# CMSC 106
# Introduction to C Programming

Instructor: Jan Plane

Fall, 2011

Sections 0101 and 0102

## The Course Logistics

- Course Syllabus
  - check webpage http://www.cs.umd.edu/class/fall2011/cmsc106
- Course Forum
  - piazza.com
- Tips for Success
  - Attend all classes and lab sections
  - Start assignments early
  - Get help early if you are having trouble
  - Study every day
    - it doesn't work to cram for these exams
    - ask questions as soon as you realize you are confused
    - Study Groups - but not on most projects

# Important things to learn:

- The C programming language:
  - Types of data and ways of storing data.
  - C language constructs used to perform calculations and manipulate data.
- Problem–solving
- Program debugging

# Computer Organization

- Hardware: physical parts of computer
  - Monitor, mouse, keyboard
  - Chips, boards
  - Cables, cards
  - etc.
- Software: non-physical ("logical") parts of computer
  - Programs = instructions for computer to perform

# Hardware Overview

- **CPU** = central processing unit
  - Executes the "instructions" in programs
- **Main memory** = random-access memory = "RAM"
  - Stores data that CPU accesses, including instructions
  - FAST, but temporary; wiped out when computer is shut off!
- **Secondary memory**: Hard disks, CDs, DVDs, flash memory, etc.
  - Stores data that can be loaded into main memory
  - SLOWER, but permanent
- **I/O devices**
  - How you communicate with your machine
  - Keyboard, monitor, mouse, speakers, etc.
- **Networking equipment**
  - How others communicate with your machine
  - Networking "cards", cables, etc.

# Main Memory

- Computer data consists of off and on pieces (often written as 0's and 1's)
- bit: A single cell in main memory that can hold either a 0 or 1
- *byte*: A sequence of 8 bits
- word: Smallest unit on a machine of memory (often a sequence of 4 bytes)
- Main memory: table of bytes indexed by "addresses"

| Address | Byte value |
|---|---|
| 1 | 1 0 0 1 1 1 0 1 |
| 2 | 0 0 0 1 1 0 0 1 |
| 3 | 1 1 1 1 1 1 0 1 |
| 4 | 1 1 0 0 0 1 0 0 |

# How Many Different Values in a…

- Bit?

  *2*
- Two bits?

  *4 = 2 x 2*
- Byte?

  *256 = 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 = $2^8$*
- Word?

  *4,294,967,296 = $2^{32}$*

# How Are Characters, Etc., Represented?

Via *encoding schemes*

Example: ASCII (American Standard Code for Information Interchange)

- Standard for encoding character values as bytes
- In ASCII:
  - 'A' 01000001
  - 'a' 01100001
  - ',' 00101100
  - etc.

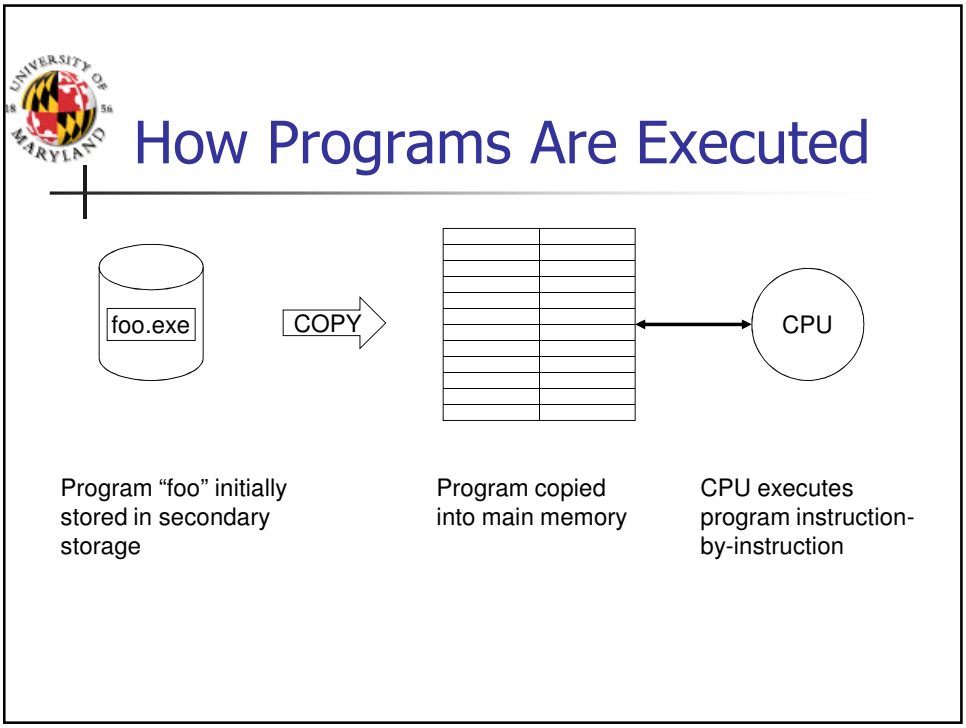
There are other character encoding schemes also: Shift-JIS, Unicode, etc.

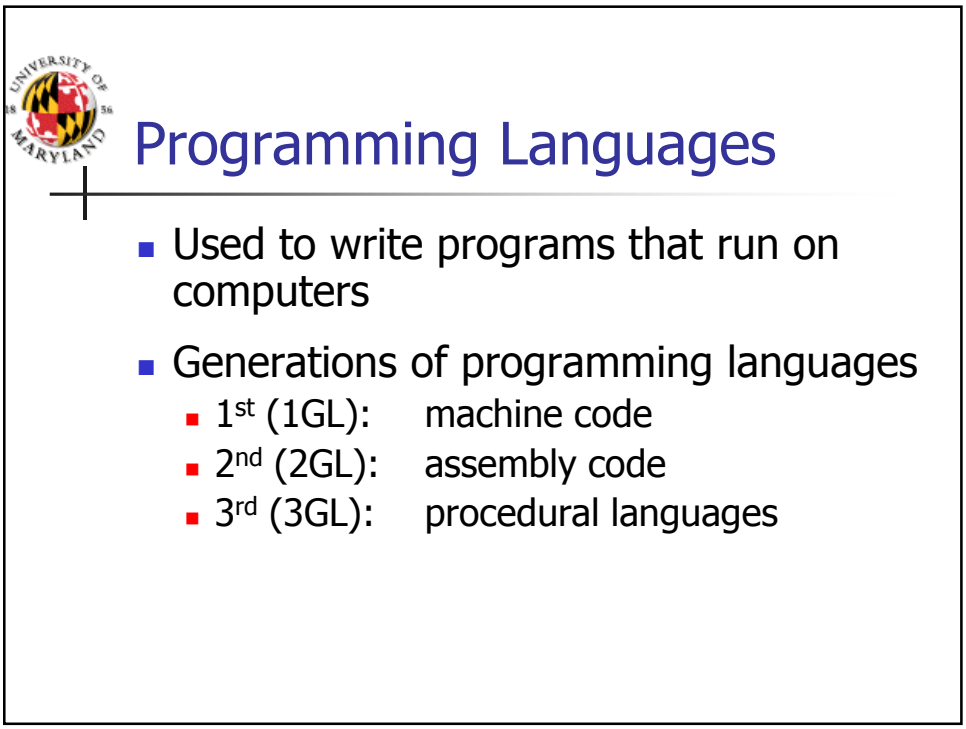
# Other Standard Terminology

| Multiples of bytes | | | | | |
|---|---|---|---|---|---|
| SI decimal prefixes | | Binary usage | IEC binary prefixes | | |
| Name (Symbol) | Value | | Name (Symbol) | Value | Actual |
| **kilobyte** (kB) | $10^3$ | $2^{10}$ | kibibyte (KiB) | $2^{10}$ | 1024 |
| megabyte (MB) | $10^6$ | $2^{20}$ | mebibyte (MiB) | $2^{20}$ | 1,048,576 |
| gigabyte (GB) | $10^9$ | $2^{30}$ | gibibyte (GiB) | $2^{30}$ | 1,073,741,824 |
| terabyte (TB) | $10^{12}$ | $2^{40}$ | tebibyte (TiB) | $2^{40}$ | 109,9511,627,776 |
| petabyte (PB) | $10^{15}$ | $2^{50}$ | pebibyte (PiB) | $2^{50}$ | 1024 TiB |
| exabyte (EB) | $10^{18}$ | $2^{60}$ | exbibyte (EiB) | $2^{60}$ | 1024 PiB |
| zettabyte (ZB) | $10^{21}$ | $2^{70}$ | zebibyte (ZiB) | $2^{70}$ | 1024 EiB |
| yottabyte (YB) | $10^{24}$ | $2^{80}$ | yobibyte (YiB) | $2^{80}$ | 1024 ZiB |

# Software Overview

1. **Operating system**: manages computer's resources; typically runs as soon as computer is turned on. Typical responsibilities:
   - *Process management*
     Determines when, how programs will run on CPU time
   - *Memory management*
     Controls access to main
   - *I/O, window system, network control*
     Performs low-level drawing, communication operations
   - *Security*
     Manages user IDs, passwords, file protections, etc.
2. **Applications**: programs users interact directly with; usually are explicitly run. Examples:
   - Word processors
   - Games
   - Spreadsheets
   - Music software,
   - Etc


How Programs Are Executed
foo.exe
COPY
CPU
Program "foo" initially stored in secondary storage
Program copied into main memory
CPU executes program instruction-by-instruction


Programming Languages
Used to write programs that run on computers
Generations of programming languages
1st (1GL): machine code
2nd (2GL): assembly code
3rd (3GL): procedural languages

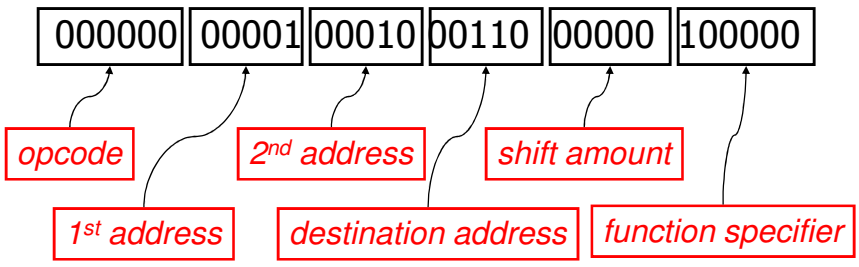
# 1st Generation: Machine Code

- Recall: computer data is 0's and 1's.
- In machine code, so are programs!
  - Program: sequence of instructions
  - Machine code: instructions consist of 0's and 1's
- Next slide: example machine code instruction from MIPS (= "Microprocessor without interlocked pipeline stages") architecture
  - Popular in mid-, late 90s
  - Instructions are 4 bytes long

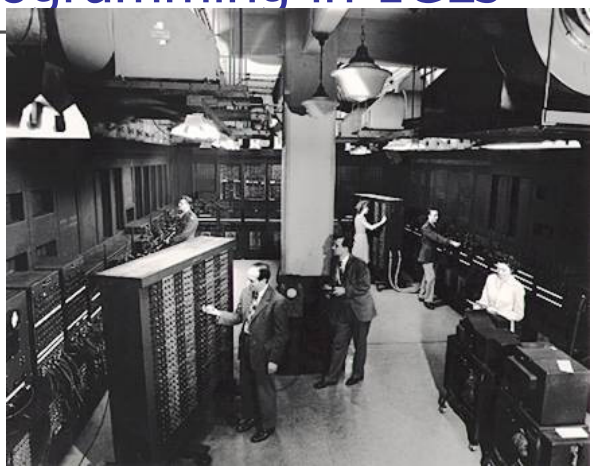
# Example MIPS Instruction

- "Add data in addresses 1, 2, store result in address 6":

  00000000001000100011000000100000???



# Programming in 1GLs



Courtesy of Microsoft Encarta Encyclopedia Online. Copyright (c) Microsoft Encarta Online

# 2nd Generation: Assembly

- Problem with 1GLs: Who can remember those opcodes, addresses, etc. as 0's, 1's?
- Solution (1950s): *assembly language*
  - Use *mnemonics* = descriptive character strings for opcodes
  - Let programmers give descriptive names to addresses
- MIPS example revisited:

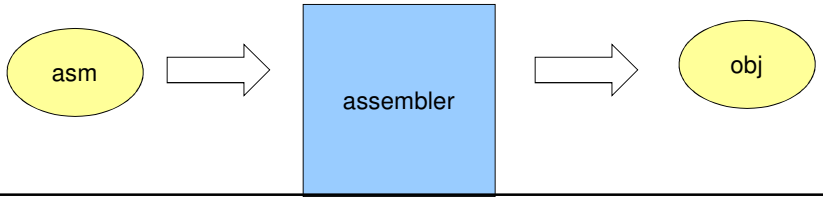
```
add $1, $2, $6
```

instead of 00000000001000100011000000100000

for "add contents of addresses 1, 2, store result in 6"

# Assemblers

- Computers still only work on machine code (1GL)
- Assembly language is not machine code
- *Assemblers* are programs that convert assembly language to machine code (= "object code")



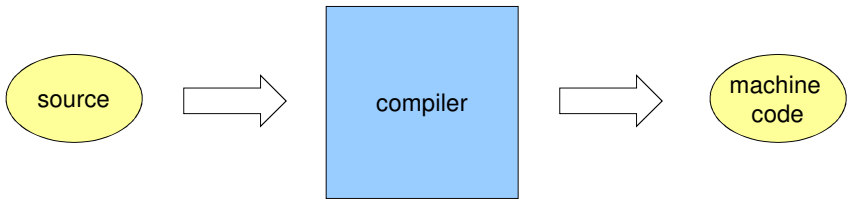

# 3rd Generation: Procedural Languages

- Problems with 2GLs
  - *Platform dependency*
    - Different kinds (*architectures*) of computers use different instruction formats

      E.g. x86, Pentium, 68K, MIPS, SPARC, etc.
    - 1GL / 2GL programs written for one kind of machine will not work on another
  - *Low level*: programs difficult to understand
- Solution (60s -- now): *procedural languages*
  - Higher-level, "universal" constructs
  - Examples: Fortran, Cobol, Pascal, C, C++, Java, C#

# Compilers

- Computers can only execute machine code
- *Compilers* are programs for translating 3GL programs ("source code") into machine code




# Algorithms

- An algorithm is a set of ordered steps solving a problem
  - steps – tell what needs to be done
  - order – tells which step gets done when
- A program implements an algorithm in a particular programing language.
- Pseudo code = used to describe an algorithm independent of a programming language
  - enough detail to tell exactly what needs to be done
  - no detail about the specific programming language that would be used for the implementation

# Software Development Process

- Understand the problem and design a solution
- type in some code
- compile it
- run it
- Test: compare it to expected results

# Programming Errors

- Types of Errors
  - Syntax Errors
    - violates languages grammar
    - compiler warns about these
    - Eclipe puts red squiggles under the offending code
  - Semantic/Logic Errors
    - program doesn't work properly
    - run-time errors = crash or hang
    - can be more subtle (harder to find)
- Debugging
  - process of finding and fixing problems
  - to minimize debugging frustration – use "unit" testing
    - write a small part, thoroughly test it, cycle back