Light and Color
Spectrum describes frequency distribution of a light source

<table>
<thead>
<tr>
<th>Wavelength (nm)</th>
<th>Amplitude</th>
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<tbody>
<tr>
<td>400</td>
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<td>450</td>
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<td>650</td>
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<td>700</td>
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</tbody>
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- blue
- green
- yel.
- red

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Course 600.456: Rendering Techniques, Professor: Jonathan Cohen
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

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

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

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Color Spaces - RGB cube

Shortcomings:

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


from Foley, vanDam, Feiner, and Hughes, Computer Graphics: Principles and Practice, plate II.4
Color Spaces - HSV hexacone

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

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

Color gamut: subspace of visible colors

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

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

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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