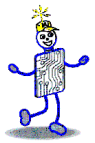


CHAPTER 10: Computer Peripherals

The Architecture of Computer Hardware, Systems Software & Networking:
An Information Technology Approach

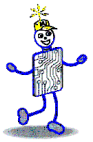
5th Edition, Irv Englander

John Wiley and Sons ©2013

PowerPoint slides authored by Angela Clark, University of South Alabama

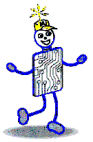
PowerPoint slides for the 4th edition were authored by Wilson Wong, Bentley University

PowerPoint slides modified by Gianluca Amato, Univ. di Chieti-Pescara



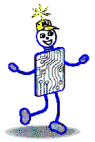
Peripherals

- Devices that are separate from the basic computer
  - Not the CPU, memory, or power source
- Classified as input, output, and storage
- Connect via
  - Ports
  - Interface to system bus



Storage Devices

- Primary memory
- Secondary storage
  - Data and programs must be copied to primary memory for CPU access
  - Permanence of data - nonvolatile
  - Online storage
  - Offline storage – loaded when needed
  - Network file storage
    - File servers, web servers, database servers



Speed

- Measured by access time and data transfer rate
- Access time: average time it takes a computer to locate data and read a piece of data
  - millisecond (msec) = one thousandth of a second; 0.01 seconds
  - microsecond (μsec) = one millionth of a second
  - nanosecond (nsec) = one billionth of a second
- Data transfer rate: amount of data that moves per second

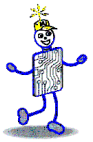
Storage Hierarchy

	Typical Access Times	Typical Data Throughput
CPU registers	0.25 nsec	NA
Cache memory (SRAM)	1–10 nsec	(see text)
Conventional memory (DRAM)	10–20 nsec	(see text)
Flash memory/solid state drive	25–100 µsec read/250 µsec write	200 MB–5 GB/sec
Hard disk drive	3–15 msec	100 MB–1 GB/sec
Optical disk drive	100–500 msec	500 KB–4.5 MB/sec
Magnetic tape cartridge	0.5 sec and up	160 MB/sec

Increasing access time *and* generally increasing storage amount/ unit cost ↓

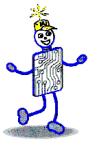
Secondary Storage Devices

- Solid state memory
- Magnetic disks
- Optical disk storage
- Magnetic tape
- Network storage
- Characteristics
  - Rotation vs. Linear
  - Direct access vs. Sequential access



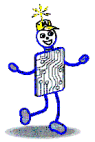
Solid state memory

- Also referred to as flash memory
- Nonvolatile electronic integrated circuit memory
- Similar to other read-only memory but uses a different technology
- Permits reading and writing individual bytes or small blocks of data
- Small size makes it useful in portable devices such as USB “thumb drives”, digital cameras, cell phones, music players
- Relatively immune to physical shocks
- Generates little heat or noise

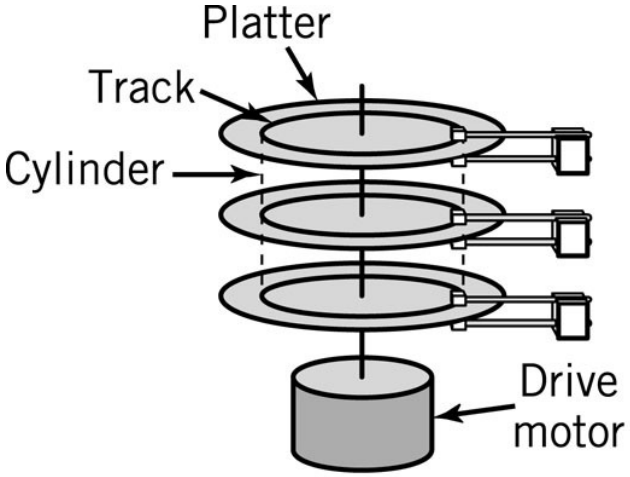


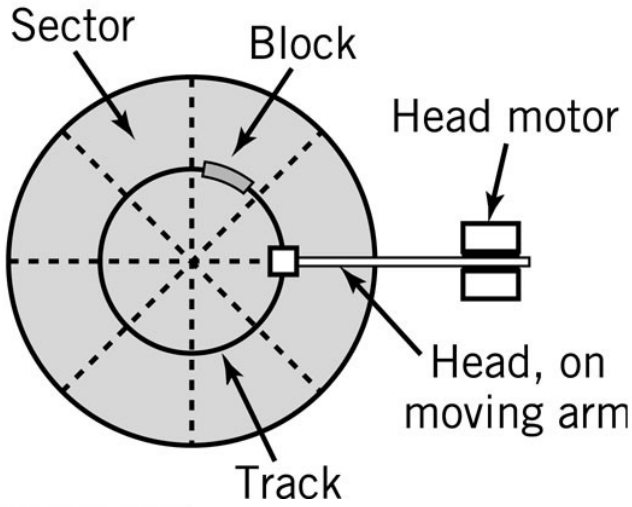
Solid State Drives

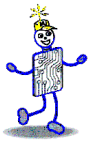
- Solid-state drives (SSD)
  - Large capacity flash memory units
  - Starting to replace magnetic disk drives as long-term storage
- Data is read/written in blocks
- Wear-leveling used to extend life
- Controller logic used to manage memory space and provide fast reads/writes



A Hard Disk Layout



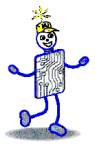




Magnetic Disks

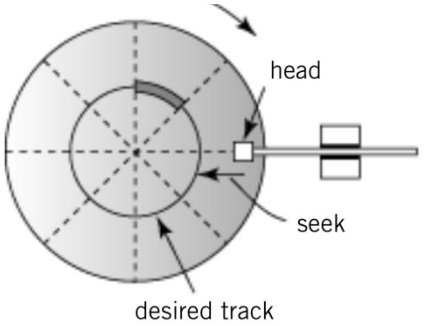
- Track – circle
- Cylinder – same track on all platters
- Block – small arc of a track
- Sector – pie-shaped part of a platter
- Head – reads data off the disk as disk rotates at high speed (4200-14000 RPM)

- Head crash
  - Disk damaged if head touches disk surface
- Parked heads

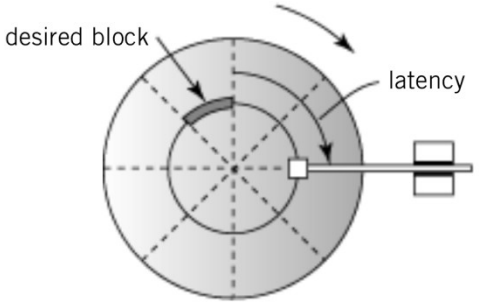


Locating a Block of Data

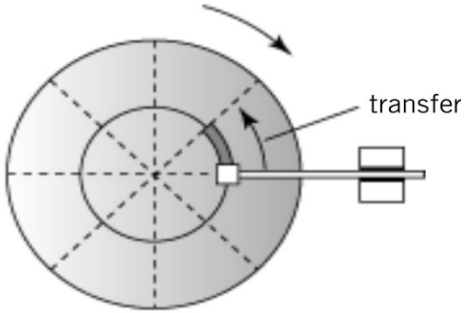
- Average seek time: time required to move from one track to another



- Latency: time required for disk to rotate to beginning of correct sector

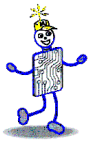


- Transfer time: time required to transfer a block of data to the disk controller buffer



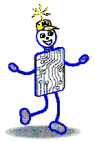
Disk Access Times

- Average Seek time
  - average time to move from one track to another
- Average Latency time
  - average time to rotate to the beginning of the sector
  - Average Latency time = ½ * 1/rotational speed
- Transfer time
  - 1/(# of sectors * rotational speed)
- Total Time to access a disk block
  - Avg. seek time + avg. latency time + avg. transfer time



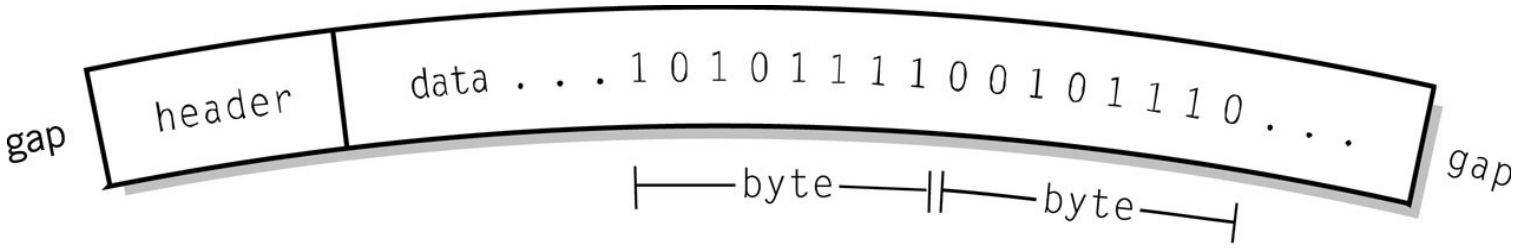
Magnetic Disks

- Data Block Format
  - Interblock gap
  - Header
  - Data
- Formatting disk
  - Establishes the track positions, blocks and headers needed before use of the disk

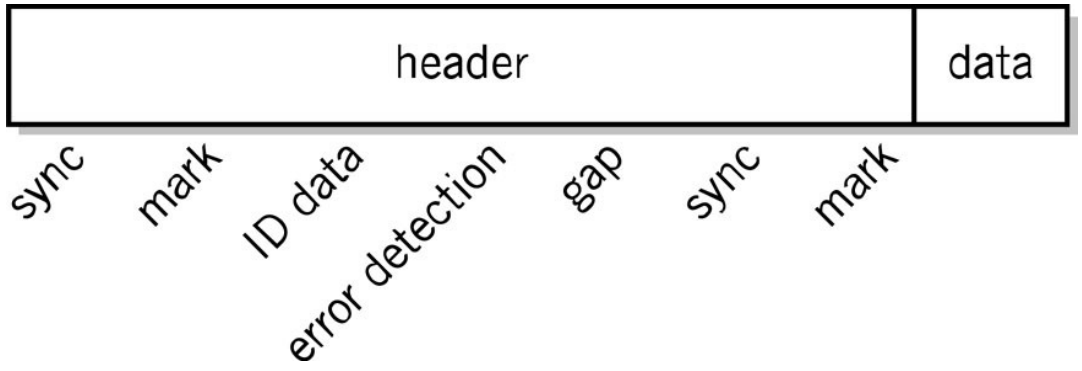


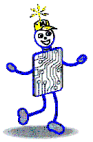
Disk Block Formats

Single Data Block



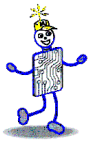
Header for SATA disk





Disk Layouts – CAV vs. CLV

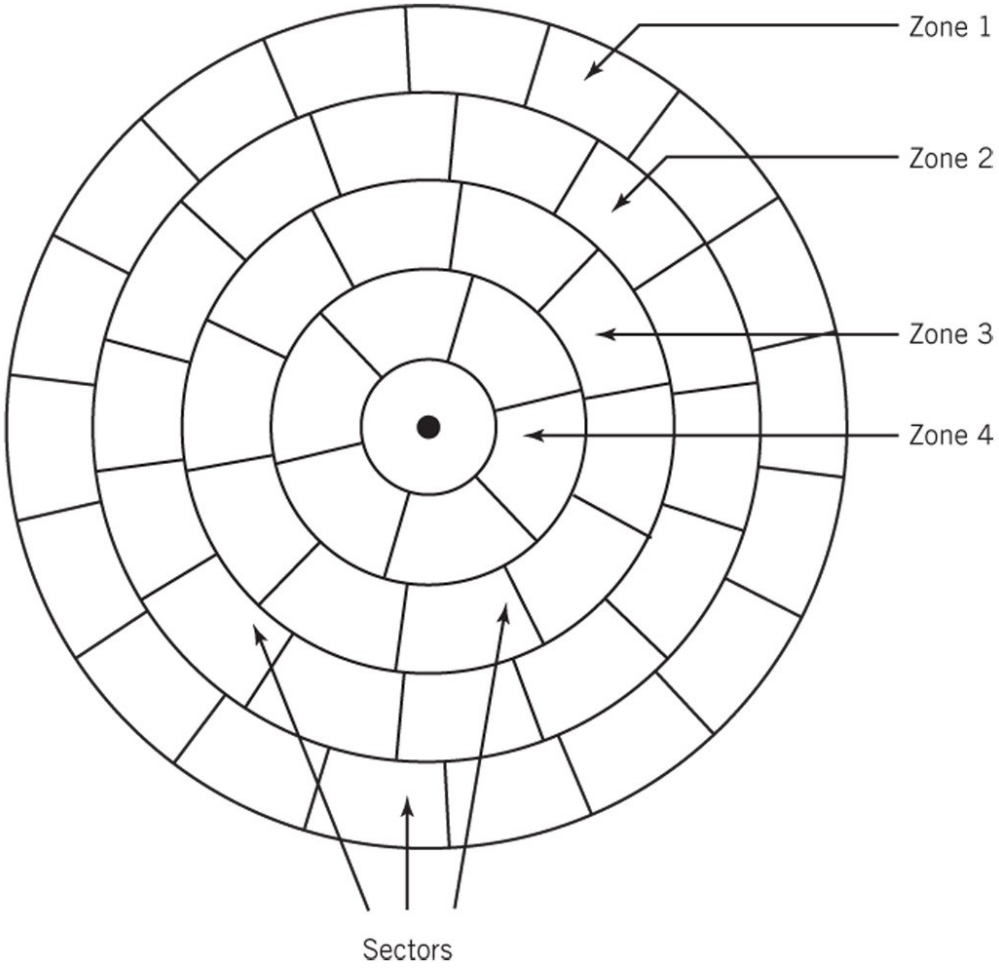
- CAV – Constant Angular Velocity
  - Number of bits on each track is the same! Denser towards the center.
  - Spins the same speed for every track
- CLV – Constant Linear Velocity
  - All tracks have the same physical length and number of bits
  - Constant speed reading data off a track
  - Drive has to speed up when accessing close to the center of the drive and slow down when accessing towards the edge of the drive

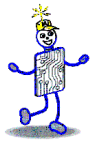


Disk Layout – Multiple Zone

- Multiple zone recording
  - Also known as zone bit recording (ZBR) or zone-CAV recording (Z-CAV)
  - Compromise between CAV and CLV
  - Disk divided into zones
  - Cylinders in different zones have a different number of sectors
  - Number of sectors in a particular zone is constant
  - Data is buffered so the data rate to the I/O interface is constant

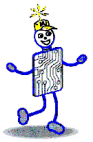
Multiple-Zone Disk Configuration





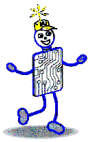
Disk Arrays

- Grouping of multiple disks together
- RAID – Redundant Array of Inexpensive Disks
  - Mirrored array
  - Striped array
  - RAID 0 to RAID 5



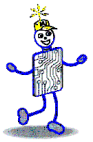
RAID – Mirrored

- Pair of disks contain the exact same stores of data
- Reading data – alternate blocks of data are read from hard drives and combined
- Access time is reduced by approximately a factor equal to the number of disk drives in array
- Read failure – block is marked and then read from the mirrored drive
- When using three or more mirrored drives, majority logic is used in the event of a failure. Fault-tolerant computers use this technique.



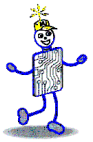
RAID - Striped

- A file segment is stored divided into blocks on different disks
- Minimum of three drives needed because one disk drive is reserved for error checking
- Writes – block of parity words from each block of data is created and put on the reserved error checking disk
- Reads – parity data is used to check original data



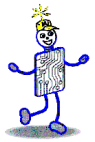
RAID Levels

- RAID 0 – not true RAID, no error checking or redundancy, but data is placed across all drives for increased speed
- RAID 1 – mirrored array
- RAID 2, 3, 4 – arrays that are striped in different ways
- RAID 5 – error checking blocks are spread across all drives



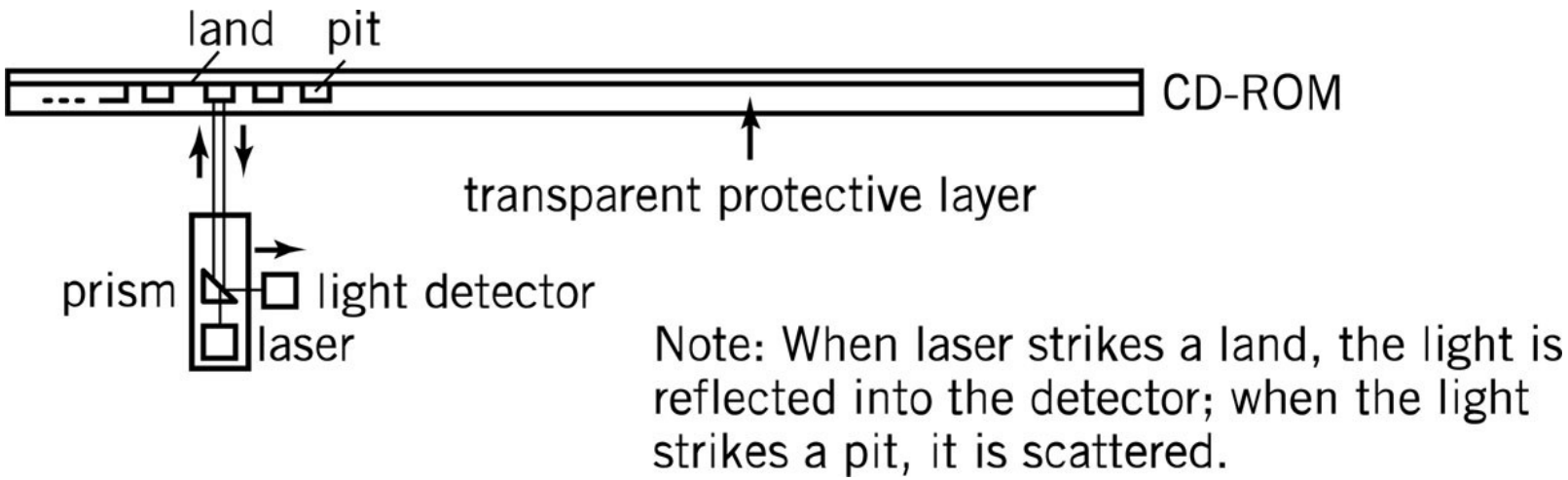
Optical Storage

- Reflected light off a mirrored or pitted surface
- CD-ROM
  - 650 MB of data
  - Spiral 3 miles long, containing 15 billion bits!
  - CLV – all blocks are same physical length
  - Block – 2352 bytes
    - 2k of data (2048 bytes)
    - 16 bytes for header (12 start, 4 id)
    - 288 bytes for advanced error control
- DVD/BluRay – similar technology to CD-ROM



Optical Storage

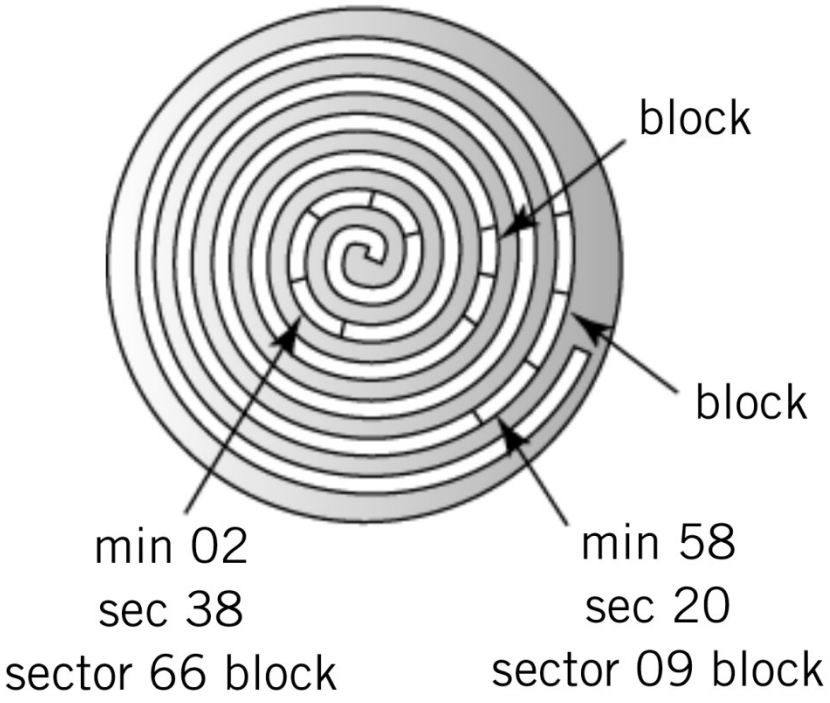
- Laser strikes land: light reflected into detector
- Laser strikes a pit: light scattered



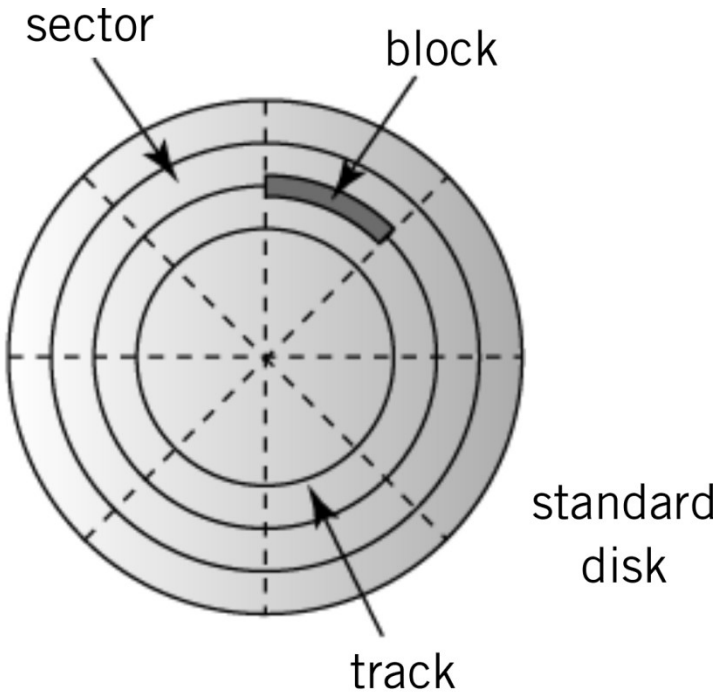
Note: When laser strikes a land, the light is reflected into the detector; when the light strikes a pit, it is scattered.

Layout: CD-ROM vs. Standard Disk

CD-ROM

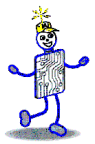


Hard Disk



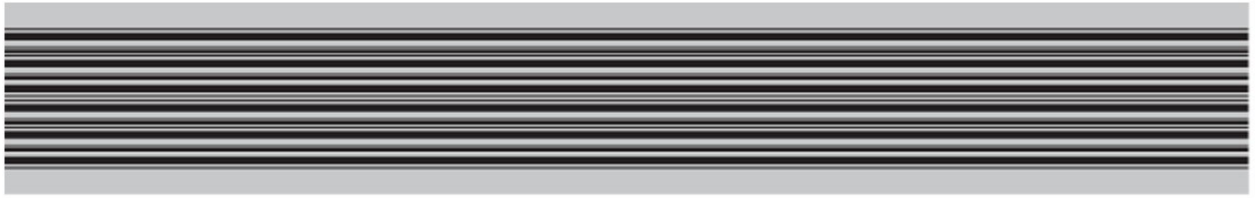
Types of Optical Storage

- Medium-powered laser blister technology also used for
  - CD-R, DVD-R, DVD-R, DVD+R
  - CD-RW, DVD-RW, DVD+RW, DVD-RAM, DVD+RAMBD-RE
- File compatibility issues between the different formats
- DVD – similar technology to CD-ROM
  - Shorter wavelength
  - Uses both sides of disc
  - Capacity up to 17GB
- Blu-Ray DVD – holds more than 50GB



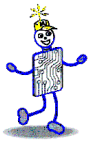
Magnetic Tape

- Offline storage
- Archival purposes
- Disaster recovery
- Tape Cartridges (1.5” up to 8.5 TB)
  - Linear tape open format vs. helical scan tape format



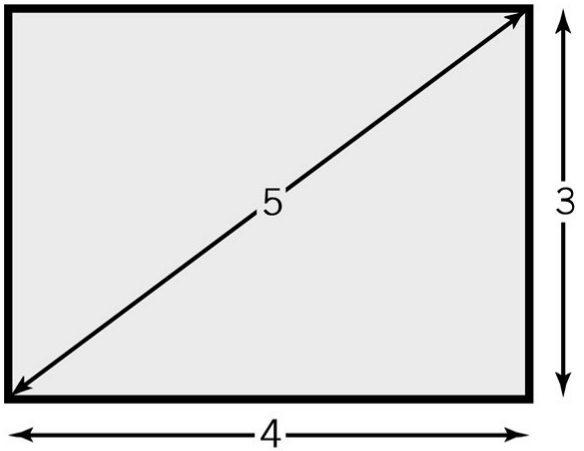
Linear tape format

Helical scan tape format

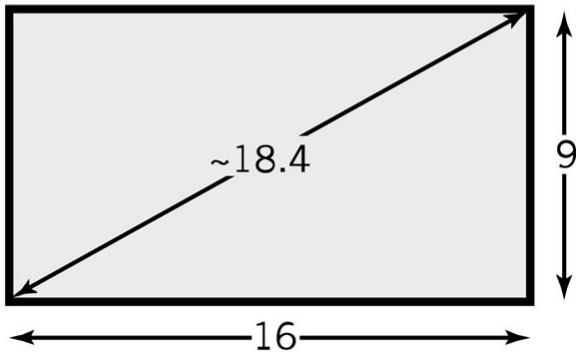


Displays

- Pixel – picture element
- Screen Size: diagonal length of screen
- Aspect ratio – X pixels to Y pixels
  - 4:3 – older displays
  - 16:9 – widescreen displays
- Pixel color is determined by intensity of 3 colors – Red, Green and Blue (RGB)
- True Color – 8 bits for each color
  - 256 levels of intensity for each color
  - 256 * 256 * 256 = 16.7 million colors



Standard



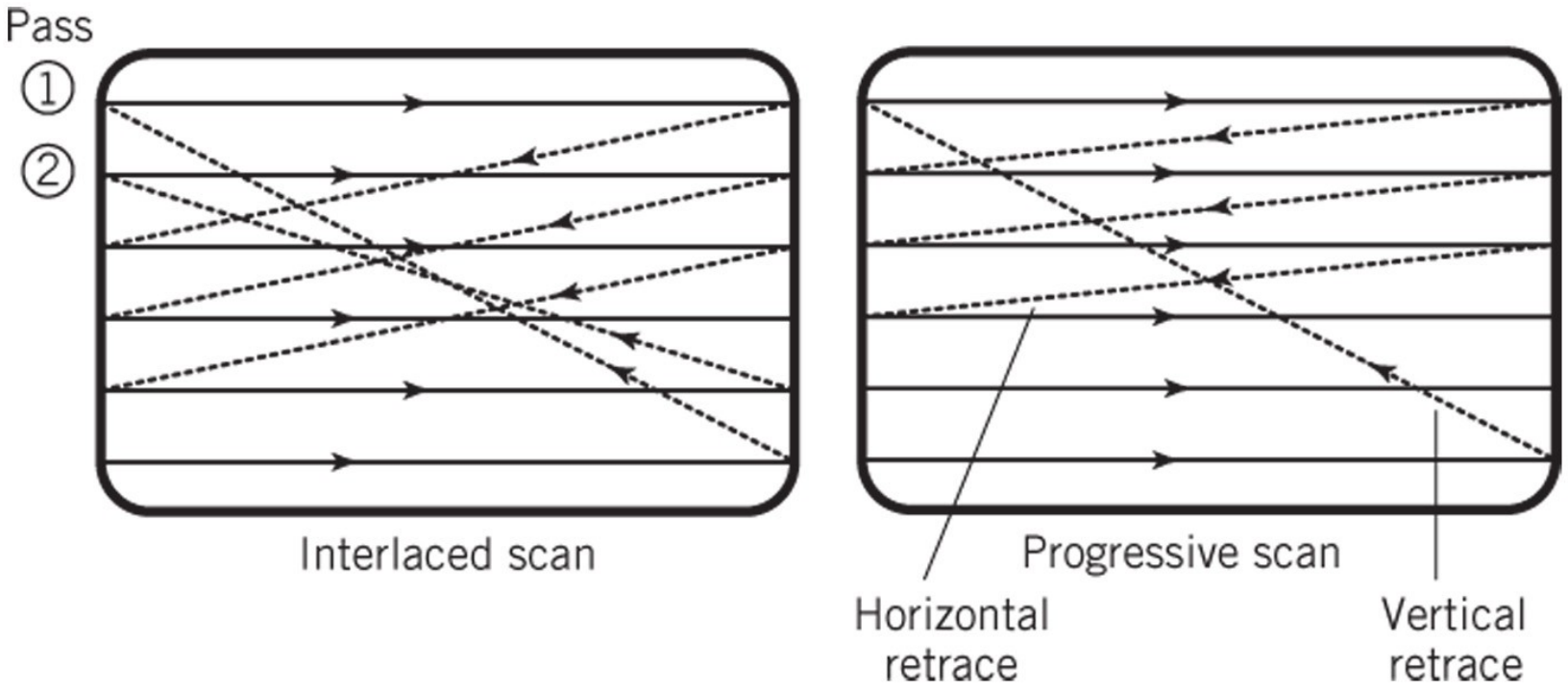
High-definition

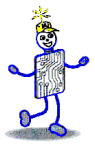
Resolution and Picture Size

- Resolution
  - Measured as either number of pixels per inch or size of an individual pixel
  - Screen resolution examples:
    - 768 x 1024
    - 1440 x 900
    - 1920 x 1080
- Picture size calculation
  - Resolution * bits required to represent number of colors in picture
  - Example: resolution is 100 pixels by 50 pixels, 4 bits required for a 16 color image

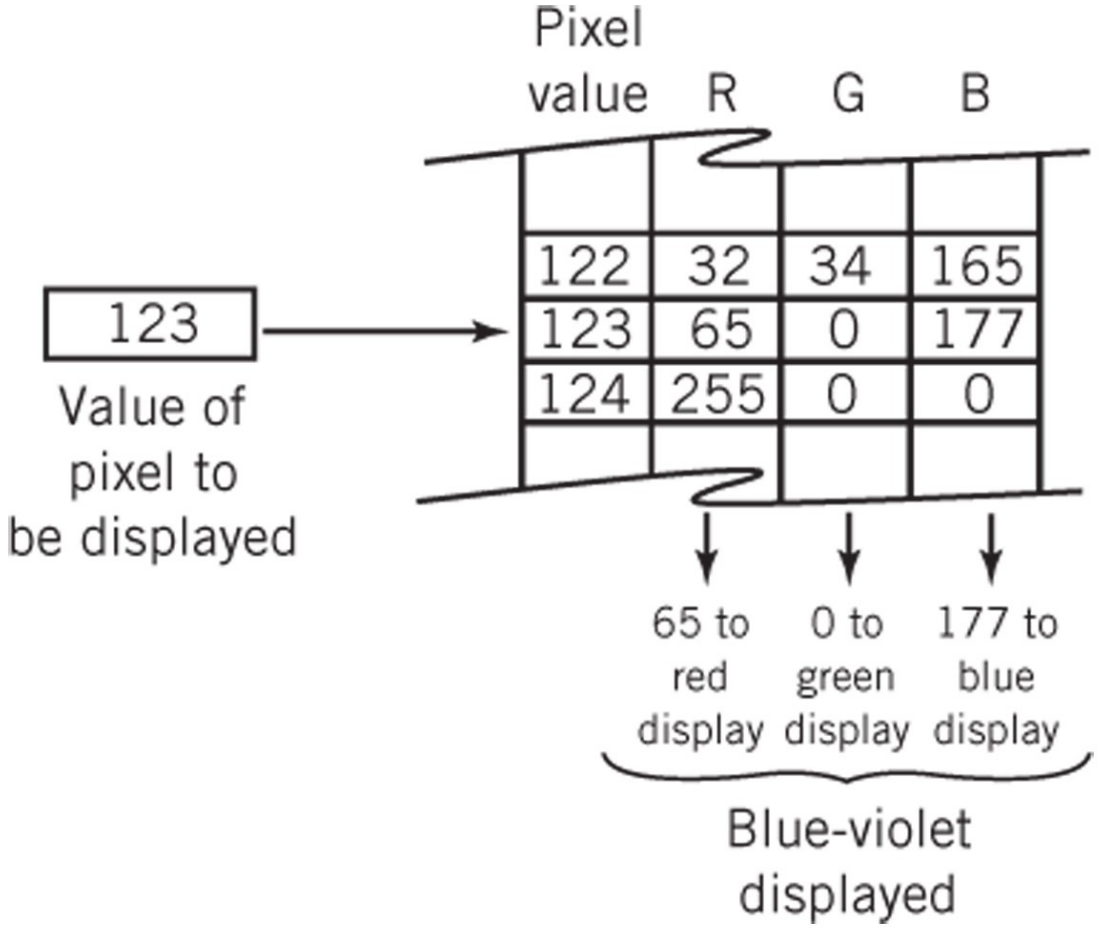
    100 * 50 * 4 bits = 20,000 bits
- Video memory requirements are significant!

Interlaced vs. Progressive Scan





Color Transformation Table



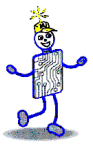
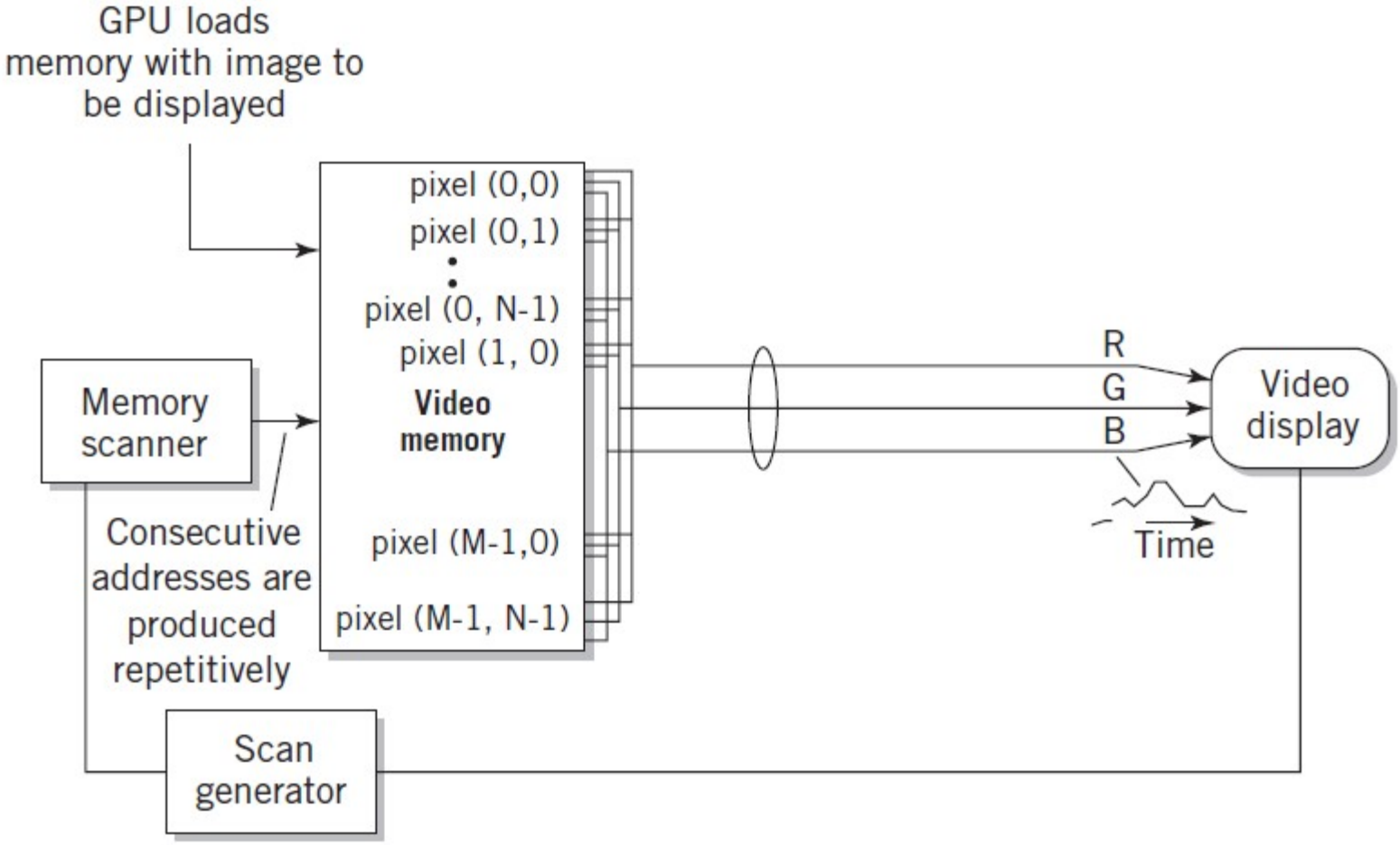
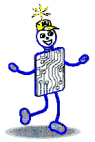


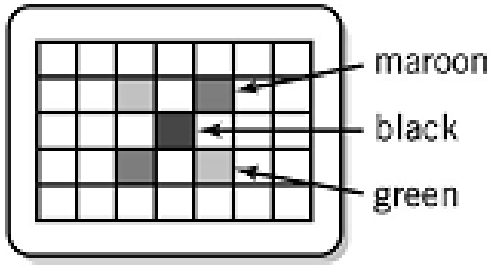
Diagram of Raster Screen Generation Process





Display Example

a. Desired display



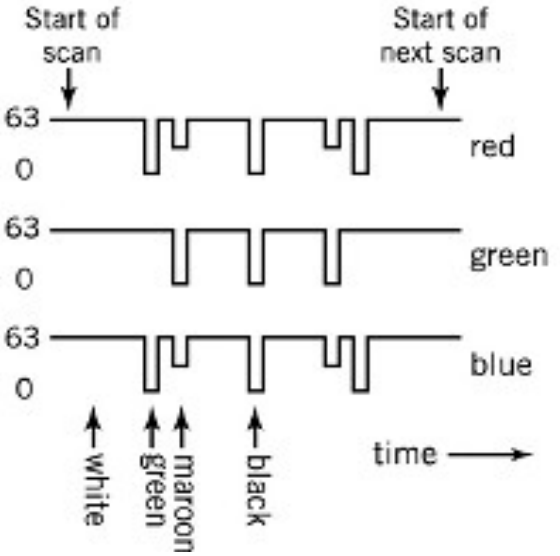
b. Video memory contents

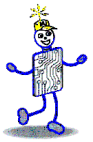
0	1	2	3	4	5	6	Address
0	0	0	0	0	0	0	Value
7	8	9	10	11	12	13	Address
0	0	17	0	123	0	0	Value
14	15	16	17	18	19	20	Address
0	0	0	255	0	0	0	Value
21	22	23	24	25	26	27	Address
0	0	123	0	17	0	0	Value
28	29	30	31	32	33	34	Address
0	0	0	0	0	0	0	Value

c. Color palette table

Pixel value	red	green	blue
0	63	63	63
...			
17	0	63	0
...			
123	31	0	31
...			
255	0	0	0

d. Color signals



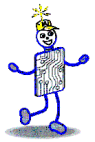


Graphical Processing Units

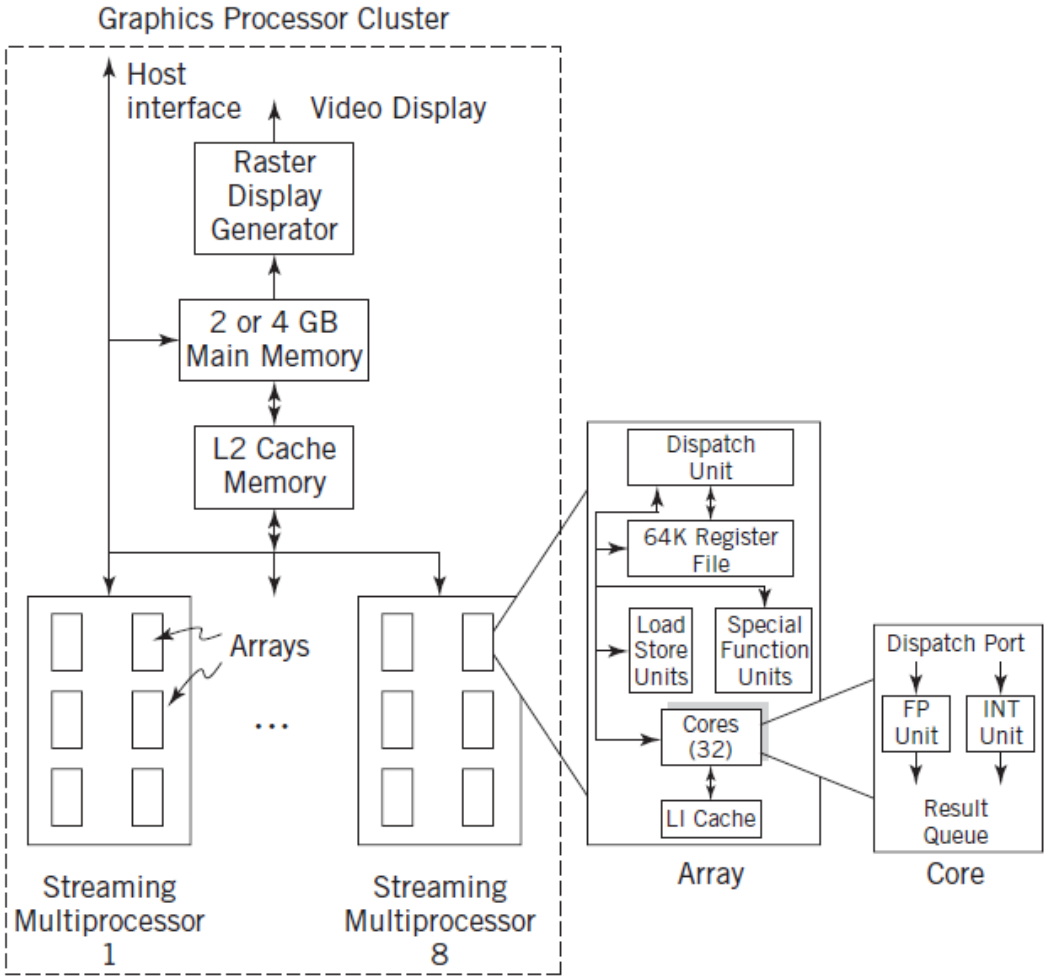
- Modern graphics requirements need dedicated processing units
- Application processing interfaces supply common graphics processing operations
- Standards
  - OpenGL
  - DirectX

Graphical Processing Units

- May be integrated, standalone units, or separate chips
- Maximize number of operations by use of parallelization
- Integrated multiple multicore processors
- Streaming dispatches instructions to CPU cores in rapid succession



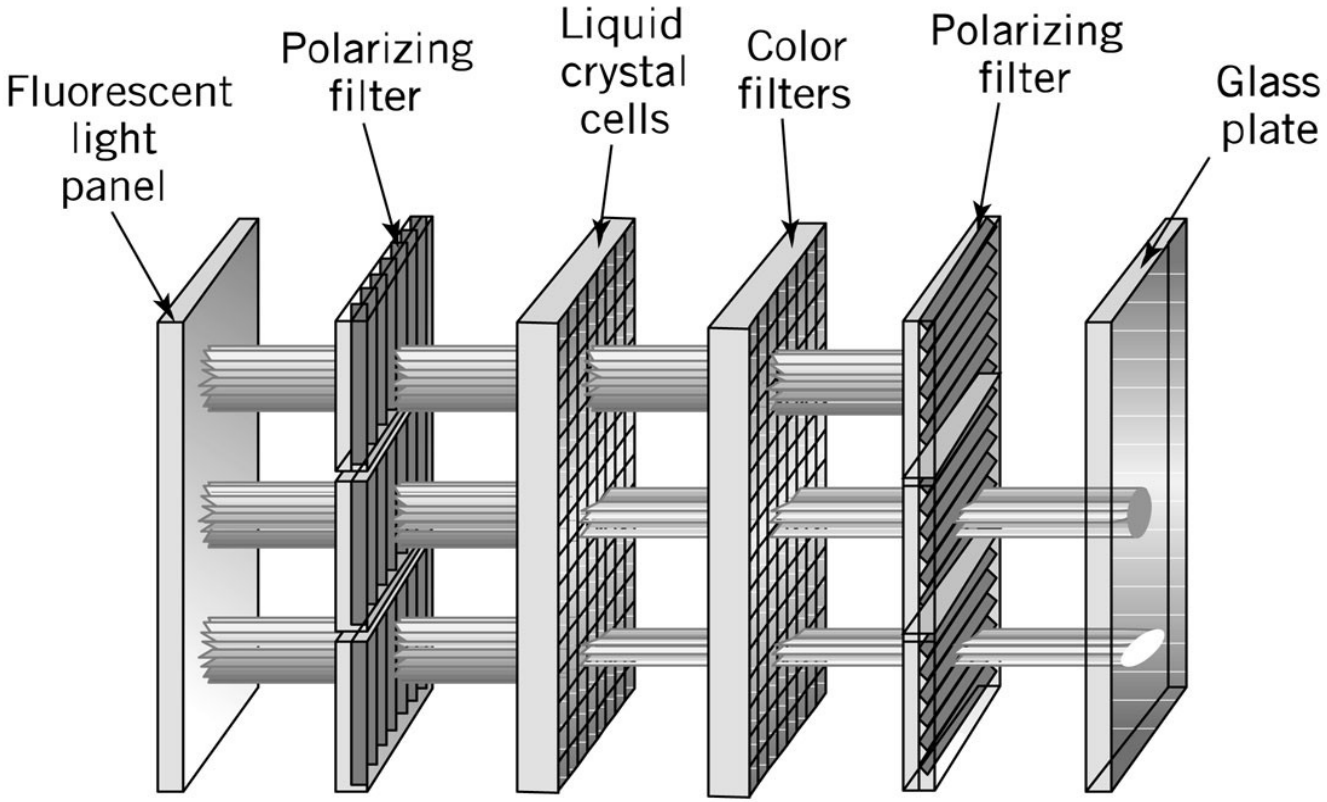
Typical GPU Block Diagram

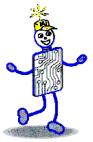


LCD – Liquid Crystal Display

- Fluorescent light or LED panel
- 3 color cells per pixel
- Operation
  - First filter polarizes light in a specific direction
  - Electric charge rotates molecules in liquid crystal cells proportional to the strength of colors
  - Color filters only let through red, green, and blue light
  - Final filter lets through the brightness of light proportional to the polarization twist

Liquid Crystal Display



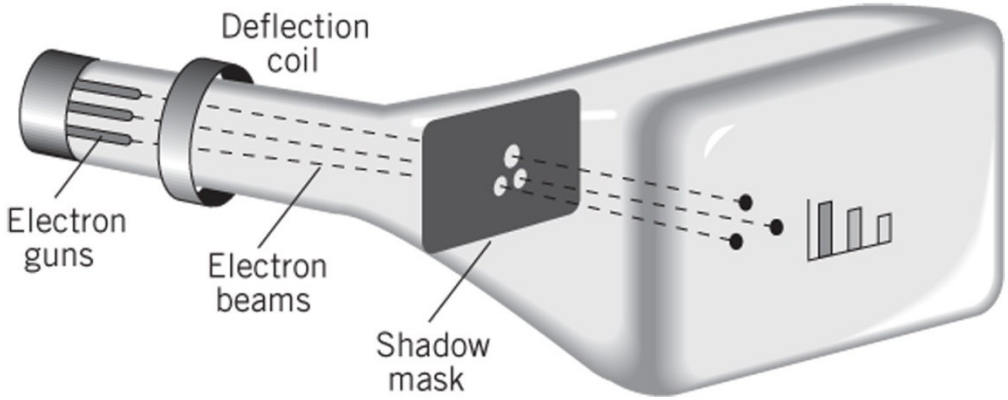


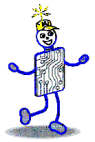
LCDs (continued)

- Active matrix
  - One transistor per cell
  - More expensive
  - Brighter picture
- Passive matrix
  - One transistor per row or column
  - Each cell is lit in succession
  - Display is dimmer since pixels are lit less frequently

CRT Display Technology

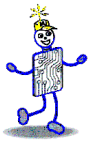
- CRTs (similar to TVs)
  - 3 stripes of phosphors for each color
  - 3 separate electron guns for each color
  - Strength of beam → brightness of color
  - Raster scan
    - 30x per second
    - Interlaced vs. non-interlaced (progressive scan)





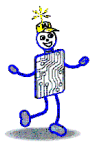
OLED Display Technology

- No backlight
- Consists of red, green and blue LEDs
- Each LED lights up individually
- Very thin displays with panels less than 3mm thick!

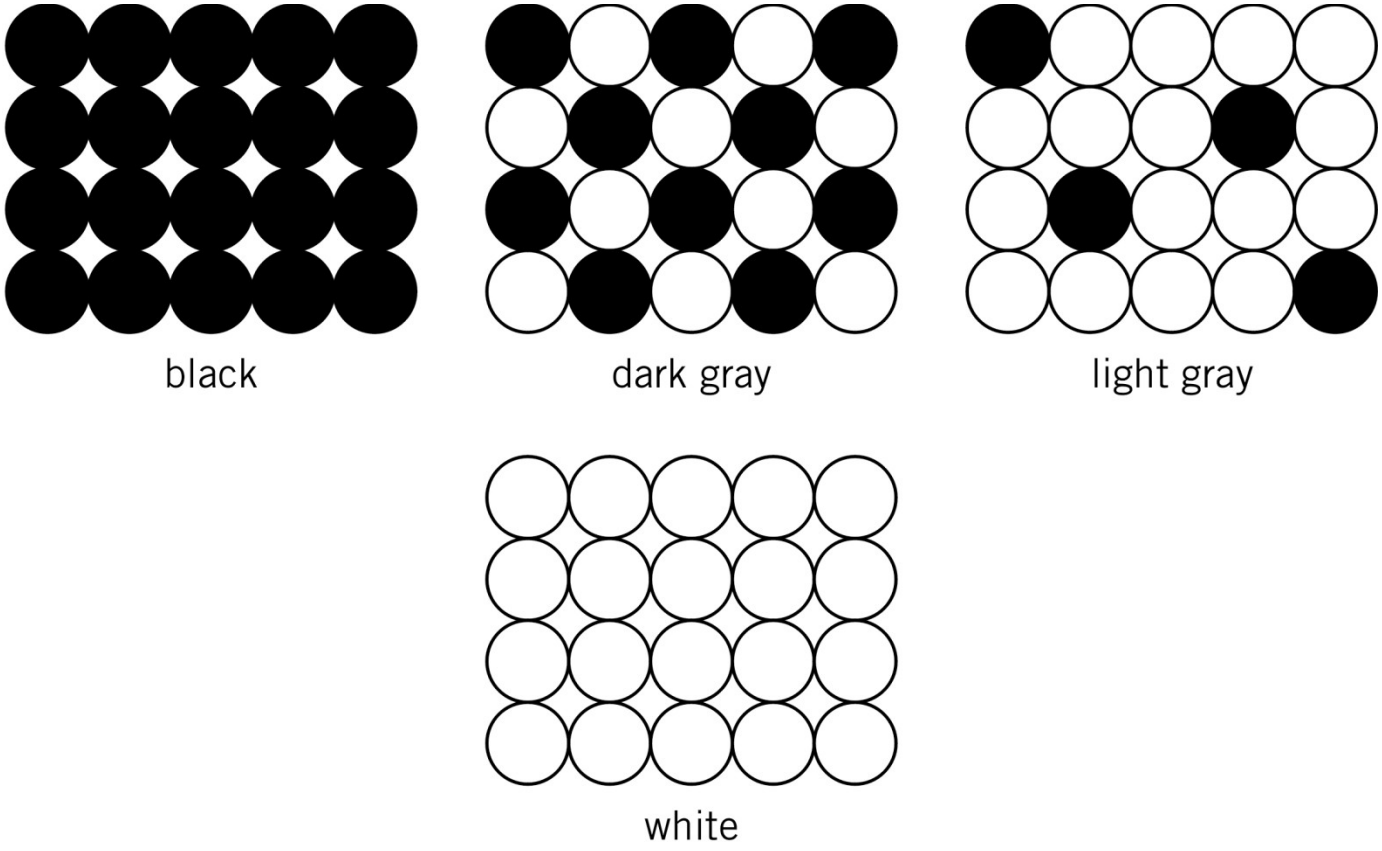


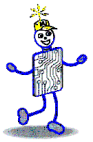
Printers

- Dots vs. pixels
  - 600-2400 dpi vs. 70-250 pixels per inch
  - Dots are on or off, pixels have intensities
- Types
  - Typewriter / Daisy wheels – obsolete
  - Impact printing - dot matrix – mostly obsolete
  - Inkjet – squirts heated droplets of ink
  - Laser printer
  - Thermal wax transfer
  - Dye sublimation



Creating a Gray Scale

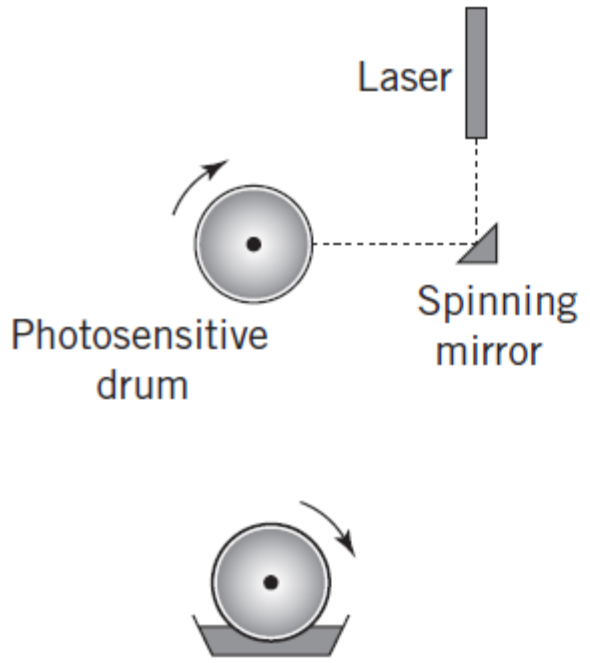




Laser Printer Operation

1. Dots of laser light are beamed onto a drum
2. Drum becomes electrically charged
3. Drum passes through toner which then sticks to the electrically charged places
4. Electrically charged paper is fed toward the drum
5. Toner is transferred from the drum to the paper
6. The fusing system heats and melts the toner onto the paper
7. A corona wire resets the electrical charge on the drum

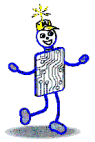
Laser Printer Operation



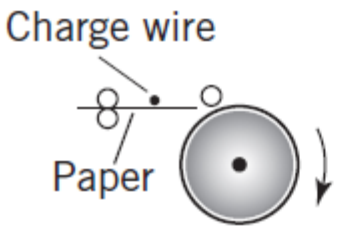
1. A laser is fired in correspondence to the dots that are to be printed. A spinning mirror causes the dots to be fanned out across the drum. The drum rotates to create the next line, usually 1/300th or 1/600th of an inch.

   The drum is photosensitive. As a result of the laser light, the drum will become electrically charged wherever a dot is to be printed.

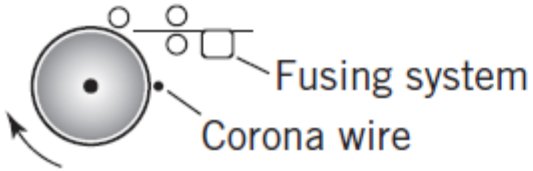
2. As the drum continues to rotate, the charged part of the drum passes through a tank of black powder called toner. Toner sticks to the drum wherever the charge is present. Thus, it looks like the image.



Laser Printer Operation

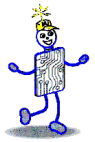


3. A sheet of paper is fed toward the drum. A charge wire coats the paper with electrical charges. When it contacts the drum, it picks up the toner from the drum.



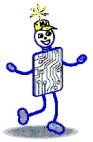
4. As the paper rolls from the drum, it passes over a heat and pressure area known as the fusing system. The fusing system melts the toner to the paper. The printed page then exits the printer.

   At the same time, the surface of the drum passes over another wire, called a corona wire. This wire resets the charge on the drum, to ready it for the next page.



Inkjet Printers

- Advantages: small size and economy
- High-quality ink capable of photographic quality color output
- Print cartridge moves across page to print rows of dots

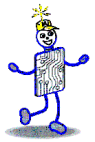


User Input Devices

- Keyboard, mouse, touch screens, graphics tablets, game controllers
- Bar code and QR code readers
- Magnetic Stripe Readers
- RFID Input and Smart Cards
- Voice Input
- Optical Character Recognition

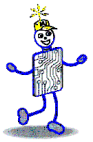
Other Computer Peripherals

- Scanners
  - Flatbed, sheet-fed, hand-held
  - Light is reflected off the sheet of paper
- Multimedia Input
  - Digital Cameras, Audio Input
- Mobile Devices
  - Smartphones, tablets
  - Global Positioning Systems (GPS)
  - Linear accelerometers



Network Communication Devices

- Network is just another I/O device
- Network I/O controller is the network interface card (NIC)
- Medium access control (MAC) protocols
  - Define the specific rules of communication for the network



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