

# Hardware

- Vector & Raster Displays
- Display Devices
- Display Technologies
- Input Devices
- Hardcopy Devices

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## What do they have in common?



Needlepoint



Tile Mosaics

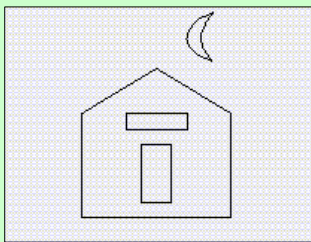


Lite Brite

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## How to represent this in a computer?

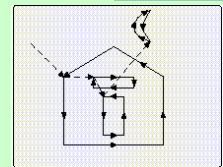


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## Vector Displays

- Also called calligraphic or stroker displays
- 1960's, 70's & 80's
- Single phosphor (monochrome)
- No Aliasing
- Wireframe
- Intensity could be controlled



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## Vector Displays (2)

```
MOVE
10
50
LINE
400
300
CHAR
A
B
C
.
.
.
JMP
```



Tektronix 4014

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## Vector Displays (3)



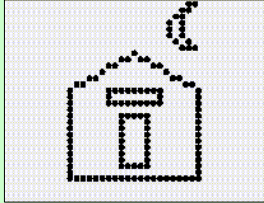
Oscilloscope draws graphs of electrical signals

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## Raster Displays

- 1980's on
- Set of horizontal scan lines (raster)
- Raster: a set of pixels
- 1 (bw) or 3 (color) beams
- Refresh/Frame buffer
- Aliasing
- Filled regions

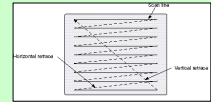
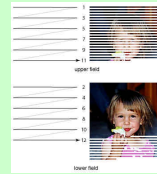


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## Raster Scan

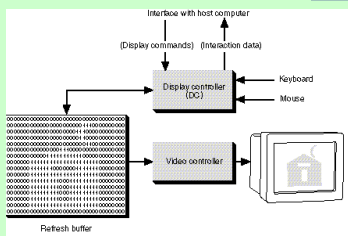
- Vertical lines: 200, 240, 480, 600, 768, ...
- Resolution Along each line: 320, 640, 800, ...
- Refresh rate (fps): 25, 30, 50, 85, ...
- Interlaced or Progressive



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## Raster Displays: Architecture



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## Display Devices

- CRT (Cathode Ray Tube): BW/Color
- LCD (Liquid Crystal Display)
- Printer: Dot Matrix, Ink Jet, Laser Jet
- Plotter: Single/Multiple Pen



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## Video Resolutions

### NTSC

- North/South America, Asia (west)
- Vertical Resolution: 525 Lines
- Horizontal Resolution: 600 Pixels
- 29.97 FPS (Interlaced)

### PAL

- Europe, Asia (east), Africa
- Vertical Resolution: 625
- 25 FPS (Interlaced): (50Hz power cycle in Europe)

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## Pixel-based Graphics

Pixel: a picture element

Resolution: Horizontal x Vertical

320x240 (CGA), 640x480 (VGA), 1024x768 (SVGA)

Color Depth: Bits/Pixel

1 (monochrome), 8 (256 levels), 24 (16 million\_

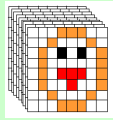
Byte per Frame?

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## Pixel-Based Graphics: Frame Buffer

- computer memory organized as a two dimensional array
- each (x,y) addressable location corresponding to one pixel
- Bit Planes/Bit Depth: number of bits for each pixel  
e.g. 640x480x8 1024x768x24

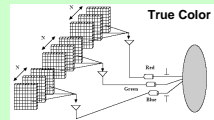
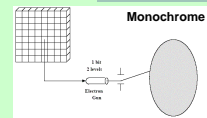


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## Technologies: CRT

- Cathode Ray Tube
- Must refresh because of phosphor decay

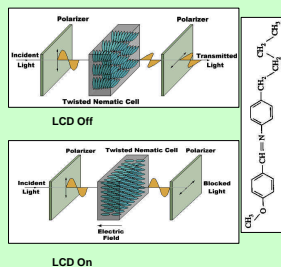


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## Technologies: LCD

- Organic Molecules
- Tend to align in crystal structure in absence of external force
- Rearrange in Liquid when force applied (heat, electromagnetic)



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## Technologies: more and more and more

- Light Emitting Diode (LED)
- Plasma Display Panel
- Head-mounted Display (HMD)
- Overhead Projector
- Fog Screen



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## Input Devices

- Locator devices  
tablet, mouse, trackball, space ball, joystick, touch screen
- Keyboard devices
- Valuator devices  
Potentiometer, dials
- Choice devices  
func keys, mouse buttons

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## Hardcopy Device

- Vector
  - flat plotter
  - drum plotter
- Raster
  - dot-matrix printer
  - Inkjet printer: sprays CMYK ink to paper
  - LaserJet printer: static electricity as temporary glue

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