CS 354 - Machine Organization & Programming
Tuesday January 24 and Thursday January 26, 2023

Instructor: Deb Deppeler**,** 5376 CS, deppeler@wisc.edu

Office Hours: See **Lectures** link on Canvas course

Lectures

- **Lecture 001 TR 9:30-10:45 AM 2650 Humanities**

Livestream link: http://128.104.155.144/ClassroomStreams/humanities2650_stream.html

- **Lecture 002 TR 2:30-3:45 PM 2340 Humanities Building**

Livestream link: http://128.104.155.144/ClassroomStreams/humanities2340_stream.html

Description

An introduction to fundamental structures of computer systems and the C programming language with a focus on the low-level interrelationships and impacts on performance. Topics include the virtual address space and virtual memory, the heap and dynamic memory management, the memory hierarchy and caching, assembly language and the stack, communication and interrupts/signals, assemblers/linkers and compiling.

Today

Getting Started	C Program Structure
Welcome Course Info Getting Started in Linux EDIT COMPILE, RUN, DEBUG, SUBMIT	C Program Structure (L2-6) C Logical Control Flow, seq,sel,rep Recall Variables Meet Pointers

Next Week

Topics: Pointers - 1D Arrays & Address Arithmetic, Passing Addresses

Scan for review and try examples:

K&R Ch. 2: Types, Operators, and Expressions
K&R Ch. 3: Control Flow
K&R Ch. 4: Functions & Program Structure

Read and take notes before next week:

K&R Ch. 5.1: Pointers and Addresses
K&R Ch. 5.2: Pointers and Function Arguments
K&R Ch. 5.3: Pointers and Arrays
K&R Ch. 5.4: Address Arithmetic

Do: Trace bingbangboom example on L2-6 to determine output, code up to verify
Start on project p1 (available soon)

Course Information

Textbooks

- The C Programming Language, Kernighan & Ritchie, 2nd Ed., 1988
- Computer Systems: A Programmer's Perspective, Bryant & O'Hallaron, 2nd Ed, 2010
  Note: 3rd edition or finding an online pdf is fine. (I cannot post a link)

Piazza

- is used for online course discussions and questions with classmates and the TAs about homeworks, projects, and course concepts as well as course logistics

CS Account

- provides access to CS Linux Computers with dev tools (rooms **1366**, 1355, 1358, **1368**)
- is needed to access your CS 354 student folder used for some course projects
- same user name/password as your prior CS 200/300 CS accounts
- IF YOU ARE NEW TO CS, go to “My CS Account” on the csl.cs.wisc.edu web page
  URL: https://apps.cs.wisc.edu/accountapp/ (or see TA or Deb)

TAs: Teaching Assistants

- are graduate students with backgrounds in computer architecture and systems
- help with course concepts, Linux, C tools and language, homeworks and projects
- do consulting in 1366 or 1368 CS Linux Computer Lab during scheduled hours, which are posted on course website’s “TA Consulting” page

PMs: Peer Mentors (available for in-person support for students)

- are undergraduate students that have recently completed CS 354
- hold drop-in hours and do a variety of activities to help students succeed, which are posted on course website’s “PM Activities” page
- limited availability this semester as fewer students were available to hire

Coursework

Canvas will have all coursework hand in deadlines.

Exams (55%)

- Midterm (15%): Thursday Feb 23, 7:30 - 9:30 PM
- Midterm (18%): Thursday Apr 6th, 7:30 - 9:30 PM
- Final (22%): Wednesday, 5/10 2:45pm-4:45pm

Conflict with these times? Complete the form at: http://tiny.cc/cs354-conflicts

Projects (30%): 6 projects, posted on course website

Homeworks (15%): ~10 homework quizzes, posted on course website

Getting Started in Linux

❋ *Use the CSL Linux computers for all CS 354 programming.*

1. Log in or connect remotely to any CSL Linux Workstation (computers)

a. open your computer's **terminal** application
b. enter **`ssh cslogin@machine.network`**
cslogin: your username for CSL workstations. https://apps.cs.wisc.edu/accountapp/
machine: a physical or virtual machine on the CSL network
- emperor-01 ... emperor-07
- rockhopper-01 ... rockhopper-09
- royal-01 ... royal-30
- snares-01 ... snares-10
- vm-instunix-01 ... vm-instunix-99

network: the CSL's network is **cs.wisc.edu**
c. ssh **cslogin**@best-linux.cs.wisc.edu (runs script to find least busy workstation)

Try some Linux Commands at the shell prompt

command shell

→ How do you:
list the contents of a directory? Show details? Hidden files?

get more information about commands?

display what directory you're currently in?

copy a file? remove a file?

move to another directory? move "up" a directory?

make a new directory?

remove a directory?

rename a file or directory?

EDIT -- Create your C source code file

1. Create new or open existing file in a text-only editor

$vim prog1.c
$vimtutor

→ Why vim?
and
other editors?

```
/* title:  First C Program
 * file:   prog1.c
 * author: Jim Skrentny
 */

#include <stdio.h>
#include <stdlib.h>
#include <string.h>

int main( int argc, char *argv[] )

   // Create space to save string of characters


   // INPUT: prompt user for input
   printf("Enter your CS login: ");

   // INPUT: read keyboard input into input_string variable
   if ( fgets(input_string, 128, stdin) == NULL )
      fprintf(stderr, "Error reading user input.\n");

   // Replace '\n' with '\0'
   int len = strlen(input_string);
   if ( input_string[len - 1] == '\n' ) {
      input_string[len - 1] = '\0';
   }

   // OUTPUT: print CS login to terminal
   printf("Your login: %s\n", input_string);

   // RETURN
return 0;

}
```

COMPILE, RUN, DEBUG, SUBMIT

2. Compile -- build executable from C source

```
$gcc prog1.c
```

OR

```
$gcc prog1.c -Wall -m32 -std=gnu99 -o prog1
```

3. Run -- run executable (program) from command line

```
$a.out
```

→ Why a.out?

OR

```
$prog1
```

4. Debug

1. Add print stmts:
2. Use gdb

5. Submit work to Canvas assignment (required for projects)

- Secure copy from lab computer to your local machine
  scp csLogin@best-linux.cs.wisc.edu:/path/to/remote/directory/srcfile local/destination

- Refresh Canvas assignment page and upload files from your local machine

C Program Structure

❋ *Variables and functions must be declared before they're used.*

➢ What is output by the following code?

```
#include <stdio.h>

int bing(int x) {
   x = x + 3;
   printf("bing %d\n", x);
   return x - 1;
}

int bang(int x) {
   x = x + 2;
   x = bing(x);
   printf("BanG %d\n", x);
   return x - 2;
}

int main(void) {
   int x = 1;
   bang(x);
   printf("BOOM %d\n", x);

   return 0;
}
```

Functions

function:

caller function:

callee function:

Functions Sharing Data

argument:

parameter:

pass-by-value (passing in):

return-by-value (passing out):

C Logical Control Flow

Sequencing

Selection

→ Which value(s) means true? **`true`** 42 -17 0

if - else

→ What is output by this code when `money` is 11, -11, 0?

```
if (money = 0)      printf("you're broke\n");
else if (money < 0) printf("you're in debt\n");
else                printf("you've got money\n");
```

→ What is output by this code when the date is 10/31?

```
if (        month)
   if (         day)
      printf("Happy Halloween!\n");
else
   printf("It's not October.\n");
```

switch

Repetition

```
int i = 0;
while (i < 11) {
   printf("%i\n", i);
   i++;
}
```

```
for (int j = 0; j < 11; j++) {
   printf("%i\n", j);
}
```

```
int k = 0;
do {
   printf("%i\n", k);
   k++;
} while (k < 11);
```

Recall Variables

What? A *scalar variable* is

→ Draw a basic memory diagram for the variable in the following code:

```
void someFunction(){
   int i = 44;
```

Aspects of a Variable

identifier:

value:

type:

address:

size:

❋ *A scalar variable used as a source operand*

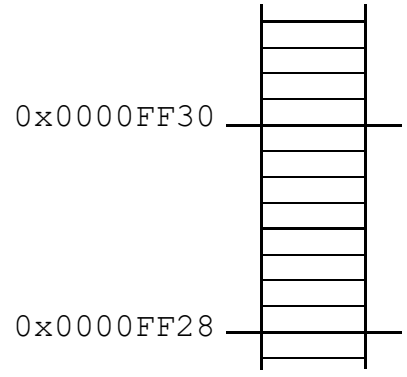
e.g., `printf("%i\n", i);`

❋ *A scalar variable used as a destination operand*

e.g., `i = 11;`

Linear Memory Diagram

A linear memory diagram is



	most significant							least
base 10								**44**
base 2	0000	0000	0000	0000	0000	0000	0010	1100
base 16	0	0	0	0	0	0	2	C

byte addressability:

endianess:

little endian:

big endian:

Meet Pointers

What? A *pointer* variable is

-
-

Why?

-
-
-
-

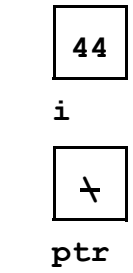
How?

→ Consider the following code:

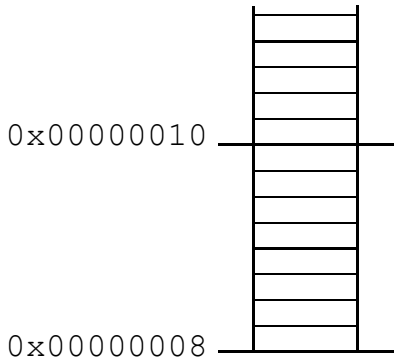
```
void someFunction(){
   int i = 44;

   int *ptr = NULL;
```

Basic Diag.



Linear Diag.



→ What is `ptr`'s initial value? address? type? size?

pointer:

pointee:

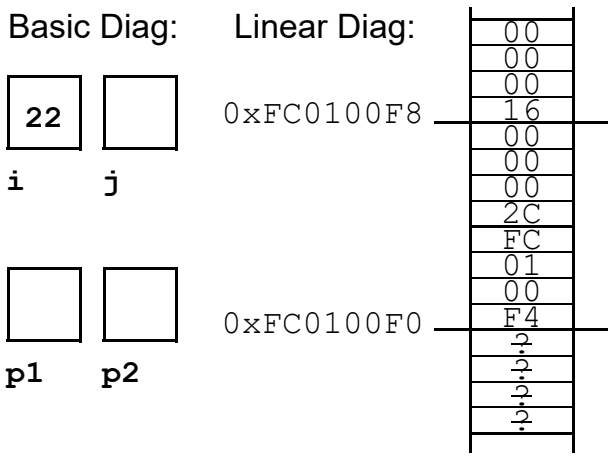
`&` *address of* operator:

`*` *dereferencing* operator:

Practice Pointers

→ Complete the following diagrams and code so that they all correspond to each other:

```
void someFunction(){
   int i =
   int j = 44;
   int *p1 = &
   int *p2;  //at addr 0xFC0100EC
```



→ What is `p1`'s value?

→ Write the code to display `p1`'s pointee's value.

→ Write the code to display `p1`'s value.

→ Is it useful to know a pointer's exact value?

→ What is `p2`'s value?

→ Write the code to initialize `p2` so that it points to nothing.

→ What happens if the code below executes when `p2` is NULL?

```
printf("%i\n", *p2);
```

→ What happens if the code below executes when `p2` is uninitialized?

```
printf("%i\n", *p2);
```

→ Write the code to make `p2` point to `i`.

→ How many pointer variables are declared in the code below?

```
void someFunction(){
   int* p1, p2;
```

→ What does the code below do?

```
int **q = &p1;
```