Overview

- Display hardware
  - How are images displayed?
- Raster graphics systems
  - How are imaging systems organized?
- Color models
  - How can we describe and represent colors?

Display Hardware

- Video display devices
  - Cathode Ray Tube (CRT)
  - Liquid Crystal Display (LCD)
  - Plasma panels
  - Thin-film electroluminescent displays
  - Light-emitting diodes (LED)
- Hard-copy devices
  - Ink-jet printer
  - Laser printer
  - Film recorder
  - Electrostatic printer
  - Pen plotter
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Raster Graphics Systems

![Diagram of raster graphics systems](Figure 2.29 from H&B)

Frame Buffer

![Diagram of frame buffer](Figure 1.2 from FvDFH)

Frame Buffer Refresh

![Diagram of frame buffer refresh](Figure 1.3 from FvDFH)

Refresh rate is usually 30-75Hz

Color Frame Buffer

![Diagram of color frame buffer](Figure 1.3 from FvDFH)
**Color CRT**

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**Electromagnetic Spectrum**

- Visible light frequencies range between ...
  - Red = $4.3 \times 10^{14}$ hertz (700nm)
  - Violet = $7.5 \times 10^{14}$ hertz (400nm)

**Visible Light**

- The color of light is characterized by ...
  - Hue = dominant frequency (highest peak)
  - Saturation = excitation purity (ratio of highest to rest)
  - Lightness = luminance (area under curve)

**Color Perception**

- Spectral-response functions of each of the three types of cones on the human retina.

**Color Models**

- RGB
- XYZ
- CMY
- HSV
- Others
RGB Color Model

<table>
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<th>B</th>
<th>Color</th>
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<td>0.0</td>
<td>Black</td>
</tr>
<tr>
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<td>Blue</td>
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<tr>
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<tr>
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<tr>
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Colors are additive

RGB Color Cube

Plate II.3 from FvDFH

RGB Spectral Colors

Amounts of RGB primaries needed to display spectral colors

XYZ Color Model (CIE)

Amounts of CIE primaries needed to display spectral colors

CIE Chromaticity Diagram

Normalized amounts of X and Y for colors in visible spectrum

CIE Chromaticity Diagram

Figure 15.7 from H&B

Figures 15.11 & 15.12 from H&B

Figure 15.5 from H&B

Figure 15.6 from H&B

Compare Color Gamuts
Identify Complementary Colors
Determine Dominant Wavelength and Purity

Figures 15.8-10 from H&B
RGB Color Gamut

Color gamut for a typical RGB computer monitor

CMY Color Model

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<th>Color</th>
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Colors are subtractive

CMY Color Cube

HSV Color Model

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<td>0.7</td>
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Summary

- Display hardware
  - Monitors: CRTs, LCDs, etc.
  - Hard-copy: printers, plotters, etc.
- Raster graphics systems
  - Display processors
  - Frame buffers
  - Video controllers
  - Devices cannot display all visible colors
- Color models
  - Tristimulus theory of color
  - Different color models for different devices, uses, etc.