



CS 11 C track: lecture 1

- Preliminaries

- Need to know basic UNIX commands
 - Tutorial linked from track home page
- Track home page:
 - http://users.cms.caltech.edu/~mvanier/CS11_C



Assignments

- 1st assignment is posted now
- Due one week after class, 2 AM
- Grading system: see "admin page"
linked from track home page



Other administrative stuff

- See admin web page
- Covers how to submit labs, collaboration policy, grading, etc.



Textbook

- Kernighan and Ritchie:

The C Programming Language, 2nd. ed.

- 1st edition NOT acceptable
- "ANSI C"
- Only for reference



C: pros and cons

- What C is good at
 - low-level programming
 - speed and memory efficiency
 - portability (sorta)
- Bad things about C
 - unsafe!!!
 - low level of abstraction



Getting started (1)

- The "hello, world!" program:

```
#include <stdio.h>
int main(void)
{
    printf("hello, world!\n");
    return 0;
}
```



Getting started (2)

- Make this into a file called `hello.c` using a text editor
 - *e.g.* `emacs`, `vi`, `VS Code`
- Compile into a program and run:

```
$ gcc hello.c -o hello
$ ./hello
hello, world!
$
```
- Woo hoo!



Source code to executable (1)

- What you write is called "source code"
- Two kinds of source code files:
 - regular code (files end in ".c")
 - **header** files (files end in ".h")
- **Compiler** turns source code into "object code"
 - (files end in ".o")
- **Linker** turns object code file(s) into executable (no special file suffix)



Source code to executable (2)

- The program `gcc` is both a compiler and a linker
- When you do this:

```
$ gcc hello.c -o hello
```
- Then `gcc`
 - compiles `hello.c` to `hello.o`
 - links `hello.o` with system libraries
 - outputs the binary executable program `hello`
 - removes `hello.o`



Source code to executable (3)

- You can do each step individually:

```
$ gcc -c hello.c           (compile only)
```

```
$ gcc hello.o -o hello     (link only)
```

- In this case, `hello.o` is not removed
- Sequence:
 - **compiling**: source code to object code
 - **linking**: object code to binary executable



The C language - overview

- Programs are built up of **functions**
- Functions
 - take in arguments
 - compute something
 - return a result
- The **main()** function
 - is where program execution starts



Data types (1)

- All data in C has to have a specified **type**
- Examples:
 - **int** (integer)
 - **char** (character)
 - **float** or **double** (approximate real number)
 - others
- Variables hold data of a particular type only
- Variables must be declared before use



Data types (2)

- Type declarations:

```
int i;    /* name = i    type = int */
```

```
char c;   /* name = c    type = char */
```

```
double d;
```

```
float some_float = 3.14;
```

- Identifiers: `i`, `c`, `d`, `some_float`
- Optional initialization (*e.g.* `some_float`)
- Booleans → `0` or nonzero (usually `1`)



Data types (3)

- Strings: **arrays** of type **char**

```
char some_string[9] = "woo hoo!";
```

```
char same_string[] = "woo hoo!";
```

- Much more on strings, arrays later
- Other types: **structs**, **pointers**



Operators (1)

- Numeric: + - * / %
- Assignment: =

```
int i = 10;    /* initialization */
```

```
int j = 20;    /* initialization */
```

```
i = 2 + i * j; /* assignment */
```

```
j = j % 2;    /* assignment */
```



Assignment operator

- Assignment works this way:
 - 1) Evaluate the right-hand side (RHS) of the assignment operator
 - 2) Assign the resulting value to the left-hand side (LHS) of the assignment operator



Operators (2)

- What does

`i = 2 + i * j;`

mean?

a) `i = (2 + i) * j;`

b) `i = 2 + (i * j);`

- `*` has a higher *precedence* than `+`
- Use `()` to force other interpretation



Operators (3)

- Other assignment operators:

- `+=`, `-=`, `*=`, ...

```
i += 2; /* i = i + 2; */
```

- increment and decrement: `++`, `--`

```
i++; /* i = i + 1; */
```

```
++i; /* same */
```



Operators (4)

- Test operators:
 - compare two values
 - < <= > >=
 - == for testing equality
 - != for testing inequality
 - read "!" as "not"



Operators (5)

- Logical operators:
 - arguments are `ints` used as booleans
 - *i.e.* usually `0` or `1` (false or true)
 - `!` operator is unary logical "not"
 - `&&` operator is binary logical "and"
 - `||` operator is binary logical "or"



Operators (6)

```
int bool1, bool2, bool3, bool4;
```

```
bool1 = 0; /* false */
```

```
bool2 = !bool1; /* bool2 --> true */
```

```
bool3 = bool1 || bool2; /* value? */
```

```
bool4 = bool1 && bool2; /* value? */
```



Operators (7)

- "Unary minus" operator:

```
int var1 = 10;
```

```
int var2;
```

```
var2 = -var1;
```

- Like `-` with nothing to the left
- Negates the value



Expressions and statements

- $i + 2 * j$ is an *expression* (has a value)
- $i = j * k;$ is a *statement*
 - ends in a semicolon
 - also is an expression (value is value of i)
- $i = j = k = 0;$ is allowed
- Equivalent to $i = (j = (k = 0));$
- NOT $((i = j) = k) = 0;$



Comments

```
/* This is a comment. */
```

```
/*
```

```
 * Comments can span
```

```
 * multiple lines.
```

```
 */
```

```
// This is NOT an ANSI comment!
```




Functions (1)

- Functions take *arguments* and return values:

```
int f(int x)
{
    int y = 10;
    return y * x;
}
```



Functions (2)

- Functions take *arguments* and return values:

```
int f(int x)
{
    int y = 10;
    return y * x;
}
```

A red arrow points from the word "name" to the function name "f" in the code above.



Functions (3)

- Functions take *arguments* and return values:

```
int f(int x)
{
    int y = 10;
    return y * x;
}
```

argument list




Functions (4)

- Functions take *arguments* and return values:

```
int f(int x)
{
    int y = 10;
    return y * x;
}
```

return type






Functions (5)

- Functions take *arguments* and return values:

```
int f(int x)
```

body



```
{  
    int y = 10;  
    return y * x;  
}
```



Functions (6)

- Functions take *arguments* and return values:

```
int f(int x)
```

```
{
```

```
    int y = 10;
```

```
    return y * x;
```

```
}
```

return statement





Functions (7)

- Calling the function we just defined:

```
/* in another function... */
```

```
int res;
```

```
int i = 10;
```

```
res = f(10);
```

```
res = f(5 + 5);
```

```
res = f(i);
```

```
res = f(i*5 + i/2);
```

- All of these are valid function calls
- Take in arguments, return result



Functions (8)

- Functions can take multiple arguments:

```
int g(int x, int y)
{
    int z = 42;
    return x * y * z;
}
```

argument list

- Argument names (**x**, **y**) preceded by types (**int**)
- Arguments separated by commas



Functions (9)

- Calling functions that take multiple arguments:

```
/* in another function... */  
int res;  
int i = 10, j = 20;  
res = g(10, 20);  
res = g(5 + 5, 20);  
res = g(i, j);  
res = g(i*5 + i/2, j * 10);
```



Functions (10)

- Not all functions return values:

```
void print_number(int i)
{
    printf("number is: %d\n", i);
}
```

- Return type is **void** (nothing to return)
- Use this when no return value needed



Functions (11)

- Not all functions return values:

```
void print_number(int i)
{
    printf("number is: %d\n", i);
    return; /* unnecessary */
}
```

- **return** statement not required
 - unless you return in the middle of the function



Functions (12)

- Calling this function:

```
/* In another function... */  
int i = 10;  
print_number(20);  
print_number(i);  
print_number(i*5 + i/2);
```

- Prints 20, 10, 55 respectively



Functions (13)

- Not all functions take arguments:

```
int five(void)
{
    return 5;
}
```

- No arguments (use **void** to indicate)



Functions (14)

- Calling functions without arguments:

```
int value;
```

```
value = five();
```

- Now value equals 5
- Note `()` after `five`
 - means "this function is being called with no arguments"
 - Without this, function won't be called!



Functions – type declarations

- **Type declarations** come at the beginning of the function

- Need a declaration for every **local variable**

```
int foo(int x)
```

```
{
```

```
    int y;    /* type declaration */
```

```
    y = x * 2;
```

```
    return y;
```

```
}
```



Functions – type declarations

- This is wrong:

```
int foo(int x)
{
    int y;        /* type decl */
    y = x * 2;    /* code */
    /* type declaration after code: */
    int z = y * y;
    return z;
}
```

- Generates a compiler warning



Local and global variables (1)

- Variable declarations can be **local** or **global**
- **Local**: inside a function
- **Global**: outside a function
 - accessible from any function



Local and global variables (2)

```
int x;          /* Global variable */
int y = 10;     /* Initialized global variable */

int foo(int z)
{
    int w;      /* local variable */
    x = 42;     /* assign to a global variable */
    w = 10;     /* assign to a local variable */
    return (x + y + z + w);
}
```



Local and global variables (3)

- In general, **avoid using global variables!**
- Global variables can be changed by *any* function
 - makes debugging much harder
- Global variables are never necessary
 - though sometimes convenient
- OK to use global "variables" if they really are constant
 - *i.e.* if you don't change their values



printf()

```
int a = 5;
double pi = 3.14159;
char s[] = "I am a string!";
printf("a = %d, pi = %f, s = %s\n",
       a, pi, s);
```

- Substitutes values for **%d**, **%f**, **%s** etc.
- **%d** : int, **%f** : float, double, **%s** : string
- **\n** : new line



The C preprocessor (1)

- What does the funky line `#include <stdio.h>` mean?
- **C preprocessor** directive
- Extra step in compilation:
 - **cpp**: source code -> expanded source code
 - **gcc**: compiles source code -> object code
 - **gcc (ld)**: links object code -> executable
 - **gcc** does all this for you



The C preprocessor (2)

- What does the funky line `#include <stdio.h>` mean?
- Includes the **declaration** of `printf()`
 - NOT the implementation
 - allows your code to use `printf()`
- The linker adds in the implementation



Conditionals (1)

- Need to be able to test for conditions:

```
int a = 10;
if (a < 20)
{
    printf("less than 20\n");
}
else
{
    printf("not less than 20\n");
}
```



Conditionals (2)

- Test: 0 is "false", anything else is "true":

```
if (1) /* true */
{
    printf("less than 20\n");
}
else
{
    printf("not less than 20\n");
}
```




Conditionals (3)

- VERY common error:

```
int a = 0;
if (a = 10) /* always true! */
{
    printf("a equals 10\n");
}
else
{
    printf("a doesn't equal 10\n");
}
```



Conditionals (4)

- Should be:

```
int a = 0;
```

```
if (a == 10) /* not always true */
```

```
{
```

```
    printf("a equals 10\n");
```

```
}
```

```
else
```

```
{
```

```
    printf("a doesn't equal 10\n");
```

```
}
```



Conditionals (5)

- **else** clause is optional:

```
int a = 0;  
if (a == 10)  
{  
    printf("a equals 10\n");  
}
```



Conditionals (5)

- **else if** for multiple cases:

```
int a = 0;
if (a == 10) {
    printf("a equals 10\n");
} else if (a < 10) {
    printf("a is less than 10\n");
} else {
    printf("a is greater than 10\n");
}
```



for loop (1)

- Need to do things repeatedly:

```
int i;  
for (i = 0; i < 10; i++)  
{  
    printf("cowabunga!!!\n");  
}
```



for loop (2)

```
for (<initialization>;  
    <test>;  
    <increment>)  
{ <body> }
```

```
for (i = 0; i < 10; i++)  
{  
    printf("cowabunga!!!\n");  
}
```



for loop (3)

```
for (<initialization>;  
    <test>;  
    <increment>)  
{ <body> }
```

```
for (i = 0; i < 10; i++)  
{  
    printf("cowabunga!!!\n");  
}
```



for loop (4)

```
for (<initialization>;  
    <test>;  
    <increment>)  
{ <body> }
```

```
for (i = 0; i < 10; i++)  
{  
    printf("cowabunga!!!\n");  
}
```




for loop (5)

```
for (<initialization>;  
    <test>;  
    <increment>)  
{ <body> }
```

```
for (i = 0; i < 10; i++)  
{  
    printf("cowabunga!!!\n");  
}
```



for loop (6)

```
for (<initialization>;  
    <test>;  
    <increment>)  
{ <body> }
```

```
for (i = 0; i < 10; i++)
```

```
{  
    printf("cowabunga!!!\n");  
}
```



That's all for now!

- Much more on all these topics in later lectures
- Do first assignment to get familiar with basics
- Use "style checker" to avoid style mistakes
- Have fun!