# Advanced Computer Concepts
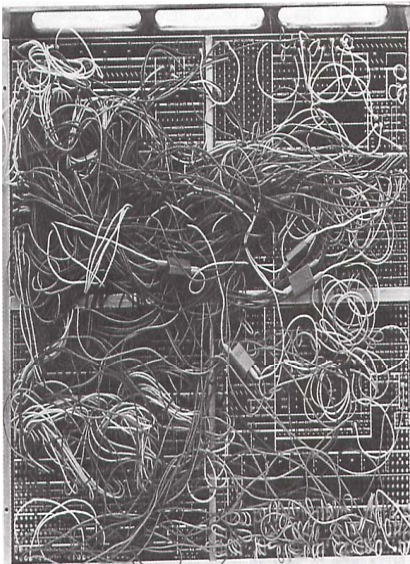
In this section you will about technical features of computers which may be used when choosing individual components.

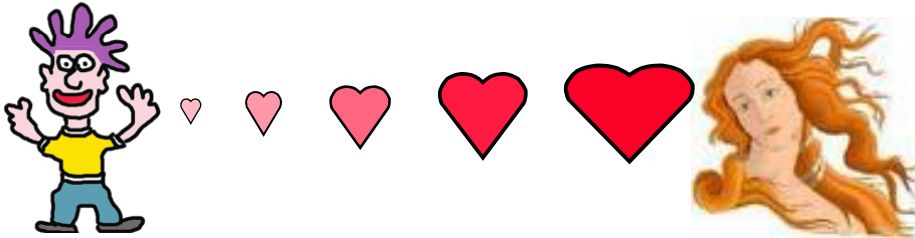# Are Computers Really So Confusing?

# How Does A Person Work?

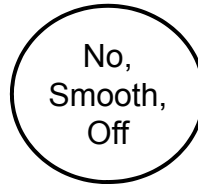•In many shades of grey (subtleties and ambiguities can exist)...

•...i.e., people are complex with many possible states (some of which may be conflicting).

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# How Does A Computer Work?

•Simple: something is either in one state or another.

Yes, Pitted, On

No, Smooth, Off

•All parts of modern computers work this way.

•This two state approach is referred to as binary (bi = two for 2 states).

# Computer Buses: How Information Is Transmitted

- Carries information between the different parts of the computer.
- Information is transmitted via electrical currents on wires.

| Processor | | RAM |
|-----------|---|-----|
| | on | |
| | on | |
| | off | |
| | on | |
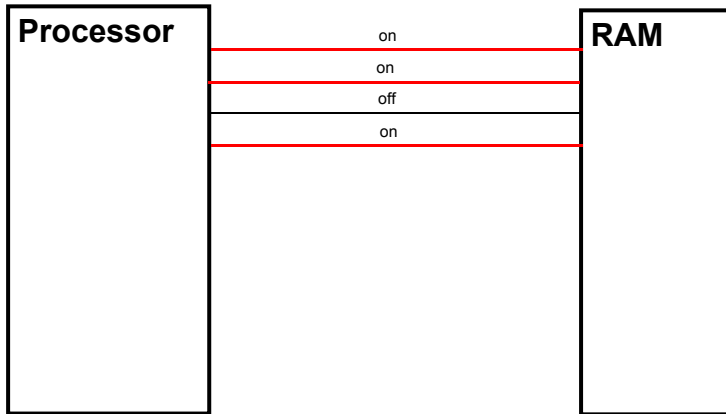
James Tam

# Advanced Computer Components To Be Covered

- RAM
- Processor
- Memory
- Storage: Hard drives
- Storage: Optical
- Graphics/Video cards
- Putting it all together

James Tam

# Large Units Of Measurement

- Kilo: One thousand 1,000
- Mega: One million 1,000,000
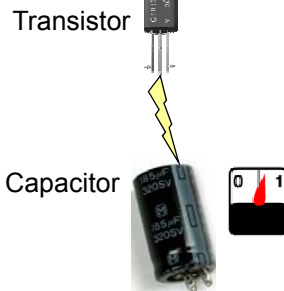- Giga: One billion 1,000,000,000
- Tera: One trillion 1,000,000,000,000

# Small Units Of Measurement

- Milli: one thousandth (1 / 1,000)
- Micro: one millionth (1 / 1,000,000)
- Nano: on billionth (1 / 1,000,000,000)

# RAM: Storing Information

•Information is stored in RAM based on power levels (on or off)

•The smallest unit of storage is a bit (*bi*nary digi*t*)

- *Bi*nary: A bit can have two states (on/off)
- On a computer:
  • Information about a particular bit is stored in a capacitor (stores electricity)
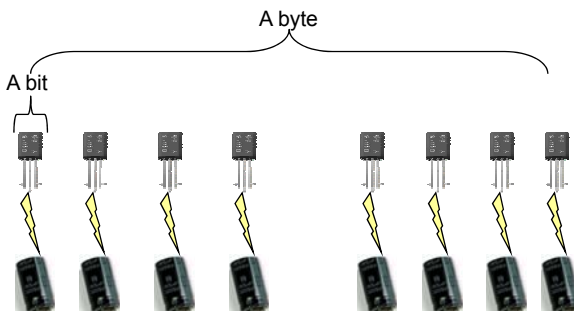  • Power to the capacitor is controlled through a transistor

Transistor

Capacitor

DRAM: Dynamic RAM (dynamic because the
power must be periodically refreshed).

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# RAM: Storing Information

•By itself a bit is useless (it can't store a useful amount of
information = 2 possible states)

•Bits must be combined together before information can be
stored

- Q: How many states can be represented with 2 bits? 3 bits? 4 bits?

•The next unit of storage is a byte = 8 bits (256 possibilities)

A byte

A bit

# Large Units Of Measurement On The Computer

•Note: powers of two are used because computer memory and storage are based on the basic unit (bit).

•Kilobyte (KB) ~ a thousand bytes ($1,024 = 2^{10}$)

•Megabyte (MB) ~ a million bytes ($1,048,576 = 2^{20}$)

•Gigabyte (GB) ~ a billion bytes ($1,073,741,824 = 2^{30}$)
  ~ A complete set of encyclopedias requires about 700 MB of storage
  ~ 30 minutes of video (~1/4 of the information stored on a typical DVD)

•Terabyte (TB) ~ a trillion bytes ($1,099,511,627,776 = 2^{40}$)
  ~ 20 million four-drawer filing cabinets full of text
  ~ 200 DVD's of information

# RAM: Storing Information



•RAM is a collection of 'slots' where information is stored.

•Each slot is a collection of bits (1 byte)
  - e.g., a 1 Gigabyte stick of RAM has ~1 billion slots with each slot consisting of a byte.
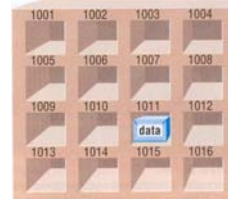
# Storing Information In RAM

•All information stored in memory must somehow be translated to binary (pattern of on/off):
  - Text
  - Graphics
  - Videos
  - The instructions in a computer program

# Storing Text Information In RAM

• Text is stored in using the _A_merican _S_tandard _C_ode for _I_nformation _I_nterchange (ASCII)

• Eight bits/one byte (256 combinations) is used to store information about a single text character.

• Each character is mapped to a number from 0 – 255.

• That number is then translated to a binary pattern (on/off states).

| Value to represent | Number | Bit pattern (8 bits / 1 byte) |
|---|---|---|
| '0' to '9' | 48 - 57 | off off on on off off off off – off off on on on off off on |
| 'A' to 'Z' | 65 – 90 | off on off off off off off on – off on off on on off on off |
| 'a' to 'z' | 97 – 122 | off on on off off off off on – off on on on n off on off |

# Beyond The Byte: The Word

- Encoding information that is more complex than simple text requires more than 8 bits (256 combinations) e.g., international languages, images, animations.
- Word
  - The word size of a computer is the number of adjacent bits that can be stored and manipulated as a unit.
  - Typical word sizes for home computers: 32 or 64 bits, 128 bits for faster machines or specialized systems.

# Beyond The Byte: The Word (2)

- The data bus and address bus the can have different word sizes.
- The size of the data bus limits the *amount or size of information* that can be sent from one part of the computer to another:
  - e.g., a computer with an 8 bit address bus can only store text in English (26 upper, 26 lower)
  - e.g., a computer with a 16 bit address bus may be able store text in Chinese (~65,000 different characters).
- The size of the address bus limits the *number of locations* to store the information:
  - e.g., older computers (32 bit) on older operating systems (e.g., Windows XP) can only have a maximum of 4 GB of RAM
  - e.g., newer computers running newer operating systems (e.g., Windows Vista) can go beyond this limit.

# Types Of RAM

1. SD-RAM (Synchronous dynamic random access memory)
   - Synchronous: Timed with the processor
   - Widely available since the 1990's
2. DDR (Double data rate) SD-RAM
   - 2001+
   - Doubles the transfer rate of regular SD-RAM
3. DDR2 SD-RAM
   - 2003+
   - Doubles again the transfer rate of DDR SD-RAM
4. DDR3 SD-RAM
   - Latter half of 2007
   - Doubles again the transfer rate of DDR2 SD-RAM

# Memory Speeds: DDR RAM

| Name | Speed |
|------|-------|
| PC-1600 | 100 MHz |
| PC-2100 | 133 MHz |
| PC-2700 | 166 MHz |
| PC-3200 | 200 MHz |

# Memory Speeds: DDR2 RAM

| Name | Speed |
|------|-------|
| PC2-3200 | 200 MHz |
| PC2-4200 | 266 MHz |
| PC2-5300 | 333 MHz |
| PC2-6400 | 400 MHz |
| PC2-8500 | 533 MHz |

# Memory Speeds: DDR3 RAM

| Name | Speed |
|------|-------|
| PC3-6400 | 400 MHz |
| PC3-8500 | 533 MHz |
| PC3-10600 | 667 MHz |
| PC3-12800 | 800 MHz |

# How Much RAM?

- Systems vary widely depending on price but the typical starting values range from 1 GB – 4 GB
- The maximum is around 4 GB – 8 GB

# Small Units Of Measurement (Processor And Memory Speed)

- Millisecond (ms) – a thousandth of a second $(1/1,000 = 10^{-3})$
- Microsecond (μs) - a millionth of a second $(1/1,000,000 = 10^{-6})$
- Nanosecond (ns) – a billionth of a second $(1/1,000,000,000 = 10^{-9})$

# Original Determinants Of Processor Speed

1. Type of processor e.g., Intel: Celeron, Pentium
2. Clock speed
   - 1 Hz = 1 pulse is sent out each second (1 second passes between each pulse)
   - 10 Hz = 10 pulses are sent out each second (0.1 seconds passes between each pulse)
   - :
   - 25 MHz = 25 million pulses sent out each second (0.000 000 04 seconds between each pulse or 40 ns between pulses)
   - 3.8 Ghz = 3.8 billion pulses sent out each second (0.26 ns between pulses)

# Common Processor Clock Speeds

- Budget processors
  - Laptop: 1.06 – 2.6 GHz
  - Desktop: 1.8 – 3 GHz
- Higher end processors
  - 2.33 – 3 GHz

## Other Factors That Could Effect Processing Speed

- Clock speed maximums have been approaching a limit:
  - Heat
  - Power consumption

- Consequently it's become less of determining factor in the processing speed of a computer.

- Other factors:
  - Number of processing cores
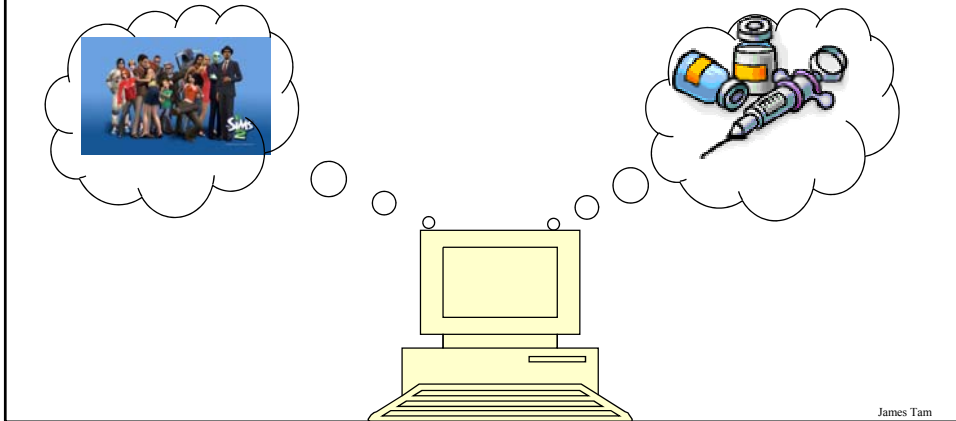  - Processor cache size
  - Front side bus speed

## Processor Core

- A core is the part of the processor that's capable of executing instructions.
  - Can perform calculations
  - Has memory to store information

# Processors With A Single Core

- Execution may be slower because when multiple programs are running because the processor must switch it's attention between them.

- Example running a game and an anti-virus program:

# Processors With Multiple Cores

- The processor is split into multiple (dual = two, quad = four) cores.

- Each core is capable of executing it's own set of instructions which can speed up processing speed.
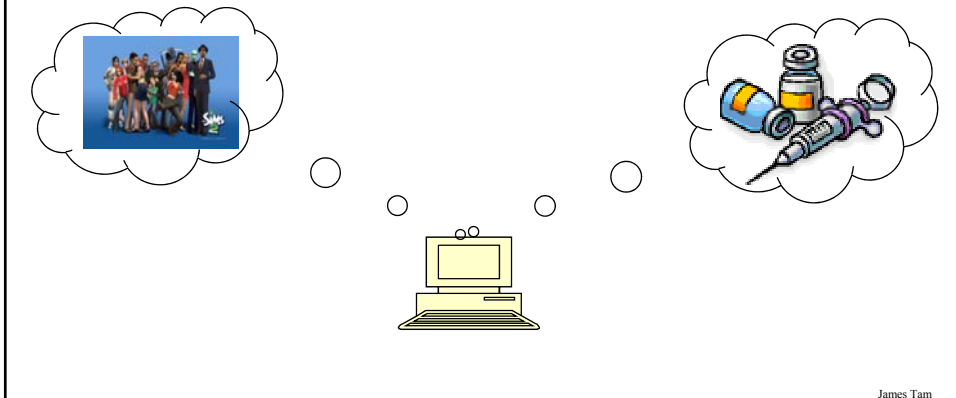
# The Processor Cache

- The cache is fast memory that's either on or near the processor.
- The processor and RAM operate at different speeds: The cache bridges the processor and RAM.
- There's different "levels" of processor caches (L1, L2, L3) but the one that typically has the greatest effect on speed is the L2 cache:
  - (Very) old processors: no cache
  - Budget processors: 2 – 6 MB L2 cache
  - Higher end processors: 4 – 12 MB L2 cache

# Front-Side Bus Speed

- Determines how quickly information can be transferred to/from some of the other parts of the computer to the processor.
- Measured in MHz

RAM

Processor

Graphics
/video
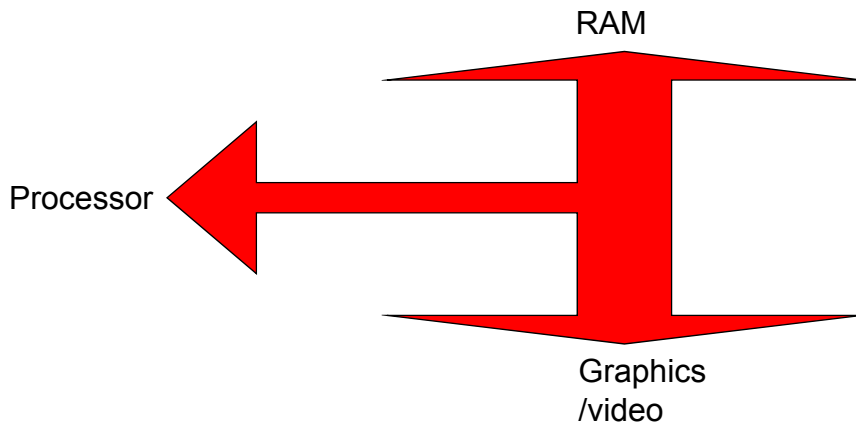
# Common Front Side Bus Speeds

- Budget processors
  - (Laptop): 800 – 1033 MHz
  - (Desktop): 800 – 1333 MHz
- Higher-end processors
  - 1066, 1333, 1600 MHz

# Storage: Hard Drives

- Typical ranges: ~250 GB – 1 TB (desktops), ~120 GB – 500 GB (laptops).
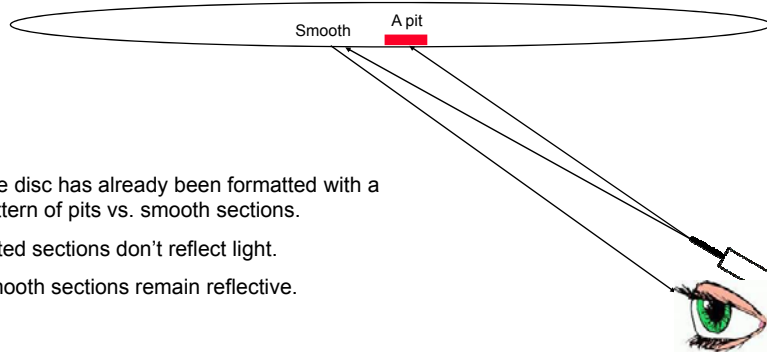- Rotational speeds: 5400, 7200, 10000+ rpm



- Type of interface: IDE/ATA (older), SATA (newer)

# Optical Drives: Reading Information
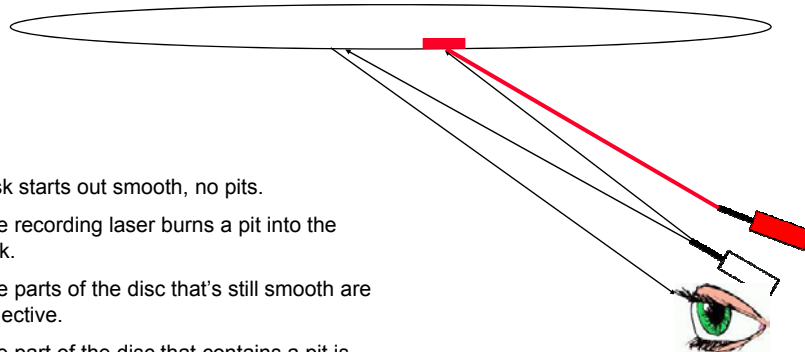
CD-ROM, DVD-ROM

Smooth    A pit

- The disc has already been formatted with a pattern of pits vs. smooth sections.
- Pitted sections don't reflect light.
- Smooth sections remain reflective.

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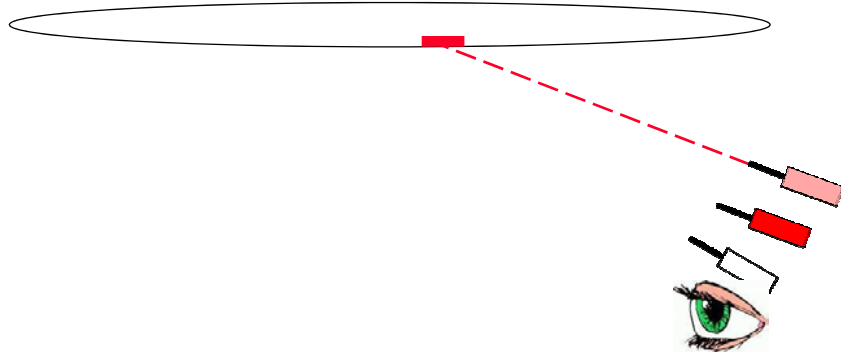# Optical Drives: *R*ecording And Reading Information

CD-R, DVD-R, DVD+R

- Disk starts out smooth, no pits.
- The recording laser burns a pit into the disk.
- The parts of the disc that's still smooth are reflective.
- The part of the disc that contains a pit is non-reflective.
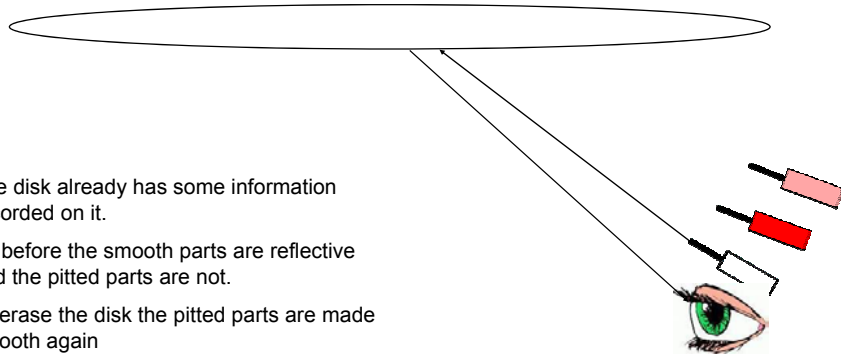
# Optical Drives: *R*e-*W*riting

CD-RW, DVD-RW, DVD+RW

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# Optical Drives: *R*e-*W*riting

CD-RW, DVD-RW, DVD+RW

- The disk already has some information recorded on it.
- As before the smooth parts are reflective and the pitted parts are not.
- To erase the disk the pitted parts are made smooth again

# CD/DVD Drives

•Some considerations:
- Speed
- Single layer/single sided and dual layer/double sided
- Next generation DVD: Blu-ray, HD-DVD (discontinued)

# CD/DVD: Speed

•**CD Speeds:**
- Stated in the form of 3 numbers e.g., 52x32x52
- These three numbers state the maximums for:
  •(Write speed) x (Re-write speed) x (Read speed)

•**DVD Speeds:**
- Sometimes they are listed in the same format as CD speeds
- Other times they are listed in the form of two numbers e.g., 16x16
  •(Write speed with 'plus' DVD discs) x (Write speed with 'minus' DVD discs)
- Or they may be listed as a single number e.g., x16
  •(Write speed with 'plus' or 'minus' DVD discs

# CD/DVD: Multi-Layer, Multi-Sided

- Double sided:
  - Allows information to be written on both sides of the disc
- Dual layer ("-DL")
  - An extra layer of dye is added to allow for double the amount of information to be written
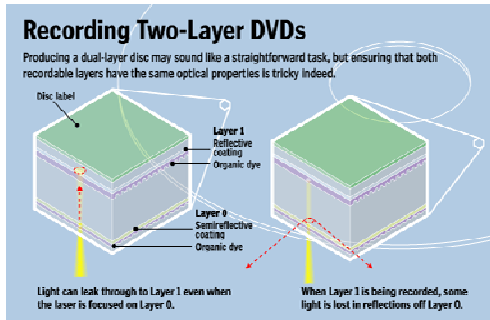


www.pcmag.com

# DVD: Capacities

| Type | Capacity |
|---|---|
| Single sided, single layer | 4.7GB |
| Single sided, dual layer | 8.5GB |
| Double sided, single layer | 8.75GB |
| Double sided, dual layer on one side | 9.4 GB |
| Double sided, dual layer on both sides | 15.9GB |

# A Next Generation DVD Format: Blu-Ray

•Uses a different light frequency for the laser.

•Results in high capacity storage:
  - 25 GB (single layer)
  - 50 GB (dual layer)

•Backward (but not forward) compatibility is possible

# Graphics/Video Cards

•Sometimes they're built in (integrated graphics) and not a separate card.
  - Integrated graphics: sufficient for applications that don't display complex graphics e.g., word processing, browsing the web.

•Other types of applications require dedicated hardware for graphics (separate graphic/video card):
  - Games: Drawing high quality graphics and producing realistic looking animations is obviously crucial for running some of the newest games.
  - Productivity software e.g., 3D drawing programs, video editing, CAD programs etc.

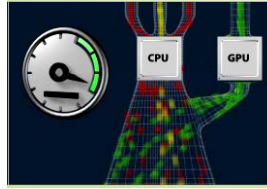•Also it can be an important consideration if you upgrade your operating system to Windows Vista.

# Some Considerations When Buying A Graphic/Video Card

1. It's mostly about U...The GPU (*G*raphic *P*rocessing *U*nit)
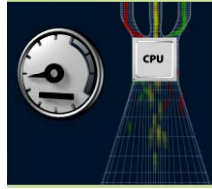


Without a GPU    With a GPU

Images from Nvidia

- Typical speeds ~550 – 730 MHz

# Some Considerations When Buying A Graphic/Video Card (2)

2. Don't forget about memory (of the graphics/video card).
   a) Video cards also have dedicated memory
   b) All things being equal a video card with a fast GPU will deliver better performance than one with a slower GPU but more memory.
   c) However with GPU's being equal the video card with additional memory may deliver superior performance.
   d) Typical ranges 256 MB – 1 GB.

# Some Considerations When Buying A Graphic/Video Card (3)

3. DirectX 10 support...possibly if you have Vista.

4. Type of interface: PCI (very old), AGP, PCI-E (newest)

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# Putting It All Together
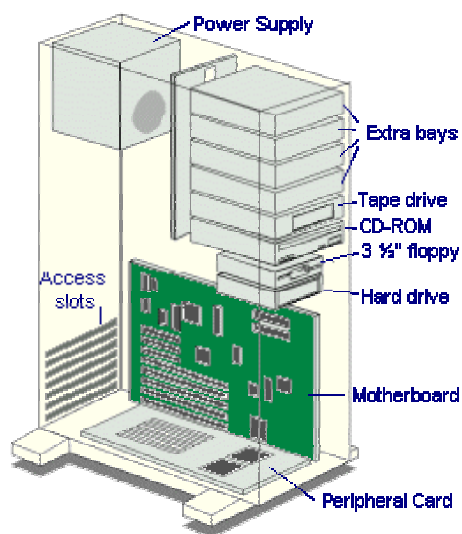


- Power Supply
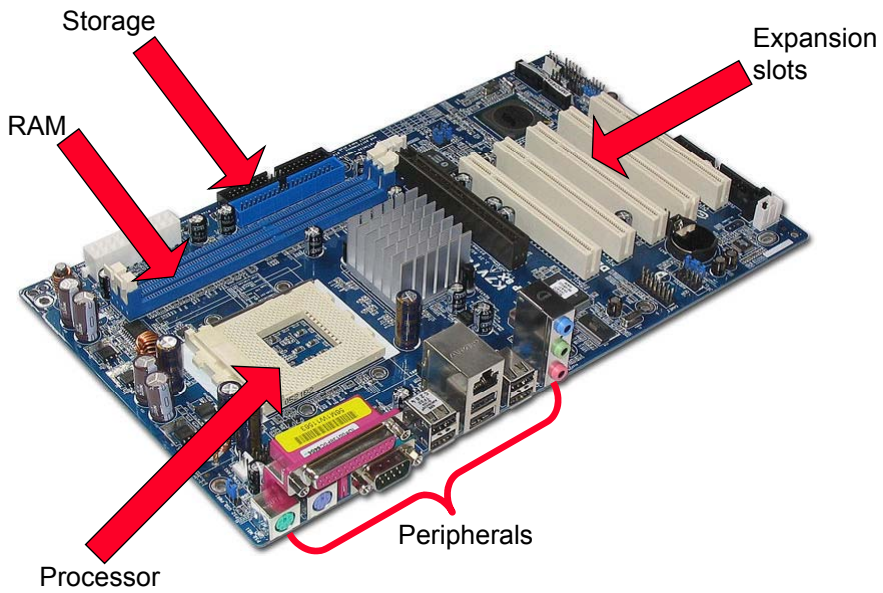- Extra bays
- Tape drive
- CD-ROM
- 3 ½" floppy
- Hard drive
- Access slots
- Motherboard
- Peripheral Card

# The Motherboard



James Tam

# The Motherboard

Storage

Expansion slots

RAM
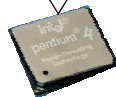
Processor

Peripherals



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# Relating The Speed Of The Computer To Its Components

Storage:
Hard drive

Memory:
RAM

Processor
cache

James Tam

# Hardware Requirements For Some Programs

| Operating system | Min RAM | Min processor speed | Hard drive space |
|---|---|---|---|
| Windows XP | 64 MB | 233 MHz | 1.5 GB |
| Windows Vista (Home basic) | 512 MB (32 MB graphics memory) | 800 MHz | 20 GB (install) + 15 GB (needed while running) |
| Windows Vista (Home premium, business versions) | 1 GB (128 MB graphics memory) | 1 GHz | 40 GB + 15 GB (needed while running) |

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## Hardware Requirements For Some Programs (2)

| Software | Min RAM | Min processor speed | Hard drive space |
|---|---|---|---|
| Office 2003 | 128 MB (8 MB for each Office program running at the same time) | 233 MHz | ~400 MB |
| Office 2007 | 256 MB | 500 MHz | 1.5 GB |
| Halo 2 (game) | 1 GB (also there's hardware requirements on graphics cards) | 2 GHz | 7 GB |
| Crysis (game) | 1 GB (256 MB graphics memory) | 2.8 GHz (Core 2 Duo is recommended) | 12 GB |

## You Should Now Know

- How computers work on a two state model
- Common units of measurement (large and small) for computers
- Processors
  - What are some of the factors that play a role in processing speed
  - Approximate values for processor clock speeds
- What is a bit and what is a byte and how they are used to store information
- The role that word size (address and data) plays in the capabilities of a computer
- What are different types of RAM and the approximate speed of each
- Some important things to consider with hard drives
- Approximate storage capacities of a new hard drive today

# You Should Now Know (2)

•How optical drives retrieve, store and erase information on discs

•Technical considerations to when buying an optical drive

•Approximate storage capacities of different optical drives

•Some of the important considerations when buying a graphics/video card

•How the different parts of the computer relate and how speed is determined by multiple hardware devices