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# Raster Graphics

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## Overview

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

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## 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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## Cathode Ray Tube (CRT)

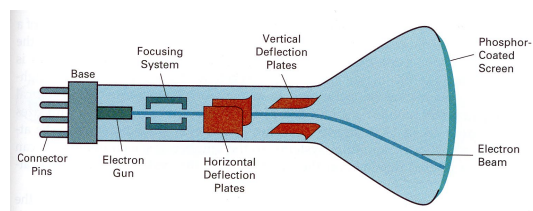


Figure 2.4 from H&B

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## Liquid Crystal Display (LCD)

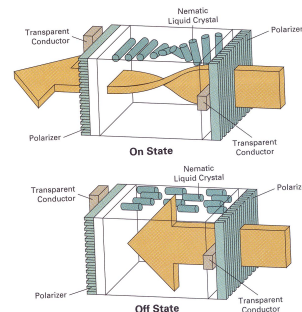


Figure 2.16 from H&B

## Display Hardware

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- Video display devices
  - » Cathode Ray Tube (CRT)
  - » Liquid Crystal Display (LCD)
  - Plasma panels
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## Raster Graphics Systems

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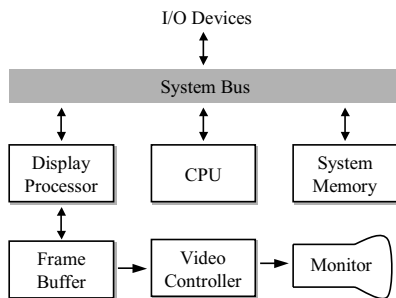


Figure 2.29 from H&B

## Frame Buffer

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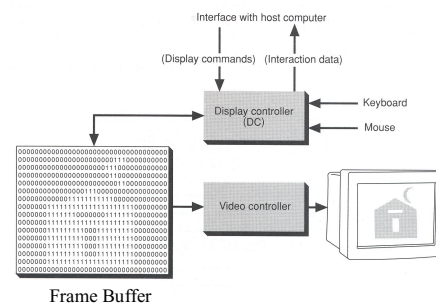
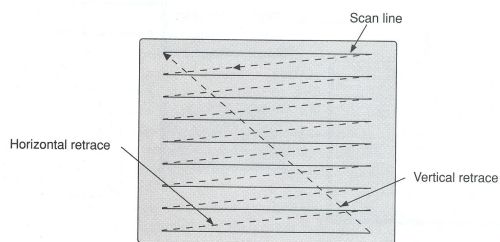


Figure 1.2 from FvDFH

## Frame Buffer Refresh

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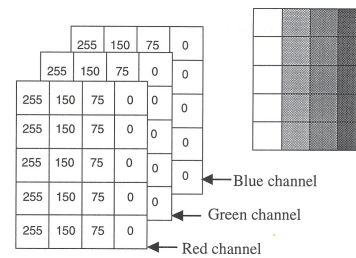


Refresh rate is usually 30-75Hz

Figure 1.3 from FvDFH

## Color Frame Buffer

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## Color CRT

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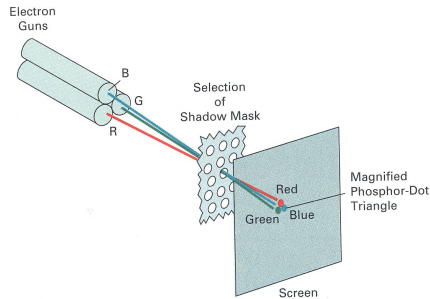


Figure 2.8 from H&B

## Overview

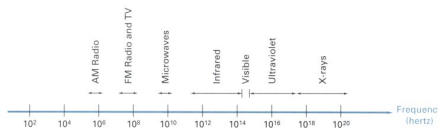
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## Electromagnetic Spectrum

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

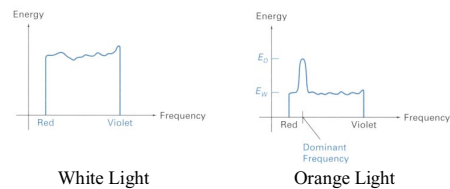


Figures 15.1 from H&B

## Visible Light

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- 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)



Figures 15.3-4 from H&B

## Color Perception

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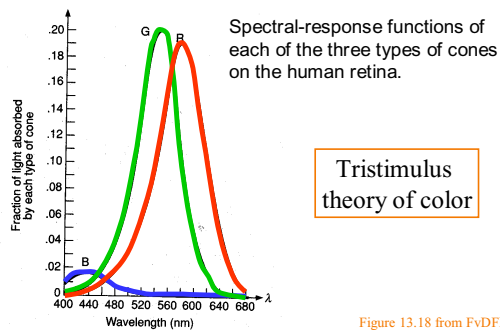


Figure 13.18 from FvDFH

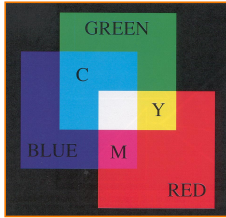
## Color Models

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- RGB
- XYZ
- CMY
- HSV
- Others

## RGB Color Model

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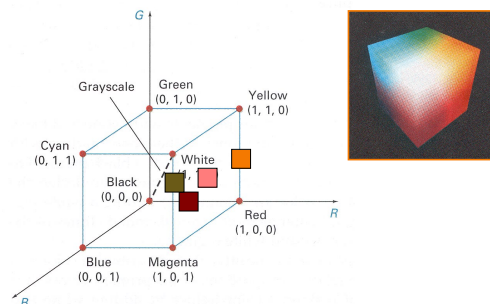
Colors are additive

R	G	B	Color
0.0	0.0	0.0	Black
1.0	0.0	0.0	Red
0.0	1.0	0.0	Green
0.0	0.0	1.0	Blue
1.0	1.0	0.0	Yellow
1.0	0.0	1.0	Magenta
0.0	1.0	1.0	Cyan
1.0	1.0	1.0	White
0.5	0.0	0.0	?
1.0	0.5	0.5	?
1.0	0.5	0.0	?
0.5	0.3	0.1	?

Plate 11.3 from FvDFH

## RGB Color Cube

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Figures 15.11&15.12 from H&B

## RGB Spectral Colors

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Amounts of RGB primaries needed to display spectral colors

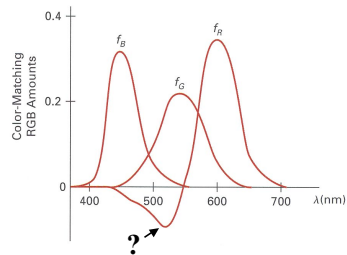


Figure 15.5 from H&B

## XYZ Color Model (CIE)

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Amounts of CIE primaries needed to display spectral colors

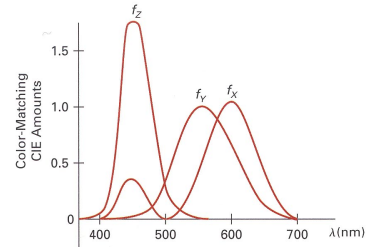


Figure 15.6 from H&B

## CIE Chromaticity Diagram

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Normalized amounts of X and Y for colors in visible spectrum

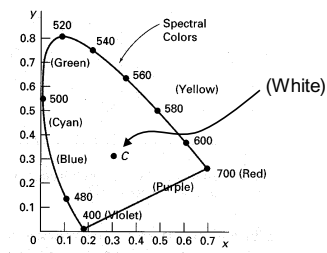
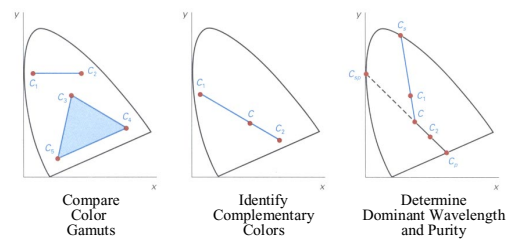


Figure 15.7 from H&B

## CIE Chromaticity Diagram

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Figures 15.8-10 from H&B

## RGB Color Gamut

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Color gamut for a typical RGB computer monitor

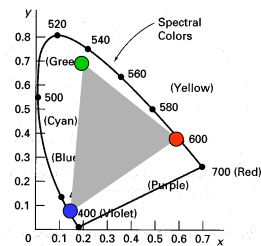
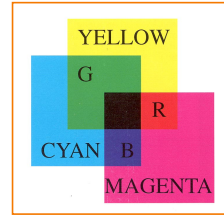


Figure 15.13 from H&B

## CMY Color Model

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Colors are subtractive

C	M	Y	Color
0.0	0.0	0.0	White
1.0	0.0	0.0	Cyan
0.0	1.0	0.0	Magenta
0.0	0.0	1.0	Yellow
1.0	1.0	0.0	Blue
1.0	0.0	1.0	Green
0.0	1.0	1.0	Red
1.0	1.0	1.0	Black
0.5	0.0	0.0	
1.0	0.5	0.5	
1.0	0.5	0.0	

Plate II.7 from FvDFH

## CMY Color Cube

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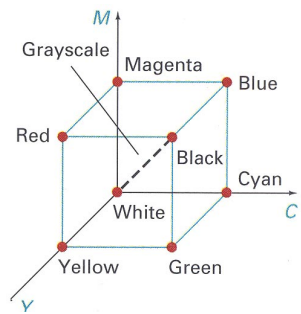
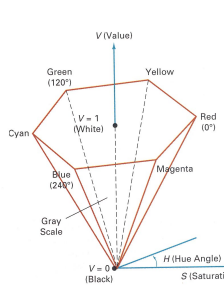


Figure 15.14 from H&B

## HSV Color Model

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H	S	V	Color
0	1.0	1.0	Red
120	1.0	1.0	Green
240	1.0	1.0	Blue
*	0.0	1.0	White
*	0.0	0.5	Gray
*	*	0.0	Black
60	1.0	1.0	
270	0.5	1.0	
270	0.0	0.7	

Figure 15.16&15.17 from H&B

## Summary

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- 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.