CS 222: Functions and Conditionals

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Week 2-1

Logistics

Reading

For today Zyante

- Ch 3 (functions)
- Ch 4 (conditionals)

For Thursday

- Ch 5 (iteration)
- Ch 6 (arrays)

Exam 1

- Next Week Thursday
- Zyante Ch 1-6
- This week's Material Included

HW 1

- Due tonight by 11:59 pm on Blackboard
- Don't forget directory structure: `ckauffm2-hw1`
- Don't forget `ID.txt`

HW 2

- Up tomorrow morning, due next Tuesday
- Conditionals, loops, possibly some arrays

HW 1

Spec

Questions?

Today

- ☒ Comments
- ☒ Statements/Expressions
- ☒ Variable Types
- ☒ Assignment
- ☒ Basic Input/Output
- ☐ Function Declarations (Session 1)
- ☐ Conditionals (if-else) (Session 2)
- ☐ Iteration (loops)
- ☐ Aggregate data (arrays, structs, objects, etc)
- ☒ Library System

Goals

- Write functions
- Vague idea of low level execution
- Zyante Ch 3
  - Many more details in Ch 3 than we'll discuss
  - Ex: Loops/Conditionals in functions
  - Ex: Pass by pointer
  - Read that material and try to understand
  - These will become clearer in the near future

Functions

- What's a function?
  - Traditional Math?
  - Programming?
- Why write code with functions?

Terminology

Function ≡ Procedure ≡ Method ≡ Routine ≡ Action Abstraction

Parts: Return Type, Name, Arguments, Body

```
return_type function_name(arg_type1 arg1, arg_type2 arg2){
  body_line_1;
  body_line_2;
  ...
  return something_of_return_type;
}
```

Examples

```
int halve(int arg){
  int result = arg / 2;
  return result;
}
```

```
void print_greeting(){
  printf("Welcome to");
  printf("functionland\n.");
}
```

Whitespace is arbitrary

Other frequent arrangments of functions

```
return_type function_name_2(arg_type1 arg1,
                            arg_type2 arg2){
  body_line_1;
  body_line_2;
  ...
  return something_of_return_type;
}
```

```
return_type
function_name_2(arg_type1 arg1,
                arg_type2 arg2)
{
  body_line_1;
  body_line_2;
  ...
  return something_of_return_type;
}
```

Calling Functions

Calling ≡ Invoking ≡ Run Body with Actual Parameters

```
int halve(int arg){
  int result = arg / 2;
  return result;
}

int main(){
  int n = 12;
  int halved = halve(n);
  printf("n is %d and half n is %d\n",
         n,halved);

  printf("Halve 19 now: %d\n",halve(19));
  return 0;
}
```

- `arg` is the formal parameter to `halve`
- Takes on actual value 12 and 19 during `main`

Declarations vs Definitions

Prototypes Declare a function exists

- Return Type
- Name
- Number and Types of Arguments

```
int my_function(double x, int y, char c);
```

Definition of functions involve a body

```
int my_function(double x, int y, char c){
  do_something;
  do_something_else;
  ...;
  return an_int;
}
```

Sample of Prototype then Definition

```
/* Get some prototypes of mathy stuff*/
#include <math.h>

/* Prototype: name and types only */
int my_function(double x, int y, char c);

/* Definition of function */
int my_function(double x, int y, char c){
  double result = x*2;
  result = result + y;
  result = result - ((int) c);
  return (int) floor(result);
}
```

Exercises

Write this function

```
// Normalize a score by subtracting the mean
// and dividing by the standard deviation
double normalize(double score,
                 double mean,
                 double stddev);

// Return the positive root of the quadratic
// defined by a*x^2 + b*x + c; this is found
// by adding the sqrt of the discriminat
// in the quadratic equation rather than
// subtracting it
double pos_root(double a, double b, double c);
```

Declaration and Definition may be in different files

Often divide function declaration of functions into Header files (.h) and Implementation files (.c).

Declaration `numerical.h`

```
// Example header file
#ifndef NUMERICAL_H
#define NUMERICAL 1

// Return half the argument given
int halve(int arg);

// Normalize a score by subtracting the mean
// and dividing by the standard deviation
double normalize(double score,
                 double mean,
                 double stddev);

// Return the positive root of the quadratic
// defined by a*(x*x) + b*x + c; this is found
// by adding the sqrt of the discriminat
// in the quadratic equation rather than
// subtracting it
double pos_root(double a, double b, double c);

#endif
```

Definitions in `numerical.c`

```
#include <math.h>
#include "numerical.h"

int halve(int arg){
  int result = arg / 2;
  return result;
}

double normalize(double score,
                 double mean,
                 double stddev){
  return (score - mean) / stddev;
}

double pos_root(double a, double b, double c){
  double discriminant = b*b - 4*a*c;
  double rootDiscr = sqrt(discriminant);
  double root1 = (-b + rootDiscr) / (2 * a);
  return root1;
}
```

A very special function: main

Where the action begins - a time-honored C convention

- Programs have a main
- Libraries (usually) don't
- Notice: numerical.c has no main()
- Does not comprise a program, only a library of functions
- numerical_main.c does have a main but not definitions of numerical functions, only header numerical.h
- Compile all together

```
> gcc numerical.c
(.text+0x20):
  undefined reference to ‘main’
collect2: error:
  ld returned 1 exit status

> gcc numerical_main.c
/tmp/ccIqZXiy.o: In function ‘main’:
numerical_main.c:(.text+0x15):
  undefined reference to ‘halve’
numerical_main.c:(.text+0x39):
  undefined reference to ‘halve’
collect2: error:
  ld returned 1 exit status

> gcc numerical.c numerical_main.c
> ./a.out
n is 12 and half n is 6
Halve 19 now: 9
Input a b c: 12 3 -5
Pos root is 0.5325
```

Returning Things

With `return`, see `returns.c`

- What about 2 or 3 or more return values?

Blocks and Scope

Blocks defined by `{ }`

- Groups code together
- Defines a scope
  - Variable visibility
  - Hierarchy of scopes
  - Contrast: Python

What can a function *see*?

Functions have their own scope

- Arguments
- Global data/functions
- Its block variables

See `scopes.c`, `scopes2.c`, `badscopes.c`

Call Stack

Functions call functions call functions

- Compiler/Runtime keeps track
- Easy to draw

Under the Hood

Functions are translated to memory manipulations

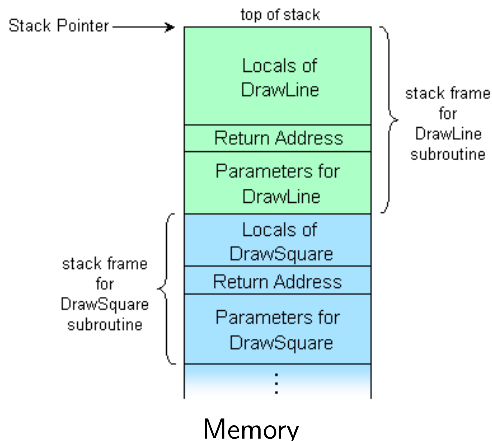
- Caller `f` is executing
- Callee `g` is being called by `f`
- Caller `f`: push args onto stack, save registers, jump to `g`
- Callee `g`: execute, put answer on stack, jump back (to `f`)
- Caller `f`: restore registers, grab answer, continue

Demonstrate with `callstack.c`

The Stack

A spot in memory

- Data for each function call
- Arguments, locals, return value



Inlining

Jumping around can be expensive

- Instructions to save registers, push args
- Inline means copy definition there

```
inline int max(int a, int b) {
  return a > b ? a : b;
}
```

- Suggests compiler inline a function
- No guarantees of speed
- Compiler may not honor
- May inline without you saying it

How long?

Using functions is good, right?

- How do you decompose a large problem into functions?
- What merits a function?
- How long should a function be?

Try Code Complete by Steve McConnel

- Online At GMU Library

This is a quality of people, not machines.

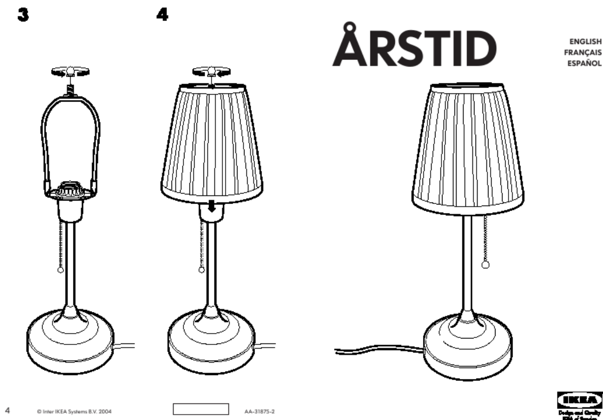
BREAKTIME

Back in 15 minutes

Goals

- Zyante Chapter 4
- Conditionals
- Comparing Numbers
- `switch/case` (maybe...)

Making Choices



Straightline code is about as interesting as Ikea instructions: rigid.

Simplest Form of `if`

```
Always do this;
if(condition)
  sometimes do this;
Always do this;

Always;
if(condition){
  sometimes this;
  and this;
  and this;
}
Always;
```

See `if_test.c`

Using Blocks

CK's preference - always use

```
if(...){
  ...
  ...
}
```

Do what works for you

- Or what your boss forces you to do

Comparing things

Operator	Meaning
`=`	Assignment, **NOT** comparison
`==`	Equality test
`!=`	Inequality
`< >`	Less / Greater
`<= >=`	Less than equal / Greater than equal

See `comparisons.c`

Consequence and Alternative

Often have 2 cases, C provides nice syntax

```
Always;
if(cond){
  do when true;
}
else{
  do when false;
}
Always;
```

Boolean Combinations

To combine conditions

Test more than one thing at once

&&	and
||	or
!	not

See `booleancomb.c`

Truthy/Falsey

Which things are truthy and falsy in C again?

Combining if elses

Nesting Arbitrary nesting of conditionals, `nesting.c`

Chaining Mutually exclusive cases, `chaining.c`

Gotchyas

Two very common errors

```
// Different meaning than intended
if(cond)
  do me;
  do me too;
always;


// Not accepted by compiler
if( 0 <= i <= 10)
```

Exercises

Define an absolute value function for single integers

```
int a = abs(7);  // 7
int b = abs(-2); // 2
int c = abs(0);  // 0
```

Define an *absolute minimum* function for three real numbers

```
double x = absmin3( 1.4, 0.5, -2.8); // 0.5
double y = absmin3(-1.4, 0.5, -0.1); // 0.1
double z = absmin3(-1.4, 5.5, -6.1); // 1.4
```

Note on true/false

C standard does allow for use of keywords `true` and `false` with type `bool` by including the `stdbool.h` header.

`booleancheck.c`:

```
/* Demonstrate the use of stdbool.h to define the names true
   false */
#include <stdio.h>
#include <stdbool.h>

int main(){
  bool t = true;                /* defined to be 1 */
  bool f = false;               /* defined to be 0 */
  printf("%d %d\n",t,f);
}
```

Composing

- Conditionals are `if/else`, `switch/case`
- Conditionals inside functions
- Conditionals inside other conditionals
  - Nesting `if/else`
  - Nesting `switch/case`
- Functions inside conditionals?
  - Sort of - preprocessor as `#IF`
- Functions inside functions?
  - Go-go gadget `gcc`

Wrap-Up

- ☒ Comments
- ☒ Statements/Expressions
- ☒ Variable Types
- ☒ Assignment
- ☒ Basic Input/Output
- ☒ Function Declarations
- ☒ Conditionals (if-else)
- ☐ Iteration (loops)
- ☐ Aggregate data (arrays, structs, objects, etc)
  - Sans memory ops
- ☒ Library System

Exam 1 Next Week