


Introduction To CPSC 231 & Computer Hardware

In this section of notes you will learn what are the basic parts of a computer and how they work.

James Tam

Administrative (James Tam)

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 - Appointment: email, phone or call
 - Drop by for urgent requests (but no guarantee that I will be in if it's outside of my office hours!)



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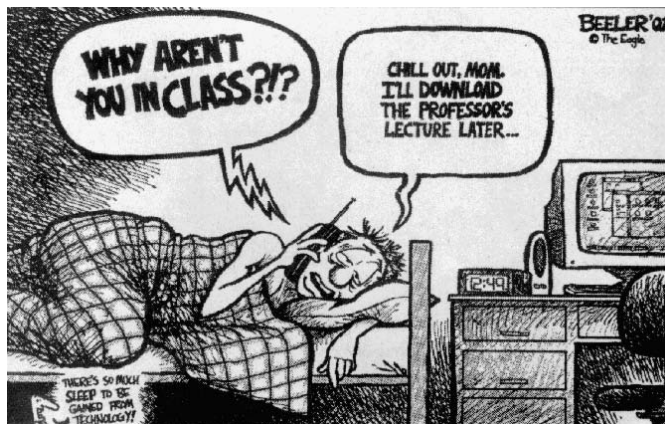
Course Resources

- Course website: <http://pages.cpsc.ucalgary.ca/~tamj/231>
- Course directory: /home/231/tamj (accessed via your UNIX Computer Science account)
- Recommended course textbook:
 - Pascal Programming & Problem Solving, 4th Edition, Leestma/Nyhoff (Prentice Hall)

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How To Use The Course Resources

- They are provided to support and supplement this class.
- Neither the course notes nor the text book are meant as a substitute for regular attendance to lecture and the tutorials.



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How To Use The Course Resources (2)

```
procedure add (var head : NodePointer;
              var newNode : NodePointer);
var
  temp : NodePointer;
begin
  if (head = NIL) then
    head := newNode
  else
    begin
      temp := head;
      while (temp^.next <> NIL) do
        temp := temp^.next;
        temp^.next := newNode;
      end;
      newNode^.next := NIL;
    end;
end;
```

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How To Use The Course Resources (2)

```
procedure add (var head : NodePointer;
              var newNode : NodePointer);
var
  temp : NodePointer;
begin
  if (head = NIL) then
    head := newNode
  else
    begin
      temp := head;
      while (temp^.next <> NIL) do
        temp := temp^.next;
        temp^.next := newNode;
      end;
      newNode^.next := NIL;
    end;
end;
```

*If you miss a class make
sure that you catch up on
what you missed (get
someone's class notes)*

*...when you do make it to
class make sure that you
supplement the slides with
your own notes (cause you
aint gonna remember it in
the exams if you don't)*

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But Once You've Made An Attempt To Catch Up

- Ask for help if you need it
- There are no dumb questions



Images from "The Simpsons" © Fox

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Is This The Course The One For You?

- Introductory Computer Science courses for non-Computer Science majors (*do not want to get a Computer Science degree*)
 - CPSC 203
 - CPSC 217
- The introductory Computer Science course for Computer Science majors (*do wish to get a Computer Science degree*)
 - CPSC 231

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CPSC 203

- **The focus is on how to *use* computer programs.**
- One important objective is to learn how computers and technology works *from the user's perspective*
 - Issues related to how computers work are largely introduced in the context of using applications.
 - E.g., Why is my computer so slow when I'm editing my movies?
 - E.g., Why did that computer game look and sound so much better on the store computer than on my machine at home?
- Assignments involve *using* popular software:
 - Productivity (business) software: MS-Office
 - Fun software: building a web site, making a computerized video etc.

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CPSC 217

- **An introduction to *writing* computer programs for students whose major is not Computer Science ('non-techies')**
 - This person will not get a degree in Computer Science
 - This person will not develop/write software for a living (become a programmer)
 - This person may work with complex specialized software (e.g., running a biological simulation) which may require customization
- One important objective is to learn how computers and technology works *from the programmer's perspective*
 - Issues related to how computers work are largely introduced in the context of creating applications.
 - E.g., How do I write a program that will let me do my work on a computer?
- Assignments involve *writing* simple programs:
 - Possible examples:
 - Displaying text onscreen
 - Saving and reading information to/from a file

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CPSC 231

A computer geek



- **An introduction to *writing* computer programs for Computer Science majors**
 - This person will get a degree in Computer Science
 - This person will likely develop/write software for a living (become a programmer)
- Typically the course is more in-depth and cover more topics than CPSC 217.
- One important objective is to learn how computers and technology works *from the programmer's perspective*
 - Issues related to how computers work are largely introduced in the context of creating applications.
 - E.g., If I write my program one way it will run faster than if I write it another way?
- This may result in having more challenging assignments than the ones in CPSC 217.

James Tam

A Bit More About CPSC 231

- It is a course geared primarily towards CPSC majors
- But it is not assumed that you have prior knowledge of Computer Science:
 - Almost all students do not have previous experience
 - Most students do get through the course
- It can be a lot of work

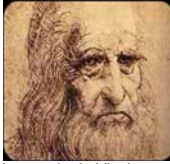


Wav file from "The Simpsons"

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How To Succeed

•Successful people



Leonardo da Vinci



Bruce Lee



J.R.R. Tolkien



Amadeus Mozart



Wayne Gretzky

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How To Succeed In This Course

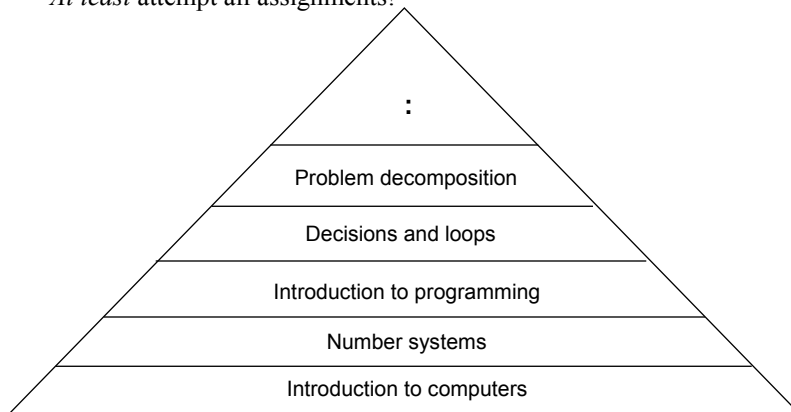
1. Practice things yourself.

- Write lots programs
 - At the *very least* attempt every assignment
 - Try to do some additional practice work (some examples will be given in class, some practice assignments will be available on the course web page).
- Trace lots of code
 - Reading through programs that other people have written and understanding how and why it works the way that it does

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How To Succeed In This Course (2)

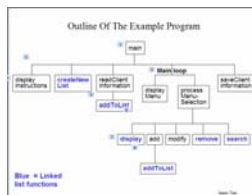
2. Make sure that you keep up with the material
 - Many of the concepts taught later depend upon your knowledge of earlier concepts.
 - Don't let yourself fall behind!
 - *At least* attempt all assignments!



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How To Succeed In This Course (3)

3. Look at the material before coming to lecture so you have a rough idea of what I will be talking about that day:
 - a) Read the slides
 - b) Look through the textbook (if you bought it)



```

Main Procedure: Example Program
begin
  var head: TNode;
  var num: integer;
  var i: integer;
  var list: TList;
  var temp: TNode;
  var done: boolean;
  var quit: boolean;
  var search: boolean;
  var found: boolean;
  var display: boolean;
  var add: boolean;
  var modify: boolean;
  var remove: boolean;
  var search: boolean;
end

```

```

2. Creating A New List (2)
Description:
This procedure creates a new list and returns it to the caller.
Example:
var list: TList;
list := CreateList(10);
end

```

```

Reading The Client Information From A File (2)
procedure readClientInformation var client: TClient;
var
  file: TFile;
  line: string;
  i: integer;
  done: boolean;
begin
  file := TFile.Create('client.dat');
  if file = nil then
    writeln('Error: Cannot open client.dat');
    exit;
  end;
  while not file.EOF do
    line := file.ReadLine;
    if line = '' then
      continue;
    end;
    if not client.IsClient then
      client := TClient.Create;
    end;
    client.Name := line;
  end;
end

```

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How To Succeed In This Course (4)

4. Start working on things as early as possible:
 - Don't cram the material just before the exam, instead you should be studying the concepts as you learn them throughout the term.
 - Don't start assignments the night (or day!) that they are due, they may take more time than you might first think so start as soon as possible.

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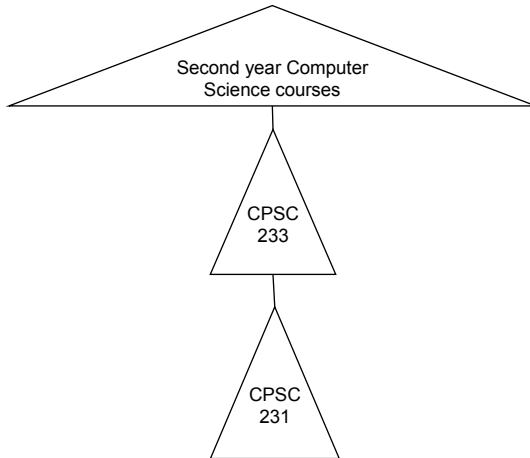
How To Succeed In This Course: A Summary

1. Practice things yourself
2. Make sure that you keep up with the material
3. Look at the material before coming to lecture
4. Start working on things early

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How To Succeed In Computer Science: Additional Note For Computer Science Majors

- The material in this course is used as a foundation for material in later courses
 - It will be assumed in the subsequent classes that you already know the material in this class.

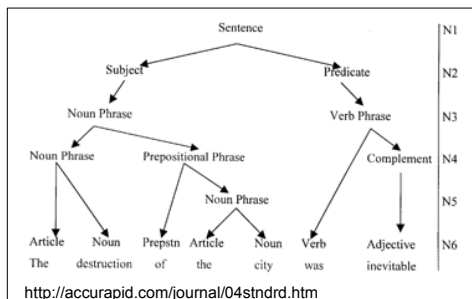


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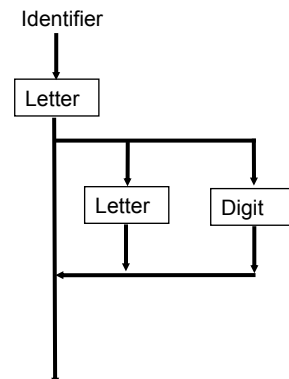
You Will Learn About Program Structure

- The required structure and rules for creating a computer program (*the syntax of the language*)
- You will then need to apply these principles throughout the term

Learning the rules of the English language: grammar



Learning the rules of the computer language: syntax



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You Will Learn About Programming Style

- Learning good programming practices
- Learning why something is regarded as ‘good’ or ‘bad’ style

Bad ☹

```
program p;  
var  
  x : integer;  
  y : integer;  
begin  
  while (true) do  
  begin  
    if (x < 0) then  
      break;  
    :  
  end;  
end.
```

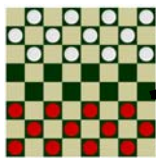
Good ☺ (or at least better)

```
(*  
  This program is a simple interest  
  calculator  
*)  
program banking;  
begin  
  var interest    : real;  
  var principle   : real;  
  var amount      : real;  
  var time        : real;  
  amount := principle * rate * time;  
  :  
end.
```

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You Will Learn How To Problem Solve

- With a knowledge of programming practices and programming style you will work out solutions to given problems (e.g., assignments).



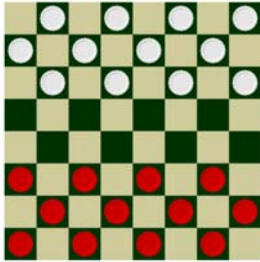
Assignment: create a computerized checkers game (western version).

```
Current player is RED  
 1 2 3 4 5 6 7 8  
- - - - -  
1| r| r| r| r| r|  
- - - - -  
2|r| r| r| r| r| |  
- - - - -  
3| r| r| r| r| r|  
- - - - -  
4| | | | | | | |  
- - - - -  
5| | | | | | | |  
- - - - -  
6| w| w| w| w| w| |  
- - - - -  
7| w| w| w| w| w|  
- - - - -  
8| w| w| w| w| w| |  
- - - - -
```

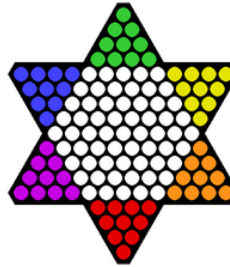
Solution: A text-based Pascal program.

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Problem Solving Is A Skill That You Need To Learn And To Improve Upon



Your assignment:
Implement a checkers
game that follows
European rules



Lecture example: A
partial implementation of
the Chinese Checkers
game

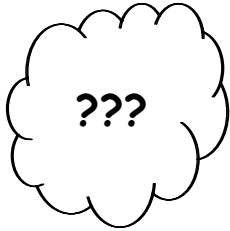
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The Problems Are Not Impossible For Beginners (They Just Seem That Way At First :p)

The Game of Life	
European checkers	
The Quest for the Fountain of Fulfillment	
Star Trek, mission: Find the dilithium and save the earth	
The Lord of The Rings: Quest to Mount Doom	
Star Wars: The Assault on the Death Star	
The Lord of The Rings: The Journey Through Khazad-dum	
The Hobbit	
Squirt the weed!	

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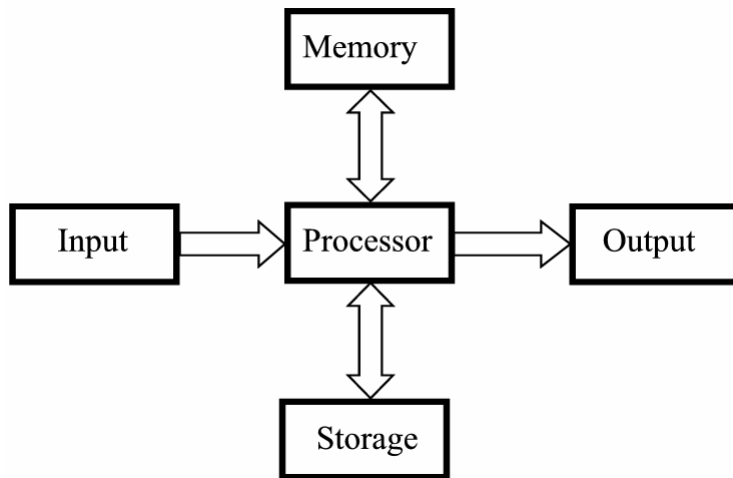
Feedback



Dilbert © United Features Syndicate

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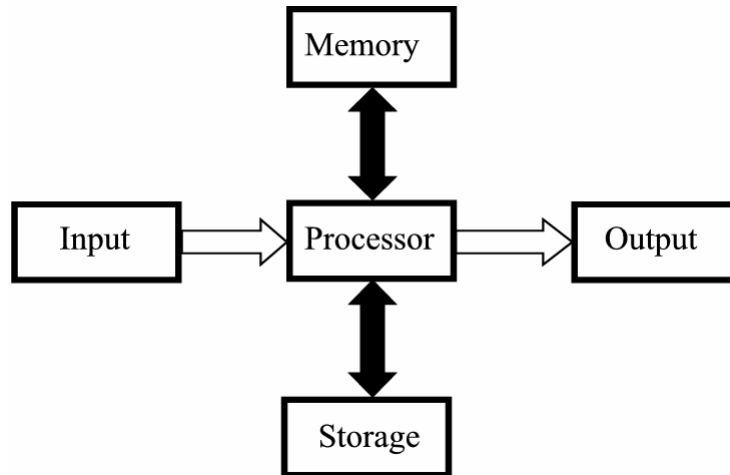
High Level View Of A Computer



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Buses

- Connect the different parts of the computer together



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Types Of Buses

- Data buses
 - Are used to transmit information to the different parts of the computer
- Address buses
 - Indicate where the information is supposed go

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Buses (2)

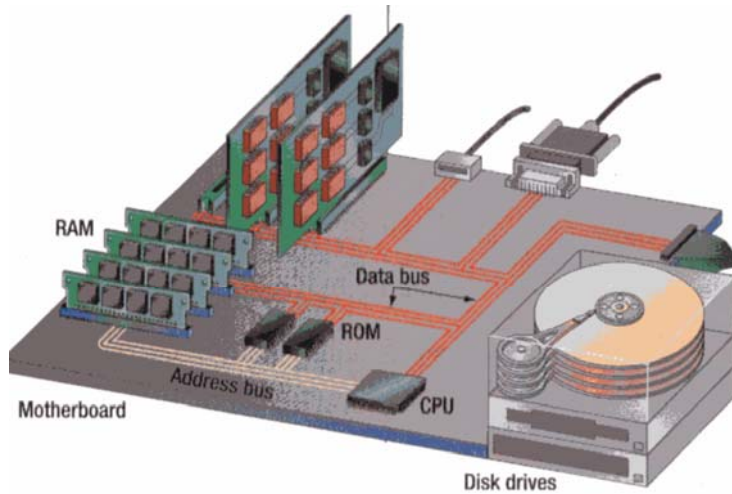




Image from Peter Norton's Computing Fundamentals (3rd Edition) by Norton P.

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Basic Units Of Measurement

Bit  on OR  off

- Binary digit
- Smallest unit of measurement
- Two possible values

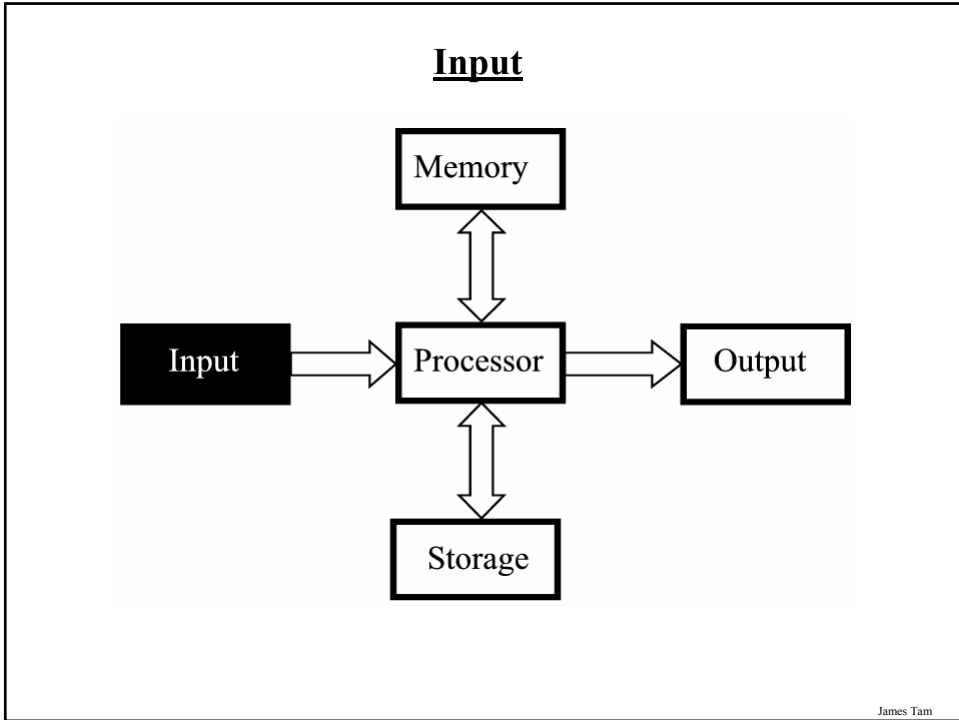
Byte 

- 8 bits

Word

- The word size of a computer is the number of adjacent bits that can be stored and manipulated as a unit
- 32, 64 for home computers, 128 for faster machines or specialized systems

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Input Devices

- Used by a person to communicate to a computer.

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Example Input Devices

- Keyboard



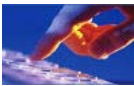
- Mouse



- Etc.

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How Keyboard Input Works



Keyboard: A key is pressed

The electrical impulse is sent via a wired or wireless connection



Keyboard controller: based on the electrical impulses it determines which key or combination of keys was pressed

A	p	p	l	e	...
---	---	---	---	---	-----

Keyboard buffer: stores the keystrokes

The keyboard controller transmits an interrupt request



Operating system

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How Keyboard Input Works



Operating system:

Q: Is the key combination a (an operating) system level command
e.g., <alt>-<ctrl>-?

Yes



Execute operating system instruction

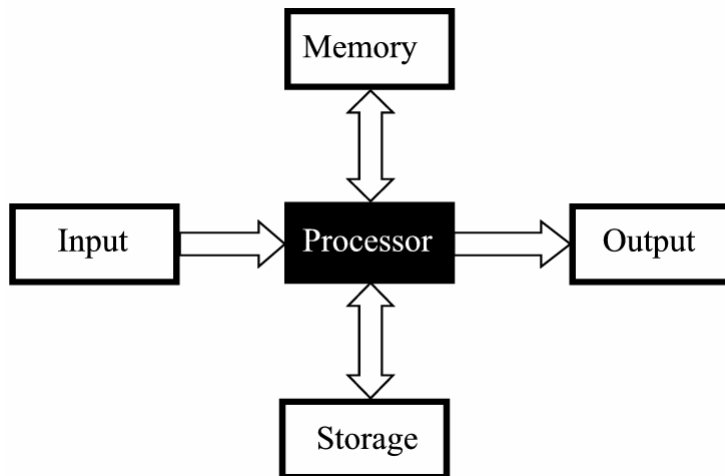
No



Pass the key combination onto current application

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Processor



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Processor

- The brains of a computer



Image from:
www.howstuffworks.com

- A common desktop processor



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Small Units Of Measurement (Processor And Memory Speed)

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

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Processor Speed

- Determined by:
 1. Type of processor e.g., Intel: Celeron, Pentium; AMD: Athlon, Opteron
 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)

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The Processor And The Computer

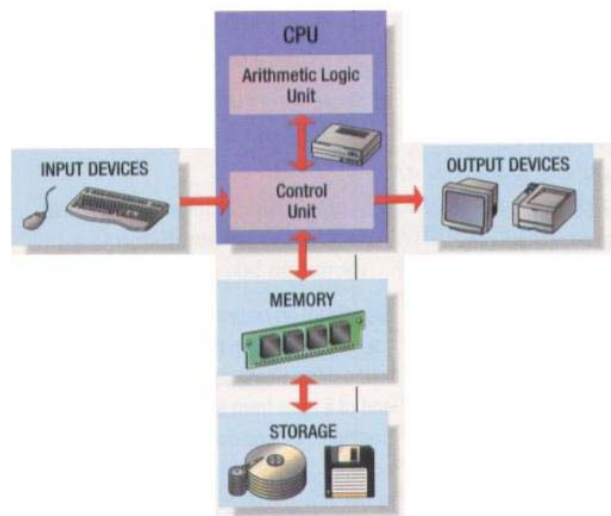
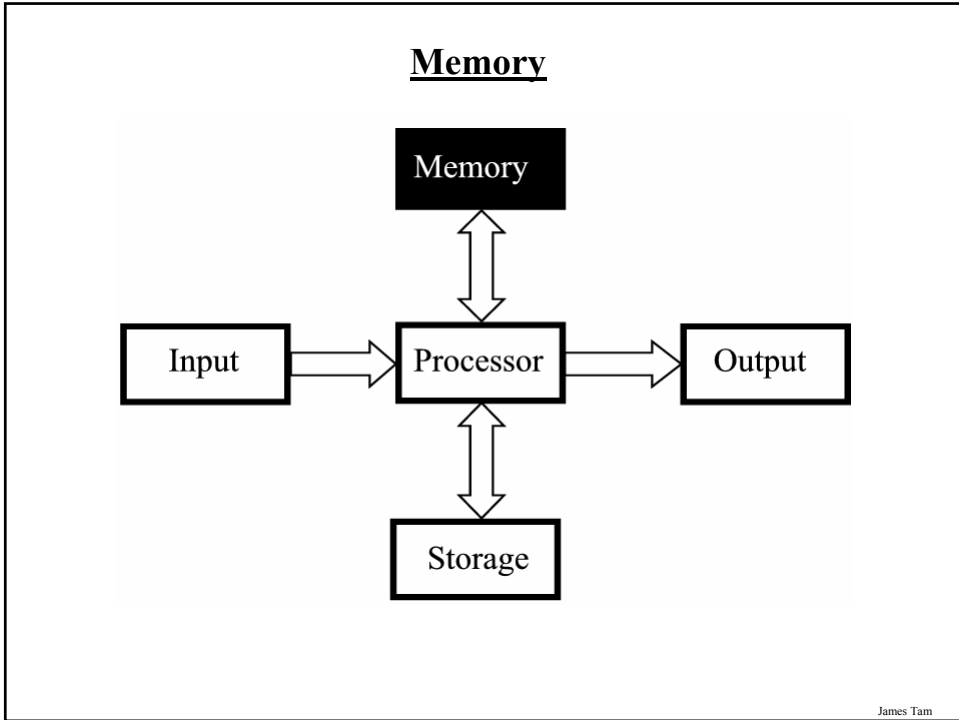



Image from Peter Norton's Computing Fundamentals (3rd Edition) by Norton P.

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Memory

- The processor has a small amount of memory that is fast but very low in capacity



My To-Do List

1. Do laundry
2. Go grocery shopping
3. Walk the dog
4. Buy gift for gf / bf...

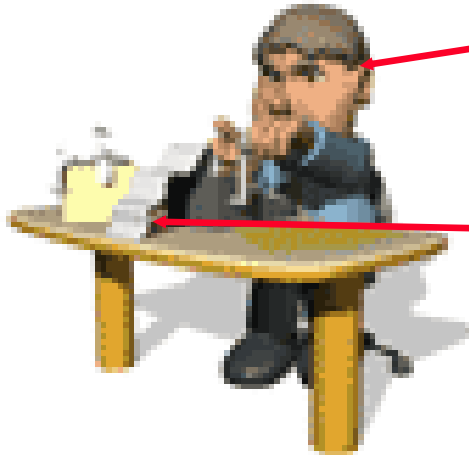


Square root
 $(456789) + (x / y) + \text{Absolute value } (10000 / -50)$

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Memory

- It is used as temporary storage for storing information and instructions that won't fit in the processor but is needed now



Processor:
'brains' that
performs the
calculations

Memory:
stores
information
needed by the
processor

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Memory: High-Level View

- Storing information in memory is based on bits (on/off state)



on

OR



off

- Since bits cannot store enough information bits are combined into bytes

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Large Units Of Measurement (Memory, Storage)

- 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 ($1,048,576 = 2^{20}$)
- Gigabyte (GB) – a billion ($1,073,741,824 = 2^{30}$)
 - ~ 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 ($1,099,511,627,776 = 2^{40}$)
 - ~ 20 million four-drawer filing cabinets full of text
 - ~ 200 DVD's of information

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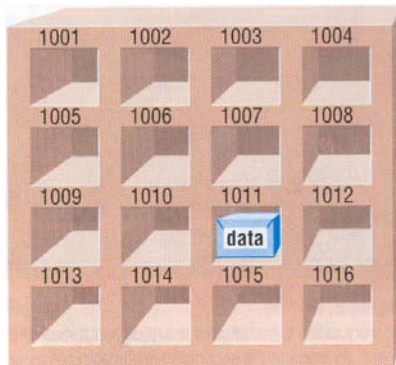
RAM

- Random Access Memory
- Volatile
 - Used for temporary storage
- Typical ranges 256 MB - 4 GB

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RAM (2)

- Random access means direct access to any part of memory
- A common form of RAM is DRAM (Dynamic RAM)



Random access
doesn't mean chaotic
or haphazard but it
means that access
does not have to be
sequential but can
occur anywhere

Picture from Computers in your future by Pfaffenberger B

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How Does DRAM Work?

- Acts like a leaky bucket

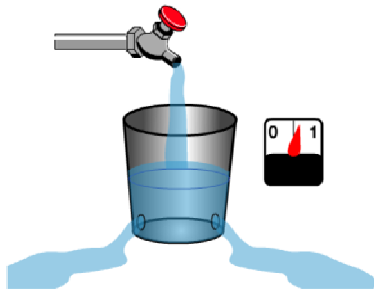
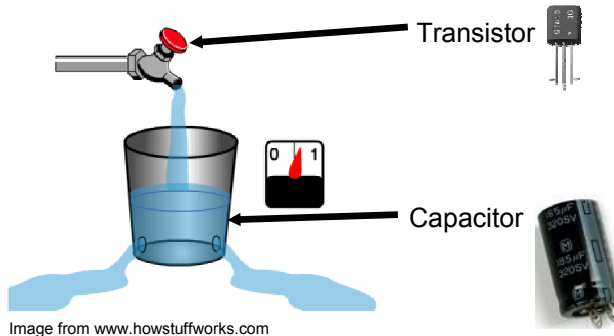


Image from www.howstuffworks.com

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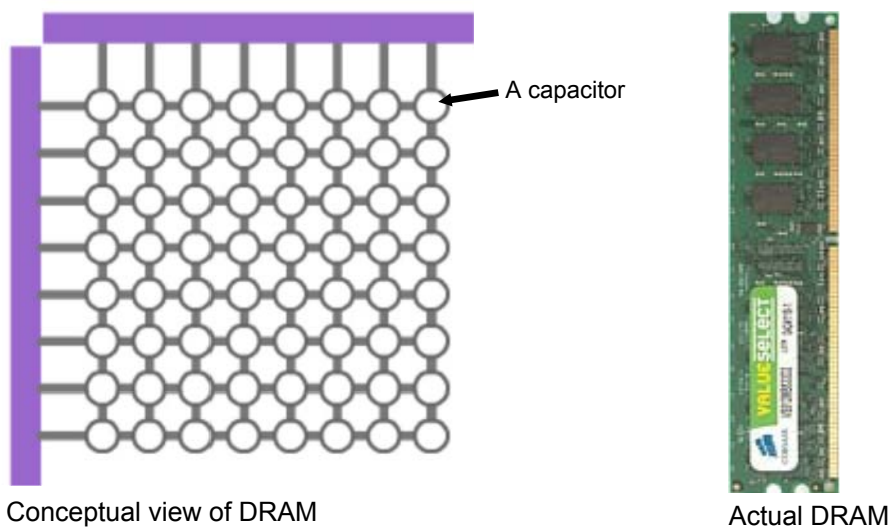
How Does DRAM Work?

- Acts like a leaky bucket



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DRAM: A Collection Of Capacitors



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The Word Size Of The Computer Determines The Maximum Amount of RAM

- Recall

- $2^{30} \sim 1$ billion

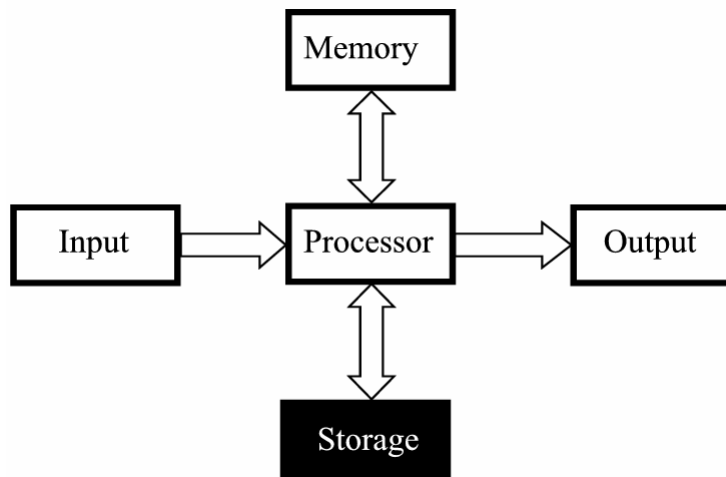
- $2^{31} \sim 2$ billion

- $2^{32} \sim 4$ billion

- This means that with a 32 bit computer the maximum amount of memory allowable is 4 billion (4 GB).

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Storage



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Storage Vs. Memory

Memory (e.g., RAM)

- The information stored is needed now
- Keep the information for a shorter period of time (usually volatile)
- Faster
- More expensive
- Low storage capacity (~1/4 of a DVD for 1 GB)



Storage (e.g., Hard disk)

- The information stored is not needed immediately
- The information is retained longer (non-volatile)
- Slower
- Cheaper
- Higher storage capacity (~50 DVD's for 200 GB)



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Categories Of Storage

1. Magnetic
 - Floppy disks
 - Zip disks
 - Hard drives
2. Optical
 - CD-ROM
 - DVD
3. Solid state storage devices
 - USB Key (a very common form of solid state storage)

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1. Magnetic Drives



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1. Magnetic Drives: Storage Capacities

- Floppy disks
 - ~ 1 MB
- Zip disks
 - 100, 250, 750 MB
- Hard drives
 - ~80 GB – 2 TB

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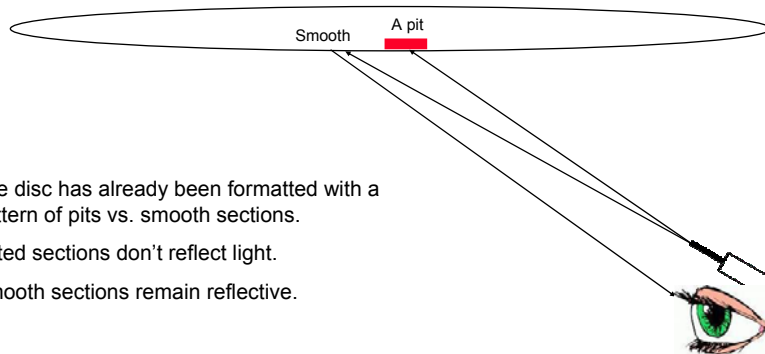
2. Optical Drives

- Use lasers to store and retrieve information (CD's and DVD's)
- Categories:
 - Can only read information off the disc (CD-ROM, DVD-ROM)
 - Can read and also record information to the disk (CD-R, DVD-R, DVD+R)
 - Can read, record and also re-write information multiple times (CD-RW, DVD-RW, DVD+RW)
- Storage capacities:
 - CD ~ 700 MB
 - DVD ~ 4 GB (drives with much larger capacities are becoming more common)

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Optical Drives: Reading Information

CD-ROM, DVD-ROM

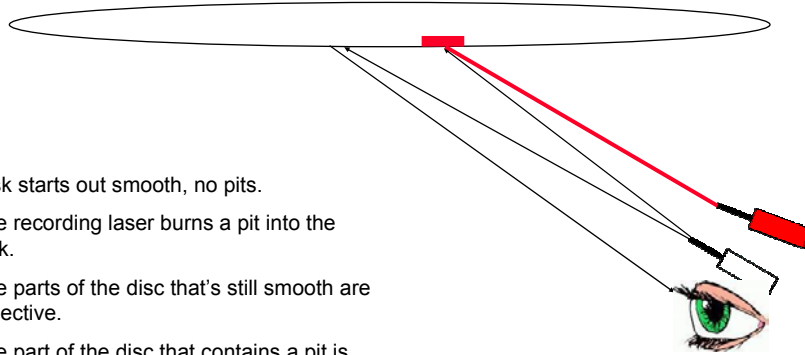


- The disc has already been formatted with a pattern of pits vs. smooth sections.
- Pitted sections don't reflect light.
- Smooth sections remain reflective.

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Optical Drives: Recording And Reading Information

CD-R, DVD-R, DVD+R

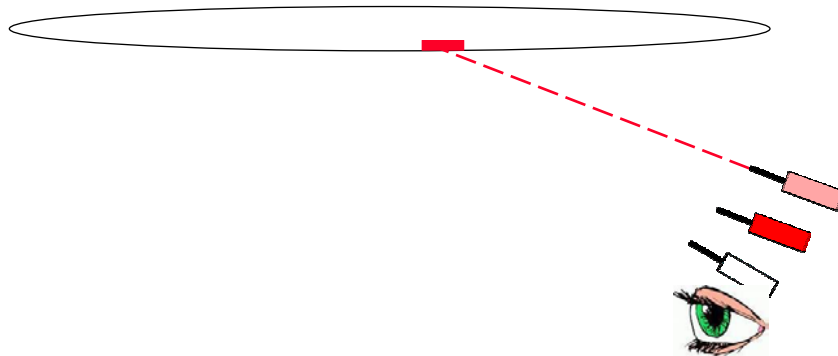


- Disk starts out smooth, no pits.
- The recording laser burns a pit into the disk.
- The parts of the disc that's still smooth are reflective.
- The part of the disc that contains a pit is non-reflective.

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Optical Drives: Re-Writing

CD-RW, DVD-RW, DVD+RW



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Optical Drives: Re-Writing

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



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3. Solid State Storage Devices

- Portable but can store a large amount of information (256 MB – 16 GB)



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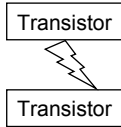
3. Solid State Storage Devices

- Require no moving parts but instead uses transistors

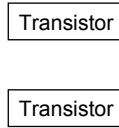


- Use a pair of transistors to store each bit of information

**Connected:
stores '1'**



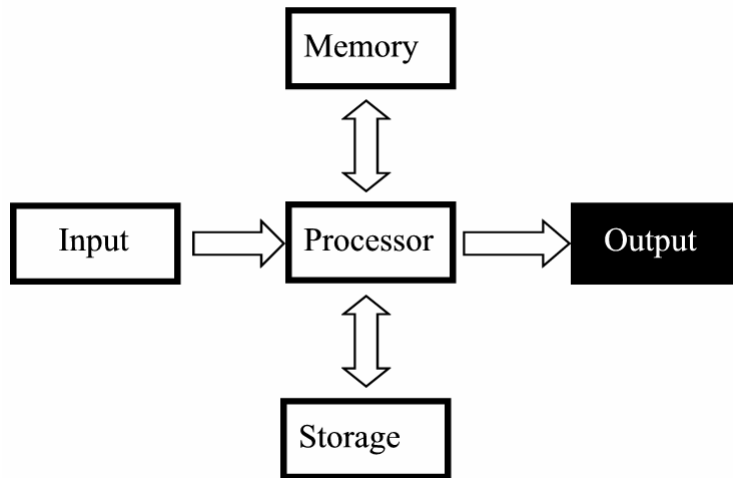
**Disconnected:
stores '0'**



- An electrical current can be used to connect and disconnect the transistors
- The pair transistors will remain in their current state (connected or disconnected) until an electrical charge is applied.

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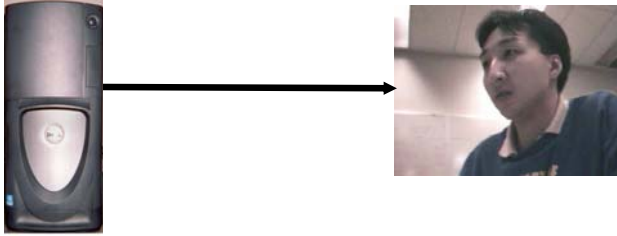
Output



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Output Devices

- Displays information from the computer to a person.



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The Most Common Output Device: The Monitor

- Common monitor technologies:
1. CRT (Cathode Ray Tube)



2. LCD (Liquid Crystal Display)



3. Plasma displays



James Tam

How Images Are Drawn On Monitors

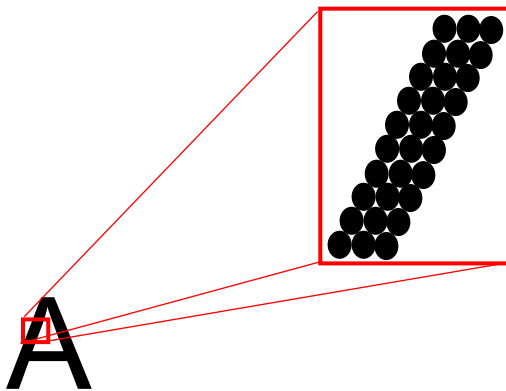
- Images and text are drawn with tiny dots (Pixels: *P*icture *e*lements)

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How Images Are Drawn On Monitors

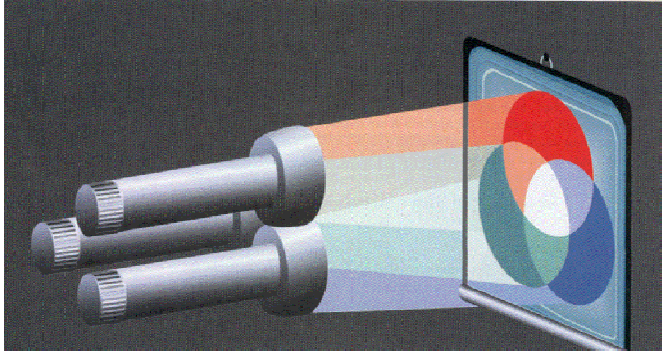
- Images and text are drawn with tiny dots (Pixels: *P*icture *e*lements)



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1. CRT Monitors

- The pixels are drawn with light ‘guns’

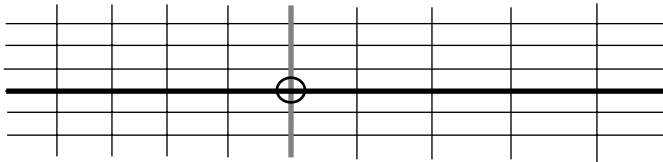


Picture from Computer Confluence by Beekman G.

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2. LCD Monitors

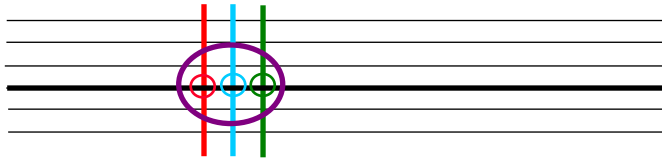
- Employ a conductive grid for each row and column
- The meeting of a row and column allows light to be emitted (a pixel can be seen)



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2. Colour LCD Monitors

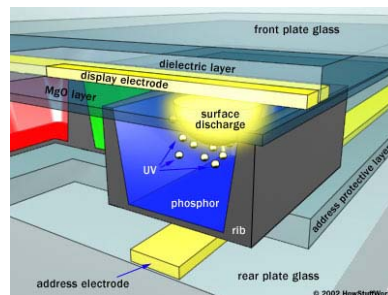
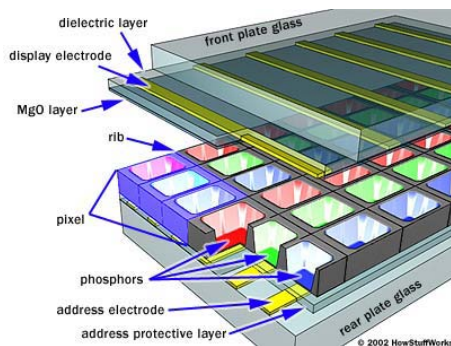
- Use three sub pixels:
 - One wire for each row
 - One wire for each sub-pixel
 - One colour filter for each colour (red, blue, green)



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3. Plasma Monitors

- Sub-pixels are “drawn” by passing an electrical current through a gas.
- Again each pixel is formed by three sub-pixels



Images from www.howstuffworks.com

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All The Basic Parts Together

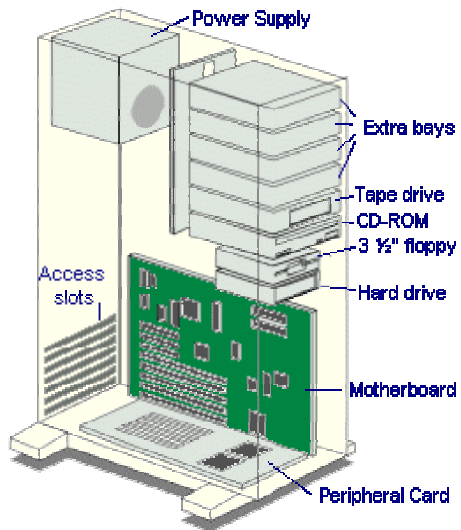
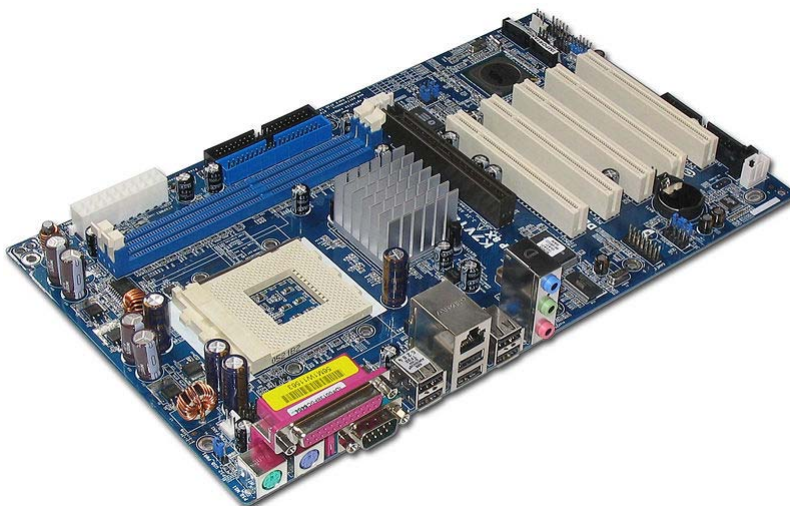


Diagram from <http://www.jegsworks.com>

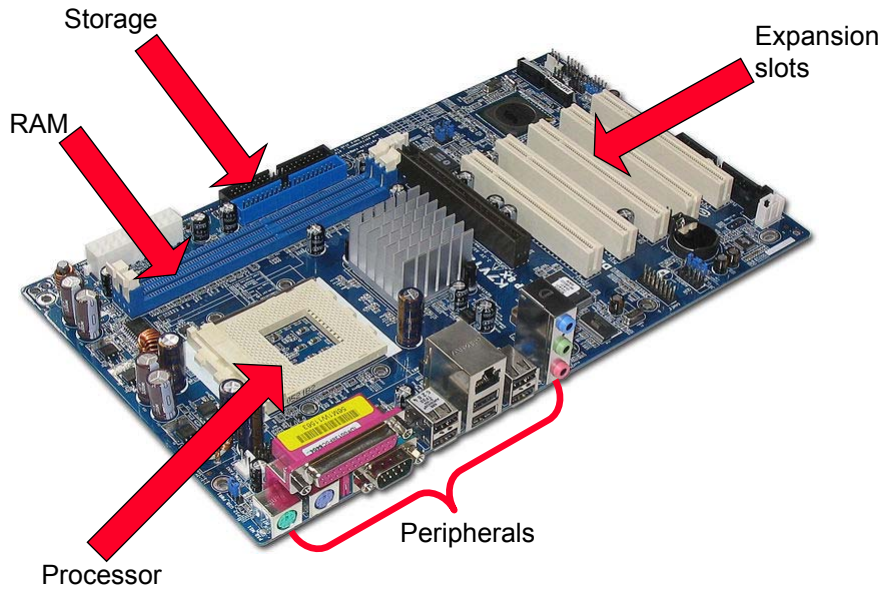
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The Motherboard



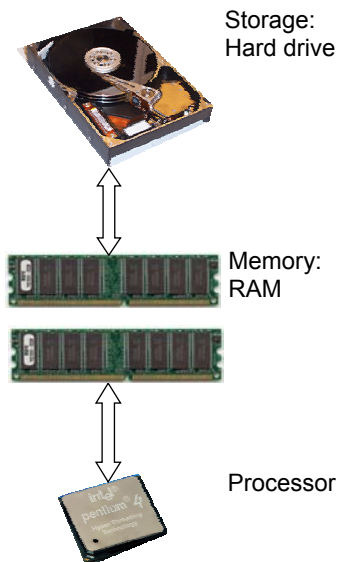
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The Motherboard



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Relating The Speed Of The Computer To Its Components



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You Should Now Know

- What are common units of measurement for the computer
- What are the basic parts of the high level view of a computer
- Example input devices
- The role of the processor in a computer
- What determines processor speed
- What are the characteristics of RAM
- How does DRAM work
- The difference between storage and memory
- What are the different categories of storage devices as well as common examples of each
- How do different storage devices work
- The approximate storage capacity of memory and different storage devices
- How do computer monitors work
- How the different hardware components affects the speed of the system