Lab 1: C

CS 105

Variables

- Declaration

```
int myVariable;
```

type name semi-colon

- Assignment

```
myVariable = 47;
```

name value 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

- Create a file called part1.c (don’t worry about running it yet)
- 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;
}
```

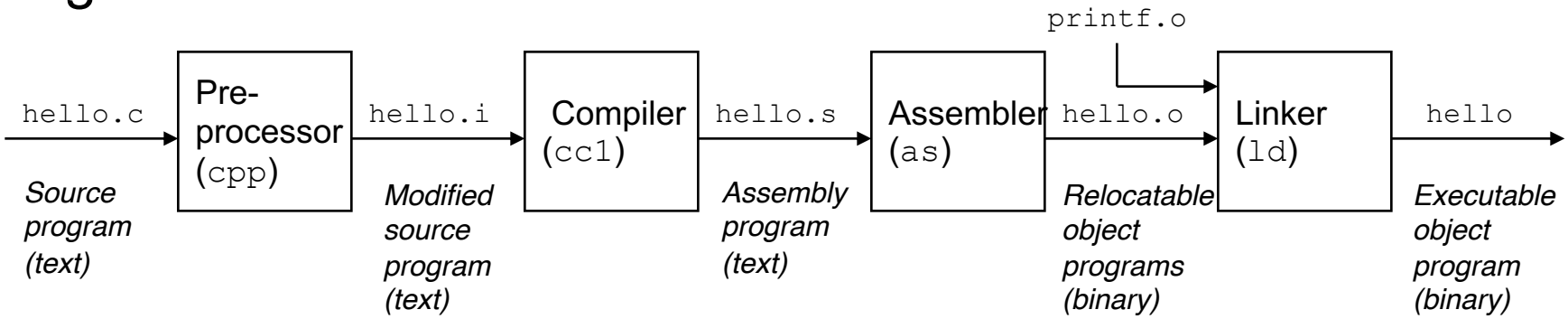
Aside: Printing

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

printf("%d is a number\n”, 13);

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

Compilation

compiler output name filename

- gcc –o hello hello.c




```
#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.c demo

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 5 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

```
#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