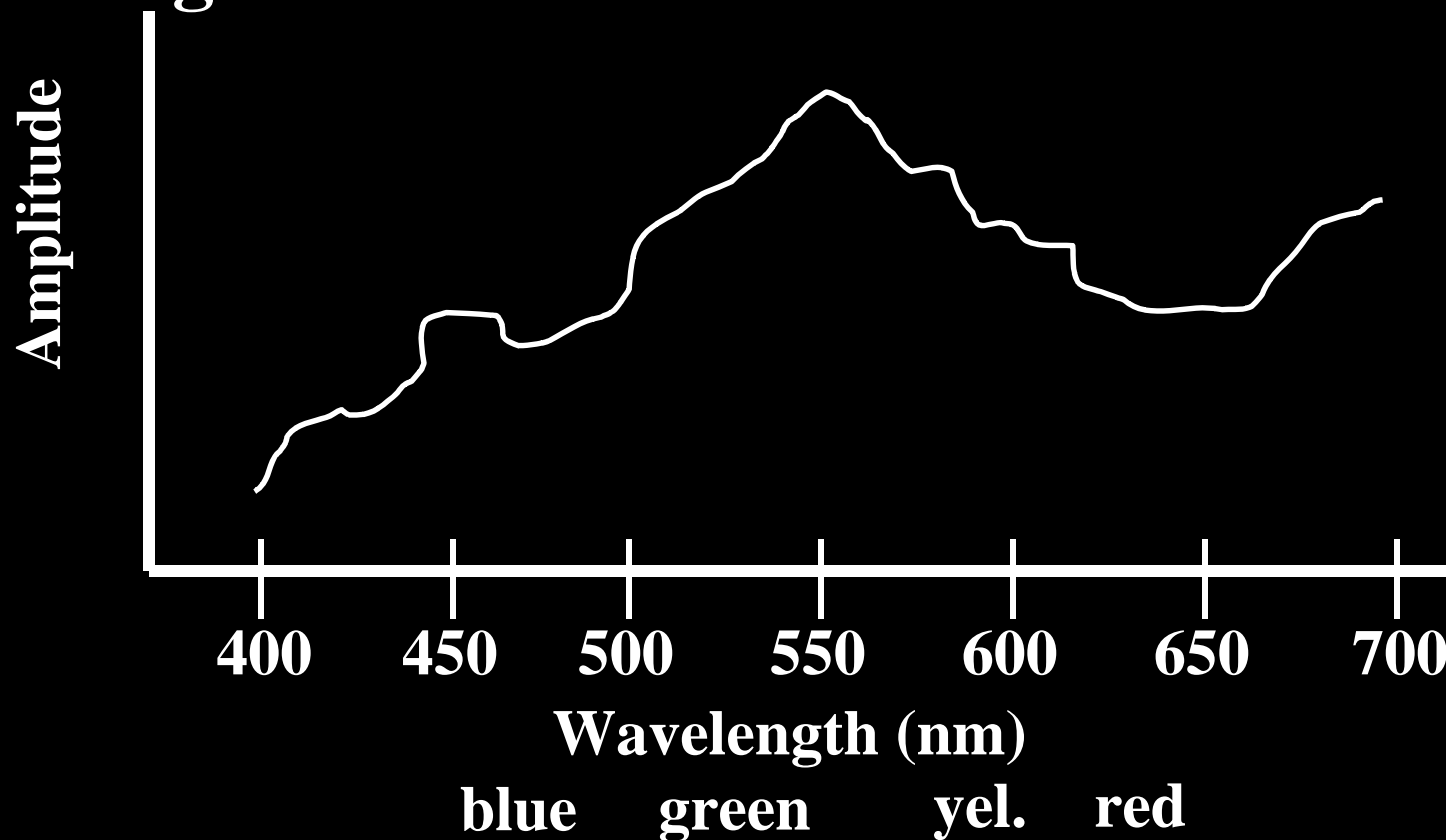
Light and Color

Johns Hopkins Department of Computer Science
Course 600.456: Rendering Techniques, Professor: Jonathan Cohen



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



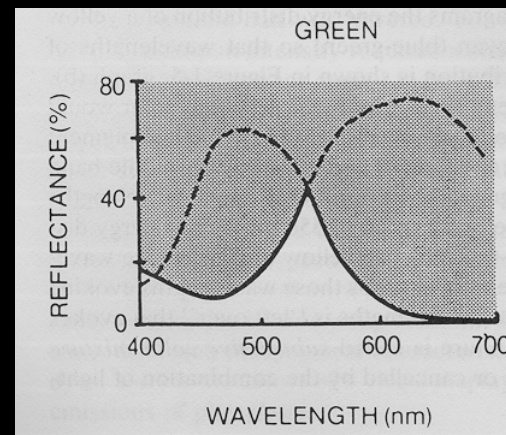
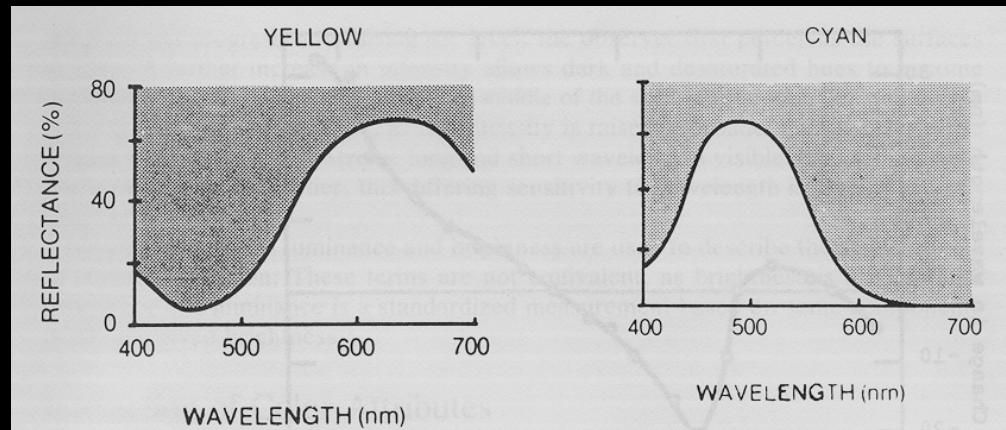
Color Mixture - Subtractive

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.



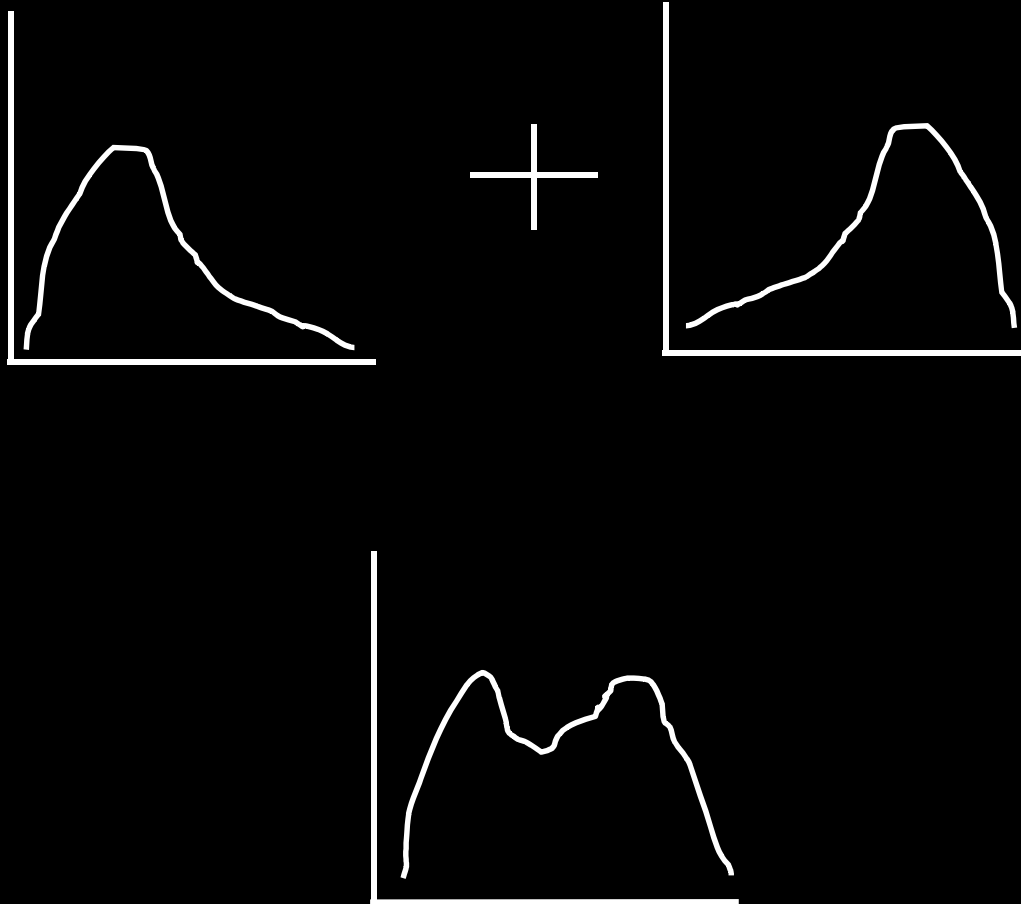
Color Mixture - Additive

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**

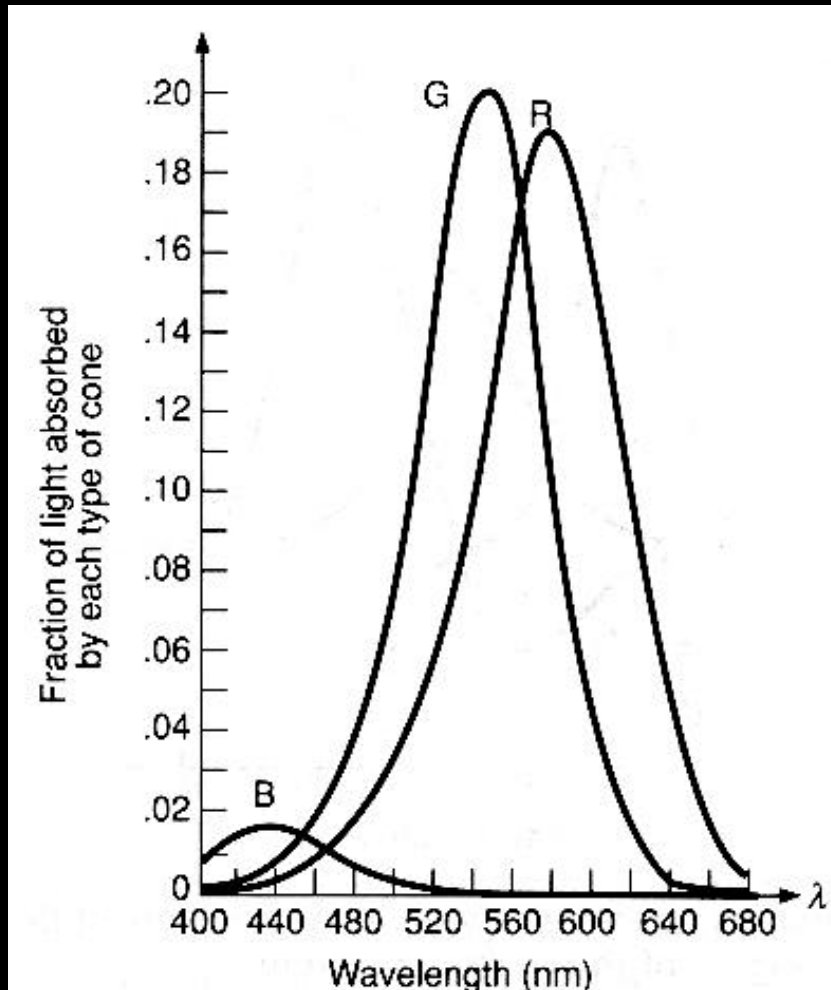


Additive Color Example





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

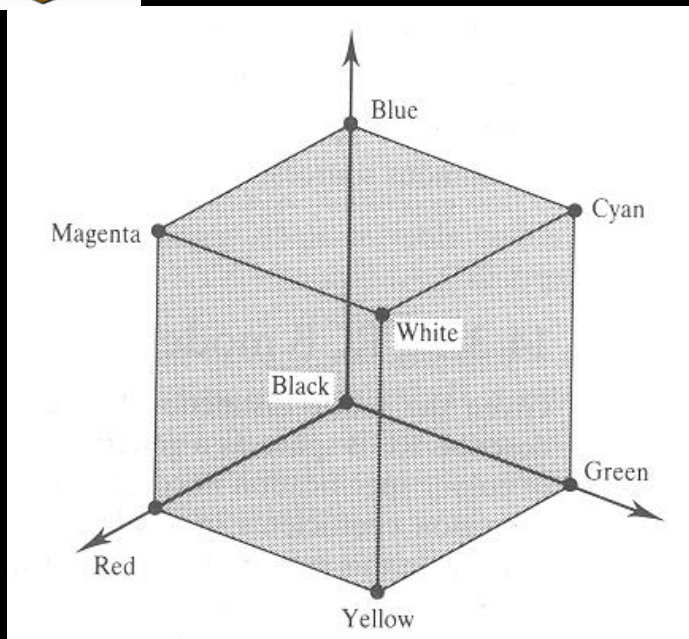
Represent frequency spectrum as discrete set of samples

- **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 Spaces - RGB cube



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



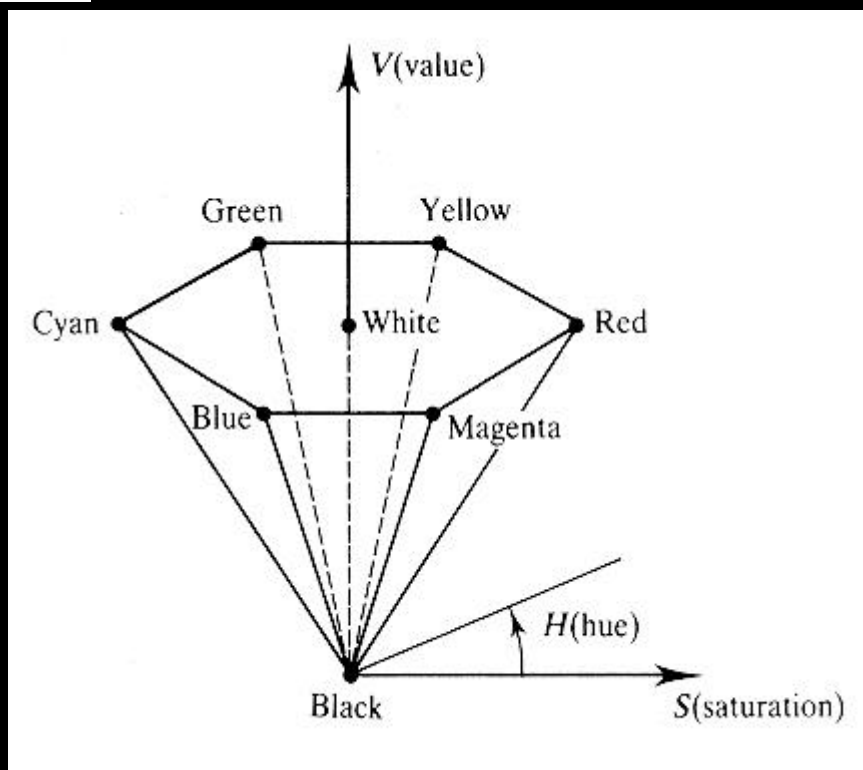
from Foley, vanDam, Feiner, and Hughes, Computer Graphics: Principles and Practice, plate II.4

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

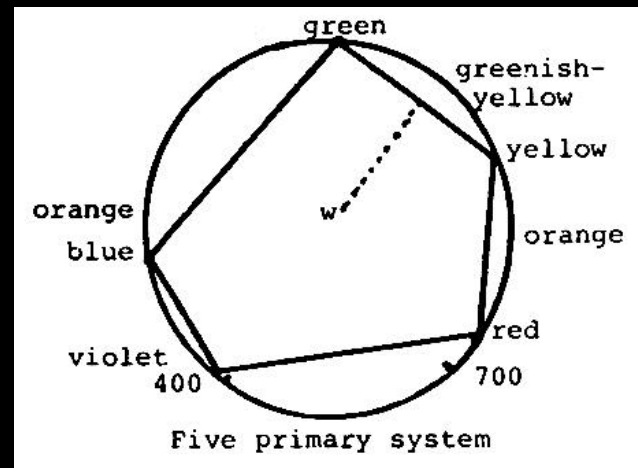
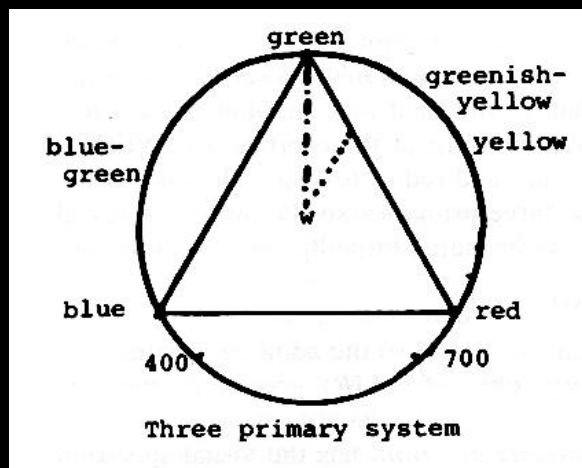
Derived from projections of RGB cube



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.



CIE Color Space

Employs 3 artificial primaries: X, Y, Z

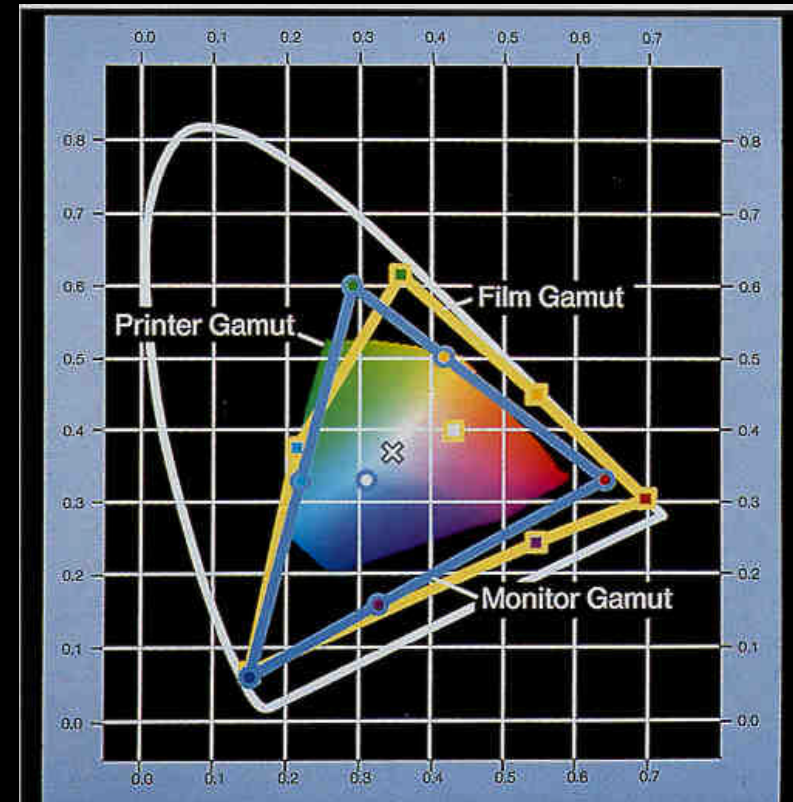
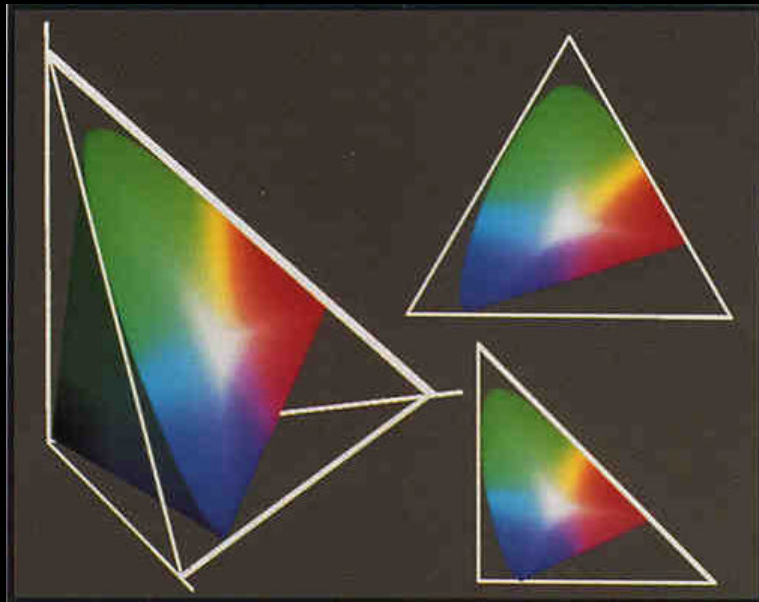
- **Mathematical abstractions, not physically realizable**
- **Allow supersaturation**

Larger than visible spectrum

Standard for representing colors and converting between spaces



CIE Space and Device Gamuts



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**