Lab 1: C

CS 105

Fall 2020

Variables

- Declaration

$$\underbrace{\texttt{int}}_{\text{type}}\ \underbrace{\texttt{myVariable}}_{\text{name}}\underbrace{\texttt{;}}_{\text{semi-colon}}$$

- Assignment

$$\underbrace{\texttt{myVariable}}_{\text{name}}\ \texttt{=}\ \underbrace{\texttt{47}}_{\text{value}}\underbrace{\texttt{;}}_{\text{semi-colon}}$$

- Declaration and assignment

```
int myVariable = 47;
```

C Data Type	x86-64
char	1
unsigned short	2
unsigned int	4
unsigned long	8
short	2
int	4
long	8
float	4
double	8

Operations

- Bitwise Operations: `&`, `|`, `^`, `~`

```
int x = 47;
int y = ~x;
y = x & y;
```

- Logical Operations: `&&`, `||`, `!`

```
int x = 47;
int y = !x;
y = x && y;
```

- Arithmetic Operations: `+`, `-`, `*`, `/`, `%`

```
int x = 47;
int y = x + 13;
y = (x * y) % 5;
```

- Boolean Operators: `==`, `!=`, `>`, `>=`, `>`, `>=`

```
int x = (13 == 47);
```

Control Flow

Conditionals

```
int x = 13;
int y;
if (x == 47){
  y = 1;
} else {
  y = 0;
}
```

While Loops

```
int x = 47;

while (x > 0){
  x = x - 1;
}
```

Do-While Loops

```
int x = 47;
do {
  x = x - 1;
} while (x > 0);
```

For Loops

```
int x = 0;
for (int i=0; i < 47; i++){
  x = x + i;
}
```

Functions

Declaring a Function

```
int myFunction(int x, int y){

  int z = x - 2*y;
  return z * x;

}
```

Calling a Function

```
int a;

a = myFunction(47, 13);
```

Exercise 1

- Open a file called part1.c In that file, define a function that takes two integers and returns an integer. If the second integer argument is greater than (or equal to) the first, it returns the sum of the integer values between those two numbers (inclusive). Otherwise it returns -1.

Hello World

```
#include<stdio.h>

int main(int argc, char** argv){
  printf("Hello world!\n");
  return 0;
}
```

Aside: Printing

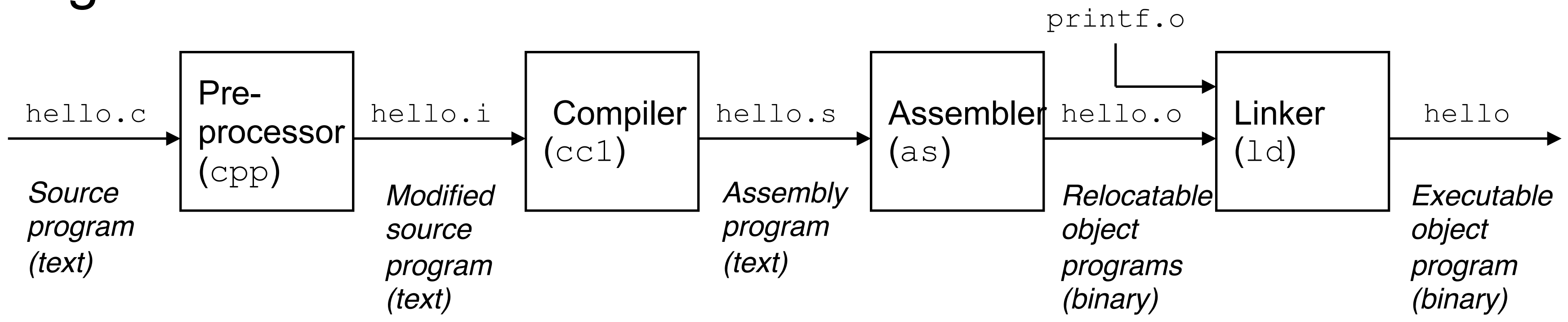
```
printf("Hello world!\n");

printf("%d is a number\n");

printf("%d is a number greater than %f\n”, 47, 3.14);
```

Compilation

- $\overbrace{\text{gcc}}^{\text{compiler}}\ \overbrace{\text{–o hello}}^{\text{output name}}\ \overbrace{\text{hello.c}}^{\text{filename}}$



```
#include<stdio.h>

int main(int argc,
         char ** argv){

  printf("Hello
          world!\n");
  return 0;
}
```

```
…
int printf(const char *
           restrict,
           ...)
__attribute__((__format_
_ (__printf__, 1, 2)));
…
int main(int argc,
         char ** argv){

  printf("Hello
          world!\n");
  return 0;
}
```

```
pushq    %rbp
movq     %rsp, %rbp
subq   $32, %rsp
leaq   L_.str(%rip), %rax
movl   $0, -4(%rbp)
movl   %edi, -8(%rbp)
movq   %rsi, -16(%rbp)
movq   %rax, %rdi
movb   $0, %al
callq _printf
xorl   %ecx, %ecx
movl   %eax, -20(%rbp)
movl   %ecx, %eax
addq   $32, %rsp
popq   %rbp
retq
```

```
55
48 89 e5
48 83 ec 20
48 8d 05 25 00 00 00
c7 45 fc 00 00 00 00
89 7d f8
48 89 75 f0
48 89 c7
b0 00
e8 00 00 00 00
31 c9
89 45 ec
89 c8
48 83 c4 20
5d
c3
```

Running a Program

- ./hello

Exercise 1b

- Add a main function to your part1.c file that calls your function with some hardcoded arguments and prints the value it returns. Then compile and run your program.

Arrays

- Contiguous block of memory
- Random access by index
  - Indices start at zero

- Declaring an array:

```
int array1[5]; // array of 10 ints named array1

char array2[47]; // array of 47 chars named array2

int array3[7][4]; // two dimensional array
```

- Accessing an array:

```
int x = array1[0];
```

- The array variable stores the address of the first element in the array

Pointers

- Pointers are addresses in memory (i.e., indexes into the array of bytes)
- Most pointers declare how to interpret the value at (or starting at) that address
- Examples:

```
int * ptr = &myVariable;
char * ptr2 = (char *) ptr;
```

- Dereferencing pointers:

```
int var2 = *ptr
char c = *ptr2;
```

Pointer Types	x86-64
void *	8
int *	8
char *	8
⋮	8

& and * are inverses of one another

Pointer Arithmetic

```
int * ptr = &myVariable;
ptr += 1;

char * ptr2 = (char *) ptr;
ptr2 += 1;
```

- Location of `ptr+k` depends on the type of `ptr`
- adding 1 to a pointer `p` adds `1*sizeof(*p)` to the address

- `array[k]` is the same as `*(array+k)`

Strings

- Strings are just arrays of characters
- End of string is denoted by null byte `\0`

- generally declared as type `char *`

Aside: Main Function Parameters

```c
#include<stdio.h>

int main(int argc, char** argv){
  printf("Hello world!\n");
  return 0;
}
```

Exercise 2

- Open a file called part2.c. In that file, write a program that computes the pair of unsigned integers x, y such that the array [x, y] has the same binary representation as the string “CS 105!”

Hint: you can do this entirely with pointer arithmetic and casts. You don’t need to compute it by hand using the ASCII table (although you can!)

Structs

- Heterogeneous records, like objects
- Typical linked list declaration:

```
typedef struct cell {
  int value;
  struct cell *next;
} cell_t;
```

- Usage:

```
cell_t c;
c.value = 42;
c.next = NULL;
```

- Usage with pointers:

```
cell_t *p;
p->value = 42;
p->next = NULL;
```

`p->next` is an abbreviation for `(*p).next`

Exercise 3

- Implement a linked list