Module 4

Memory and Storage Devices

Objectives

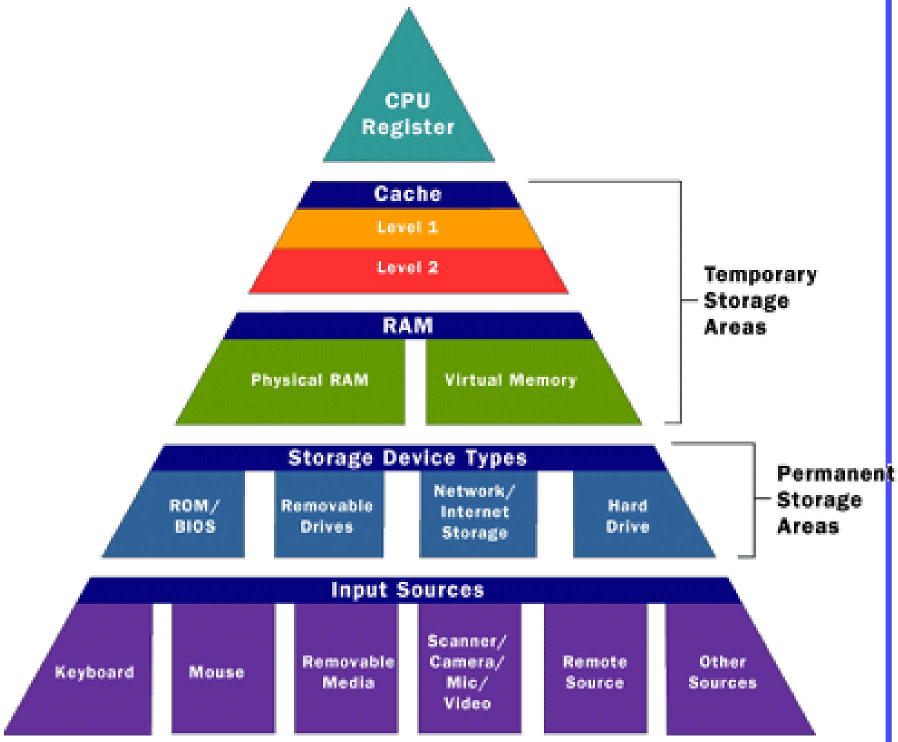
PC Hardware

1. 1.5 Compare and contrast RAM types and features
2. 1.6 Install and configure storage devices and use appropriate media

MEMORY

Memory Hierarchy

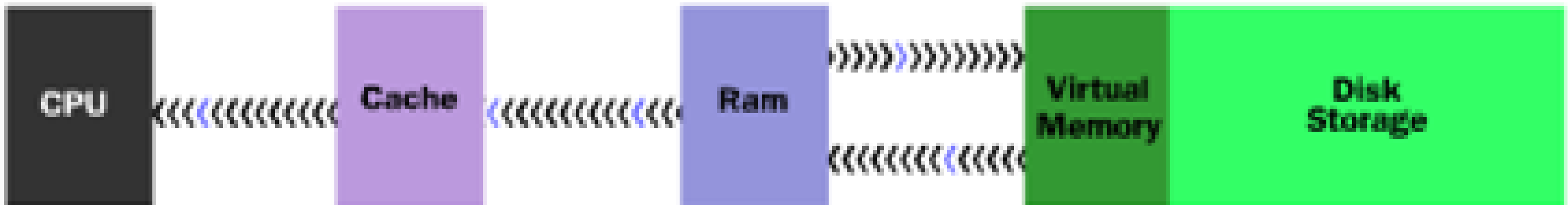
1. CPUs access memory according to a distinct hierarchy
2. All data goes in **random access memory** (RAM) first
3. CPU stores pieces of data it will need to access a **cache**
4. Maintains certain special instructions in the **register**



Memory Systems

A typical computer has:

1. L1, L2, and L3 caches
2. Normal system RAM
3. Virtual memory
4. A hard disk



Types of Memory

1. **ROM** - Read Only Memory (discussed in Module 2)
2. **CMOS**
3. **Cache** (discussed in Module 3)
4. **RAM** – Random Access Memory

Random Access Memory (RAM)

1. Volatile in nature
   A. Loses its contents if the power is turned off
2. Holds data and programs the CPU is using
3. Main memory for the computer
4. Can be shared with other devices, such as video
5. Measured in MegaBytes (MB)
6. As general rule, install as much RAM as you can afford
7. Upgrading RAM can speed up a slow system (to a point)

Minimum Amounts of RAM

OS	Minimum	Recommended	Best Performance
DOS 6.2	640 KB	640 KB	-
Windows 3.x	1 MB	1 MB	-
Windows 95	8 MB	8 MB	-
Windows 98	16 MB	32 MB	64 MB
Windows 2000	64 MB	96 MB	128 MB
Windows XP	64 MB	128 MB	256MB
Windows Vista	512 MB	1 GB	2 GB
Windows 7	512 MB	1 GB	2 GB
Windows 8	512 MB	1 GB	2 GB

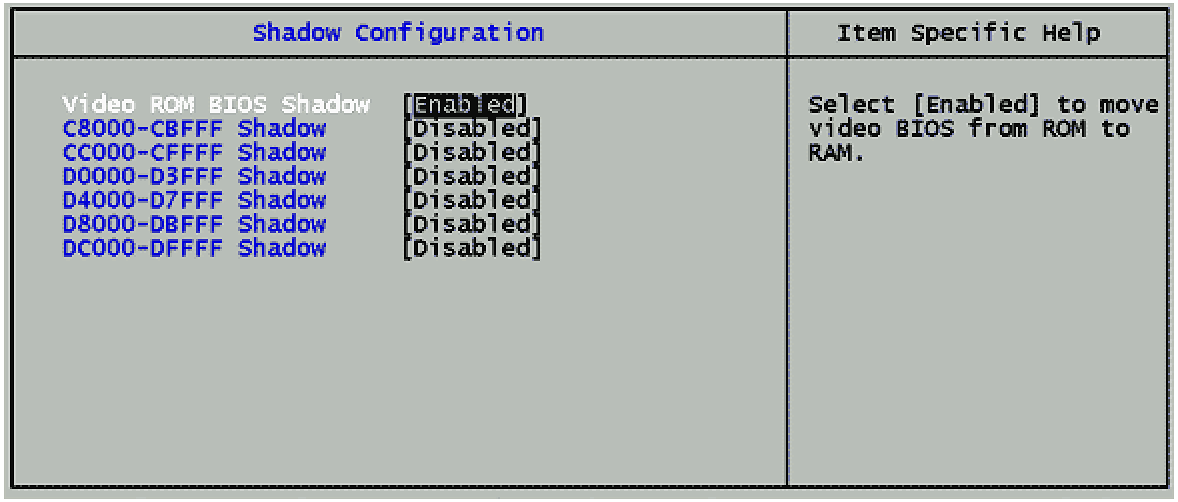
System RAM

Speed is controlled by bus width and bus speed

1. Bus width refers to the number of bits that can be sent to the CPU simultaneously
2. Bus speed refers to the number of times a group of bits can be sent each second
3. 32- or 64-bit data paths
4. Front Side Bus

Shadowing

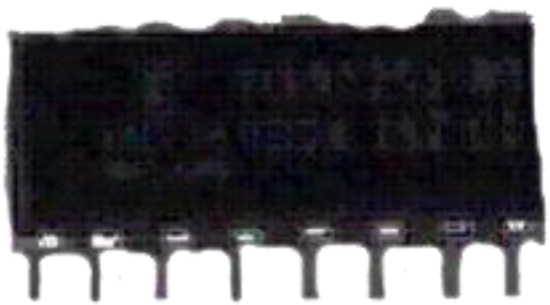
Copying ROM BIOS information into the Reserved Memory area of RAM for faster execution

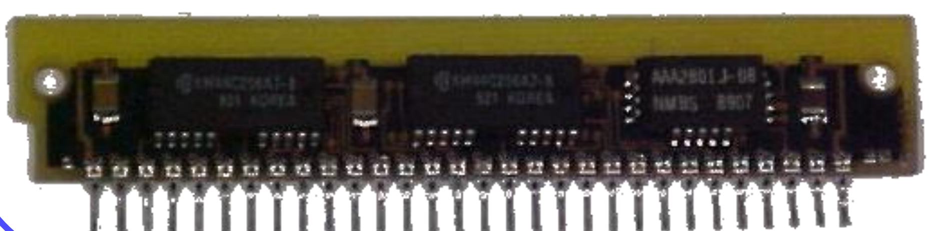


Types of RAM

1. **DRAM**
   A. Dynamic Random Access Memory
   B. Uses capacitors that need constant power to keep them from fading
   C. This process of charging is called **Refresh**
   D. Most DRAM needs to be refreshed every 2 ms
   E. Small and affordable, but slower than SRAM
2. **SRAM**
   A. Static Random Access Memory
   B. Uses transistors
   C. Large and expensive, but fast
   D. Commonly used as cache

DRAM Types





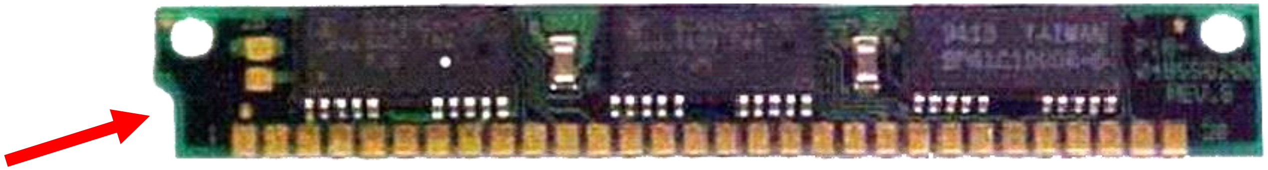
1. **DIP** (Dual Inline Pin) socket types
   A. Small amount of memory (>1MB)
2. **SIPP** (Single Inline Pin Package)
   A. Extinct because the pins were easy to bend and break

DRAM Types

3. **SIMM** (Single Inline Memory Module)
   A. Small amounts of DIP chips on a single board
   B. Used with 80286 – 80486 CPU’s
   C. Two different styles – 30 pin and 72 pin

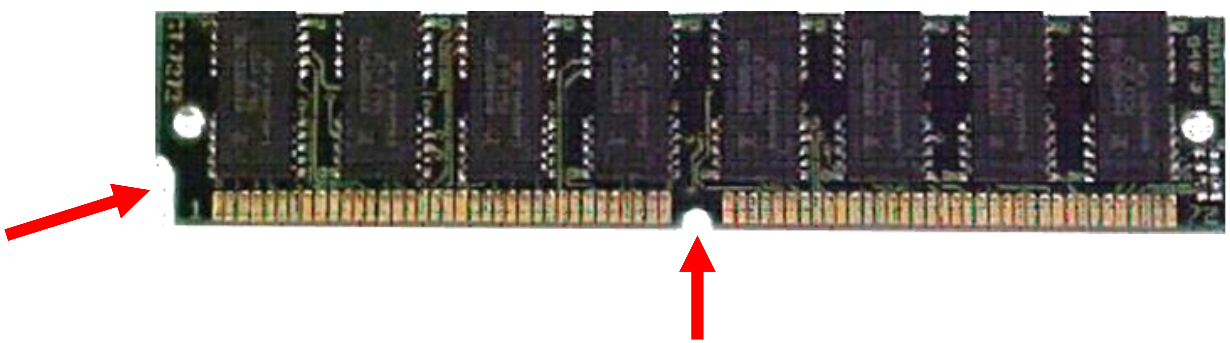
30 Pin SIMM

1. Has contacts on both sides of the module
2. Only contacts one side
3. Used in later 80286 and 80386 CPU's
4. 16 bit data bus



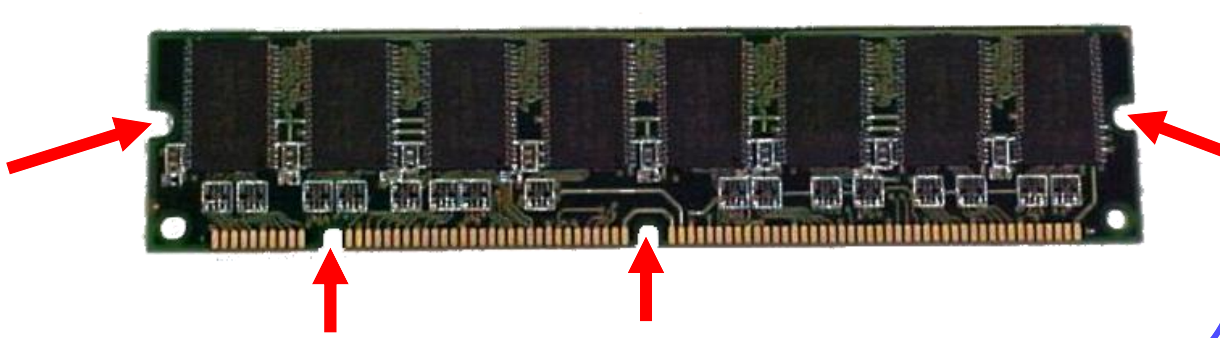
72 Pin SIMM

1. Has contacts on both sides of the module
2. Only contacts one side
3. Notch in the middle of the chip
4. Used in later 80386 and 80486 CPU's
5. 32 bit data bus



DRAM Types

4. **DIMM** (Dual Inline Memory Module)
   A. 168 pins long (84 contacts per side)
   B. Also called **SDRAM** (Synchronous DRAM)
   C. Runs at the same speed as the FSB
   D. 64 bit data bus
   E. +3.3v



DRAM Types

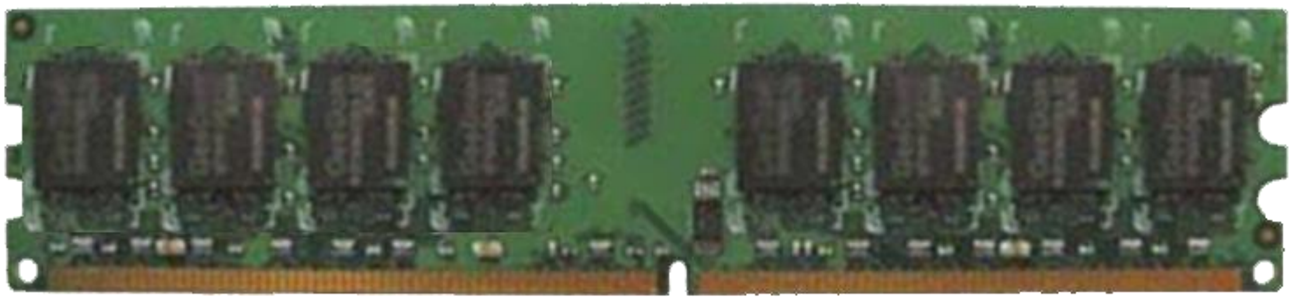
5. **DDR-SDRAM** (Double Data Rate Synchronous DRAM)
   A. 184 pins
   B. Twice as fast as SDRAM (if used in dual channel configuration)
   C. Will not interchange with SDRAM
   D. 64 bit data bus

DDR

Standard name	Memory clock	Time between signals	I/O Bus clock	Data transfers per second	Module name	Peak transfer rate
DDR-200	100 MHz	10 ns	100 MHz	200 Million	PC-1600	1.600 GB/s
DDR-266	133 MHz	7.5 ns	133 MHz	266 Million	PC-2100	2.133 GB/s
DDR-333	166 MHz	6 ns	166 MHz	333 Million	PC-2700	2.667 GB/s
DDR-400	200 MHz	5 ns	200 MHz	400 Million	PC-3200	3.200 GB/s

DRAM Types

6. **DDR2**
   A. Faster than DDR-SDRAM memory
   B. Improves performance by decreasing noise and crosstalk between the signal wires
   C. 240 pins



DDR2

Standard name	Memory clock	Time between signals	I/O Bus clock	Data transfers per second	Module name	Peak transfer rate
DDR2-400	100 MHz	10 ns	200 MHz	400 Million	PC2-3200	3.200 GB/s
DDR2-533	133 MHz	7.5 ns	266 MHz	533 Million	PC2-4200	4.264 GB/s
DDR2-667	166 MHz	6 ns	333 MHz	667 Million	PC2-5400	5.336 GB/s
DDR2-800	200 MHz	5 ns	400 MHz	800 Million	PC2-6400	6.400 GB/s
DDR2-1066	266 MHz	3.75 ns	533 MHz	1066 Million	PC2-8500	8.500 GB/s

DRAM Types

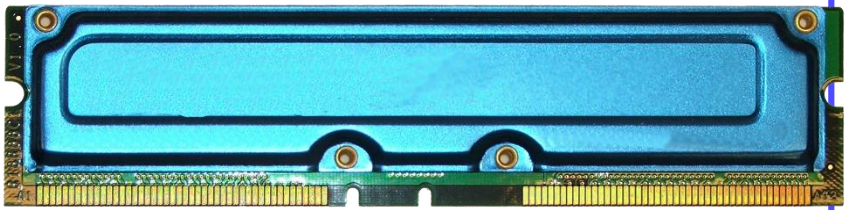
7. **DDR3**
   A. Higher bandwidth performance increase (up to effective 1600 MHz)
   B. Performance increase at low power (+3.3v)
   C. Improved thermal design (cooler)
   D. Modules up to 16 GB
   E. 240 pins

DDR3

Standard name	Memory clock	Time between signals	I/O Bus clock	Data transfers per second	Module name	Peak transfer rate
DDR3-800	100 MHz	10 ns	400 MHz	800 Million	PC3-6400	6.40 GB/s
DDR3-1066	133 MHz	7.5 ns	533 MHz	1.066 Billion	PC3-8500	8.53 GB/s
DDR3-1333	166 MHz	6 ns	667 MHz	1.333 Billion	PC3-10600	10.67 GB/s
DDR3-1600	200 MHz	5 ns	800 MHz	1.6 Billion	PC3-12800	12.80 GB/s

DRAM Types

8. **Rambus**
   A. Also called RDRAM and RIMM
   B. Runs up to 800 MHz
   C. All memory slots on the motherboard must be filled
   D. Unused slots must have continuity modules installed
   E. New version called nDRAM will run at 1600 MHz
   F. 16 bit data bus



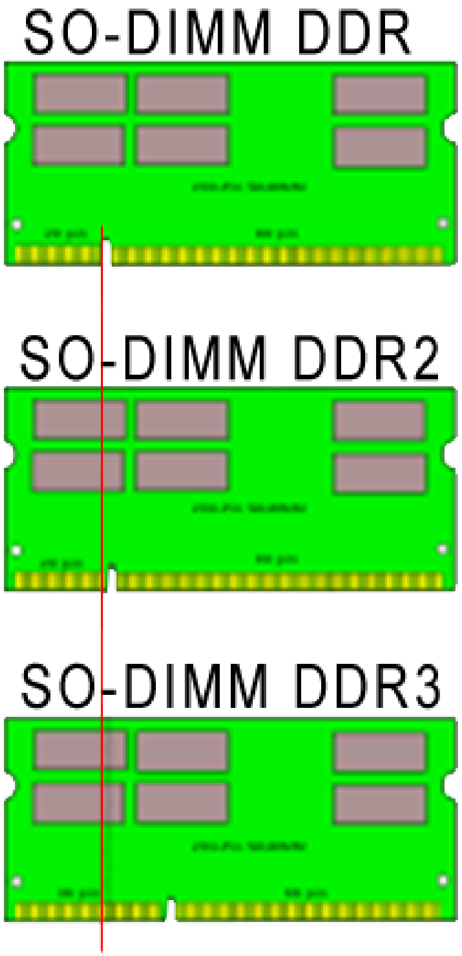
DRAM Types

9. **SO-DIMM**
1. Small Outline Dual In-line Memory Module
2. Smaller alternative to a DIMM (roughly half)
3. Used in systems which have space restrictions such as:
   A. notebooks
   B. small footprint PCs (such as those with a Mini-ATX motherboard)
   C. high-end upgradable printers
   D. networking hardware like routers

SO-DIMM

Recognized by the distinctive notches used to “key” them for different applications:

1. 100-pin SO-DIMMs have two notches,
2. 144-pin SO-DIMMs have a single notch near (but not at) the center, and
3. 200-pin SO-DIMMs (DDR & DDR2) have a single notch nearer to one side. The exact location of this notch varies
4. 204-pin SO-DIMMs for DDR3



Installation of DRAM

Type of DRAM	Amount Required
30 pin SIMM's (16 bits)	4 to a set
72 pin SIMM's (32 bits)	2 to a set
168 pin DIMM's (64 bits)	Single modules
184 pin DDR (64 bits)	Single modules
Rambus (16 bits)	All slots filled

Remember that it takes two 32-bit SIMM modules to make a bank for a 64-bit data bus such as the Pentium

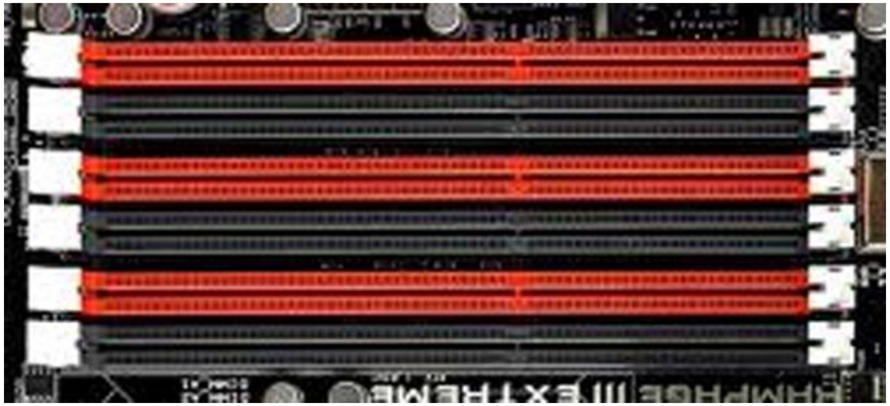
Installation of DRAM

1. Install DRAM starting from Bank 0-Slot 0
2. Some motherboards have a combination of socket types
   A. Different types of memory cannot be used in the same computer (SDRAM and DDR; DDR2 and DDR3)
3. Largest chips in the first bank/slot
4. Slowest chips in the first bank/slot
   A. If different speeds are used together, all memory will slow down to the lowest speed

Multi-Channel Memory

1. A technology that increases the transfer speed of data between the memory and the chipset by adding more channels of communication between them
2. Multiplies the data rate by the number of channels present
   A. Dual-channel memory employs two channels
3. Modern higher-end chipsets support triple-channel up to eight channel memory

Dual-Channel Memory



Triple-Channel Memory

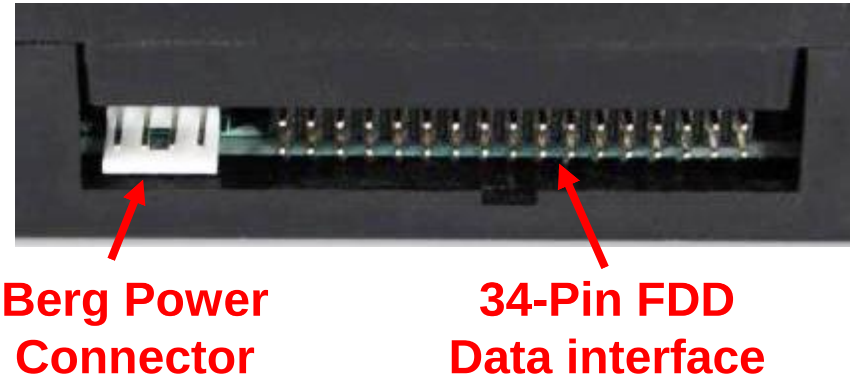
Error Checking

1. Memory errors occur when the data is not stored correctly in the RAM chips
2. Use different methods to detect and correct data errors in memory
3. The three different methods of memory error checking are:
   A. **Non-parity**: Non-parity memory does not check for errors in memory.
   B. **Parity**: Parity memory contains eight bits for data and one bit for error checking. The error-checking bit is called a parity bit.
   C. **ECC**: Error Correction Code memory can detect multiple bit errors in memory and correct single bit errors in memory thus improving reliability. Primarily used in servers and high-end computers.

STORAGE DEVICES

Floppy Disk Drives

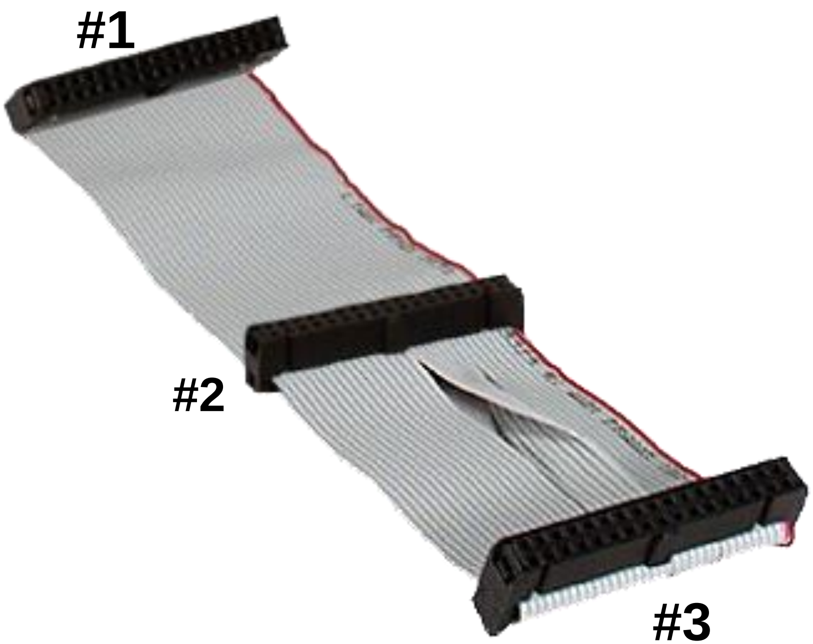
1. Used to store files and programs
2. 5.25-inch disk held 360 kilobytes
3. 3.5-inch disk held 1.44 megabyte
4. Today, floppy drives are just an add-on to our systems



Floppy Drive Connections

1. Allows up to 2 drives per cable
2. Designated by A: and B:
3. Position on the cable determines whether it is A: or B:
4. Drive type set in CMOS
5. Always connect pin 1 on the cable to pin 1 on the drive
6. Colored stripe indicates pin 1

Cable Positions



1. Uses a Ribbon Type cable with 34 pins
2. The drive after the twist is A: (#3)
3. Drives in the middle are B: (#2)
4. The end plugs into the motherboard (#1)

Tape Drives

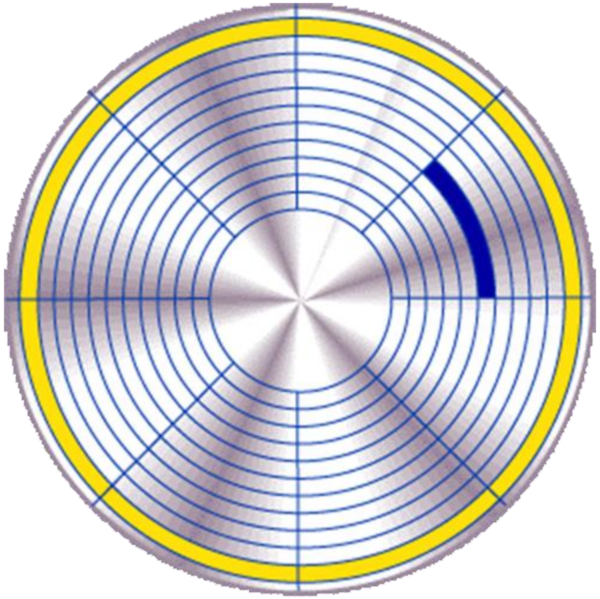
1. Data storage device that reads and writes digital data on a magnetic tape
2. Typically used for offline, archival data storage
3. Has a favorable unit cost
4. Long archival stability
5. High capacity (5000GB+)
6. Best for large system backups
7. SCSI most common

Hard Drives

This drive has three platters and six read/write heads

1. Platters spin at:
   A. 5,400 rpm
   B. 7,200 rpm (170 mph)
   C. 10,000 rpm
   D. 15,000 rpm
2. Have multiple platters to increase the amount of information the drive can store

Storing the Data



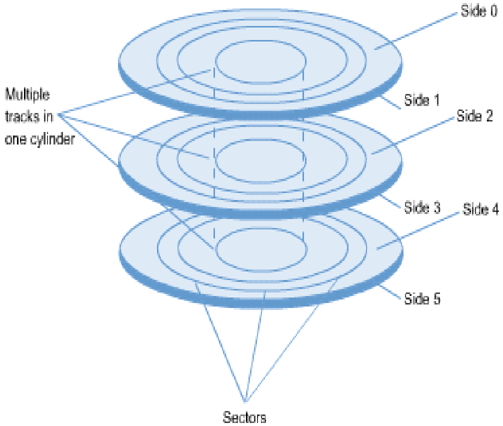
Track is shown in yellow
Sector is shown in blue

Data is stored on the surface of a platter in:

1. **Tracks** – concentric circles
2. **Sectors** – pie-shaped wedges on a track
3. Sectors are often grouped together into **clusters**.

The Difference Between Tracks and Cylinders

1. A hard disk is usually made up of multiple platters
2. Each platter has two heads to record and read data
   A. One for the top of the platter
   B. One for the bottom of the platter
3. The heads that access the platters are locked together on an assembly of head arms
4. All the heads move in and out together
5. All heads are always physically located at the same track number
6. Location of the heads is referred to by a **cylinder** number.



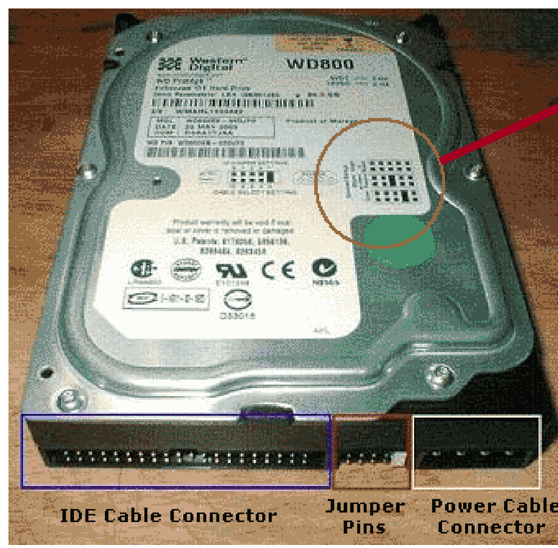
Storing the Data

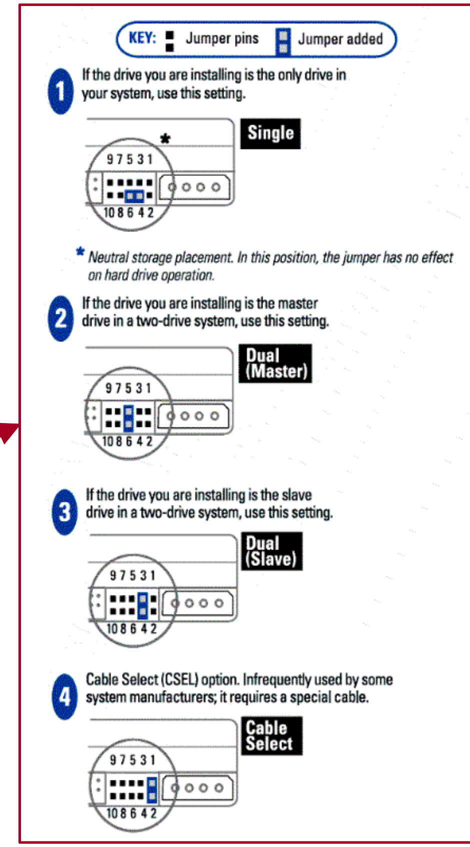
1. **Low-level formatting**
   A. Establishes the tracks and sectors on the platter
   B. The starting and ending points of each sector are written onto the platter
   C. Prepares the drive to hold blocks of bytes
2. **High-level formatting**
   A. Writes the file-storage structures, like the file-allocation table, into the sectors
   B. Prepares the drive to hold files
3. **Partitioning**
   A. The process of assigning part or all of a drive to the computer (formatting)

Jumper Settings

Most hard drives have 4 jumper settings to control drive hierarchy:

1. Master with no Slave
2. Master with Slave present
3. Slave
4. Cable Select





Optical Drive Basics

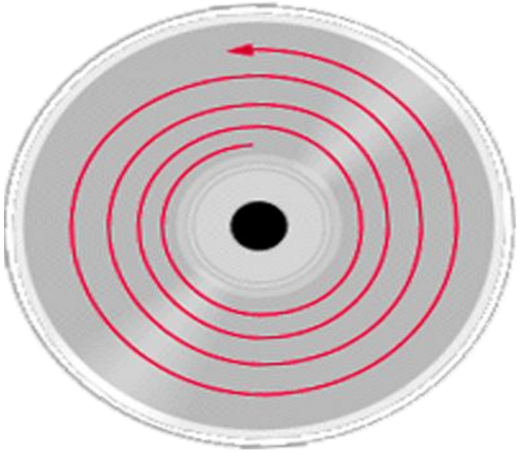
1. High capacity
2. Broad application
3. Inexpensive media
4. The plastic disc is 12 cm in diameter and 1.2 mm thick
5. Same size for all optical media
6. Base unit of measurement for a CD Writer is 150KBps
7. A 48x burner writes as 7,200 KBps

Reading the Disk

Focuses the laser on the track of bumps:

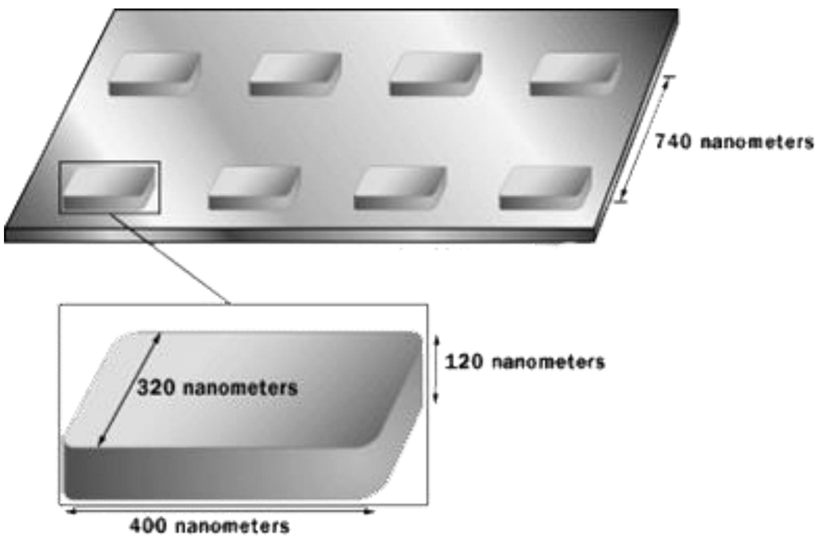
1. The laser beam passes through the polycarbonate layer
2. Reflects off the aluminum layer
3. Hits an opto-electronic device that detects changes in light
4. Electronics in the drive interpret the changes in reflectivity

The CD Medium



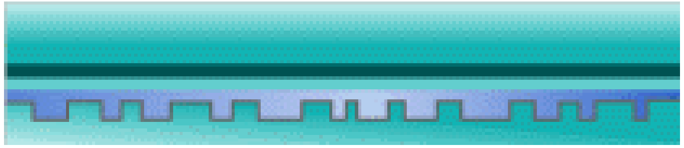
1. Incredibly small the data track:
   A. Approximately 0.5 microns wide
   B. 1.6 microns separating one track from the next (A micron is a millionth of a meter)
2. Bumps that make up the track:
   A. 0.5 microns wide
   B. Minimum of 0.83 microns long
   C. 125 nanometers high (A nanometer is a billionth of a meter)
   D. Spiral configuration

DVD Formats

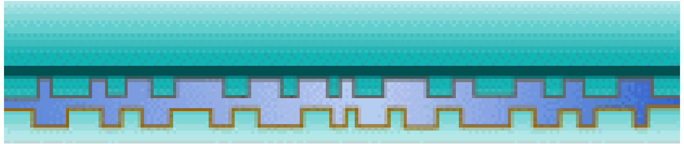


1. Same spiral track as CDs:
   A. 320 nm wide
   B. 740 nm spacing
2. Bumps that make up the track:
   A. 400nm long
   B. 120 nm tall

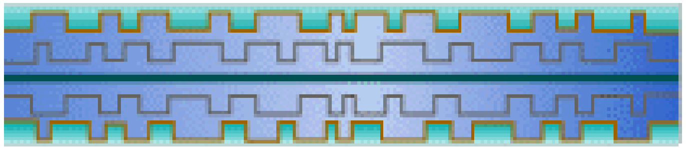
Single-sided, single layer (4.7GB)



Single-sided, double layer (8.5GB)



Double-sided, double layer (17GB)



Blu-ray Formats

1. The name refers to the blue laser used to read the disc (405nm)
2. Allows information to be stored at a greater density
3. Largest optical storage capacity
4. Becoming the industry standard for feature-length video discs
5. Conventional Blu-ray Discs contain 25 GB per layer
6. Dual layer discs 50 GB
7. Triple layer discs 100 GB
8. Quadruple layers 128 GB

Type	Layers	Capacity (GB)
Standard disc size, single layer (12cm)	1	25.0
Standard disc size, dual layer (12cm)	2	50
Standard disc size, XL 3 layer (12cm)	3	100
Standard disc size, XL 4 layer (12cm)	4	128
Mini disc size, single layer (8cm)	1	7.8
Mini disc size, dual layer (8cm)	2	15.6

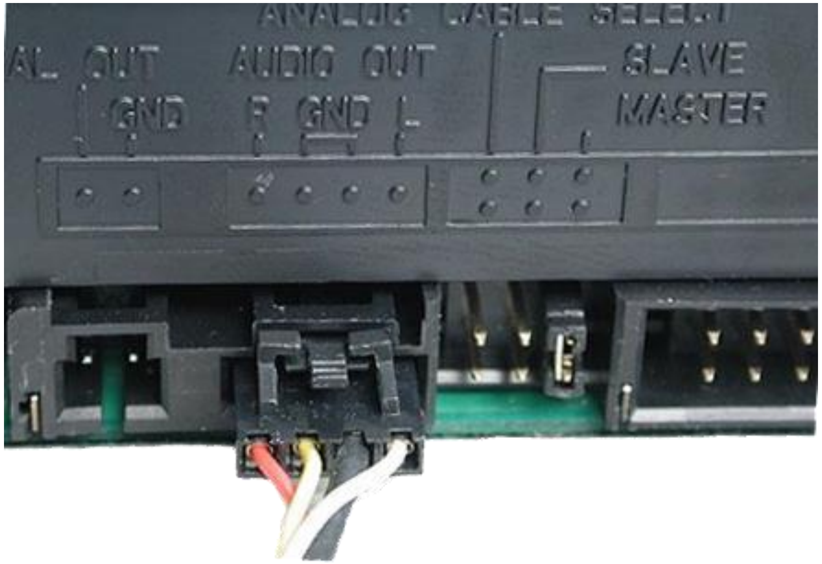
CD vs. DVD vs. Blue-ray

Specification	CD	DVD	Blu-ray
Track Pitch (Height)	1.6 microns	.74 microns	.32 microns
Minimum Pit Length	.83 microns	.4 microns	.14 microns
Minimum Pit Width	.5 microns	.32 microns	.12 microns

Format	Capacity	Approx. Movie Time
Standard CD	700MB	80 minutes
DVD Single-sided/single-layer	4.7GB	2 hours
DVD Single-sided/double-layer	8.6 GB	4 hours
DVD Double-sided/single-layer	8.75 GB	4.5 hours
DVD Double-sided/double-layer	17 GB	9 hours
Blu-ray Single-layer	25 GB	4.5 hrs of HD or 11.5 hrs of SD
Blu-ray Dual-layer	50 GB	9 hrs of HD or 23 hrs of SD

Troubleshooting CD/DVD

You must have an audio cable connected to the CD/DVD and motherboard to use the PATA CD/DVD drive as an audio device



Power Connectors

1. 5-1/4” drives use a Molex connector
2. 3-1/2” drives use a Berg connector
3. Can be inserted one way only
4. Requires 12v to operate

Berg

Molex

Flash or Thumb Drives

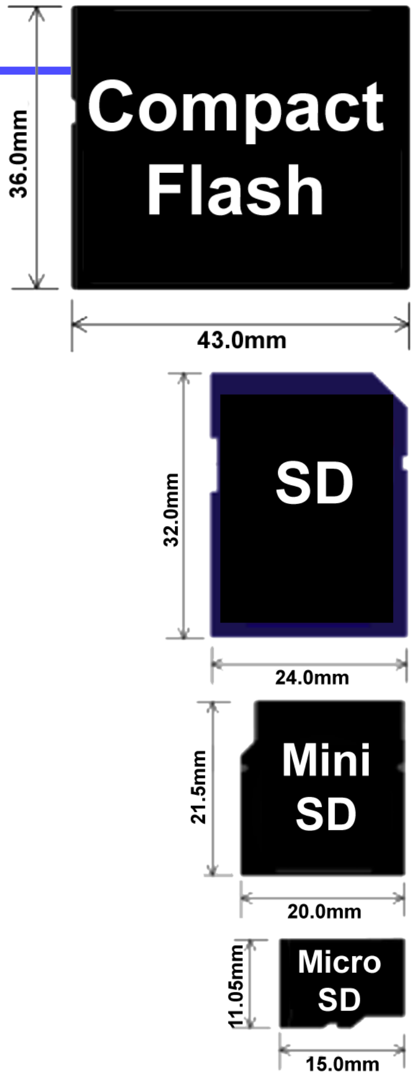
1. Consists of flash memory with an integrated USB interface
2. Up to 256GB and larger are available
3. Some allow up to 100,000 write/erase cycles and 10 years shelf storage time
4. Durable and reliable because of their lack of moving parts
5. Draw power from the computer via the USB connection

Solid State Drive (SSD)

1. Retains data in non-volatile memory chips
2. Contains no moving parts
3. Typically less susceptible to physical shock
4. Silent
5. Lower access time and latency
6. More expensive
7. Same interface as hard disk drives
8. Can out perform even 15,000 RPM hard drives
9. Hybrid drives combine the features of an HDD and an SSD into one unit, containing a large HDD, with a smaller SSD cache to improve performance of frequently accessed files

Solid State Drive (SSD)

1. **Compact Flash** (CF)
   A. Used in Digital cameras and other mass storage devices
   B. 2MB to 256GB capacity
2. **Secure Digital** (SD)
   A. Used in mobile phones, digital cameras, GPS navigation devices, and tablet computers
   B. 1MB to 2TB capacity
3. **Micro-SD**
4. **Mini-SD**
5. **xD**



IDE, EIDE, Ultra, and SCSI Controllers

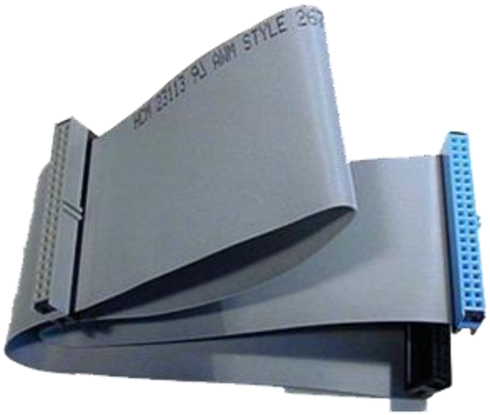
1. **Integrated Drive Electronics** (IDE)
   A. Hardware interface widely used to connect hard disks, CD-ROMs, and tape drives to a PC
   B. Officially known as the **AT Attachment** (ATA)
2. **Enhanced IDE** (EIDE) or **ATA-2**
   A. 8.4 GB or more capacity
3. **Ultra ATA**
   A. Typically much faster than the older ATA and ATA-2 disk drives
   B. 50 GB or more capacity

IDE, EIDE, Ultra, ATAPI, and SCSI Controllers

1. **AT Attachment with Packet Interface (ATAPI)**
   A. The standard interface used to connect storage devices such as hard disks and CD-ROM drives inside personal computers.
   B. The original ATA was retroactively renamed **Parallel ATA** (PATA) when Serial ATA or SATA was released
   C. Parallel ATA standards allow cable lengths up to only 18 inches (46 centimeters)
2. **SCSI** devices have the controlling electronics on each of the drives
   A. Much more advanced interface controller than ATA-2/EIDE
   B. Ideal for high-end computers and network servers

IDE Cables

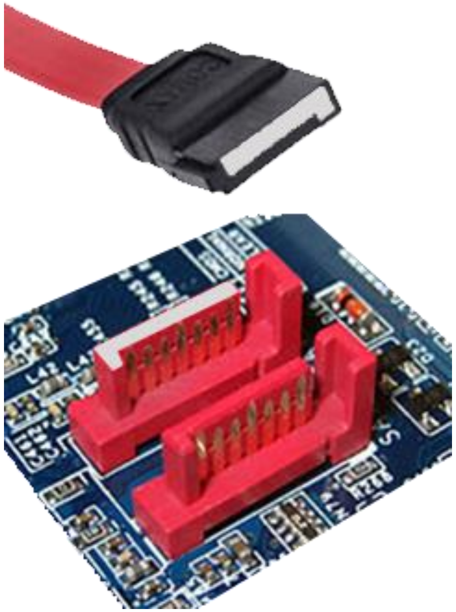
1. ATA/33 cable has 40 wire
2. ATA/66 cable 80 wires.
3. Both use the same 40 pin keyed connectors to attach the device to the controller



Serial ATA

SATA or Serial Advanced Technology Attachment

1. Designed to replace the older ATA (AT Attachment) or parallel ATA (PATA) interface
2. 7 conductors
3. Native hot swapping
4. 1 device per controller
5. Cables up to 36” long
6. Faster transfer speeds:
   A. SATA 1 – 1.5 Gbps
   B. SATA 2 – 3 Gbps
   C. SATA 3 – 6 Gbps



Cabling

1. Data cables connect drives to the drive controller
2. Controllers are located on an adapter card or on the motherboard
3. Common types of data cables:
   A. **Floppy disk drive (FDD) data cable** – Data cable has up to two 34-pin drive connectors and one 34-pin connector for the drive controller. 6”-24” lengths available
   B. **PATA (IDE) data cable** – Parallel ATA data cable has 40 conductors and 40 wires, up to two 40-pin connectors for drives, and one 40-pin connector for the drive controller. 12”-18” lengths
   C. **PATA (EIDE) data cable** – Parallel ATA data cable has 40 conductors and 80 wires, up to two 40-pin connectors for drives, and one 40-pin connector for the drive controller. 12”-18” lengths
   D. **SATA data cable** – Serial ATA data cable has seven conductors, one keyed connector for the drive, and one keyed connector the drive controller. 4”-36” lengths available

Summary

In the module we discussed:

1. Types of memory and capacity
2. Types of secondary storage
3. Drive interfaces and cabling