Computer Programming 143 – Lecture 20
Pointers III

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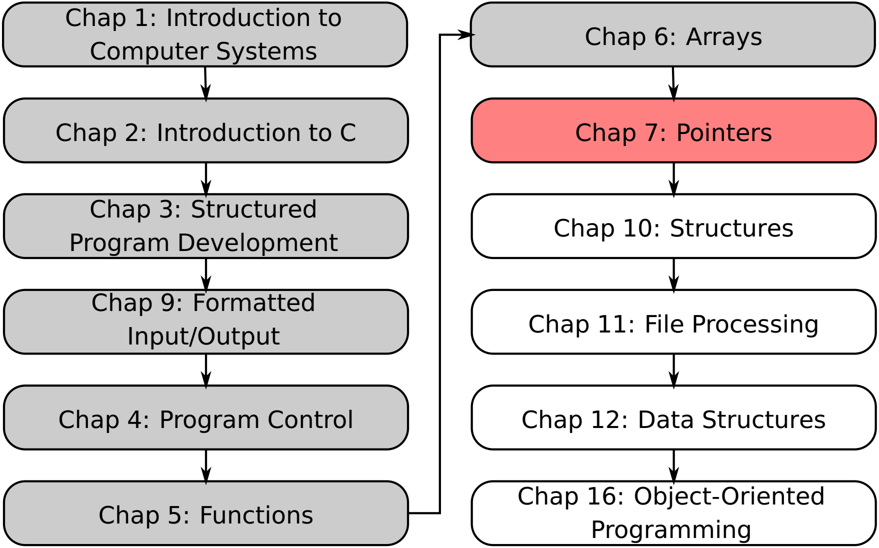
Module Overview



Chap 1: Introduction to Computer Systems

Chap 2: Introduction to C

Chap 3: Structured Program Development

Chap 9: Formatted Input/Output

Chap 4: Program Control

Chap 5: Functions

Chap 6: Arrays

Chap 7: Pointers

Chap 10: Structures

Chap 11: File Processing

Chap 12: Data Structures

Chap 16: Object-Oriented Programming

Lecture Overview

1. Using the `const` Qualifier with Pointers (7.5)

2. Bubble Sort Using Call-by-Reference (7.6)

3. `sizeof` Operator (7.7)

7.5 Using the const Qualifier with Pointers I

const qualifier

- Variable cannot be changed

```
const double PI = 3.141592653589793238;
```

- Use const if function does not need to change a variable
- Attempting to change a const variable produces a compiler error

7.5 Using the const Qualifier with Pointers II

const qualifier with pointers

There are 4 possible combinations:

1. Non-constant pointer to non-constant data

   ```
   int *myPtr;
   ```

   - Both the value (address) of myPtr and the integer it points to (*myPtr) may be changed

2. Non-constant pointer to constant data

   ```
   const int *myPtr;
   ```

   - The value (address) of myPtr may be changed, but the integer it points to (*myPtr) may not

7.5 Using the const Qualifier with Pointers III

const qualifier with pointers

3. Constant pointer to non-constant data

```
int * const myPtr = &x;
```

   - The value (address) of myPtr may not be changed, but the integer it points to (*myPtr) may – myPtr points to an unchanging memory position
   - The value (address) of myPtr must be initialised at declaration

4. Constant pointer to constant data

```
const int * const myPtr = &x;
```

   - Not the value (address) of myPtr nor the integer it points to (*myPtr) may be changed
   - The value (address) of myPtr must be initialised at declaration

7.5 Using the const Qualifier with Pointers IV

When to use which combination?

- Applicable to argument declaration when writing function definitions
- Use the *principle of least privilege*
- Prevents errors – ensures that your function does not accidentally alter data

7.5 Using the const Qualifier with Pointers V

Example: non-constant pointer to non-constant data (Fig.7.10)

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

void convertToUppercase( char *sPtr ); // prototype

int main( void )
{
   char string[] = "characters and $32.98"; // initialise char array

   printf( "The string before conversion is: %s", string );
   convertToUppercase( string );
   printf( "\nThe string after conversion is: %s\n", string );
   return 0; // indicates successful termination
} // end main
```

7.5 Using the const Qualifier with Pointers VI

...Example: non-constant pointer to non-constant data

```
// convert string to uppercase letters
void convertToUppercase( char *sPtr )
{
   while ( *sPtr != ’\0’ ) { // current character is not ’\0’

      if ( islower( *sPtr ) ) { // if character is lowercase
         *sPtr = toupper( *sPtr ); // convert to uppercase
      } // end if

      ++sPtr; // move sPtr to the next character
   } // end while
} // end function convertToUppercase
```

7.5 Using the const Qualifier with Pointers VII

Output

```
The string before conversion is: characters and $32.98
The string after conversion is: CHARACTERS AND $32.98
```

Discussion of example

- `void convertToUppercase( char *sPtr )`
  - Passes a non-constant pointer to a non-constant character array as argument
- Library `ctype.h` contains character classification and manipulation functions
  - Function `islower()` tests if its argument is a lowercase character
  - Function `toupper()` returns the uppercase character of its argument
- `++sPtr` moves to the pointer to the next character (next lecture)

7.5 Using the const Qualifier with Pointers VIII

Example: non-constant pointer to constant data (Fig.7.11)

```c
#include <stdio.h>

void printCharacters( const char *sPtr );

int main( void )
{
   // initialise char array
   char string[] = "print characters of a string";

   printf( "The string is:\n" );
   printCharacters( string );
   printf( "\n" );
   return 0; // indicates successful termination
} // end main
```

7.5 Using the const Qualifier with Pointers IX

...Example: non-constant pointer to constant data

```
/* sPtr cannot modify the characters to which it points,
 * i.e., sPtr is a "read-only" pointer */
void printCharacters( const char *sPtr )
{
   // loop through entire string
   while (*sPtr != ’\0’) { // no initialisation
        printf( "%c", *sPtr );
        sPtr++;
   } // end for
} // end function printCharacters
```

Output

```
The string is:
print characters of a string
```

7.5 Using the const Qualifier with Pointers X

Refer to Fig. 7.12-7.14 in Deitel & Deitel for more examples of `const` and pointers

7.6 Bubble Sort Using Call-by-Reference I

```
void swap( int *element1Ptr, int *element2Ptr ); // prototype
// sort an array of integers using bubble sort algorithm
// could also use ‘int array[]‘ instead of ‘int * const array‘ below
void bubbleSort( int * const array, const int size ) {
   int pass; // pass counter
   int j; // comparison counter

   // loop to control passes
   for ( pass = 0; pass < size - 1; pass++ ) {
      // loop to control comparisons during each pass
      for ( j = 0; j < size - 1; j++ ) {
         // swap adjacent elements if they are out of order
         if ( array[ j ] > array[ j + 1 ] ) {
            swap( &array[ j ], &array[ j + 1 ] );
         } // end if
      } // end inner for
   } // end outer for
} // end function bubbleSort
```

7.6 Bubble Sort Using Call-by-Reference II

```c
/* swap values at memory locations to which element1Ptr and
 * element2Ptr point  */
void swap( int *element1Ptr, int *element2Ptr )
{
   int hold = *element1Ptr;
   *element1Ptr = *element2Ptr;
   *element2Ptr = hold;
} // end function swap
```

Refer to Fig. 7.15 in Deitel & Deitel for the full program listing

7.7 sizeof Operator

sizeof

- Returns size of operand in bytes
- For arrays: size of 1 element × number of elements
- if sizeof(int) equals 4 bytes, then

```
int myArray[ 10 ];
printf( "%d", sizeof( myArray ) );
```

will print 40

sizeof can be used with

- Variable names
- Type name
- Constant values

```c
/*   Demonstrating the sizeof operator */
#include <stdio.h>

int main()
{
   char c;              /* define c */
   short s;             /* define s */
   int i;               /* define i */
   long l;              /* define l */
   float f;             /* define f */
   double d;            /* define d */
   long double ld;      /* define ld */
   int array[ 20 ];     /* initialize array */
   int *ptr = array;    /* create pointer to array */

   printf( "\n sizeof c            = %d", sizeof( c ));
   printf( "\t sizeof(char)        = %d", sizeof( char ));
   printf( "\n sizeof s            = %d", sizeof( s ));
   printf( "\t sizeof(short)       = %d", sizeof( short ));
   printf( "\n sizeof i            = %d", sizeof( i ));
   printf( "\t sizeof(int)         = %d", sizeof( int ));
   printf( "\n sizeof l             = %d",  sizeof( l ));
   printf( "\t sizeof(long)         = %d", sizeof( long ));
   printf( "\n sizeof f             = %d",  sizeof( f ));
   printf( "\t sizeof(float)        = %d", sizeof( float ));

   printf( "\n sizeof d             = %d", sizeof( d ));
   printf( "\t sizeof(double)       = %d", sizeof( double ));
   printf( "\n sizeof ld            = %d", sizeof( ld ));
   printf( "\t sizeof(long double) = %d", sizeof( long double ));

   printf( "\n sizeof array         = %d", sizeof( array ));
   printf( "\t   sizeof ptr         = %d", sizeof( ptr ));
   printf("\n");

   return 0;
}
```

```
sizeof c      = 1     sizeof(char)        = 1
sizeof s      = 2     sizeof(short)       = 2
sizeof i      = 4     sizeof(int)         = 4
sizeof l      = 4     sizeof(long)        = 4
sizeof f      = 4     sizeof(float)       = 4
sizeof d      = 8     sizeof(double)      = 8
sizeof ld     = 12    sizeof(long double) = 12
sizeof array  = 80    sizeof ptr          = 4
```

sizeof and arrays

- sizeof only works on arrays inside the scope where the array is defined.
- If an array is passed to a function, sizeof cannot determine the memory size used by the array.
- sizeof(array) returns amount of memory consumed by all array elements.

Perspective

Today

Pointers III

- Using the `const` qualifier with pointers
- Bubble sort using call-by-reference
- `sizeof` operator

Next lecture

Pointers IV

- Pointer arithmetic
- Pointers and arrays

Homework

1. Study Sections 7.5-7.7 in Deitel & Deitel
2. Do Self Review Exercise 7.6 in Deitel & Deitel
3. Do Exercises 7.11, 7.19 in Deitel & Deitel