



Computer Peripherals

Reading: Chapter 10 (except 10.6)



Peripherals

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



Storage Devices

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

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Speed

- Measured by access time and data transfer rate
- Access time: average time it takes a computer to locate data and read it
 - millisecond = one-thousandth of a second
- Data transfer rate: amount of data that moves per second

Note the access time issue is different from the access time of memory – for physical device reasons

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Storage Hierarchy

<i>Device</i>	<i>Typical access times</i>
CPU registers	0.25 nsec
Cache memory (SRAM)	1-10 nsec
Conventional memory (DRAM)	10-50 nsec
Flash memory	120 μ sec
Magnetic disk drive	10-50 msec
Optical disk drive	100-500 msec
Magnetic tape	0.5 and up sec

Increasing storage capacity

Increasing access times

Declining in importance

Be familiar with notation for nanosecond, microsecond, and millisecond

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Secondary Storage Devices

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

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Flash Memory

Nonvolatile means that no power is required to maintain the data

- Nonvolatile electronic integrated circuit memory
- Type of EEPROM
- 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

Possible replacement for laptop hard drives

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Magnetic Disks

- Consists of one or more flat circular platters
- Particles can be polarized, thereby supporting 0/1 storage
- Circles on the disk are called tracks
- Consecutive tracks are called cylinders



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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

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Disk Layout – Multiple Zone

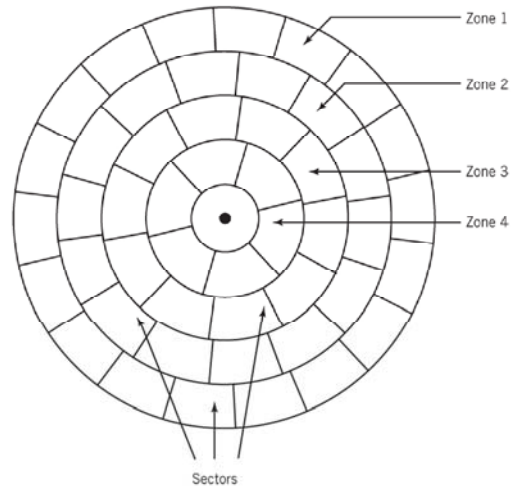
- Multiple zone recording
 - Also known as zone bit recording (ZBR) or zone-CAV recording (Z-CAV)
 - Compromise between CAV and CLV
 - Disk divided into zones
 - Cylinders in different zones have a different number of sectors
 - Number of sectors in a particular zone is constant
 - Data is buffered so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

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Multiple-Zone Disk Configuration



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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)

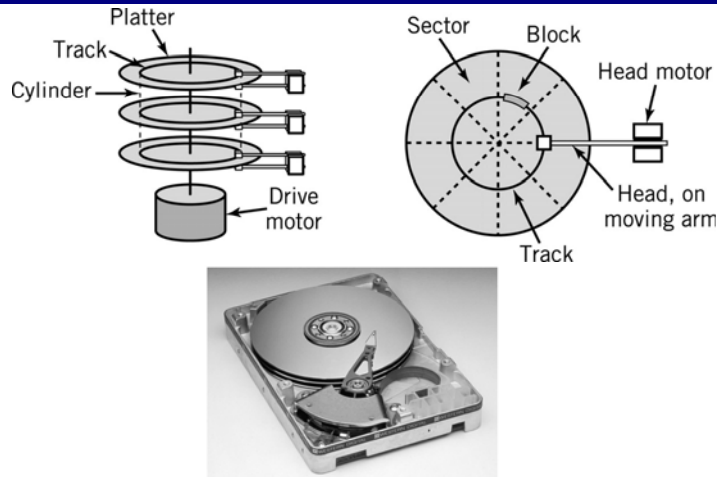
- Head crash
 - Disk damaged if head touches disk surface
- Parked heads

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10-12



A Hard Disk Layout



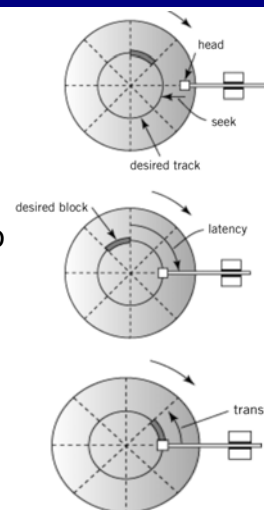
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Locating a Block of Data

- 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



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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 = $\frac{1}{2} * 1/\text{rotational speed}$
- Transfer time
 - $1/(\# \text{ of sectors} * \text{rotational speed})$
- Total Time to access a disk block
 - Avg. seek time + avg. latency time + avg. transfer time

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Magnetic Disks

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

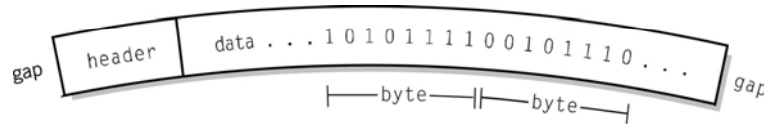
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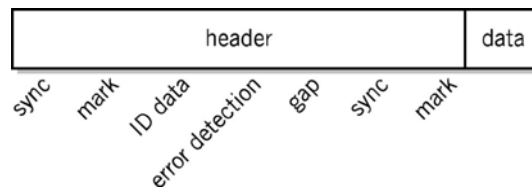


Disk Block Formats

Single Data Block



Header for Windows disk



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Disk Arrays

- Grouping of multiple disks together
- RAID – Redundant Array of Independent Disks
 - Mirrored array
 - Striped array
 - RAID 0 to RAID 5 (1928 patent)

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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.

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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

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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

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New RAID Classification

- Classifications
 - Failure resistant disk systems
 - Failure tolerant disk systems
 - Disaster tolerant disk systems
- Criteria based definitions (specific list of protections)

Caused by confusion over RAID levels
(e.g., higher means better and new
vendor levels)

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Optical Storage

- Reflected light off a mirrored or pitted surface
- CD-ROM
 - 650 MB of data, approximately 550 MB after formatting and error checking
 - 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 – similar technology to CD-ROM
- WORM – write-once read-many

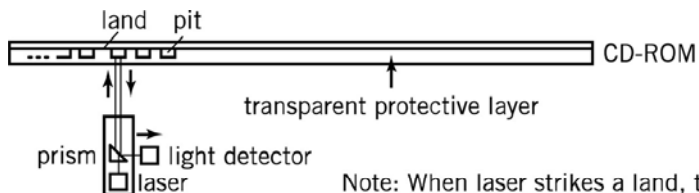
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Optical Storage

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



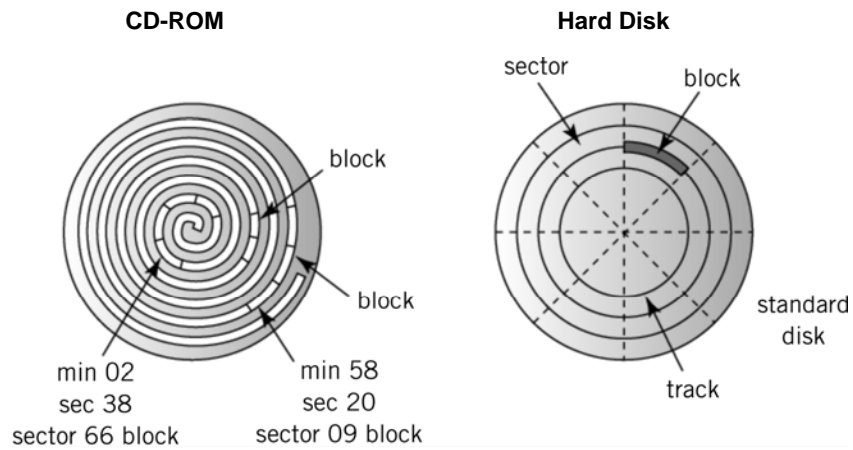
Note: When laser strikes a land, the light is reflected into the detector; when the light strikes a pit, it is scattered.

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Layout: CD-ROM vs. Standard Disk



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Types of Optical Storage

- WORM Disks
 - Write-once-read-many times
 - Medium can be altered by using a medium-powered laser to blister the surface
- 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 CD, DVD and WORM formats

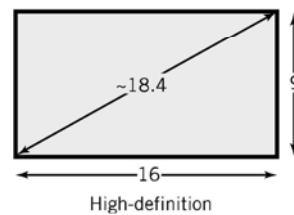
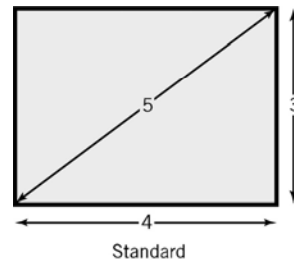
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Displays

- 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



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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!

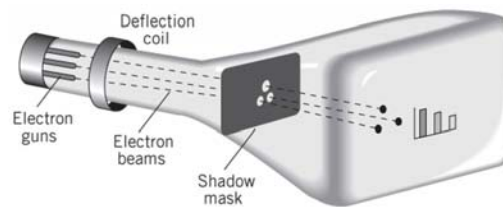
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10-28



CRT Display Technology

- CRTs
 - 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)



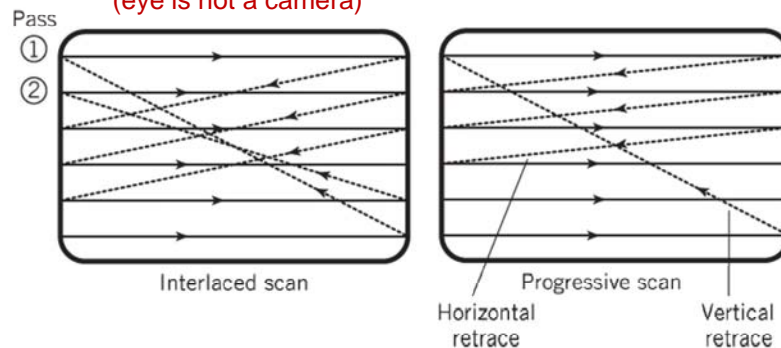
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Interlaced vs. Progressive Scan

Approach based on human vision system
(eye is not a camera)



Persistence of vision is the phenomenon of the eye by which an afterimage is thought to persist for approximately one twenty-fifth of a second on the retina

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LCD – Liquid Crystal Display

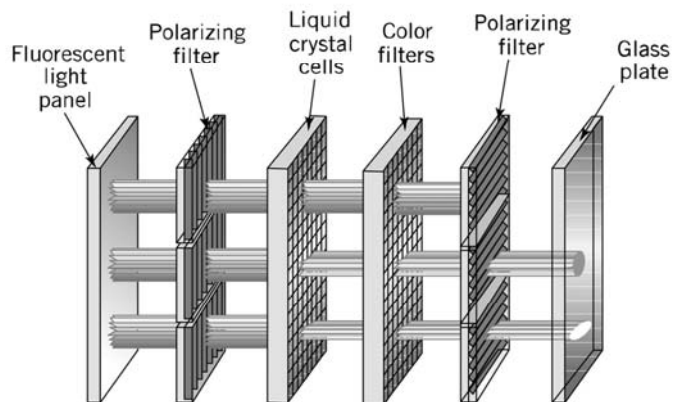
- Fluorescent light or LED panel
- 3 color cells per pixel
- Operation
 - 1st filter polarizes light in a specific direction
 - Electric charge rotates molecules in liquid crystal cells proportional to the strength of colors
 - Color filters only let through red, green, and blue light
 - Final filter lets through the brightness of light proportional to the polarization twist

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Liquid Crystal Display



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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

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10-33



Printers

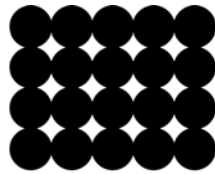
- Dots vs. pixels
 - 300-2400 dpi vs. 70-100 pixels per inch
 - Dots are on or off, pixels have intensities

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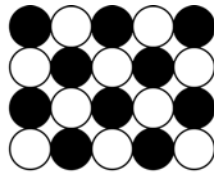
10-34



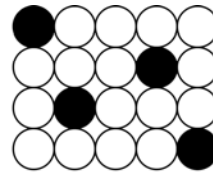
Creating a Gray Scale



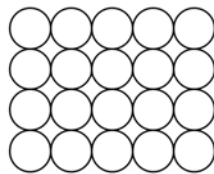
black



dark gray



light gray



white

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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

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10-36



Other Computer Peripherals

- Scanners
 - Flatbed, sheet-fed, hand-held
 - Light is reflected off the sheet of paper
- User Input Devices
 - Keyboard, mouse, light pens, graphics tablets
- Communication Devices
 - Telephone modems
 - Network devices

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Network Communication Devices

More when we cover communications

- Network is just another I/O device
- Network I/O controller is the network interface card (NIC)
- Types of network connections
 - Ethernet, FDDI fiber, token-ring
- Medium access control (MAC) protocols
 - Define the specific rules of communication for the network

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