

# (1-1) C Review: Pointers, Arrays, Strings, & Structs

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# Crash Review on Critical C Topics

- Pointers
- Arrays
- Strings
- Structs



# CS Discord

- <https://discord.com/invite/TkMb3deW>



# Pointers



# Pointer Review (1)

- A pointer variable contains the address of another cell containing a data value
- Note that a pointer is “useless” unless we make sure that it points somewhere:

```
- int num = 3, int *nump = &num;
```

*nump* is positioned under `int` and `*nump`. *num* is positioned under `&num`.



- The *direct* value of *num* is 3, while the *direct* value of *nump* is the address (1000) of the memory cell which holds the 3



# Pointer Review (2)

- The integer 3 is the *indirect* value of *nump*, this value can be accessed by following the pointer stored in *nump*
- If the indirection, dereferencing, or “pointer-following” operator is applied to a pointer variable, the indirect value of the pointer variable is accessed
- That is, if we apply *\*nump*, we are able to access the integer value 3
- The next slide summarizes...



# Pointer Review (3)



Reference	Explanation	Value
<code>num</code>	Direct value of <code>num</code>	3
<code>nump</code>	Direct value of <code>nump</code>	1000
<code>*nump</code>	Indirect value of <code>nump</code>	3
<code>&amp;nump</code>	Address of <code>nump</code>	2000



# Pointers as Function Parameters (1)

- Recall that we define an output parameter to a function by passing the address (&) of the variable to the function
- The output parameter is defined as a pointer in the formal parameter list
- Also, recall that output parameters allow us to return more than one value from a function
- The next slide shows a long division function which uses *quotientp* and *remainderp* as pointers





# Pointers as Function Parameters (2)

- Function with Pointers as Output Parameters

```
#include <stdio.h>

void long_division (int dividend, int divisor, int *quotientp, int *remainderp);

int main (void)
{
    int quot, rem;

    long_division (40, 3, &quot, &rem);
    printf ("40 divided by 3 yields quotient %d ", quot);
    printf ("and remainder %d\n", rem);

    return 0;
}

void long_division (int dividend, int divisor, int *quotientp, int *remainderp)
{
    *quotientp = dividend / divisor;
    *remainderp = dividend % divisor;
}
```



# Arrays



# What is an array?

- A sequence of items that are contiguously allocated in memory
- All items in the array are of the same data type and of the same size
- All items are accessed by the same name, but a different index
- The length or size is fixed



# More About Arrays

- An array is a data structure
  - A data structure is a way of storing and organizing data in memory so that it may be accessed and manipulated efficiently



# Uses for Arrays?

- Store related information
  - Student ID numbers
  - Names of players on the Seattle Seahawks roster
  - Scores for each combination in Yahtzee
  - Many more...



# The Many Dimensions of an Array

- A single dimensional array is logically viewed as a linear structure
- A two dimensional array is logically viewed as a table consisting of rows and columns
- What about three, four, etc., dimensions?



# Declaring a Single Dimensional Array (1)

- Arrays are declared in much the same way as variables:

```
int a[6];
```

declares an array `a` with 6 cells that hold integers:

<code>a[0]</code>	<code>a[1]</code>	<code>a[2]</code>	<code>a[3]</code>	<code>a[4]</code>	<code>a[5]</code>
10	12	0	89	1	91

Notice that array indexing begins at 0.



# Strings





# String Fundamentals

- A string is a sequence of characters terminated by the null character ('\0')
  - “This is a string” is considered a string literal
  - A string may include letters, digits, and special characters
- A string may always be represented by a character array, but a character array is not always a string
- A string is accessed via a pointer to the first character in it



# String Basics (1)

- As with other data types, we can even initialize a string when we declare it:

```
char name[20] = "Bill Gates";  
char *name = "Bill Gates";  
char name[] = {'B', 'i', 'l', 'l', ' ', 'G', 'a', 't', 'e',  
              's', '\\0'};  
  
// These are equivalent string declarations!
```

- Here's what the memory allocated to `name` looks like after either of the above is executed:

    null character (terminates all strings)

name	B	i	l	l		G	a	t	e	s	\0	?	?	?	?	?	?	?	?	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19



# String Basics (2)

- When a variable of type `char*` is initialized with a string literal, it may be placed in memory where the string can't be modified
- If you want to ensure modifiability of a string store it into a character array when initializing it



# String Basics (3)

- Arrays of Strings

- Suppose we want to store a list of students in a class
- We can do this by declaring an array of strings, one row for each student name:

```
#define NUM_STUDENTS 5
#define MAX_NAME_LENGTH 31
char student_names[NUM_STUDENTS][MAX_NAME_LENGTH];
```

- We can initialize an array of strings "in line":

```
char student_names[NUM_STUDENTS][MAX_NAME_LENGTH] =
{"John Doe", "Jane Smith", "Sandra Connor", "Damien White",
 "Metilda Cougar"};
```

- In most cases, however, we're probably going to want to read the names in from the keyboard or a file...



# String Basics (4)

- Use `gets()` to read a complete line, including whitespace, from the keyboard until the `<enter>` key is pressed; the `<enter>` is not included as part of the string
  - Usage: `gets(my_array)`
  - If the user enters “Bill Gates” and presses `<enter>`, the entire string will be read into `my_array` excluding the `<enter>` or newline
- Use `puts()` to display a string followed by a newline
  - Usage: `puts(my_array)`



# String Manipulation in C (1)

- Standard operators applied to most numerical (including character) types cannot be applied to strings in C
  - The assignment operator (=) can't be applied except during declaration
  - The + operator doesn't have any true meaning (in some languages it means append)
  - The relational operators (==, <, >) don't perform string comparisons
  - Others?



# String Manipulation in C (2)

- The string-handling library `<string.h>` provides many powerful functions which may be used in place of standard operators
  - `strcpy ( )` or `strncpy ( )` replaces the assignment operator
  - `strcat ( )` or `strncat ( )` replaces the `+` or append operator
  - `strcmp ( )` replaces relational operators
  - Several others...i.e. `strtok ( )`, `strlen ( )`



# Pointers Representing Arrays and Strings (1)

- Consider representing two arrays as follows:
  - `double list_of_nums[20];`
  - `char your_name[40];`
- When we pass either of these arrays to functions, we use the array name without a subscript
- The array name itself represents the address of the initial array element





# Pointers Representing Arrays and Strings (2)

- Hence, when we pass the array name, we are actually passing the entire array as a pointer
- So, the formal parameter for the string *name* may be declared in two ways:
  - `char name[]`
  - `char *name`
- Note that, in general, it is a good idea to pass the maximum size of the array to the function, e.g.:
  - `void func (char *name, int size);`



# Structs



# struct Type (1)

- C supports another kind of user-defined type: the `struct`
- `structs` are a way to combine multiple variables into a single "package" (this is called "encapsulation")
- Sometimes referred to as an *aggregate*, where all variables are under one name
- Suppose, for example, that we want to create a database of students in a course. We could define a `student struct` as follows:



# struct Type (2)

```
typedef enum {freshman, sophomore, junior, senior}
            class_t; /* class standing */

typedef enum {anthropology, biology, chemistry,
            english, compsci, polisci,
psychology,
            physics, engineering, sociology}
            major_t; /* representative majors */

typedef struct
{
    int id_number;
    class_t class_standing; /* see above */
    major_t major; /* see above */
    double gpa;
    int credits_taken;
} student_t;
```



# struct Type (3)

- We can then define some students:

```
student_t student1, student2;  
student1.id_num = 123456789;  
student1.class_standing = freshman;  
student1.major = anthropology;  
student1.gpa = 3.5;  
student1.credits_taken = 15;  
student2.id_num = 321123456;  
student2.class_standing = senior;  
student2.major = biology;  
student2.gpa = 3.2;  
student2.credits_taken = 100;
```

Notice how we use the "." (selection) operator to access the "fields" of the struct



# More About Structs

- Recall structs are used to represent real world objects
- They contain attributes that describe these objects
  - Such as a car, where the attributes of the struct car could include steering wheel, seats, engine, etc.
  - Such as a student, where the attributes of the struct student could include ID#, name, standing, etc.
- In many cases, we need a list or array of these objects
  - A list of cars representing a car lot
  - A list of students representing an attendance sheet



# Arrays of Structs (1)

- Let's first define a struct student

```
typedef struct student
{
    int ID;
    char name[100];
    int present; // Attended class or not
} Student;
```
- Next we will build up an attendance sheet



# Arrays of Structs (2)

```
int main (void)
{
    Student attendance_sheet[100]; // 100 students in the class

    return 0;
}
```

- Let's look at a logical view of this attendance sheet on the next slide





# Arrays of Structs (3)

- Attendance sheet, which consists of multiple struct student types

0	1	2	...	99
{ID, name, present}	{ID, name, present}	{ID, name, present}	...	{ID, name, present}
1000	1108	1216		10692



# Arrays of Structs (4)

- To initialize one item in the array, try:  
`attendance_sheet[index].ID = 1111;`  
`strcpy (attendance_sheet[index].name, "Bill Gates");`  
`Attendance_sheet[index].present = 1;`  
`// 1 means in attendance, 0 means not in present`



# Pointers to Structures

- Recall that when we have a pointer to a structure, we can use the indirect component selection operator `->` to access components within the structure

```
typedef struct
{
    double x;
    double y;
} Point;

int main (void)
{
    Point p1, *struct_ptr;
    p1.x = 12.3;
    p1.y = 2.5;

    struct_ptr = &p1;

    struct_ptr->x; /* Access the x component in Point, i.e. 12.3 */
    :
    :
    .
}
```



# Keep Reviewing C Material!



# References

- J.R. Hanly & E.B. Koffman, *Problem Solving and Program Design in C (8<sup>th</sup> Ed.)*, Addison-Wesley, 2016.
- P.J. Deitel & H.M. Deitel, *C How to Program (7<sup>th</sup> Ed.)*, Pearson Education , Inc., 2013.



# Collaborators

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