

Introduction to Low-Level Programming

- Review Syllabus
- Class Grades Server
 - grades.cs.umd.edu
- Program #1A on the web page later today
 - due two weeks from today
 - to help you get used to the language and environment
- Discussion Sections
 - new material (outside of lecture)
 - hands-on practice and projects
 - quizzes
- Reading
 - Chapters 1 & 2 (by Tuesday)
 - Skip 1.1.4

What is “low-level” Programming

- Possible Definitions

- Low-level languages are closer to the hardware than are high-level programming languages, which are closer to human languages. (www.webopedia.com)
- Computer languages are classed a low-level if each instruction specifies only one operation of the computer, or high-level if each instruction may specify a complex combination of operations. (onlinedictionary.datasegment.com)
- Programming where details and intricacies of the hardware are visible

- The C Language

- lower than Java (need to manage memory)
- higher level than assembly

Why Study Low-level Programming?

- Provides Understanding of How Things Work
 - Compilers, Processors, Data Structures
- Allows access to Hardware when required
 - Writing device drivers
 - Creating Operating Systems
- You are in Control
 - Can be faster
 - If you are careful and good
 - Can be slower
 - If you rewrite low level routines where faster ones exist
 - Can be Dangerous – easier to have software that
 - Crashes program (or OS)
 - Fails in odd ways (memory corruption)

The “C” Programming Language

- Widely Used for System Programming
 - Writing Operating Systems and Compilers
- “Middle Aged” Language – created in late 1970’s
 - Reflects lessons learned from Fortran, COBOL
- Goals
 - Designed to allow low-level programming
 - Small language
 - Syntax is relatively simple
 - Libraries provided but optionally used
 - Assumes you know what you are doing
- Major Differences from JAVA
 - Explicit Memory Allocation and Deallocation
 - Procedural rather than object oriented
 - Can compile directly to machine code (rather than byte codes)

What Does a C Program Look Like?

```
#include <stdio.h>
int main(void)
{
    printf("Hello World\n");
    return 0;
}
```

- This Code
 - Includes a library file so you can use the functions defined there
 - Defines the main function
- First thing executed is the main function
- Returning from main function terminates the program

Compilation Stages

- Preprocessor
 - makes sure the parts each have the parts they need
 - begin with a # (pound sign)
 - do not end in a ;
- Translation
 - makes sure individual portions are consistent within themselves
 - creates an object file
- Linking
 - brings those parts together
 - makes sure the parts are consistent with each other
 - creates an executable file

Preprocessor

- function prototypes

- Define name, parameters, and return types
- Sort of like how methods are defined within class definitions
- example

```
int Funct1(int x, int y);
```

- #include

- Provides ability to include definitions from other files
- Generally only include prototypes from external files
 - Actual code is kept in a separate file
 - Files are generally compiled individually to object code
 - And then compiled together to make executable code

- Two ways to use

- #include <stdio.h>
- #include "swap.h"

Formatting Your program

- Comments
 - Must be surrounded by `/*` and `*/`
 - May span multiple lines
 - Common bug is to forget to close a comment
 - Can not be nested
- Vertical White Space
 - Blank lines before a new function definition
 - Blank lines within a function to separate different tasks
- Horizontal White Space
 - Indentation
 - Generally corresponds to nesting level

Basic C Syntax

- Variable Declarations

- Format:
 - type variableName1, variableName2;
- Examples
 - int a;
 - float x, y;
 - int m = 8;
- Must be before any executable code
- May be global (whole file) or specific to a function

- Looping and Conditionals

- while, do, for
- if, switch

- Function Calls

- FunctName(argument1, argument2, ...)

- Block of code

- { }

printf Function

- Definition

- included with `#include <stdio.h>`
- then just use it because it has already been defined for you

- Syntax:

- `printf(formatString);`
- `printf(formatString, variable1, variable2, variable3, ..);`

- Within Format String:

- Defines constants to print, or format for variables:
 - `%d` Print an integer in decimal
 - `%x` Print an integer in hex
 - `%f` Print a floating point value
 - `%c` Print a character
 - `%s` Print a character string
 - `\n` Print a newline

- Example assuming `int a;` and `a` has the value 23

- code: `printf("%d is smaller than %d\n", a, a+5);`
- output: 23 is smaller than 28

Passing Arguments to Functions

- Comma separated list of arguments
- All arguments are passed by value
- May pass literal values
- Compiler will check parameter usage:
 - Match a given call to its prototype
 - Match a function definition to its prototype
 - Pitfall: Critical to have only one prototype for each function
 - Put in a common file (.h)
 - the .h file is then included in and shared by all files that use and/or define that function
- Which of these is legal assuming the current scope contains:
`int a, b, c;                      and                      int Func1(int x, int y);`
 - `a = Func1(1, 2);`
 - `c = Func1(a, b+2);`
 - `printf("%d",Func1(a + b, a));`
 - `c = Func1(a * 3, 4) + b;`
 - `Func1(a, Func1(1,2));`

Using Linux

- Logging in
 - Can login at console or remotely (ssh)
- Basic operations (command line)
 - ls list directory
 - pwd print current directory
 - mkdir <dir> create a new file
 - rmdir <dir>
 - cp <f1> <f2> copy file <f1> into file <f2>
 - rm <f1> delete file <f1>
 - logout end session
- Section on Monday will allow you to test and practice using UNIX

Compiling & Running a Program

- Programs must be compiled to execute
- Compiler is invoked as:
 - gcc <options> <source files>
 - Common Options:
 - -g Enable Debugging
 - -Wall Warn about common errors
 - -o <filename> Filename for the executable
 - -c Only compile to object code
 - -fprofile-arcs Count how often statements run
 - -ftest-coverage Test program coverage
 - A simple command line:
 - gcc -g -Wall -o prog1 prog1.c tools.c
- Make
 - covers this for you