

# Input and Output Devices

Foley & Van Dam, Chapter 4



# Topics

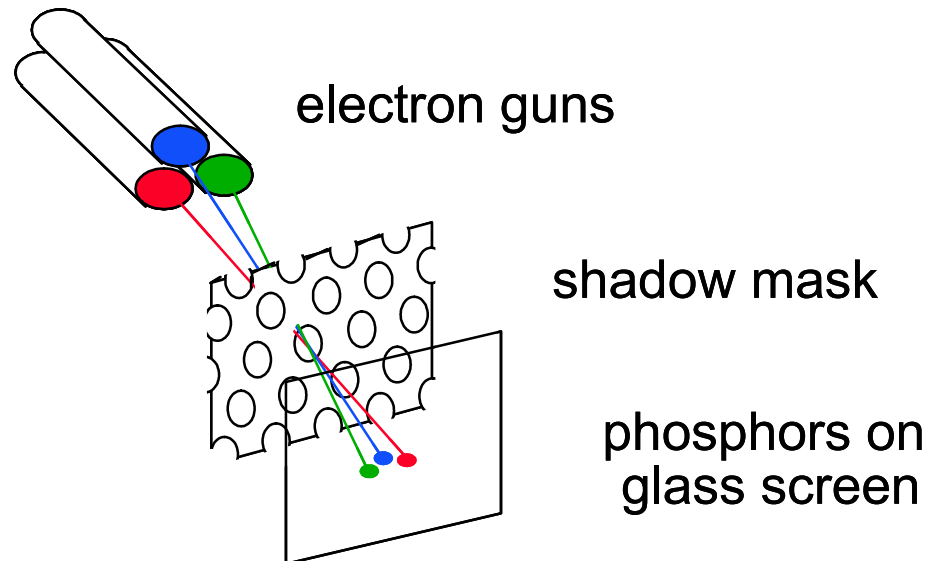
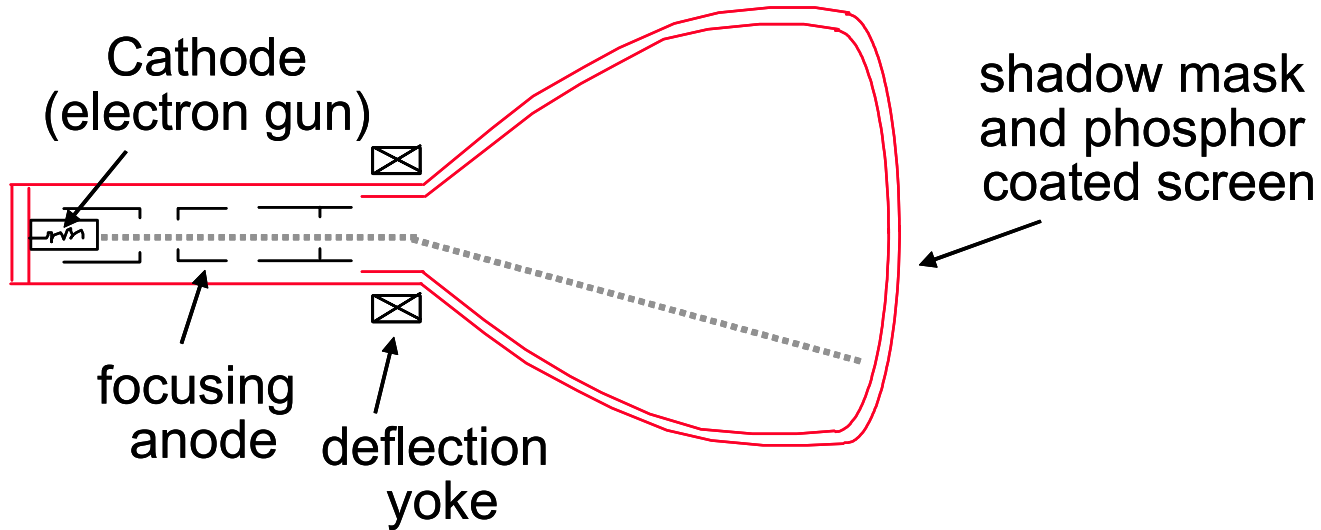
## Output Devices:

- Display Devices - (CRTs, Monitors)
- Hard Copy Devices - (Printers, Plotters)

## Input Devices:

- Alphanumeric input- (Keyboards)
- 2D Inputs - (Joystick, Mouse, Digitizer etc)
- 3D Inputs - (Glove, Space Ball)
- Image Inputs - (Camera, Scanner)

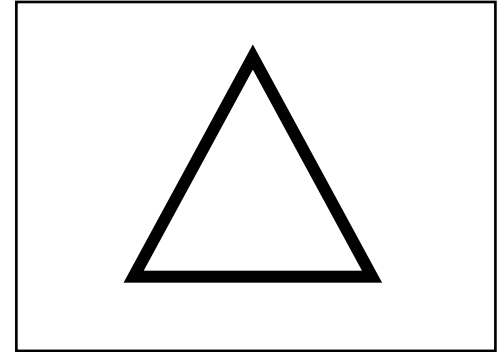
# CRT - Cathode Ray Tube



# Vector vs. Raster Display

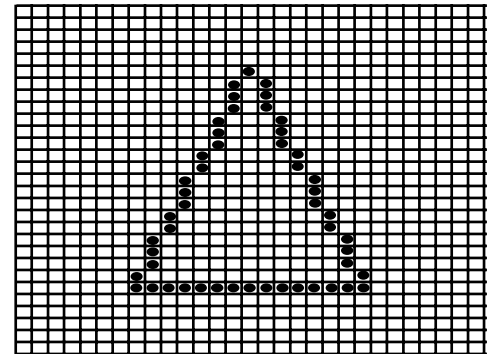
## Vector Display:

- Only lines can be drawn
- Locations are converted to analog voltage applied to the deflection yoke
- Lines drawn by gradual change of voltage
- Also known as random scan
- Refresh time is scene dependent
- Old fashioned - very uncommon today



## Raster Display:

- Discrete grid of elements (frame buffer's pixels)
- Complex to draw “nice” lines
- Arbitrary shapes can be drawn
- Frame buffer is scanned, one line at a time
- Used almost everywhere.



# Terminology

**Pixel:** Picture element.

- Smallest accessible element in picture
- Assume rectangular or circular shape

**Aspect Ratio:** Ratio between physical dimensions of a pixel (not necessarily 1)

**Dynamic Range:** The ratio between the minimal (not zero!) and the maximal light intensity a display pixel can emit

**Resolution:** The number of distinguishable rows and columns in the device.  
Measured in:

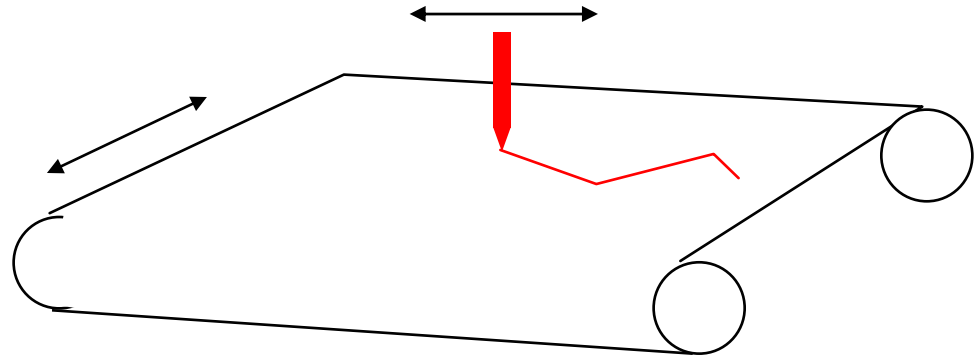
- Absolute values (1K x 1K) or,
- Density values (300 dpi [=dots per inch])

**Screen Space:** A discrete Cartesian coordinate system of the screen pixels

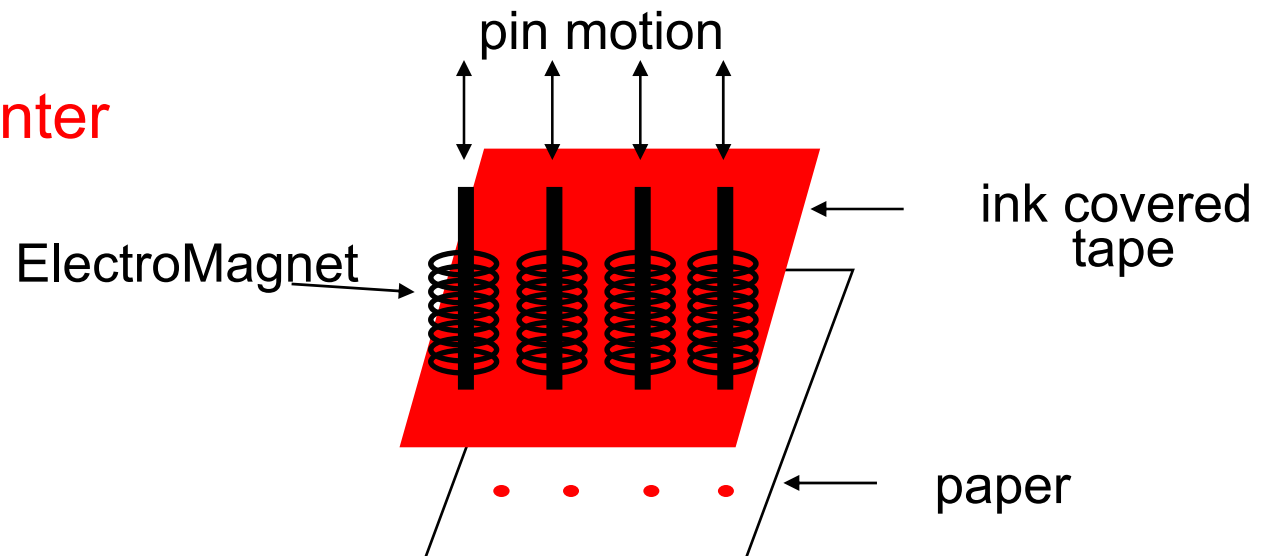
**Object Space:** The Cartesian coordinate system of the universe, in which the objects (to be displayed) are embedded

# Hardcopy Devices

Pen Plotter

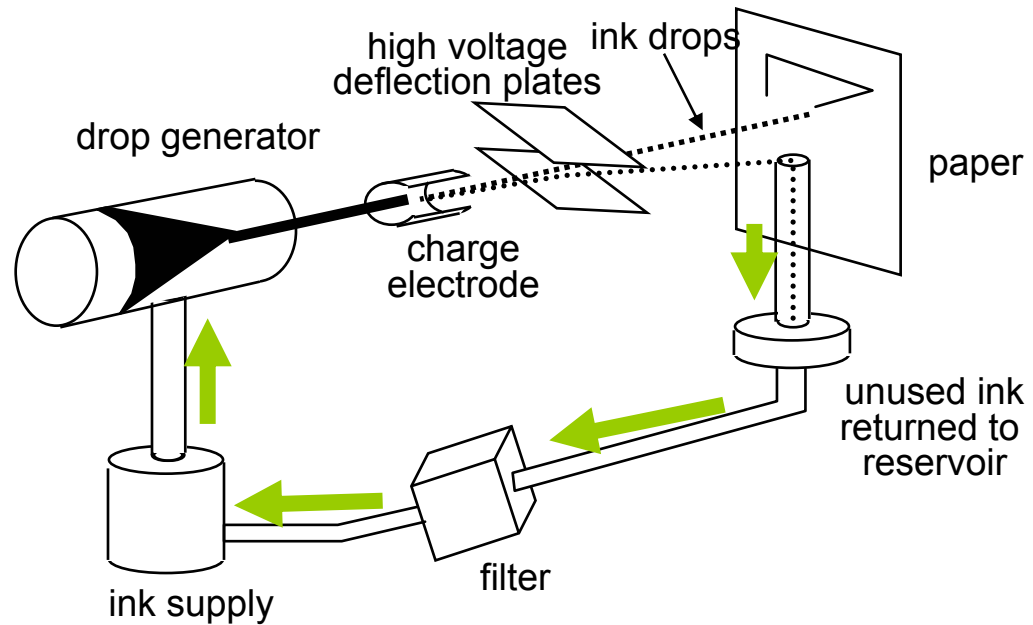


Dot Matrix Printer



# Hardcopy Devices

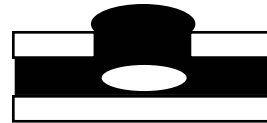
## Ink Jet Printer



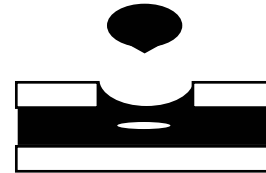
## Thermal-Bubble Ink Jet Printer



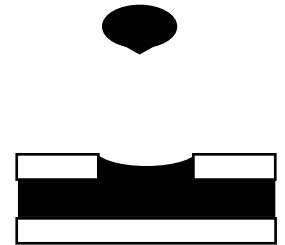
Resistor is heated and bubble nucleates.



Bubble grows to maximum ink drop is ejected.



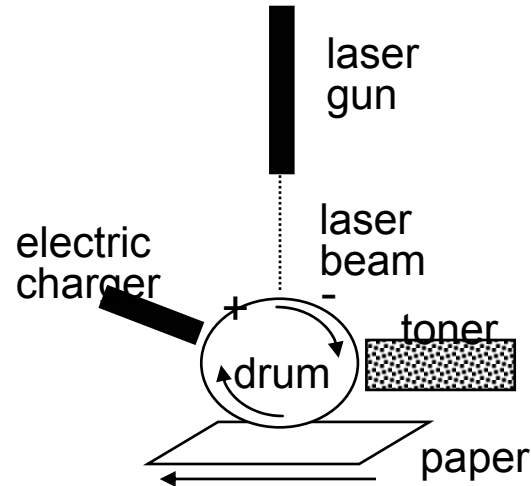
Bubble collapses. Drop breaks off.



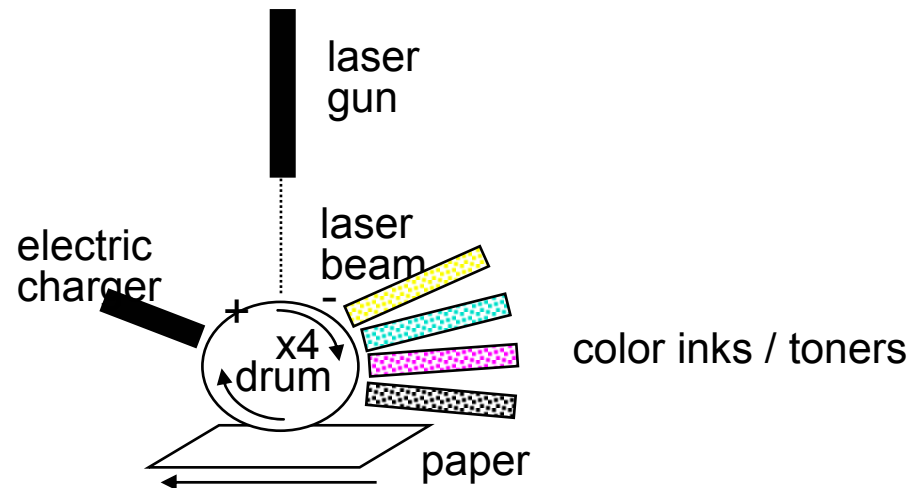
System returns to initial state.

# Hardcopy Devices

## Laser Printer



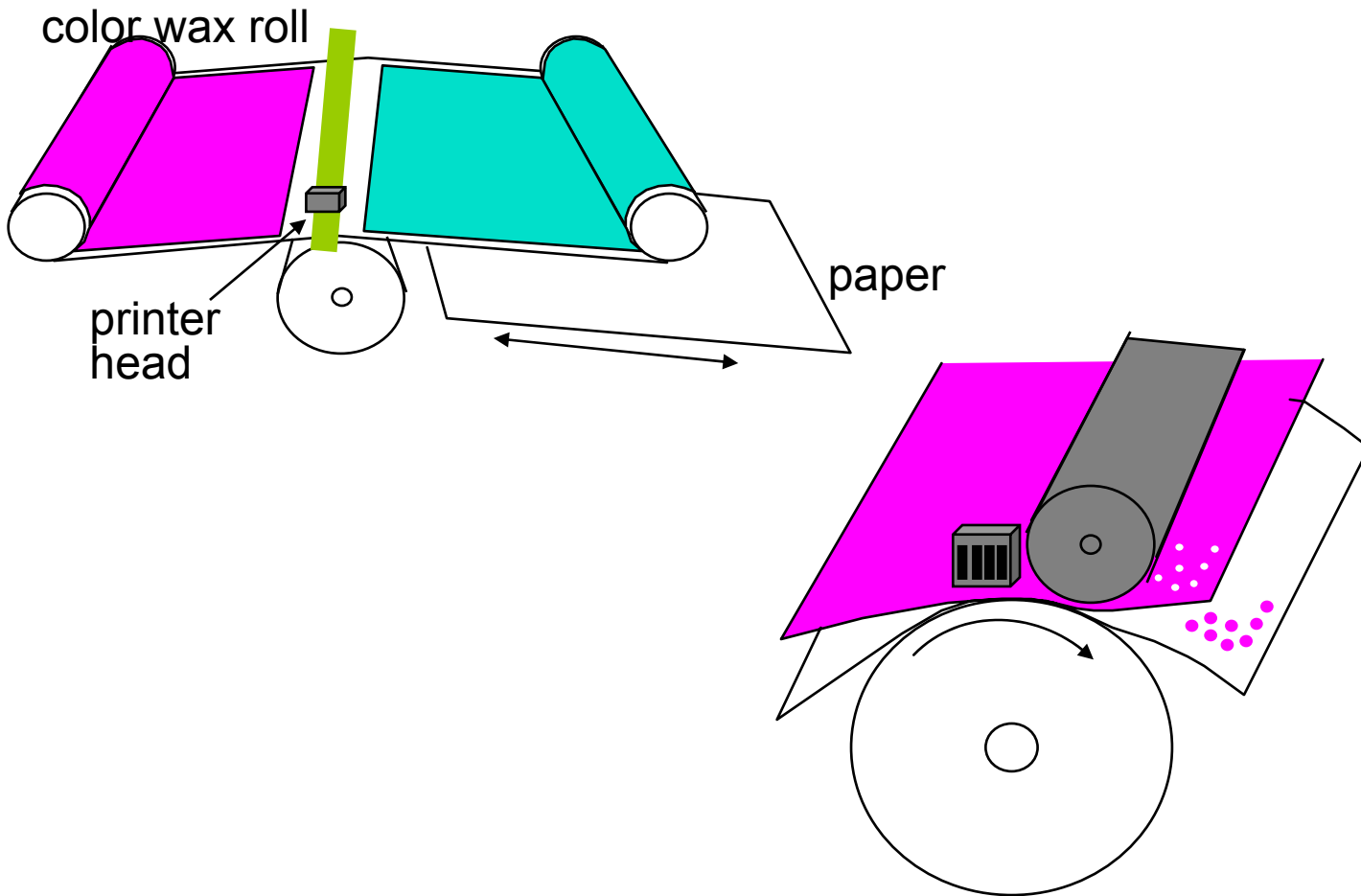
## Color Laser Printer





# Hardcopy Devices

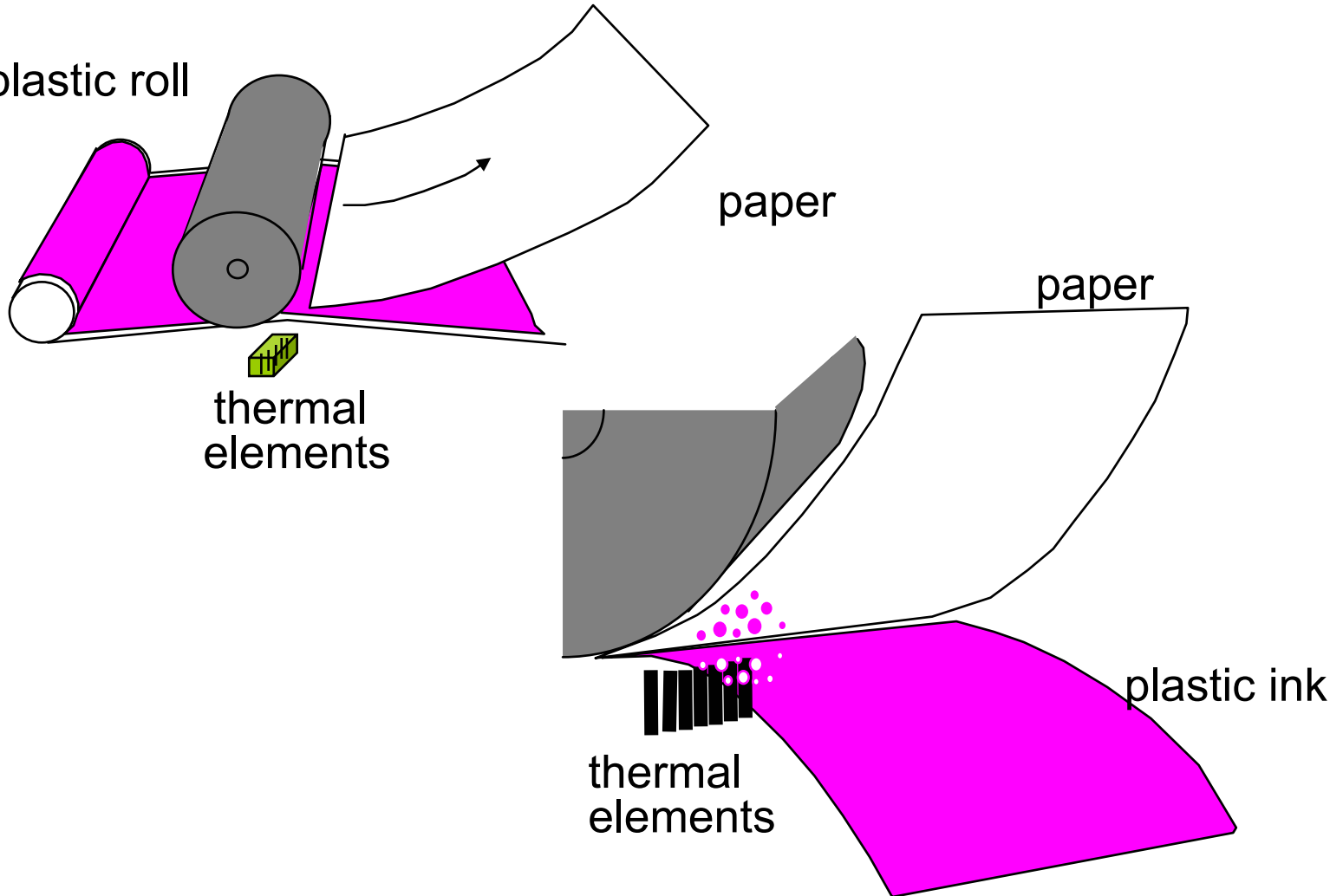
## Thermal Wax Printer



# Hardcopy Devices

## Dye Sublimation Printer

color plastic roll



# Input Devices

## Keyboard:

- For alphanumeric input

## Joystick:

- Usually two degrees of freedom
- Provides relative movement information

## Mouse/Trackball

- A two degrees of freedom device controlled by a rolling ball
- Provides relative movement information

## Digitizer/Tablet

- A two degrees of freedom device controlled by electro-magnetic or sound sensing
- Provides absolute position information

## Touch Screen

- A CRT screen that can sense pressure on its surface

## Light Pen

- A two degrees of freedom sensing device
- Synchronized with the CRT scan, it can locate a position on the screen

# Input Devices

## Data Glove/Polhemus

- A modern attempt to provide the user with more degrees of freedom
- Common in Virtual Reality applications
- Polyhemus can provide six degrees of freedom (rotation and translation)

## Head Mounted Display

- Although primary a display device, it can also track position and orientation like Polhemus

## Space Ball

- Six degrees of freedom sphere

## Video Camera

- Captures an array of image pixels

## Scanner

- Digitizes a hardcopy images

# Data Gloves



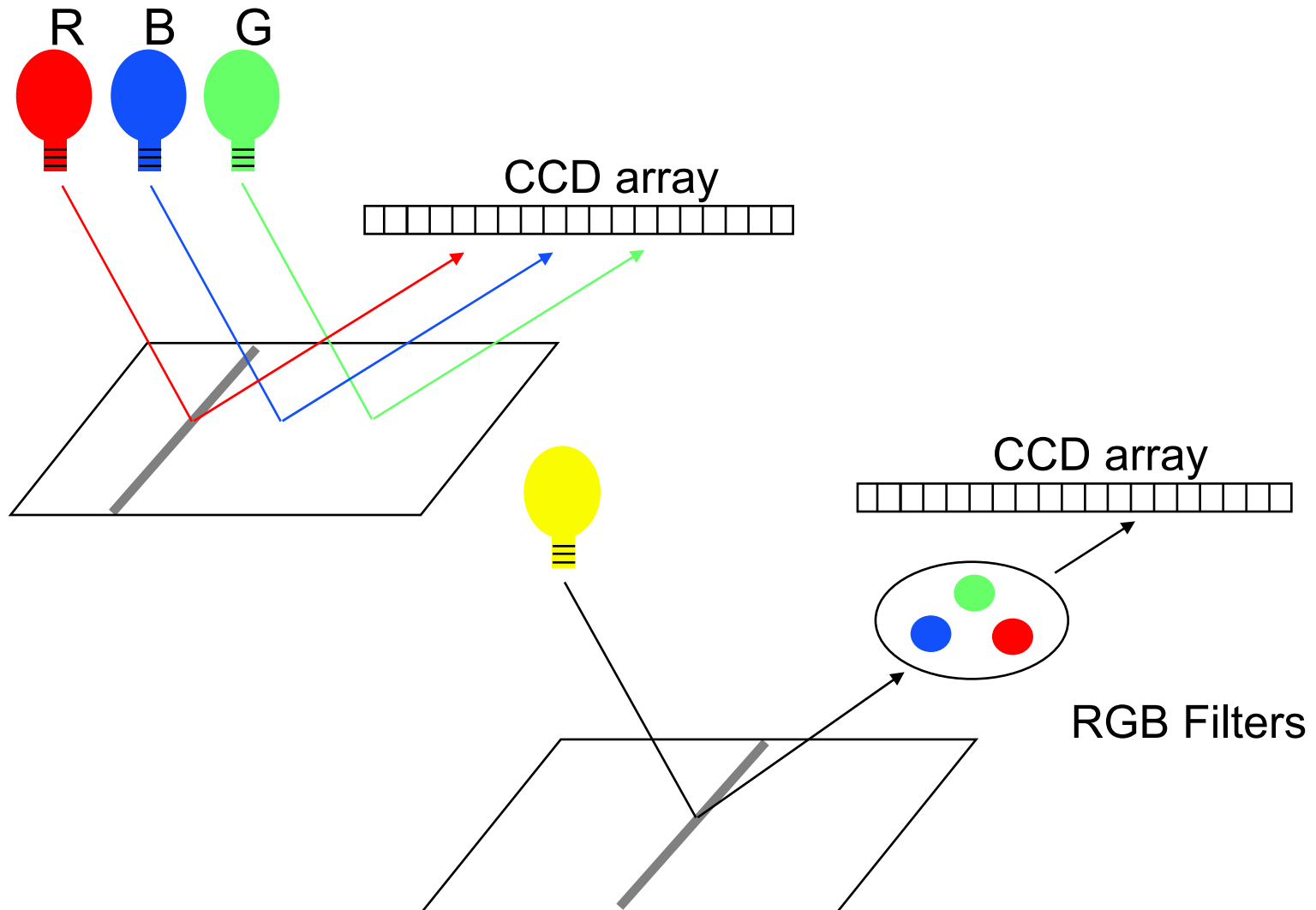
# Head Mounted Display



# Space Ball

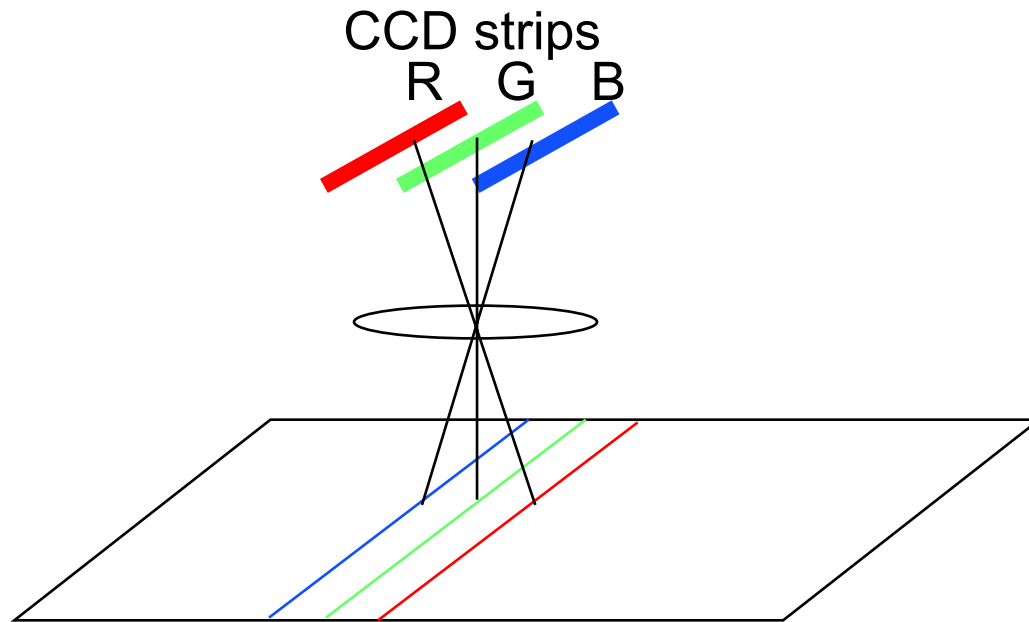


# Three Pass Color Scanner

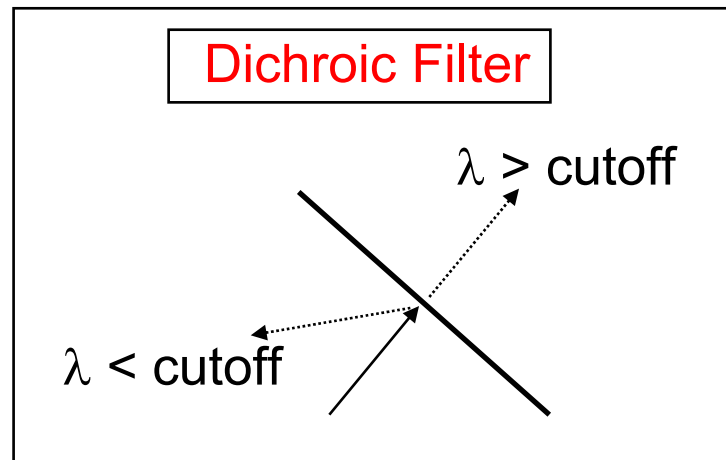
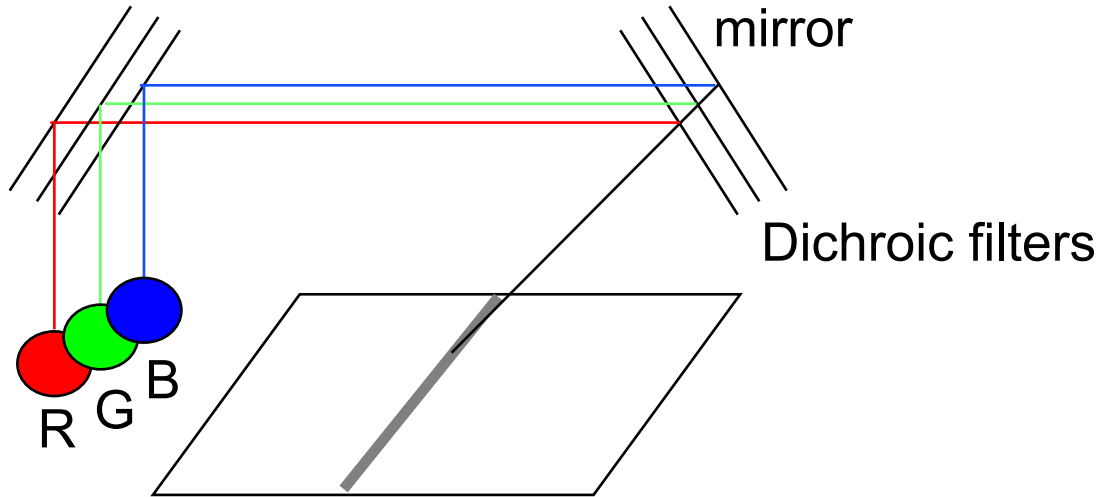




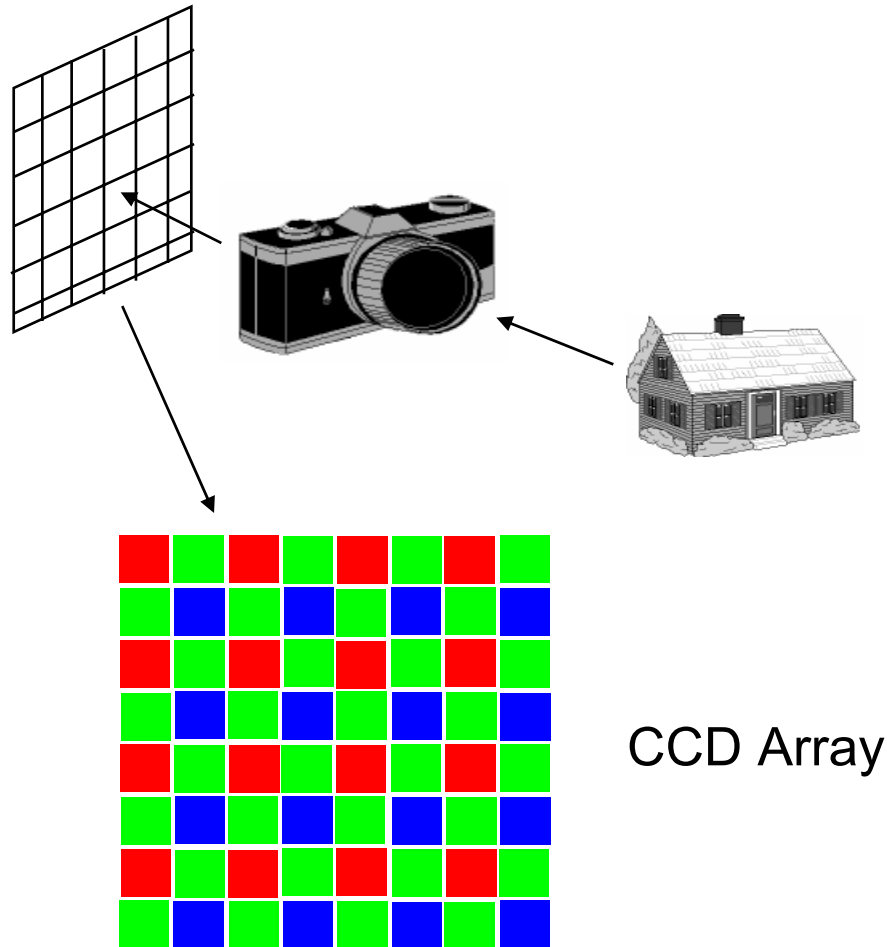
# Single Pass Color Scanner



# Single Pass Color Scanner



# Low Cost Digital Camera



# Virtual Ink Mimio



# Logitech Digital Pen

