Raster Graphics

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Overview

- Display hardware
  - How are images displayed?

- Raster graphics systems
  - How are imaging systems organized?

- Perception and color
  - How do we perceive images?
  - 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
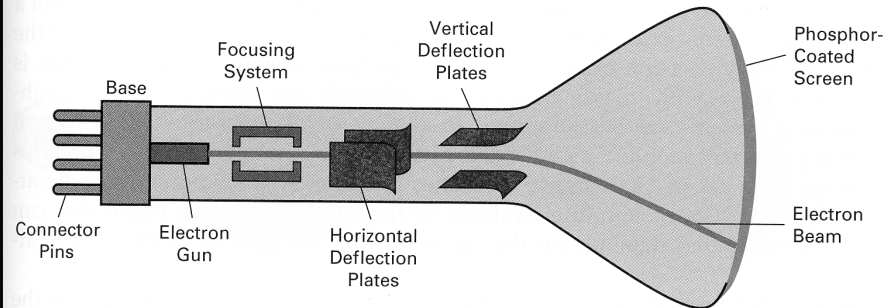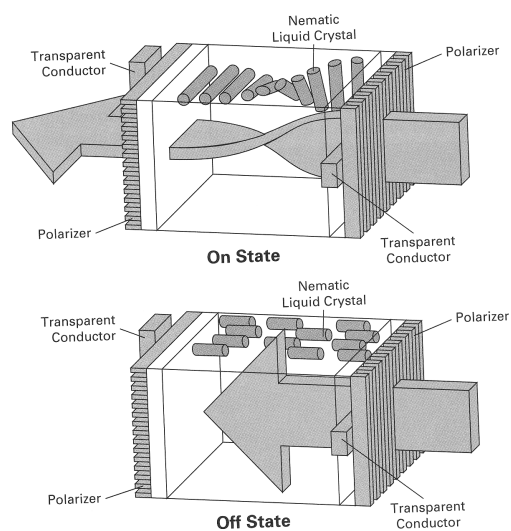 - Pen plotter

Cathode Ray Tube (CRT)

Focusing System

Vertical Deflection Plates

Phosphor-Coated Screen

Base

Connector Pins

Electron Gun

Horizontal Deflection Plates

Electron Beam

Figure 2.4 from H&B

Liquid Crystal Display (LCD)

Nematic Liquid Crystal

Transparent Conductor

Polarizer

Polarizer

Transparent Conductor

On State

Nematic Liquid Crystal

Transparent Conductor

Polarizer

Polarizer

Transparent Conductor

Off State

Figure 2.16 from H&B

Display Hardware

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- Hard-copy devices
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  - ○ Pen plotter

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Raster Graphics Systems

I/O Devices

System Bus
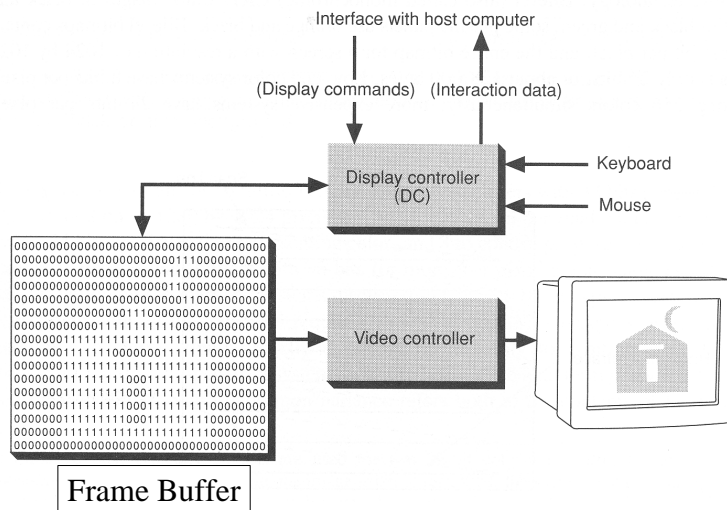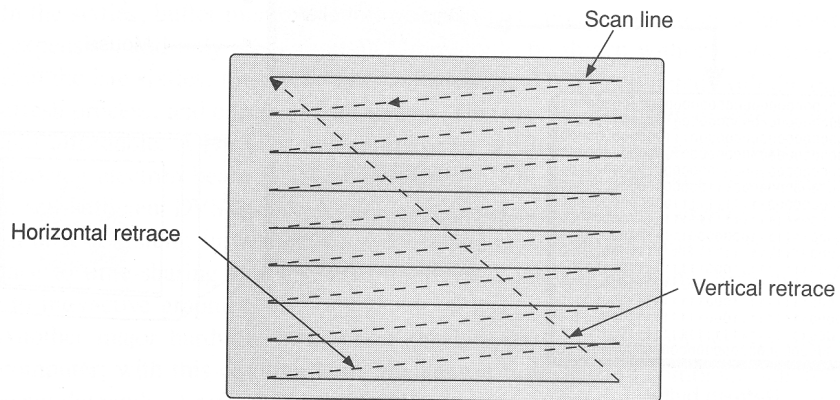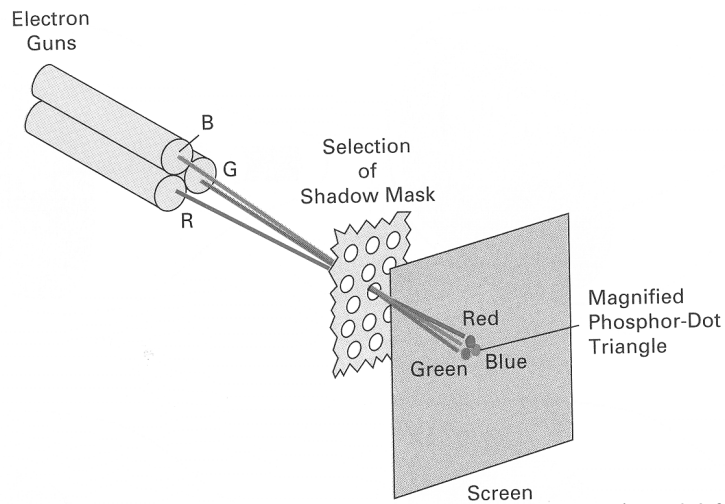
Display Processor

CPU

System Memory

Frame Buffer → Video Controller → Monitor
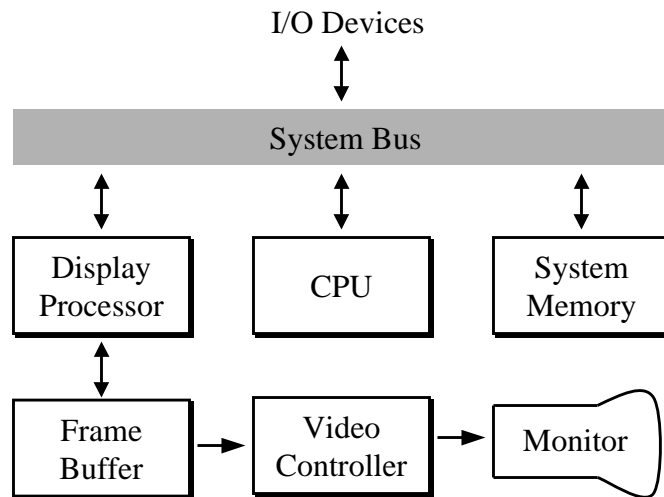
Figure 2.29 from H&B

Frame Buffer

Interface with host computer

(Display commands)   (Interaction data)

Display controller (DC)

Keyboard

Mouse

Video controller

Frame Buffer

Figure 1.2 from FvDFH

Frame Buffer Refresh

Scan line

Horizontal retrace

Vertical retrace

Refresh rate is usually 30-75Hz

Figure 1.3 from FvDFH

Color Frame Buffer

| 255 | 150 | 75 | 0 |
| 255 | 150 | 75 | 0 |

Blue channel

Green channel

Red channel

Color CRT

Electron
Guns

B

G

R

Selection
of
Shadow Mask

Red

Green Blue

Magnified
Phosphor-Dot
Triangle

Screen
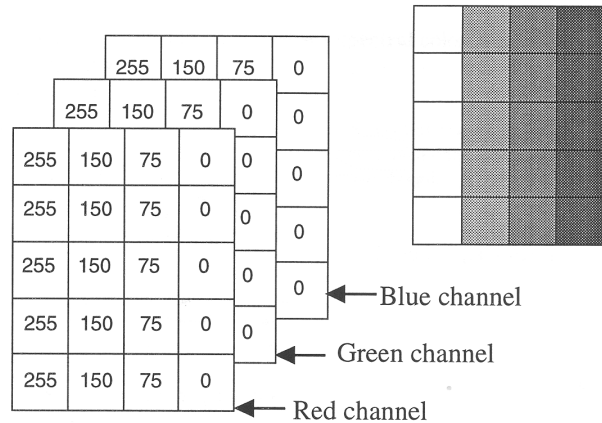
Figure 2.8 from H&B

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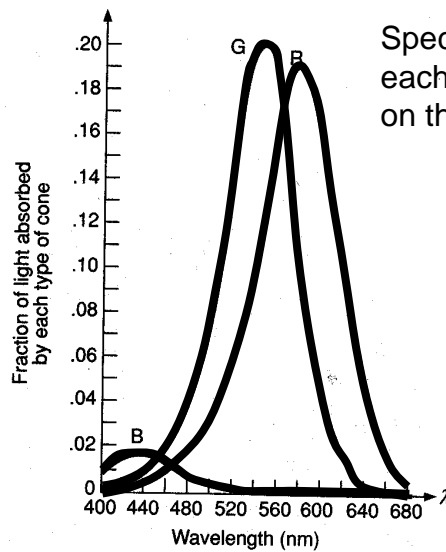
Spectral-response functions of each of the three types of cones on the human retina.

Tristimulus theory of color

Figure 13.18 from FvDFH

Color Models

- RGB

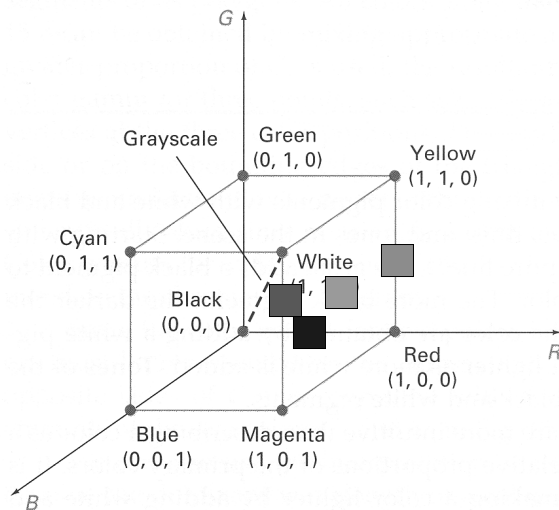- XYZ

- CMY

- HSV

- Others

RGB Color Model

GREEN

C

Y

BLUE M

RED
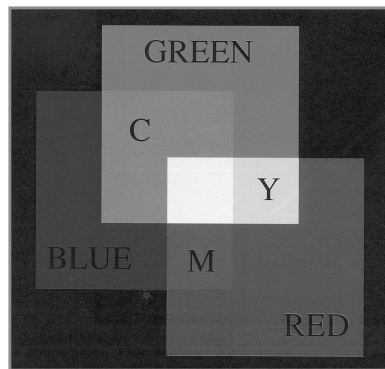
Colors are additive

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 II.3 from FvDFH

RGB Color Cube

G

Grayscale

Green
(0, 1, 0)

Yellow
(1, 1, 0)

Cyan
(0, 1, 1)

White
(1,

Black
(0, 0, 0)

Red
(1, 0, 0)

R

Blue
(0, 0, 1)

Magenta
(1, 0, 1)

B

Figures 15.11&15.12 from H&B

RGB Spectral Colors

Amounts of RGB primaries needed to display spectral colors
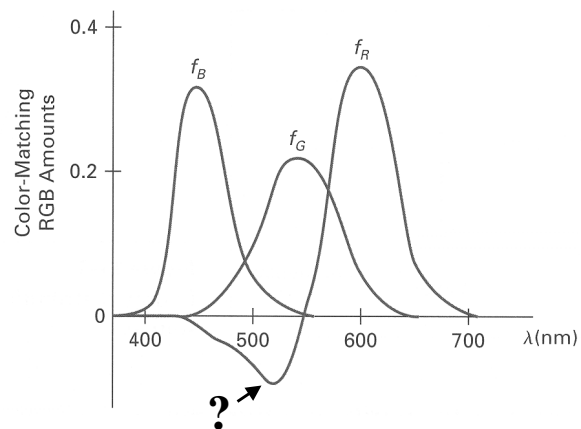
Figure 15.5 from H&B

XYZ Color Model (CIE)

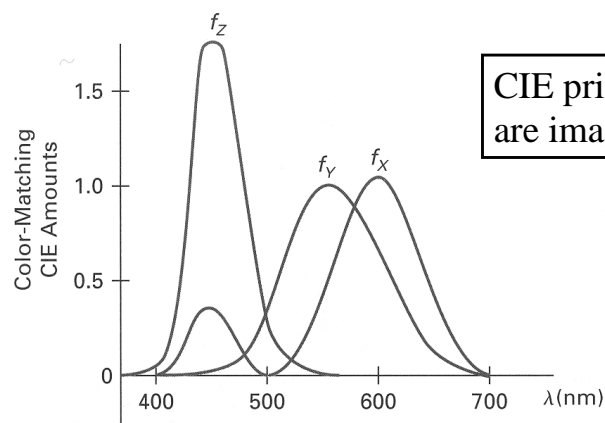Amounts of CIE primaries needed to display spectral colors

CIE primaries are imaginary

Figure 15.6 from H&B

CIE Chromaticity Diagram

Normalized amounts of X and Y for colors in visible spectrum

RGB Color Gamut
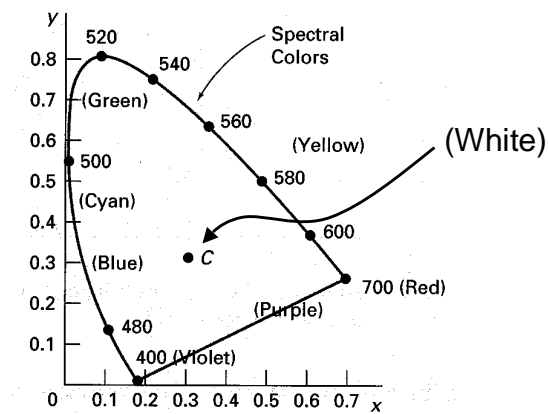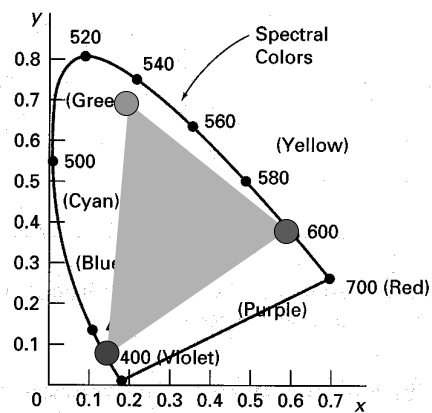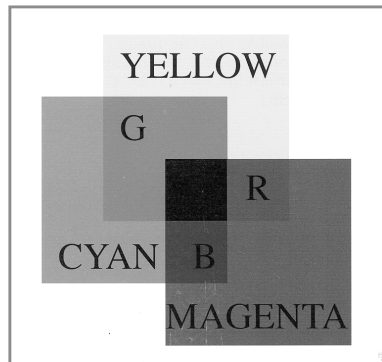
Color gamut for a typical RGB computer monitor

CMY Color Model

YELLOW

G

R

CYAN B

MAGENTA

Colors are subtractive

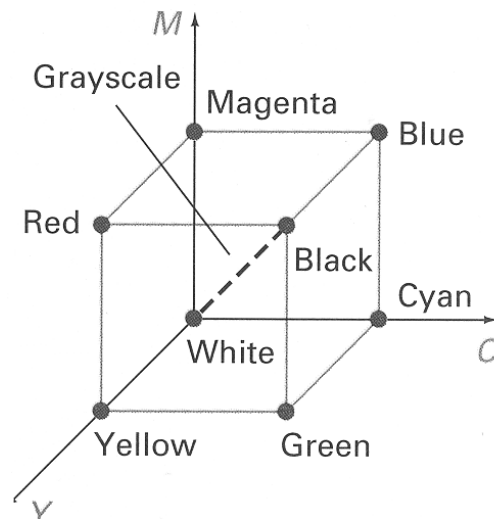| C	M	Y	Color
0.0	0.0	0.0	White
1.0	0.0	0.0	Cyan
0.0	1.0	0.0	Magenta
0.0	0.0	1.0	Yellow
1.0	1.0	0.0	Blue
1.0	0.0	1.0	Green
0.0	1.0	1.0	Red
1.0	1.0	1.0	Black
0.5	0.0	0.0	
1.0	0.5	0.5	
1.0	0.5	0.0	

Plate II.7 from FvDFH

CMY Color Cube

Figure 15.14 from H&B

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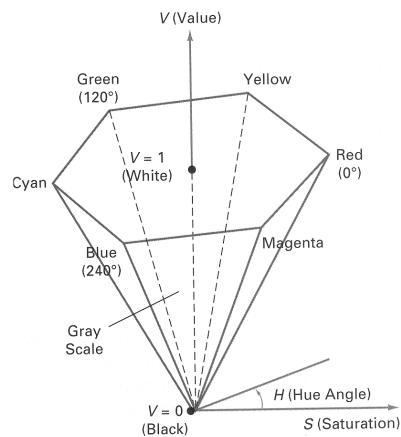
H	S	V	Color
0	1.0	1.0	Red
120	1.0	1.0	Green
240	1.0	1.0	Blue
*	0.0	1.0	White
*	0.0	0.5	Gray
*	*	0.0	Black
60	1.0	1.0	
270	0.5	1.0	
270	0.0	0.7	

Figure 15.16&15.17 from H&B

Summary

- Display hardware
  - Monitors: CRTs, LCDs, etc.
  - Hard-copy: printers, plotters, etc.

- Raster graphics systems
  - Display processors
  - Frame buffers
  - Video controllers

- Perception and color
  - Tristimulus theory of color
  - Devices cannot display all visible colors
  - Different color models for different devices, uses, etc.