CSC231—Bash Labs

Week #10 — Spring 2017

Introduction to C

Dominique Thiébaut
dthiebaut@smith.edu
Learning C in 4 Hours!

D. Thiebaut
- Dennis Ritchie
- 1969 to 1973
- AT&T Bell Labs
- Close to Assembly
- Unix
- Standard
- Many languages based on C. (C++, Obj. C, C#)
- Many influenced by C (Java, Python, Perl)
C Lacks...

- Exceptions
- Garbage collection
- OOP
- Polymorphism
- But...
C Lacks...

- Exceptions
- Garbage collection
- OOP
- Polymorphism
- But... it is usually faster!
Good Reference

• Essential C, by Nick Parlante, Stanford U.  
  http://cslibrary.stanford.edu/101/EssentialC.pdf
Hello World!

- Library
- Strings
- Block-structured language
- main()

```c
#include <stdio.h>

void main() {
    printf("\nHello World\n");
}
```
Hello World!

- Library
- Strings
- Block-structured language
- main()

```c
#include <stdio.h>

void main() {
    printf("\nHello World\n");
}
```
• gcc Gnu compiler
• man gcc for help

[~/handout]$ gcc hello.c
[~/handout]$ ./a.out
Hello World

[~/handout]$ gcc -o hello hello.c
[~/handout]$ ./hello
Hello World
[~/handout]$ ls -l
total 28
-rwx------ 1 352a 352a 6583 Oct 6 16:41 a.out*
-rwx------ 1 352a 352a 6583 Oct 6 16:48 hello*
-rw------- 1 352a 352a   66 Oct 6 16:41 hello.c
-rw------- 1 352a 352a   67 Oct 6 16:39 hello.c~
Exercise

- Write your own Hello World! program
- Make it print something like:

  ********************
  * C Rocks! *
  ********************
The GNU C Reference Manual

Table of Contents

- The GNU C Reference Manual
- Preface
  - Credits
- 1 Lexical Elements
  - 1.1 Identifiers
  - 1.2 Keywords
  - 1.3 Constants
    - 1.3.1 Integer Constants
    - 1.3.2 Character Constants
    - 1.3.3 Real Number Constants
    - 1.3.4 String Constants
  - 1.4 Operators
  - 1.5 Separators
  - 1.6 White Space
- 2 Data Types
  - 2.1 Primitive Data Types
    - 2.1.1 Integer Types
    - 2.1.2 Real Number Types
    - 2.1.3 Complex Number Types

Printing

- `printf( "string with %-operators", list of vars);`
  - `%d int`
  - `%f float`
  - `%s string`
• Simple types
• No strings!
• No booleans (only 0 for false and !0 for true)
• No classes, no objects!

int    -> integer variable
short  -> short integer
long   -> long integer
float  -> single precision real (floating point) variable
double -> double precision real (floating point) variable
char   -> character variable (single byte)
/*
programName.c
author

This is the header */
#include <stdio.h>
#include <string.h>

void main() {
    // line comment
    printf( "Hello!\n" )
}

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

void main() {
    char hello[] = "hello";
    char world[] = "world!";
    char sentence[100] = ""
;
    strcpy( sentence, hello ); // sentence <- "hello"
    strcat( sentence, " " ); // sentence <- "hello "
    strcat( sentence, world ); // sentence <- "hello world!"

    printf( "sentence = %s\n", sentence );
}

[~/handout]$ gcc strings2.c
[~/handout]$ a.out

sentence = hello world!
[~/handout]
Strings end with ‘\0’

```c
#include <stdio.h>
#include <string.h>

void main() {
    char sentence[100] = "Hello world!";

    printf( "sentence = %s\n", sentence );
    sentence[5] = '\0';
    printf( "sentence = %s\n", sentence );
}
```

```
~/handout]$ a.out
sentence = Hello world!
sentence = Hello
[~/handout]$
```
#include <stdio.h>
#include <string.h>

void main() {
    int a = 3;
    int b = 5;
    int c = 0;
    char firstName[] = "your first name here";
    char lastName[] = "your last name here";
    char fullName[100];
    ...
}

- make the program store the sum of a and b into c, and then print your full name and the value in c. Also, make it output the number of characters in your full name; it must count the number of chars using a string function (use strlen).
#include <stdio.h>

void main() {
    int i;
    int sum = 0;

    // compute the sum of all the numbers from 1 to 100
    for ( i=1; i<=100; i++ ) {
        sum += i;
    }

    printf( "\nsum = %d\n\n", sum );
}
```c
#include <stdio.h>

void main() {
    int i;
    int sum = 0;

    // compute the sum of all the numbers from 1 to 100
    i = 1;
    while ( i<=100 ) {
        sum += i;  // could have also used i++
        i += 1;
    }

    printf( "\nsum = %d\n\n", sum );
}
```
# Infinite Loops

```c
#include <stdio.h>

void main() {

    while ( 1 ) {
        printf( "hello!\n" );
    }
}
```

```c
#include <stdio.h>

void main() {

    for ( ;; ) {
        printf( "hello!\n" );
    }
}
```
We stopped here last time.
Exercise

• Write a program that displays your full name underlined (line of dashes below). The underline length must be computed and the number of characters equal to the number of characters in your full name.

Hints: strlen() returns # of chars

man strlen
Write a program that displays a triangle of $N$ lines of stars:

*  
**  
***  
****  
*****
#include <stdio.h>
#define NAME      "Mickey"
#define HEIGHT    5
#define YEARBORN  1928

void main() {
  printf( "%s is %d inches high, and was created in %d\n\n", 
    NAME, HEIGHT, YEARBORN );
}
#include <stdio.h>

define NAME "Mickey"
define HEIGHT 5
define YEARBORN 1928

void main() {
    printf("%s is %d inches high, and was created in %d\n\n", "Mickey", 5, 1928);
}
#include <stdio.h>

void main() {
    int a = 5;
    int b = 3;
    int c = 7;

    if ( a <= b && a <= c )
        printf( "%d is the smallest\n\n", a );
    else if ( b <= a && b <= c )
        printf( "%d is the smallest\n\n", b );
    else
        printf( "%d is the smallest\n\n", c );
}
Conditionals

&&    and

||    or

!     not
switch ( ordinal_expression ) {
    case ordinal_value: {
        // ...
        break;
    }
    case ordinal_value: {
        // ...
        break;
    }
    default: {
        // ...
    }
}
switch (ordinal_expression) {
    case ordinal_value: {
        // ...
        break;
    }
    case ordinal_value: {
        // ...
        break;
    }
    default: {
        // ...
    }
}
Pointers
float x = 6.5;
float* px = &x;
#include <stdio.h>
#define SIZE 10

int main() {
    float A[SIZE];
    int i;

    for ( i=0; i<SIZE; i++ )
        A[i] = i;

    for ( i=0; i<SIZE; i++ )
        printf( "A[%d] = %.2f\n", i, A[i] );
}
Example: Initialize an Array

```c
#include <stdio.h>
#define SIZE 10

void main() {
    float A[SIZE];
    float* p;
    int i;

    p = A;
    for ( i=0; i<SIZE; i++ ) {
        *p = i;
        p++;
    }

    p = A;
    for ( i=0; i<SIZE; i++ ) {
        printf( "p=%p A[%d] = %1.2f *p = %1.2f\n",
            p, i, A[i], *p );
        p = p + 1;
    }
}
```
a.out

p=0x7fff88d54560 A[0] = 0.00 *p = 0.00
p=0x7fff88d54564 A[1] = 1.00 *p = 1.00
p=0x7fff88d54568 A[2] = 2.00 *p = 2.00
p=0x7fff88d5456c A[3] = 3.00 *p = 3.00
p=0x7fff88d54570 A[4] = 4.00 *p = 4.00
p=0x7fff88d54574 A[5] = 5.00 *p = 5.00
p=0x7fff88d54578 A[6] = 6.00 *p = 6.00
p=0x7fff88d5457c A[7] = 7.00 *p = 7.00
p=0x7fff88d54580 A[8] = 8.00 *p = 8.00
p=0x7fff88d54584 A[9] = 9.00 *p = 9.00
Arrays

```
TYPE v[DIM];
TYPE* pv;

pv = v;
```
Arrays

- The name of an array is a pointer to the first cell of the array.

```
char name[DIM];
```

- name is the same as \&(name[0])
* has two meanings, depending on context
  • “Pointer to”
  • “Contents of”

& means “the address of”
* and &

```c
int A[DIM];
int* p = A; // "int pointer p"
int *q = &A[0]; // "int pointer q"

*p = 3; // what p is pointing to gets 3
*(q+1) = 5; // what q is pointing to gets 5
```
Write a C program that copies Array A into Array B using indexing, and then using pointers.

```c
#define DIM 10
int A[DIM];
int B[DIM];
int i;

for ( i=0; i<DIM; i++ ) A[i] = 13*i % 11;
```
Exercise

```c
#define DIM 10
int A[DIM];
int i;

for ( i=0; i<DIM; i++ ) A[i] = 13*i % 11;
```

- Write a C program that finds the largest integer in Array A, using pointers.
We stopped here last time...
Functions

- Functions are always declared before they are used.
- Functions can return values of simple types (int, char, floats), and even pointers.
- Functions get parameters of simple types, and pointers.
- Passing by value is automatic. Passing by reference requires passing a pointer.
```c
#include <stdio.h>

int sum( int a, int b ) {
    return a+b;
}

void main() {
    int x = 10;
    int y = 20;
    int z;

    z = sum( x, y );
    printf( "z = %d\n", z );

    z = sum( 3, 8 );
    printf( "z = %d\n", z );

    printf( "sum( 11, 22) = %d\n", sum( 11, 22 ) );
}
```

```
z = 30
z = 11
sum( 11, 22) = 33
```
#include <stdio.h>

void sum2( int a, int b, int  c ) {
    c = a+b;
}

void main() {
    int x = 10;
    int y = 20;
    int z;

    sum2( x, y,   z );
    printf( "z = %d\n", z );

    sum2( 3, 8,   x );
    printf( "x = %d\n", x );
}

z = 30
x = 11
#include <stdio.h>

void main() {
    int age;
    float myPi;
    char name[80];

    printf( "Enter your name, please: " );
    fgets( name, sizeof(name) stdin );
    // will truncate to first
    // 80 chars entered

    printf( "Enter your age: " );
    scanf( "%d", &age );

    printf( "Enter your version of pi: " );
    scanf( "%f", &myPi );

    printf( "%s is %d years old, and thinks pi is %1.10f\n\n", name, age, myPi );
}

a.out
Enter your name, please: Mickey
Enter your age: 21
Enter your version of pi: 3.14159
Mickey is 21 years old, and thinks pi is 3.1415901184
Exercise

• Write a C program (no functions) that finds the smallest, the largest, and computes the sum of all the ints in A.

• Write another program that does the same thing but uses functions. The results are passed using return statements
Exercise

- Write another program that does the same thing but uses functions, and this time the results are passed back by reference.
Dynamic Variables
#include <stdio.h>
#include <stdlib.h>

void main() {
    int *A, N, i, smallest;

    printf( "How many ints? " );
    scanf( "%d", &N );
    A = (int *) malloc( N * sizeof( int ) );

    for ( i=0; i<N; i++ ) {
        printf( "> " );
        scanf( "%d", &(A[i]) );
    }

    smallest = A[0];
    for ( i=1; i<N; i++ )
        if ( A[i] < smallest )
            smallest = A[i];
    free( A );

    printf( "The smallest = %d\n", smallest );
}
Exercise

• Modify the previous program that computed the min and max of an array, but this time you allocate the array dynamically from the user input, i.e. ask the user for number of ints, then the ints.

(use scanf("%d",&x) to get an int from keyboard into x)
sizeof() can be tricky…
```c
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

int main( int argc, char* argv[] ) {
    int A[] = { 1, 2, 3, 4, 5 };
    int *B = (int *) malloc( 5 * sizeof( int ) );
    int *p = A;
    char name[] = "Smith College";
    int a = 3;
    float x = 3.14159;
    int i;

    for ( i=0; i<5; i++ ) B[i] = i;

    printf( "sizeof(A)    = %lu\n", sizeof( A ) );
    printf( "sizeof(A[0]) = %lu\n", sizeof( A[0] ) );
    printf( "sizeof(B)    = %lu\n", sizeof( B ) );
    printf( "sizeof(B[0]) = %lu\n", sizeof( B[0] ) );
    printf( "sizeof(p)    = %lu\n", sizeof( p ) );
    printf( "sizeof(*p)   = %lu\n", sizeof( *p ) );
    printf( "sizeof(name) = %lu\n", sizeof( name ) );
    printf( "strlen(name) = %lu\n", strlen( name ) );
    printf( "sizeof(a)    = %lu\n", sizeof( a ) );
    printf( "sizeof(x)    = %lu\n", sizeof( x ) );

    return 0;
}
```
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

int main( int argc, char* argv[] ) {
    int A[] = { 1, 2, 3, 4, 5 };
    int *B = (int *) malloc( 5 * sizeof( int ) );
    int *p = A;
    char name[] = "Smith College";
    int a = 3;
    float x = 3.14159;
    int i;

    for ( i=0; i<5; i++ ) B[i] = i;

    printf( "sizeof(A)    = %lu\n", sizeof( A ) );
    printf( "sizeof(A[0]) = %lu\n", sizeof( A[0] ) );
    printf( "sizeof(B)    = %lu\n", sizeof( B ) );
    printf( "sizeof(B[0]) = %lu\n", sizeof( B[0] ) );
    printf( "sizeof(p)    = %lu\n", sizeof( p ) );
    printf( "sizeof(*p)   = %lu\n", sizeof( *p ) );
    printf( "sizeof(name) = %lu\n", sizeof( name ) );
    printf( "strlen(name) = %lu\n", strlen( name ) );
    printf( "sizeof(a)    = %lu\n", sizeof( a ) );
    printf( "sizeof(x)    = %lu\n", sizeof( x ) );

    return 0;
}
```c
#include <stdio.h>
#include <string.h>
#include <stdlib.h>

int main( int argc, char* argv[] ) {
    int A[] = { 1, 2, 3, 4, 5 };
    int *B = (int *) malloc( 5 * sizeof( int ) );
    int *p = A;
    char name[] = "Smith College";
    int a = 3;
    float x = 3.14159;
    int i;

    for ( i=0; i<5; i++ ) B[i] = i;

    printf( "sizeof(A)    = %lu\n", sizeof( A ) );
    printf( "sizeof(A[0]) = %lu\n", sizeof( A[0] ) );
    printf( "sizeof(B)    = %lu\n", sizeof( B ) );
    printf( "sizeof(B[0]) = %lu\n", sizeof( B[0] ) );
    printf( "sizeof(p)    = %lu\n", sizeof( p ) );
    printf( "sizeof(*p)   = %lu\n", sizeof( *p ) );
    printf( "sizeof(name) = %lu\n", sizeof( name ) );
    printf( "strlen(name) = %lu\n", strlen( name ) );
    printf( "sizeof(a)    = %lu\n", sizeof( a ) );
    printf( "sizeof(x)    = %lu\n", sizeof( x ) );

    return 0;
}
```

Different!

- sizeof(A) = 20
- sizeof(A[0]) = 4
- sizeof(B) = 8
- sizeof(B[0]) = 4
- sizeof(p) = 8
- sizeof(*p) = 4
- sizeof(name) = 14
- strlen(name) = 13
- sizeof(a) = 4
- sizeof(x) = 4
```c
#include <stdio.h>

void main() {
    FILE *fp;
    int i;
    char name[] = "Smith College";

    fp = fopen("hello.txt", "w");  // open file for writing
    fprintf(fp, "\nHello ");      // write constant string
    fprintf(fp, "%s\n\n", name );  // write string

    fclose(fp);                    // close file
}
```
#include <stdio.h>

void main() {
    FILE *fp;
    char line[80];

    fp = fopen( "fgets2.c", "r" );  // open file for reading

    while ( !feof( fp ) ) {         // while not eof
        fgets( line, 80, fp );      // get at most 80 chars
        if ( feof( fp ) )           // if eof reached stop
            break;
        line[79] = '\0';            // truncate line to be safe
        printf( "%s", line );       // print it
    }

    fclose( fp );                    // close file
}
File I/O: Input Numbers

[~handout] `cat fileOfInts.txt`

4
1 2 3
4 5 6
7 8 9
10 11 12
#include <stdio.h>

void main() {
    FILE *fp;
    char line[80];
    int N, n1, n2, n3;

    fp = fopen( "fileOfInts.txt", "r" ); // 1st number is # of lines
    // then 3 ints per line

    if ( feof( fp ) ) {
        printf( "Empty file!

" );
        return;
    }

    // get the number of lines
    fscanf( fp, "%d", &N );

    while ( !feof( fp ) ) {
        fscanf( fp, "%d %d %d", &n1, &n2, &n3 );
        if ( feof( fp ) )
            break;
        printf( "%d, %d, %d
", n1, n2, n3 );
    }

    fclose( fp );
}
File I/O: Reading Ints

[~handout]  a.out
1, 2, 3
4, 5, 6
7, 8, 9
10, 11, 12
Exercise

• At the Bash prompt type:

```bash
cat > data.txt
4
10
1
2
3
^D
```

• Write a program that reads the file data.txt, which has the number of ints in contains on the first line, then one int per line for the rest of the file. Your program must use a dynamically created array to store the numbers, and find the min and max of the array, and print them.
Function Prototypes and Multiple-File Projects