計算機程式
OBJECT-ORIENTED PROGRAMMING
物件導向程式設計
DME1584

Lecture #04

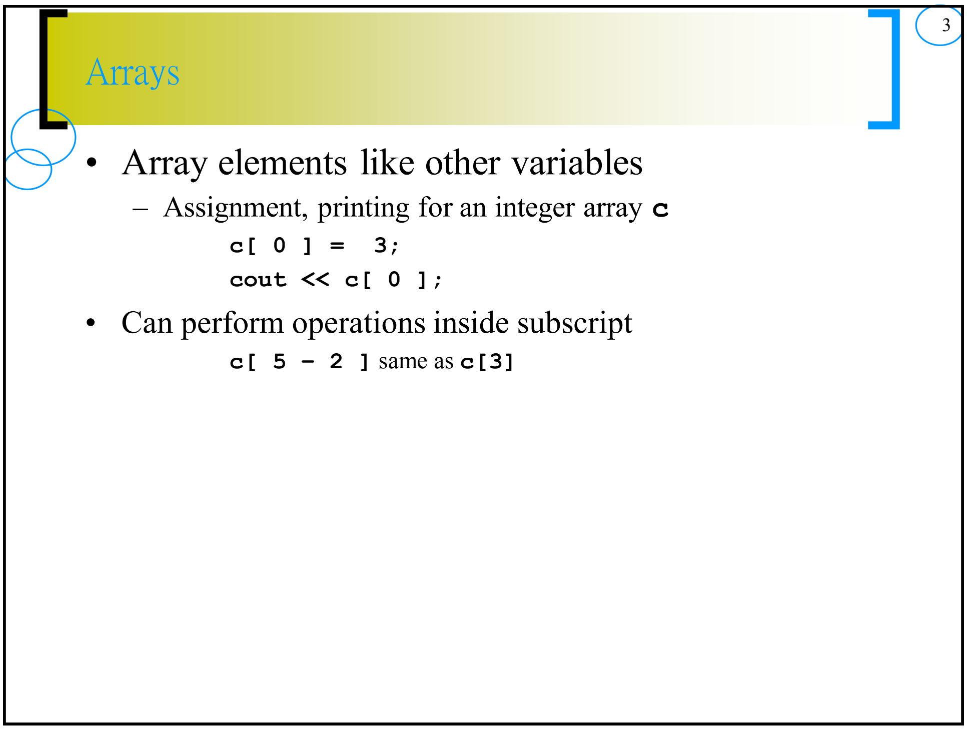
The C language Preview

Part 3

Arrays

- Array
  - Consecutive group of memory locations
  - Same name and type (**`int`**, **`char`**, etc.)
- To refer to an element
  - Specify array name and position number (index)
  - Format: arrayname[position number]
  - First element at position 0
- N-element array c

  `c[ 0 ]`, **`c[ 1 ]`** … **`c[ n - 1 ]`**
  - Nth element as position N-1



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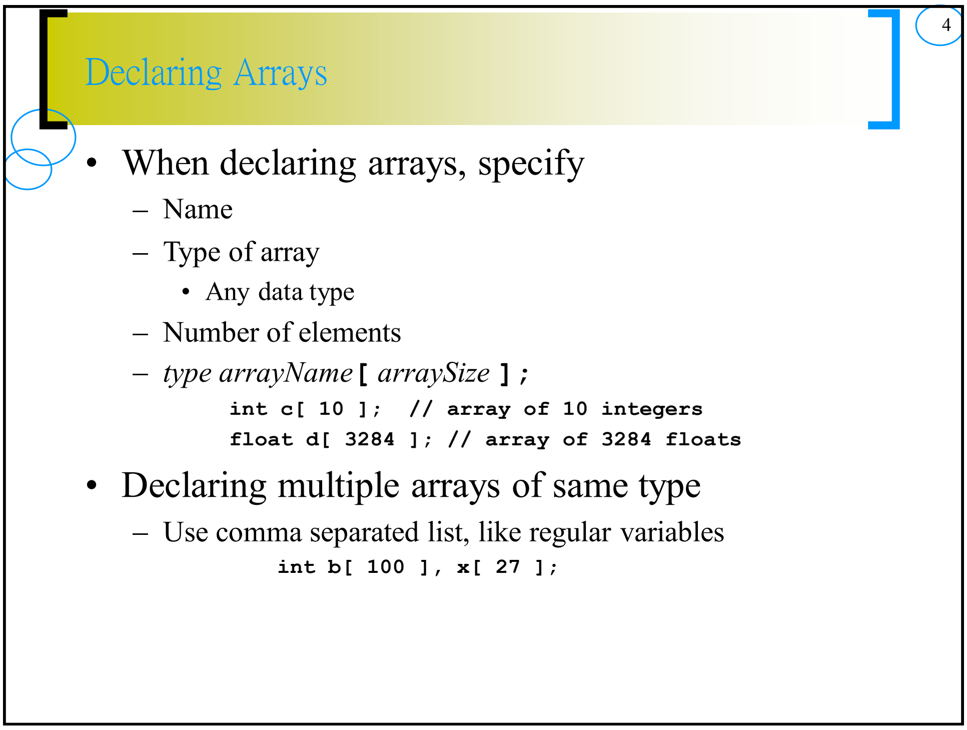
Arrays

- Array elements like other variables
  - Assignment, printing for an integer array **`c`**

```
c[ 0 ] =  3;
cout << c[ 0 ];
```

- Can perform operations inside subscript

`c[ 5 – 2 ]` same as **`c[3]`**



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Declaring Arrays

- When declaring arrays, specify
  - Name
  - Type of array
    - Any data type
  - Number of elements
  - *type arrayName* **[** *arraySize* **] ;**

```
int c[ 10 ];  // array of 10 integers
float d[ 3284 ]; // array of 3284 floats
```

- Declaring multiple arrays of same type
  - Use comma separated list, like regular variables

```
int b[ 100 ], x[ 27 ];
```

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Examples Using Arrays

- Initializing arrays
  - For loop
    - Set each element
  - Initializer list
    - Specify each element when array declared

    ```
    int n[ 5 ] = { 1, 2, 3, 4, 5 };
    ```

    - If not enough initializers, rightmost elements 0
    - If too many syntax error
  - To set every element to same value

    ```
    int n[ 5 ] = { 0 };
    ```

  - If array size omitted, initializers determine size

    ```
    int n[] = { 1, 2, 3, 4, 5 };
    ```

    - 5 initializers, therefore 5 element array

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Examples Using Arrays

- Strings
  - Arrays of characters
  - All strings end with **`null`** (**`'\0'`**)
  - Examples
    - **`char string1[] = "hello";`**
      - **`Null`** character implicitly added
      - **`string1`** has 6 elements
    - **`char string1[] = { 'h', 'e', 'l', 'l', 'o', '\0' };`**
  - Subscripting is the same

    `String1[ 0 ]` is **`'h'`**

    `string1[ 2 ]` is **`'l'`**

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Examples Using Arrays

- Input from keyboard

```
        char string2[ 10 ];
        cin >> string2;
```

  - Puts user input in string
    - Stops at first whitespace character
    - Adds **null** character
  - If too much text entered, data written beyond array
    - We want to avoid this
- Printing strings
  - **cout << string2 << endl;**
    - Does not work for other array types
  - Characters printed until **null** found

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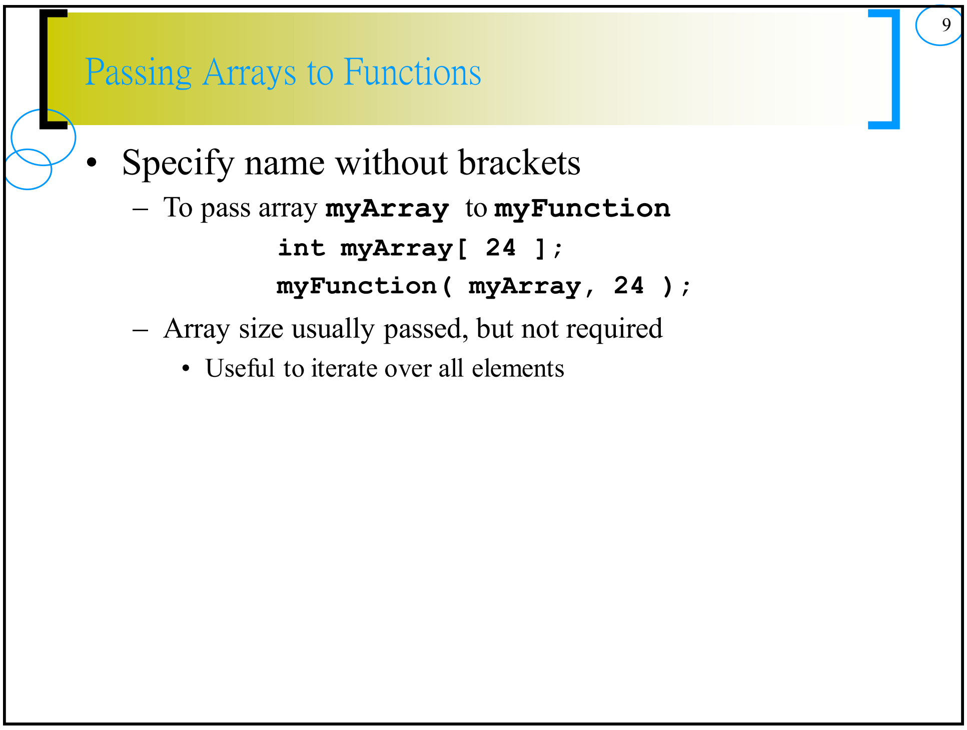
Examples Using Arrays

- Recall static storage
  - If **static**, local variables save values between function calls
  - Visible only in function body
  - Can declare local arrays to be static
    - Initialized to zero

```
    static int array[3];
```

- If not static
  - Created (and destroyed) in every function call

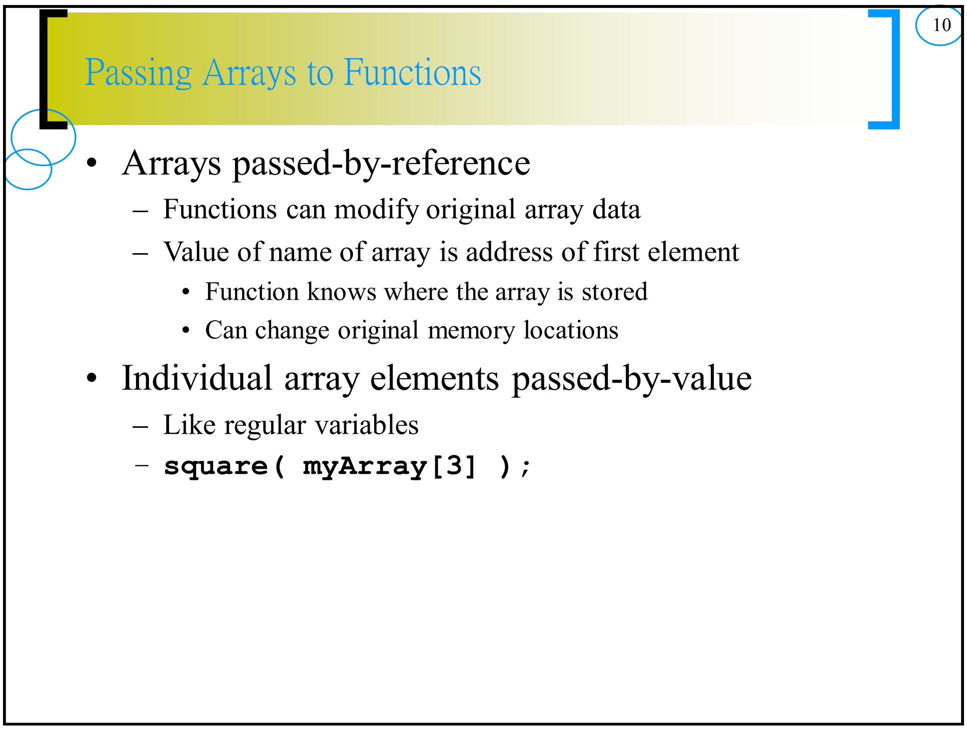


Passing Arrays to Functions

- Specify name without brackets
  - To pass array **`myArray`** to **`myFunction`**

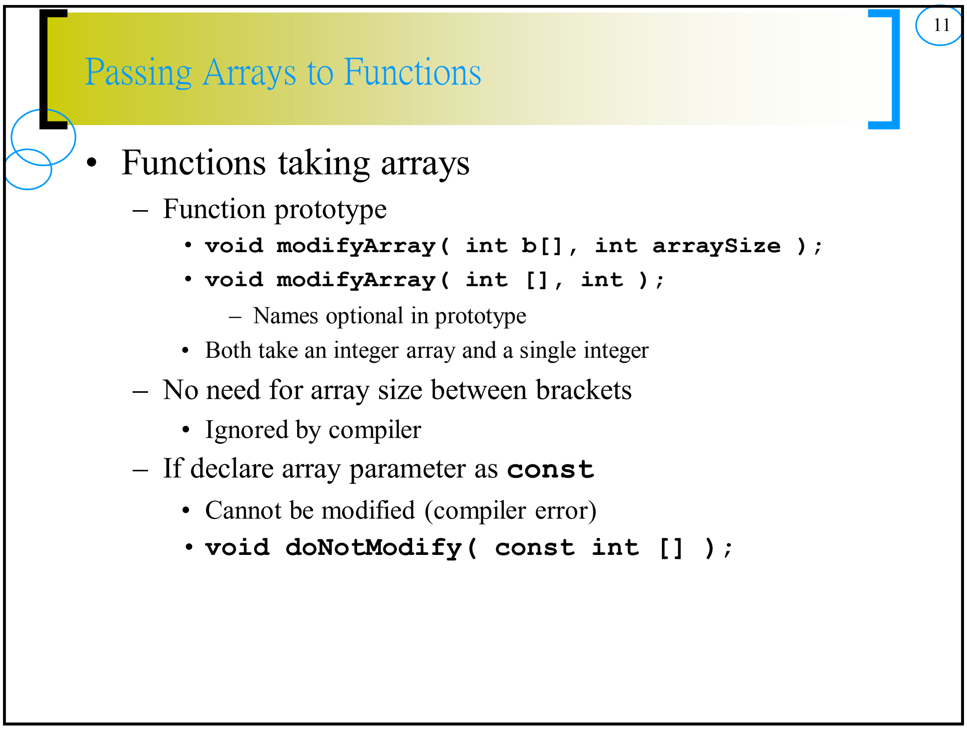
```
int myArray[ 24 ];
myFunction( myArray, 24 );
```

  - Array size usually passed, but not required
    - Useful to iterate over all elements



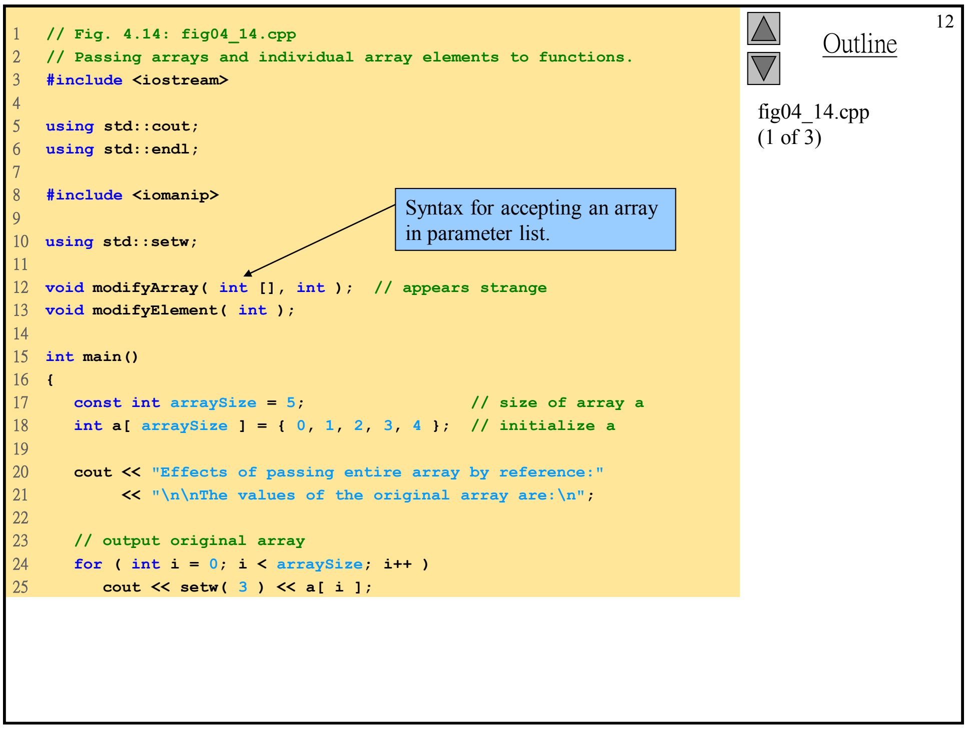
Passing Arrays to Functions

- Arrays passed-by-reference
  - Functions can modify original array data
  - Value of name of array is address of first element
    - Function knows where the array is stored
    - Can change original memory locations
- Individual array elements passed-by-value
  - Like regular variables
  - **`square( myArray[3] );`**



Passing Arrays to Functions

- Functions taking arrays
  - Function prototype
    - **`void modifyArray( int b[], int arraySize );`**
    - **`void modifyArray( int [], int );`**
      - Names optional in prototype
    - Both take an integer array and a single integer
  - No need for array size between brackets
    - Ignored by compiler
  - If declare array parameter as **`const`**
    - Cannot be modified (compiler error)
    - **`void doNotModify( const int [] );`**



Outline

fig04_14.cpp
(1 of 3)

```
// Fig. 4.14: fig04_14.cpp
// Passing arrays and individual array elements to functions.
#include <iostream>

using std::cout;
using std::endl;

#include <iomanip>

using std::setw;

void modifyArray( int [], int );  // appears strange
void modifyElement( int );

int main()
{
   const int arraySize = 5;                 // size of array a
   int a[ arraySize ] = { 0, 1, 2, 3, 4 };  // initialize a

   cout << "Effects of passing entire array by reference:"
        << "\n\nThe values of the original array are:\n";

   // output original array
   for ( int i = 0; i < arraySize; i++ )
      cout << setw( 3 ) << a[ i ];
```

Syntax for accepting an array in parameter list.

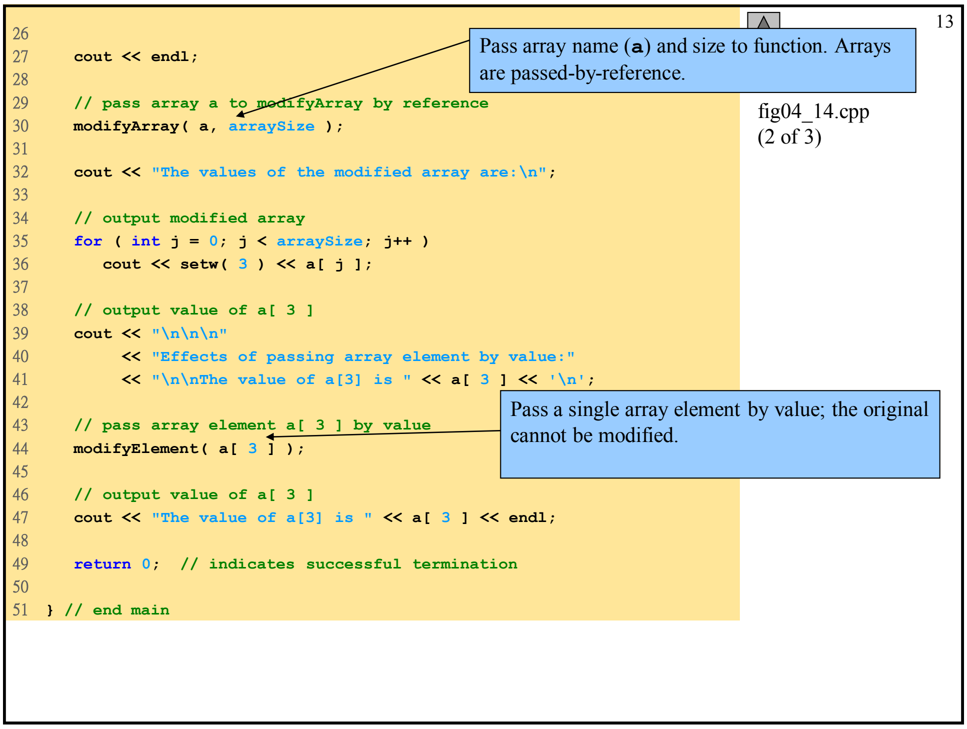


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fig04_14.cpp
(2 of 3)

```

   cout << endl;

   // pass array a to modifyArray by reference
   modifyArray( a, arraySize );

   cout << "The values of the modified array are:\n";

   // output modified array
   for ( int j = 0; j < arraySize; j++ )
      cout << setw( 3 ) << a[ j ];

   // output value of a[ 3 ]
   cout << "\n\n\n"
        << "Effects of passing array element by value:"
        << "\n\nThe value of a[3] is " << a[ 3 ] << '\n';

   // pass array element a[ 3 ] by value
   modifyElement( a[ 3 ] );

   // output value of a[ 3 ]
   cout << "The value of a[3] is " << a[ 3 ] << endl;

   return 0;  // indicates successful termination

} // end main
```

Pass array name (**a**) and size to function. Arrays are passed-by-reference.

Pass a single array element by value; the original cannot be modified.

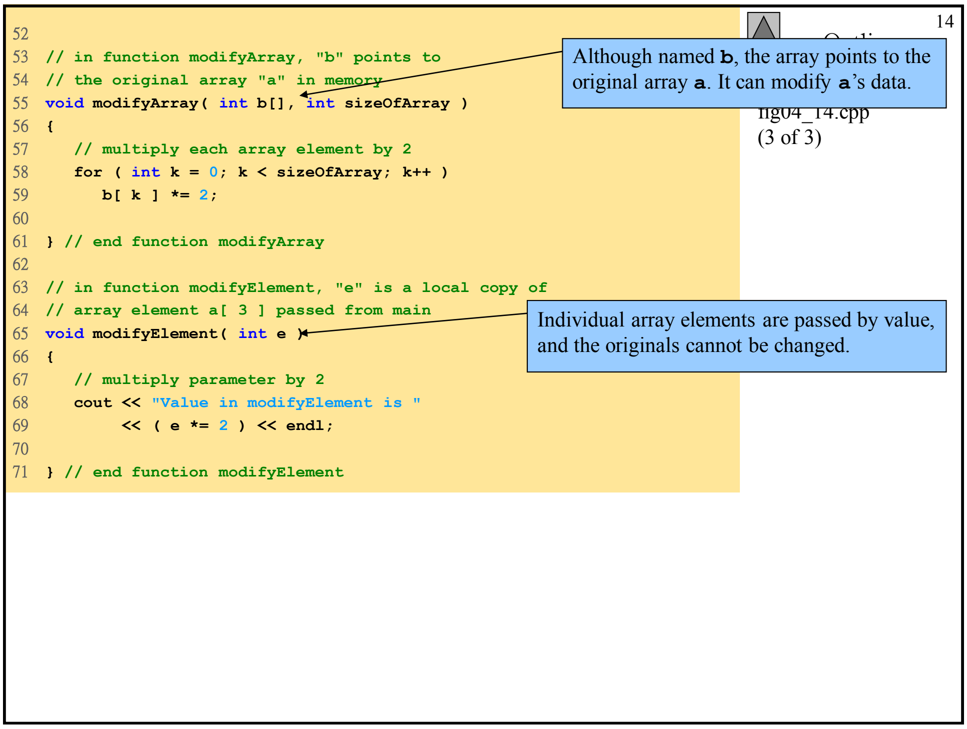

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fig04_14.cpp
(3 of 3)

```

// in function modifyArray, "b" points to
// the original array "a" in memory
void modifyArray( int b[], int sizeOfArray )
{
   // multiply each array element by 2
   for ( int k = 0; k < sizeOfArray; k++ )
      b[ k ] *= 2;

} // end function modifyArray

// in function modifyElement, "e" is a local copy of
// array element a[ 3 ] passed from main
void modifyElement( int e )
{
   // multiply parameter by 2
   cout << "Value in modifyElement is "
        << ( e *= 2 ) << endl;

} // end function modifyElement
```

Although named **b**, the array points to the original array **a**. It can modify **a**'s data.

Individual array elements are passed by value, and the originals cannot be changed.

```
Effects of passing entire array by reference:

The values of the original array are:
  0  1  2  3  4
The values of the modified array are:
  0  2  4  6  8


Effects of passing array element by value:

The value of a[3] is 6
Value in modifyElement is 12
The value of a[3] is 6
```

Outline

fig04_14.cpp
output (1 of 1)

```
// Fig. 4.15: fig04_15.cpp
// Demonstrating the const type qualifier.
#include <iostream>

using std::cout;
using std::endl;

void tryToModifyArray( const int [] );  // function prototype

int main()
{
   int a[] = { 10, 20, 30 };

   tryToModifyArray( a );

   cout << a[ 0 ] << ' ' << a[ 1 ] << ' ' << a[ 2 ] << '\n';

   return 0;  // indicates successful termination

} // end main

```

Outline

Array parameter declared as **`const`**. Array cannot be modified, even though it is passed by reference.

Outline

fig04_15.cpp
(2 of 2)

fig04_15.cpp
output (1 of 1)

```
22  // In function tryToModifyArray, "b" cannot be used
23  // to modify the original array "a" in main.
24  void tryToModifyArray( const int b[] )
25  {
26     b[ 0 ] /= 2;    // error
27     b[ 1 ] /= 2;    // error
28     b[ 2 ] /= 2;    // error
29
30  } // end function tryToModifyArray
```

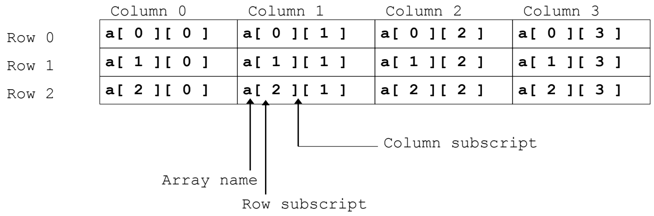
```
d:\cpphtp4_examples\ch04\Fig04_15.cpp(26) : error C2166:
   l-value specifies const object
d:\cpphtp4_examples\ch04\Fig04_15.cpp(27) : error C2166:
   l-value specifies const object
d:\cpphtp4_examples\ch04\Fig04_15.cpp(28) : error C2166:
   l-value specifies const object
```

Sorting Arrays

- Example:
  - Go left to right, and exchange elements as necessary
    - One pass for each element
  - Original: 3 4 2 7 6
  - Pass 1:   3 2 4 6 7   (elements exchanged)
  - Pass 2:   2 3 4 6 7
  - Pass 3:   2 3 4 6 7   (no changes needed)
  - Pass 4:   2 3 4 6 7
  - Pass 5:   2 3 4 6 7
  - Small elements "bubble" to the top (like 2 in this example)
- Swap function?

Multiple-Subscripted Arrays

- Multiple subscripts
  - **`a[ i ][ j ]`**
  - Tables with rows and columns
  - Specify row, then column
  - “Array of arrays”
    - **`a[0]`** is an array of 4 elements
    - **`a[0][0]`** is the first element of that array



	Column 0	Column 1	Column 2	Column 3
Row 0	`a[ 0 ][ 0 ]`	`a[ 0 ][ 1 ]`	`a[ 0 ][ 2 ]`	`a[ 0 ][ 3 ]`
Row 1	`a[ 1 ][ 0 ]`	`a[ 1 ][ 1 ]`	`a[ 1 ][ 2 ]`	`a[ 1 ][ 3 ]`
Row 2	`a[ 2 ][ 0 ]`	`a[ 2 ][ 1 ]`	`a[ 2 ][ 2 ]`	`a[ 2 ][ 3 ]`

Multiple-Subscripted Arrays

- To initialize
  - Default of **0**
  - Initializers grouped by row in braces

```
int b[ 2 ][ 2 ] = { { 1, 2 }, { 3, 4 } };
```

Row 0 **Row 1**

1	2
3	4

```
int b[ 2 ][ 2 ] = { { 1 }, { 3, 4 } };
```

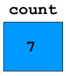
1	0
3	4

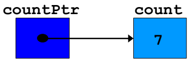
Pointers

- Pointers
  - Powerful, but difficult to master
  - Simulate pass-by-reference
  - Close relationship with arrays and strings
- Can declare pointers to any data type
- Pointer initialization
  - Initialized to **`0`**, **`NULL`**, or address
    - **`0`** or **`NULL`** points to nothing

Pointer Variable Declarations and Initialization

- Pointer variables
  - Contain memory addresses as values
  - Normally, variable contains specific value (direct reference)
  - Pointers contain address of variable that has specific value (indirect reference)





- Indirection
  - Referencing value through pointer
- Pointer declarations
  - **`*`** indicates variable is pointer

```
int *myPtr;
```

  declares pointer to **`int`**, pointer of type **`int *`**
  - Multiple pointers require multiple asterisks

```
int *myPtr1, *myPtr2;
```

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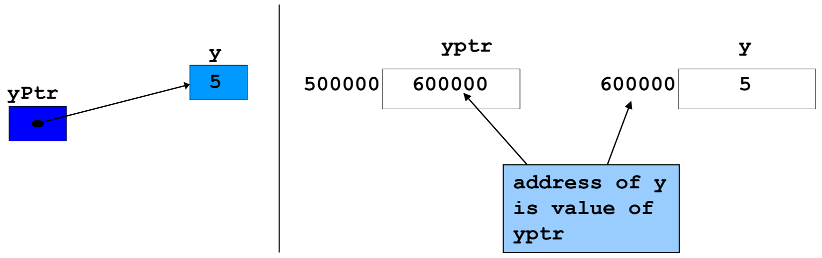
Pointer Operators

- **&** (address operator)
  - Returns memory address of its operand
  - Example

```
int y = 5;
int *yPtr;
yPtr = &y;     // yPtr gets address of y
```

  - **yPtr** “points to” **y**



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Pointer Operators

- ***** (indirection/dereferencing operator)
  - Returns synonym for object its pointer operand points to
  - ***yPtr** returns **y** (because **yPtr** points to **y**).
  - dereferenced pointer is lvalue

```
*yptr = 9;       // assigns 9 to y
```

- ***** and **&** are inverses of each other

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Calling Functions by Reference

- 3 ways to pass arguments to function
  - Pass-by-value
  - Pass-by-reference with reference arguments
  - Pass-by-reference with pointer arguments
- `return` can return one value from function
- Arguments passed to function using reference arguments
  - Modify original values of arguments
  - More than one value “returned”

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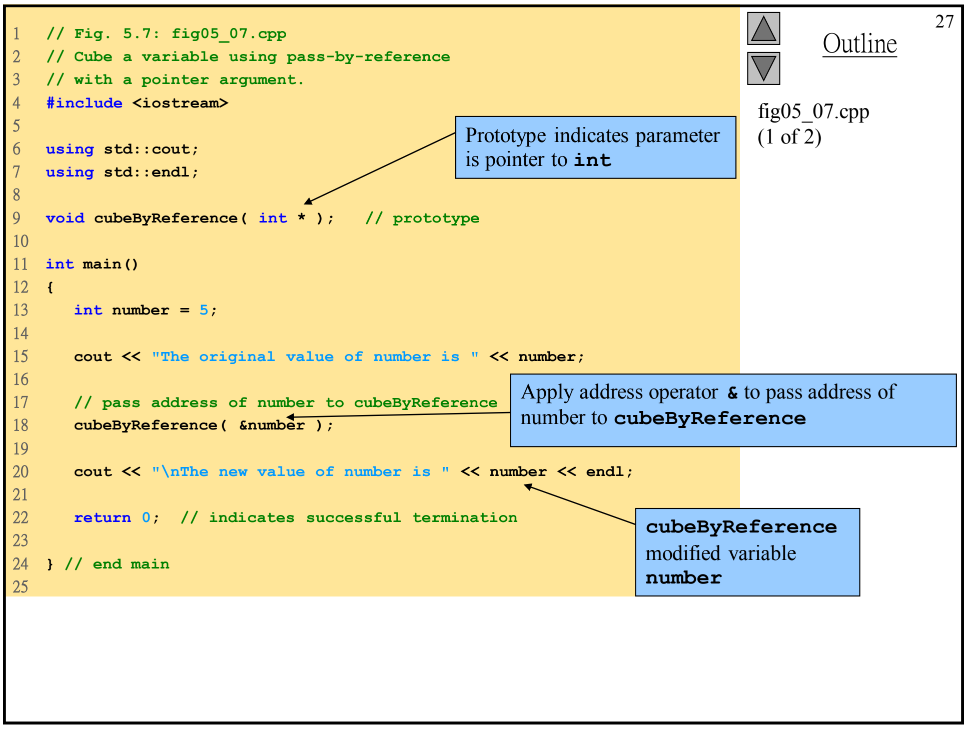
Calling Functions by Reference

- Pass-by-reference with pointer arguments
  - Simulate pass-by-reference
    - Use pointers and indirection operator
  - Pass address of argument using **&** operator
  - Arrays not passed with **&** because array name already pointer
  - ***** operator used as alias/nickname for variable inside of function



Outline

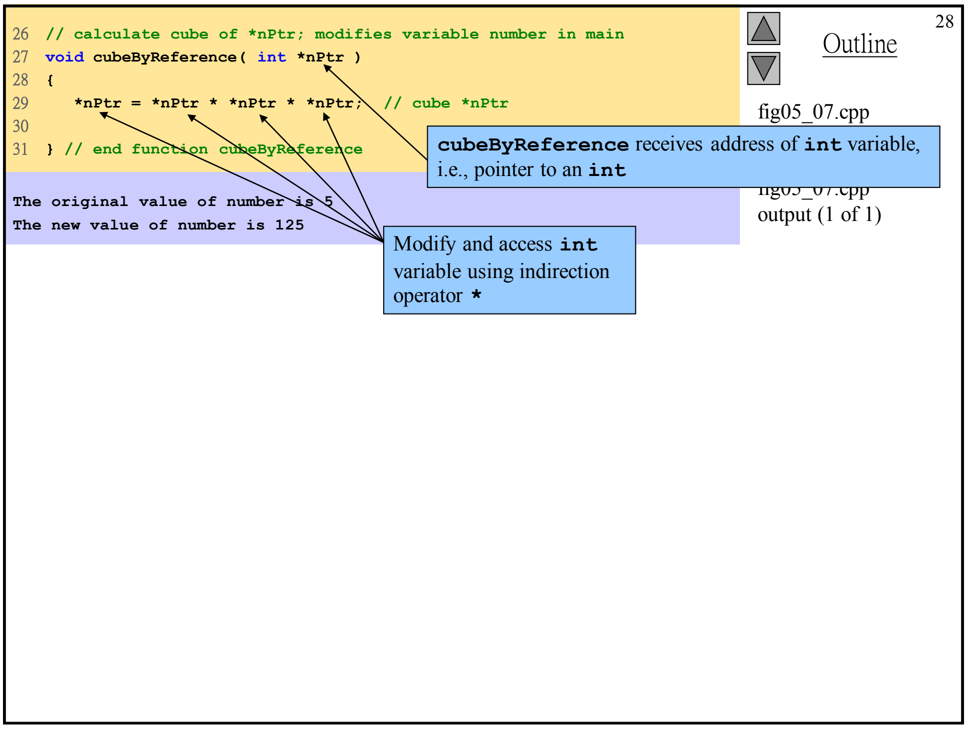
fig05_07.cpp
(1 of 2)

```
// Fig. 5.7: fig05_07.cpp
// Cube a variable using pass-by-reference
// with a pointer argument.
#include <iostream>

using std::cout;
using std::endl;

void cubeByReference( int * );   // prototype

int main()
{
   int number = 5;

   cout << "The original value of number is " << number;

   // pass address of number to cubeByReference
   cubeByReference( &number );

   cout << "\nThe new value of number is " << number << endl;

   return 0;  // indicates successful termination

} // end main

```

Prototype indicates parameter is pointer to **`int`**

Apply address operator **`&`** to pass address of number to **`cubeByReference`**

`cubeByReference` modified variable **`number`**



Outline

fig05_07.cpp

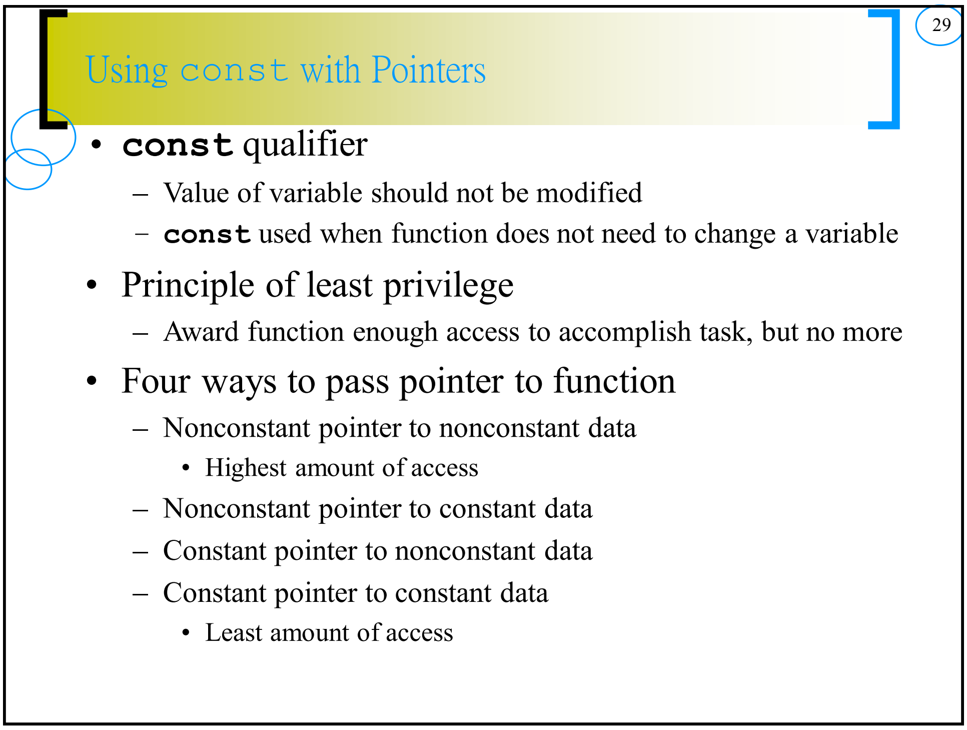
```
// calculate cube of *nPtr; modifies variable number in main
void cubeByReference( int *nPtr )
{
   *nPtr = *nPtr * *nPtr * *nPtr;  // cube *nPtr

} // end function cubeByReference
```

```
The original value of number is 5
The new value of number is 125
```

fig05_07.cpp
output (1 of 1)

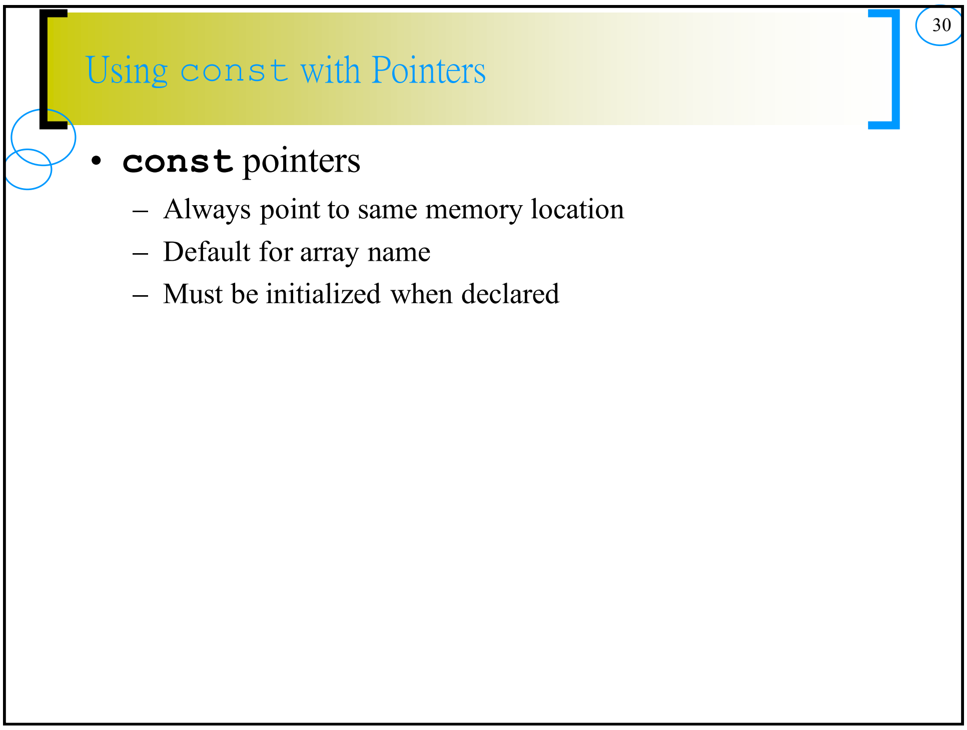
`cubeByReference` receives address of **`int`** variable, i.e., pointer to an **`int`**

Modify and access **`int`** variable using indirection operator **`*`**



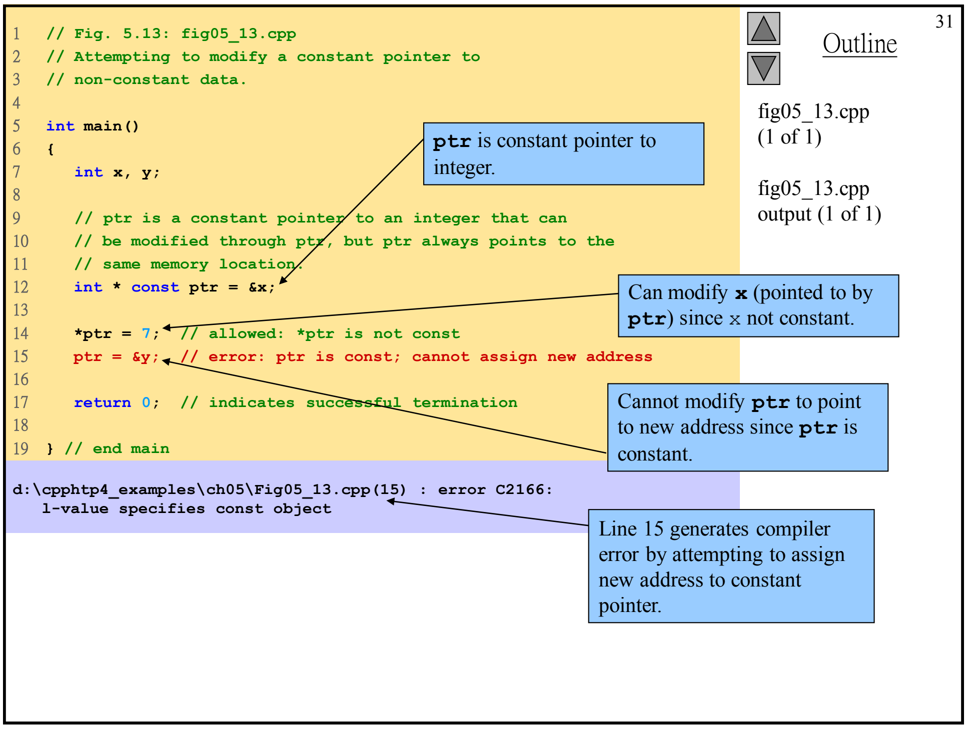
Using `const` with Pointers

- **`const`** qualifier
  - Value of variable should not be modified
  - **`const`** used when function does not need to change a variable
- Principle of least privilege
  - Award function enough access to accomplish task, but no more
- Four ways to pass pointer to function
  - Nonconstant pointer to nonconstant data
    - Highest amount of access
  - Nonconstant pointer to constant data
  - Constant pointer to nonconstant data
  - Constant pointer to constant data
    - Least amount of access



Using `const` with Pointers

- **`const`** pointers
  - Always point to same memory location
  - Default for array name
  - Must be initialized when declared



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Outline

fig05_13.cpp
(1 of 1)

fig05_13.cpp
output (1 of 1)

```
1   // Fig. 5.13: fig05_13.cpp
2   // Attempting to modify a constant pointer to
3   // non-constant data.
4
5   int main()
6   {
7      int x, y;
8
9      // ptr is a constant pointer to an integer that can
10     // be modified through ptr, but ptr always points to the
11     // same memory location.
12     int * const ptr = &x;
13
14     *ptr = 7; // allowed: *ptr is not const
15     ptr = &y; // error: ptr is const; cannot assign new address
16
17     return 0;  // indicates successful termination
18
19  } // end main
```

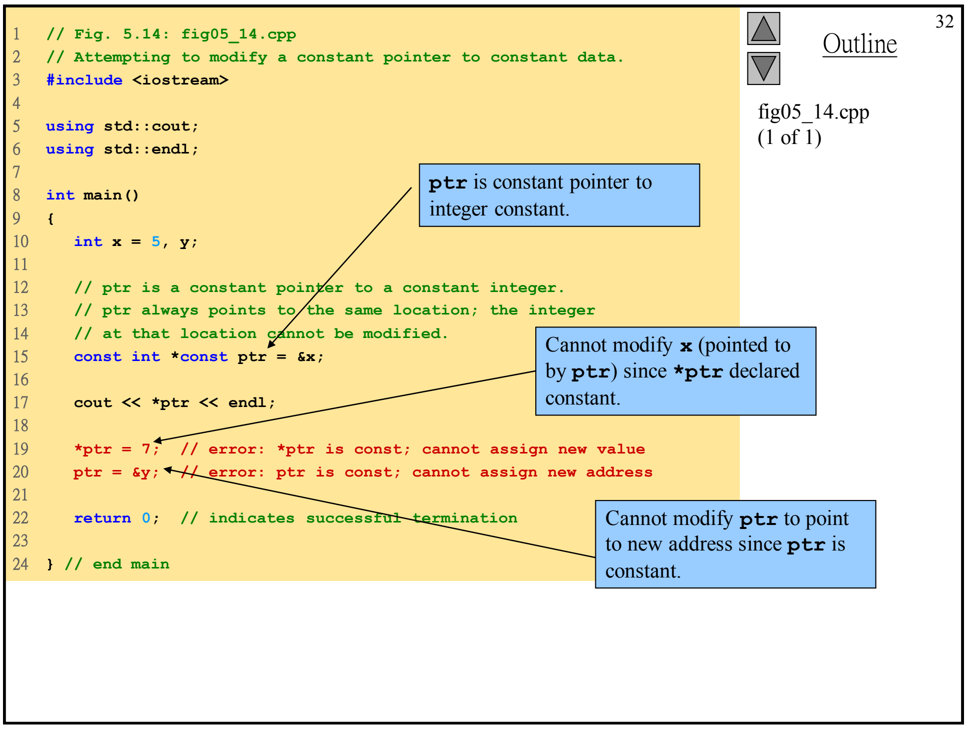
```
d:\cpphtp4_examples\ch05\Fig05_13.cpp(15) : error C2166:
   l-value specifies const object
```

ptr is constant pointer to integer.

Can modify **x** (pointed to by **ptr**) since x not constant.

Cannot modify **ptr** to point to new address since **ptr** is constant.

Line 15 generates compiler error by attempting to assign new address to constant pointer.



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Outline

fig05_14.cpp
(1 of 1)

```
// Fig. 5.14: fig05_14.cpp
// Attempting to modify a constant pointer to constant data.
#include <iostream>

using std::cout;
using std::endl;

int main()
{
   int x = 5, y;

   // ptr is a constant pointer to a constant integer.
   // ptr always points to the same location; the integer
   // at that location cannot be modified.
   const int *const ptr = &x;

   cout << *ptr << endl;

   *ptr = 7;  // error: *ptr is const; cannot assign new value
   ptr = &y;  // error: ptr is const; cannot assign new address

   return 0;  // indicates successful termination

} // end main
```

ptr is constant pointer to integer constant.

Cannot modify **x** (pointed to by **ptr**) since ***ptr** declared constant.

Cannot modify **ptr** to point to new address since **ptr** is constant.

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Outline

14.cpp
t (1 of 1)

```
d:\cpphtp4_examples\ch05\Fig05_14.cpp(19) : error C2166:
    l-value specifies const object
d:\cpphtp4_examples\ch05\Fig05_14.cpp(20) : error C2166:
    l-value specifies const object
```

Line 19 generates compiler error by attempting to modify constant object.

Line 20 generates compiler error by attempting to assign new address to constant pointer.

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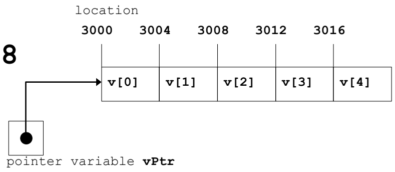
Pointer Expressions and Pointer Arithmetic

- Pointer arithmetic
  - Increment/decrement pointer (`++` or `--`)
  - Add/subtract an integer to/from a pointer(`+` or `+=` , `-` or `-=`)
  - Pointers may be subtracted from each other
  - Pointer arithmetic meaningless unless performed on pointer to array
- 5 element **`int`** array on a machine using 4 byte **`int`**s
  - **`vPtr`** points to first element **`v[ 0 ]`**, which is at location 3000

    `vPtr = 3000`
  - **`vPtr += 2`**; sets **`vPtr`** to **`3008`**

    `vPtr` points to **`v[ 2 ]`**



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Pointer Expressions and Pointer Arithmetic

- Subtracting pointers
  - Returns number of elements between two addresses

```
vPtr2 = v[ 2 ];
vPtr = v[ 0 ];
vPtr2 - vPtr == 2
```

- Pointer assignment
  - Pointer can be assigned to another pointer if both of same type
  - If not same type, cast operator must be used
  - Exception: pointer to **`void`** (type **`void *`**)
    - Generic pointer, represents any type
    - No casting needed to convert pointer to **`void`** pointer
    - **`void`** pointers cannot be dereferenced

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Pointer Expressions and Pointer Arithmetic

- Pointer comparison
  - Use equality and relational operators
  - Comparisons meaningless unless pointers point to members of same array
  - Compare addresses stored in pointers
  - Example: could show that one pointer points to higher numbered element of array than other pointer
  - Common use to determine whether pointer is 0 (does not point to anything)

Relationship Between Pointers and Arrays

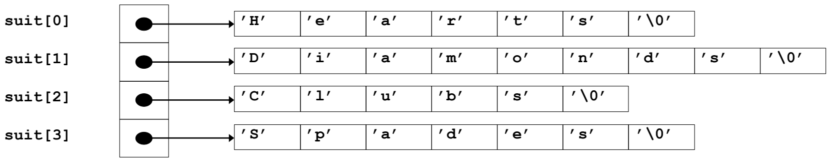
- Arrays and pointers closely related
  - Array name like constant pointer
  - Pointers can do array subscripting operations
- Accessing array elements with pointers
  - Element **`b[ n ]`** can be accessed by **`*( bPtr + n )`**
    - Called pointer/offset notation
  - Addresses
    - **`&b[ 3 ]`** same as **`bPtr + 3`**
  - Array name can be treated as pointer
    - **`b[ 3 ]`** same as **`*( b + 3 )`**
  - Pointers can be subscripted (pointer/subscript notation)
    - **`bPtr[ 3 ]`** same as **`b[ 3 ]`**

Arrays of Pointers

- Arrays can contain pointers
  - Commonly used to store array of strings

```
char *suit[ 4 ] = {"Hearts", "Diamonds",
                   "Clubs", "Spades" };
```

  - Each element of **suit** points to **`char *`** (a string)
  - Array does not store strings, only pointers to strings



suit[0] 'H' 'e' 'a' 'r' 't' 's' '\0'

suit[1] 'D' 'i' 'a' 'm' 'o' 'n' 'd' 's' '\0'

suit[2] 'C' 'l' 'u' 'b' 's' '\0'

suit[3] 'S' 'p' 'a' 'd' 'e' 's' '\0'

  - **`suit`** array has fixed size, but strings can be of any size

Function Pointers

- Calling functions using pointers
  - Assume parameter:
    - **`bool ( *compare ) ( int, int )`**
  - Execute function with either
    - **`( *compare ) ( int1, int2 )`**
      - Dereference pointer to function to execute

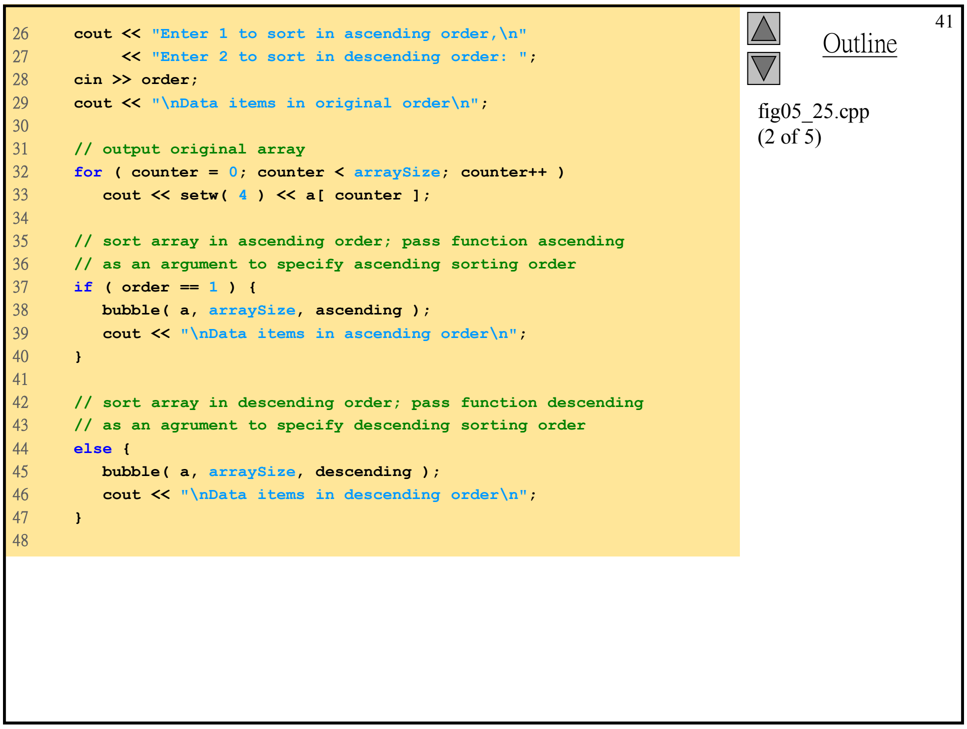
    OR
    - **`compare( int1, int2 )`**
      - Could be confusing
        - User may think **`compare`** name of actual function in program

Outline

fig05_25.cpp
(1 of 5)

```
// Fig. 5.25: fig05_25.cpp
// Multipurpose sorting program using function pointers.
#include <iostream>

using std::cout;
using std::cin;
using std::endl;

#include <iomanip>

using std::setw;

// prototypes
void bubble( int [], const int, bool (*)( int, int ) );
void swap( int * const, int * const );
bool ascending( int, int );
bool descending( int, int );

int main()
{
   const int arraySize = 10;
   int order;
   int counter;
   int a[ arraySize ] = { 2, 6, 4, 8, 10, 12, 89, 68, 45, 37 };

```

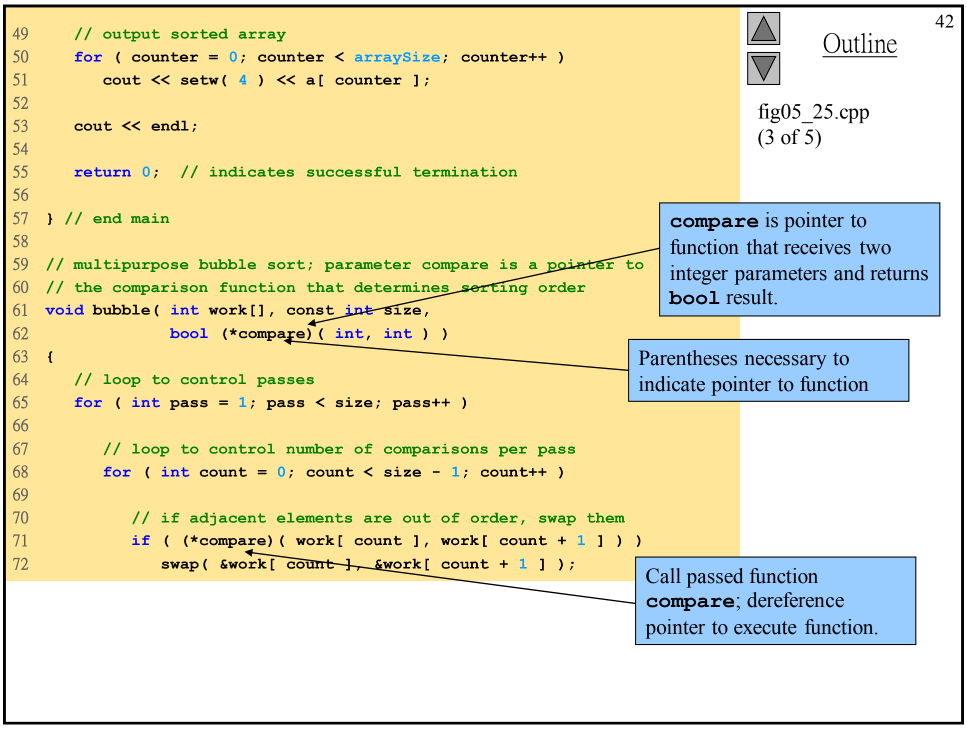
Parameter is pointer to function that receives two integer parameters and returns **`bool`** result.



Outline

fig05_25.cpp
(2 of 5)

```
   cout << "Enter 1 to sort in ascending order,\n"
        << "Enter 2 to sort in descending order: ";
   cin >> order;
   cout << "\nData items in original order\n";

   // output original array
   for ( counter = 0; counter < arraySize; counter++ )
      cout << setw( 4 ) << a[ counter ];

   // sort array in ascending order; pass function ascending
   // as an argument to specify ascending sorting order
   if ( order == 1 ) {
      bubble( a, arraySize, ascending );
      cout << "\nData items in ascending order\n";
   }

   // sort array in descending order; pass function descending
   // as an agrument to specify descending sorting order
   else {
      bubble( a, arraySize, descending );
      cout << "\nData items in descending order\n";
   }

```



Outline

fig05_25.cpp
(3 of 5)

```
   // output sorted array
   for ( counter = 0; counter < arraySize; counter++ )
      cout << setw( 4 ) << a[ counter ];

   cout << endl;

   return 0;  // indicates successful termination

} // end main

// multipurpose bubble sort; parameter compare is a pointer to
// the comparison function that determines sorting order
void bubble( int work[], const int size,
             bool (*compare)( int, int ) )
{
   // loop to control passes
   for ( int pass = 1; pass < size; pass++ )

      // loop to control number of comparisons per pass
      for ( int count = 0; count < size - 1; count++ )

         // if adjacent elements are out of order, swap them
         if ( (*compare)( work[ count ], work[ count + 1 ] ) )
            swap( &work[ count ], &work[ count + 1 ] );
```

compare is pointer to function that receives two integer parameters and returns **bool** result.

Parentheses necessary to indicate pointer to function

Call passed function **compare**; dereference pointer to execute function.

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Outline

fig05_25.cpp
(4 of 5)

```

} // end function bubble

// swap values at memory locations to which
// element1Ptr and element2Ptr point
void swap( int * const element1Ptr, int * const element2Ptr )
{
   int hold = *element1Ptr;
   *element1Ptr = *element2Ptr;
   *element2Ptr = hold;

} // end function swap

// determine whether elements are out of order
// for an ascending order sort
bool ascending( int a, int b )
{
   return b < a;   // swap if b is less than a

} // end function ascending

```

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Outline

fig05_25.cpp
(5 of 5)

fig05_25.cpp
output (1 of 1)

```
// determine whether elements are out of order
// for a descending order sort
bool descending( int a, int b )
{
   return b > a;   // swap if b is greater than a

} // end function descending
```

```
Enter 1 to sort in ascending order,
Enter 2 to sort in descending order: 1

Data items in original order
   2   6   4   8  10  12  89  68  45  37
Data items in ascending order
   2   4   6   8  10  12  37  45  68  89
```

```
Enter 1 to sort in ascending order,
Enter 2 to sort in descending order: 2

Data items in original order
   2   6   4   8  10  12  89  68  45  37
Data items in descending order
  89  68  45  37  12  10   8   6   4   2
```

Function Pointers

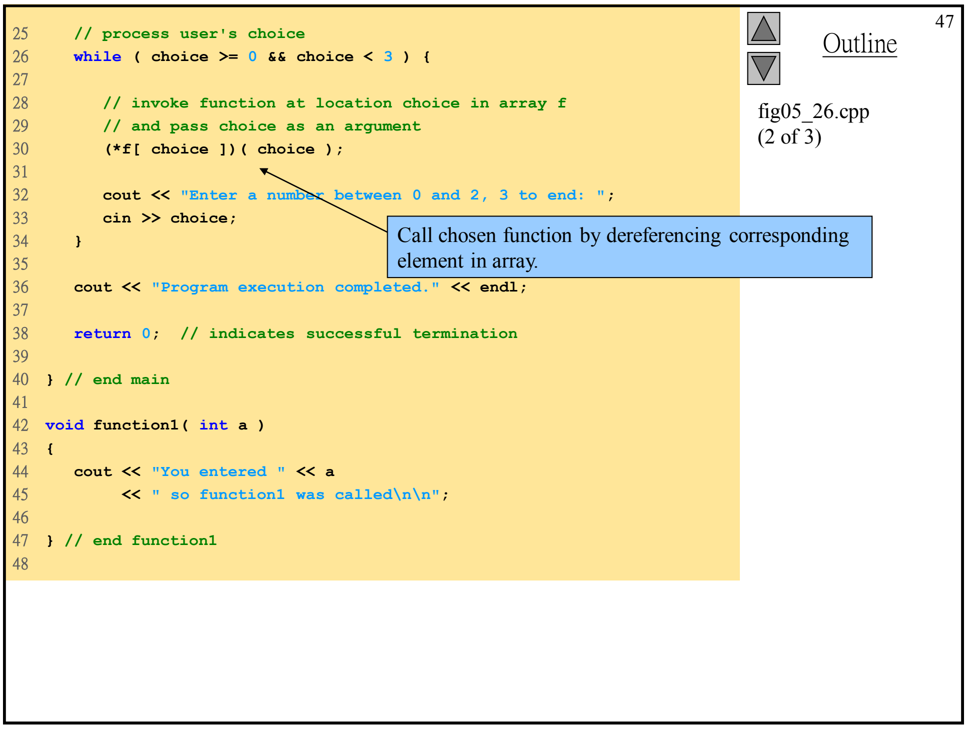
- Arrays of pointers to functions
  - Menu-driven systems
  - Pointers to each function stored in array of pointers to functions
    - All functions must have same return type and same parameter types
  - Menu choice → subscript into array of function pointers

Outline

fig05_26.cpp
(1 of 3)

```cpp
// Fig. 5.26: fig05_26.cpp
// Demonstrating an array of pointers to functions.
#include <iostream>

using std::cout;
using std::cin;
using std::endl;

// function prototypes
void function1( int );
void function2( int );
void function3( int );

int main()
{
   // initialize array of 3 pointers to functions that each
   // take an int argument and return void
   void (*f[ 3 ])( int ) = { function1, function2, function3 };

   int choice;

   cout << "Enter a number between 0 and 2, 3 to end: ";
   cin >> choice;

```

Array initialized with names of three functions; function names are pointers.



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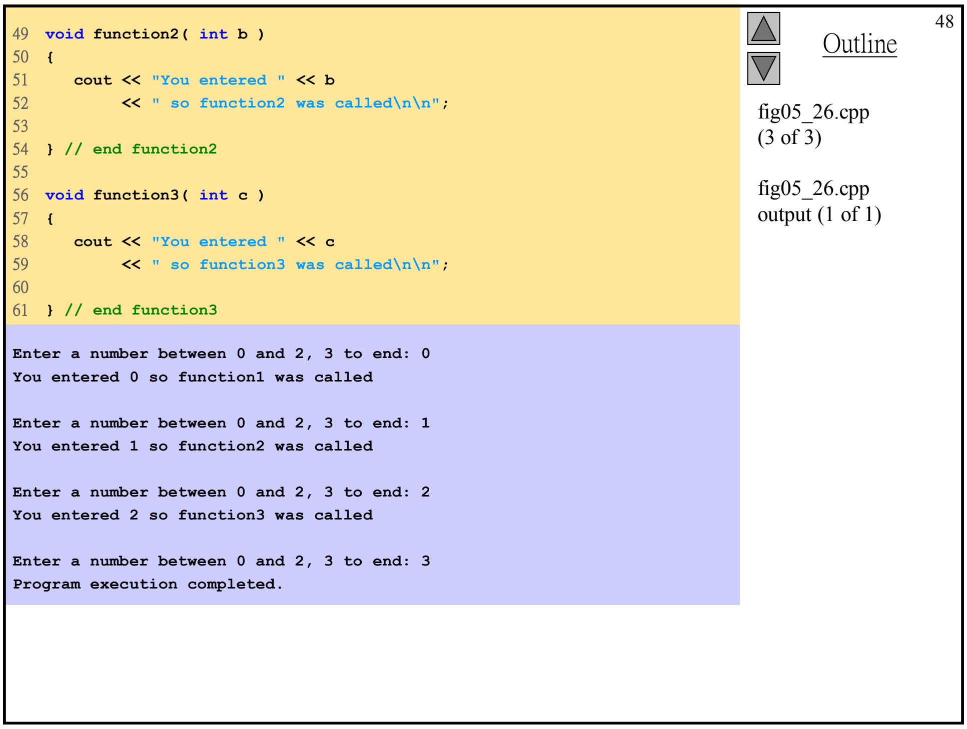
Outline

fig05_26.cpp
(2 of 3)

```
   // process user's choice
   while ( choice >= 0 && choice < 3 ) {

      // invoke function at location choice in array f
      // and pass choice as an argument
      (*f[ choice ])( choice );

      cout << "Enter a number between 0 and 2, 3 to end: ";
      cin >> choice;
   }

   cout << "Program execution completed." << endl;

   return 0;  // indicates successful termination

} // end main

void function1( int a )
{
   cout << "You entered " << a
        << " so function1 was called\n\n";

} // end function1

```

Call chosen function by dereferencing corresponding element in array.



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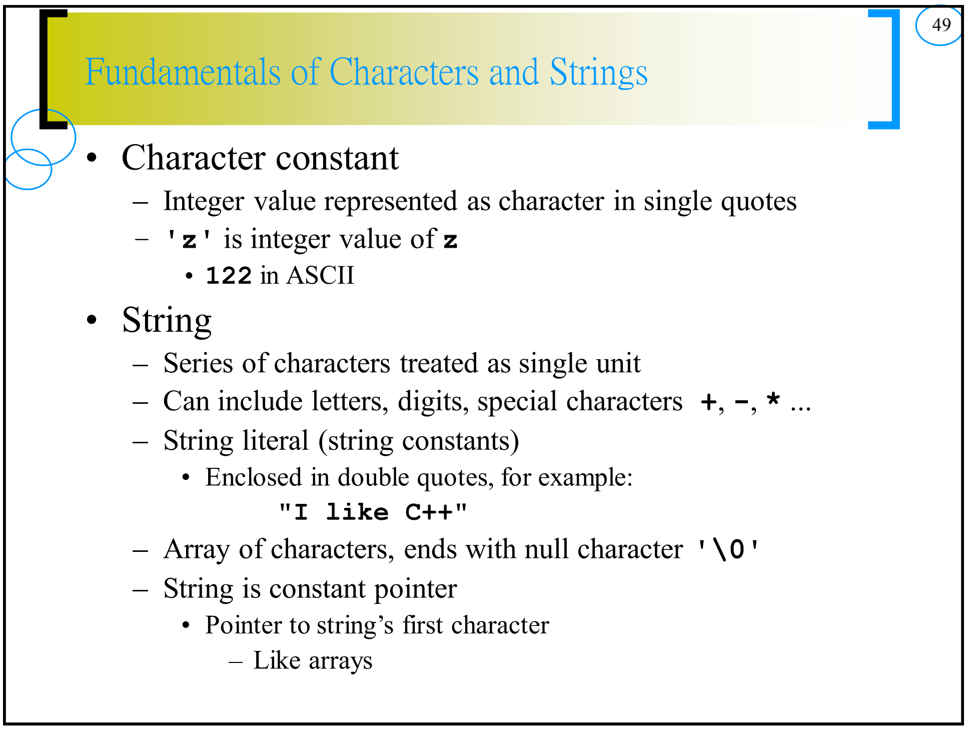
Outline

fig05_26.cpp
(3 of 3)

fig05_26.cpp
output (1 of 1)

```
void function2( int b )
{
   cout << "You entered " << b
        << " so function2 was called\n\n";

} // end function2

void function3( int c )
{
   cout << "You entered " << c
        << " so function3 was called\n\n";

} // end function3
```

```
Enter a number between 0 and 2, 3 to end: 0
You entered 0 so function1 was called

Enter a number between 0 and 2, 3 to end: 1
You entered 1 so function2 was called

Enter a number between 0 and 2, 3 to end: 2
You entered 2 so function3 was called

Enter a number between 0 and 2, 3 to end: 3
Program execution completed.
```



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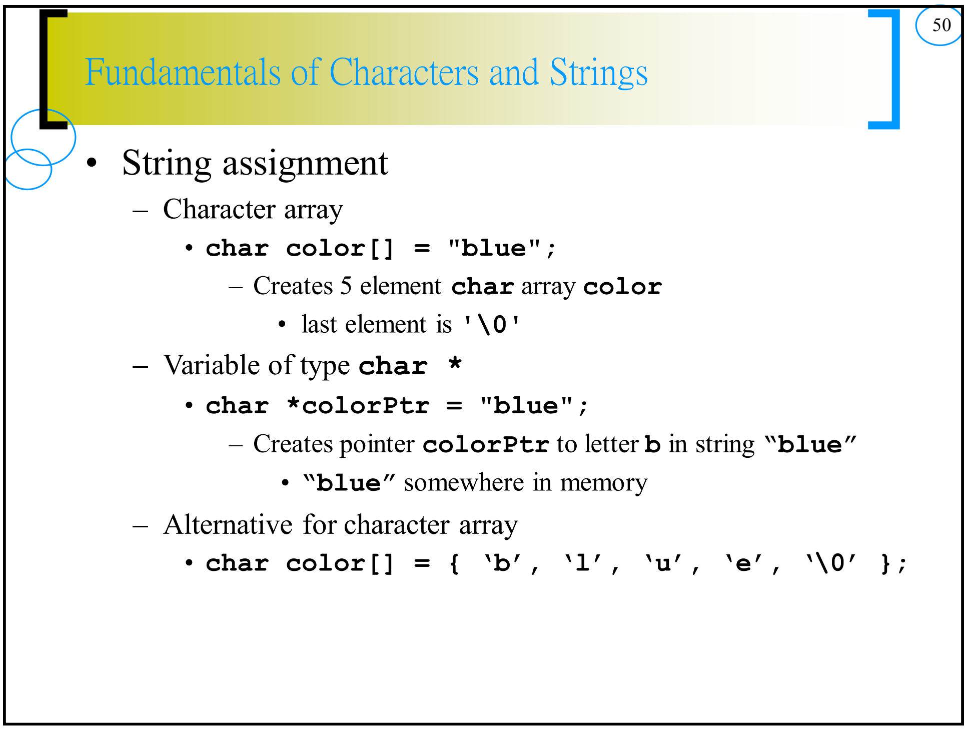
Fundamentals of Characters and Strings

- Character constant
  - Integer value represented as character in single quotes
  - `'z'` is integer value of `z`
    - `122` in ASCII
- String
  - Series of characters treated as single unit
  - Can include letters, digits, special characters `+`, `-`, `*` ...
  - String literal (string constants)
    - Enclosed in double quotes, for example:

      `"I like C++"`
  - Array of characters, ends with null character `'\0'`
  - String is constant pointer
    - Pointer to string’s first character
      - Like arrays



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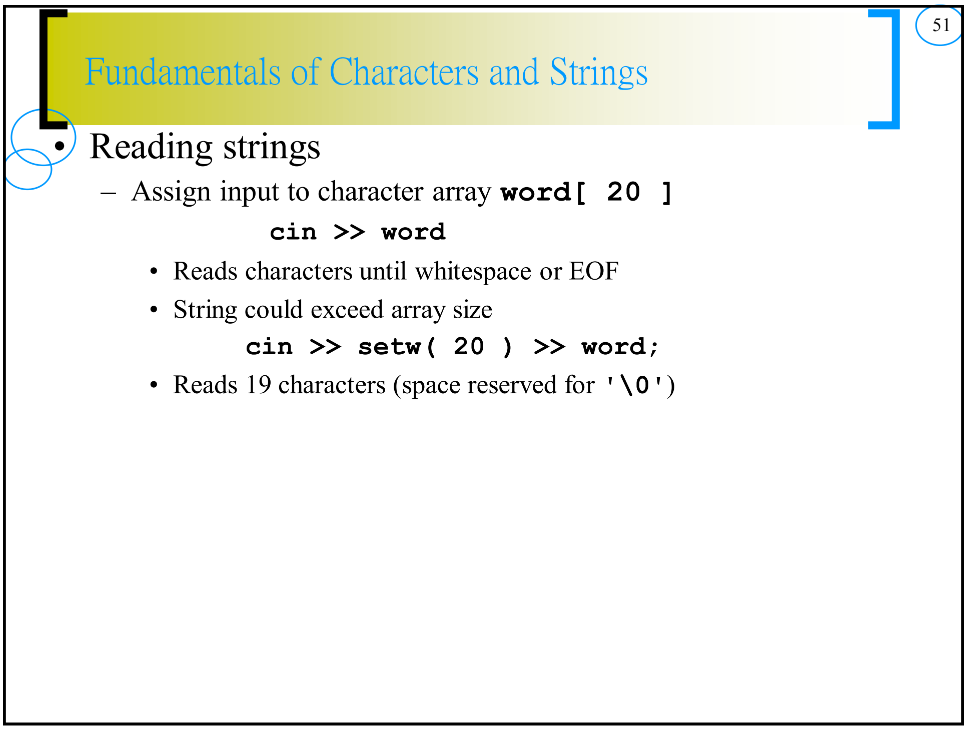
Fundamentals of Characters and Strings

- String assignment
  - Character array
    - `char color[] = "blue";`
      - Creates 5 element `char` array `color`
        - last element is `'\0'`
  - Variable of type `char *`
    - `char *colorPtr = "blue";`
      - Creates pointer `colorPtr` to letter `b` in string `“blue”`
        - `“blue”` somewhere in memory
  - Alternative for character array
    - `char color[] = { ‘b’, ‘l’, ‘u’, ‘e’, ‘\0’ };`



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Fundamentals of Characters and Strings

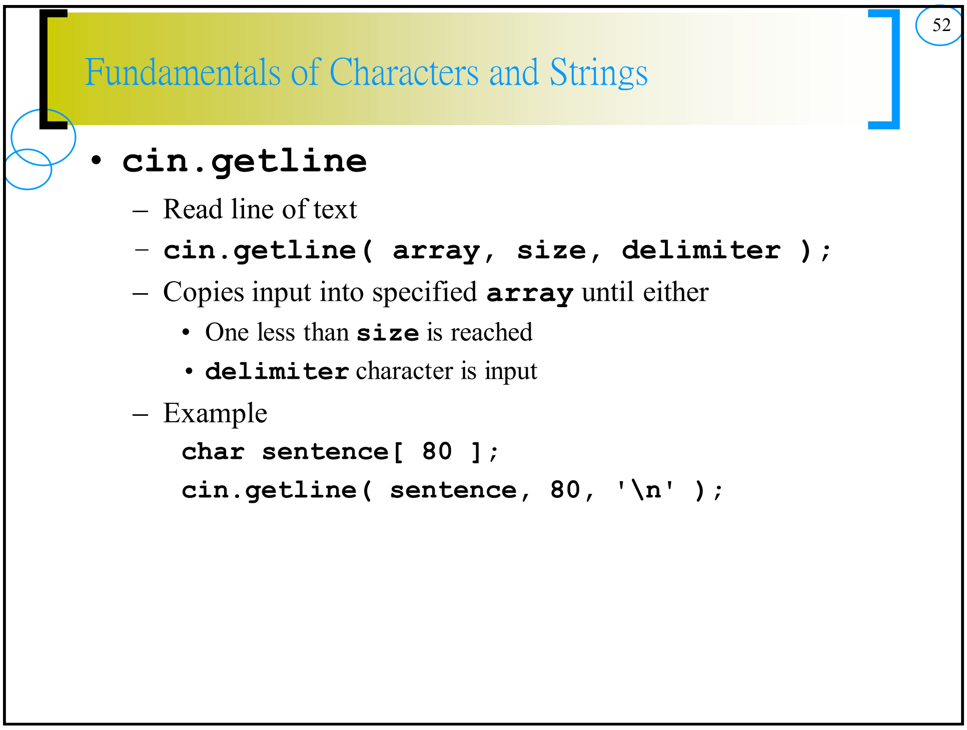
- Reading strings
  - Assign input to character array **word[20]**

    ```
    cin >> word
    ```

    - Reads characters until whitespace or EOF
    - String could exceed array size

      ```
      cin >> setw( 20 ) >> word;
      ```

    - Reads 19 characters (space reserved for **'\0'**)



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Fundamentals of Characters and Strings

- **cin.getline**
  - Read line of text
  - **cin.getline(array, size, delimiter);**
  - Copies input into specified **array** until either
    - One less than **size** is reached
    - **delimiter** character is input
  - Example

    ```
    char sentence[ 80 ];
    cin.getline( sentence, 80, '\n' );
    ```

String Manipulation Functions of the String-handling Library

- String handling library **`<cstring>`** provides functions to
  - Manipulate string data
  - Compare strings
  - Search strings for characters and other strings
  - Tokenize strings (separate strings into logical pieces)

String Manipulation Functions of the String-handling Library

`char *strcpy( char *s1, const char *s2 );`	Copies the string **`s2`** into the character array **`s1`**. The value of **`s1`** is returned.
`char *strncpy( char *s1, const char *s2, size_t n );`	Copies at most **`n`** characters of the string **`s2`** into the character array **`s1`**. The value of **`s1`** is returned.
`char *strcat( char *s1, const char *s2 );`	Appends the string **`s2`** to the string **`s1`**. The first character of **`s2`** overwrites the terminating null character of **`s1`**. The value of **`s1`** is returned.
`char *strncat( char *s1, const char *s2, size_t n );`	Appends at most **`n`** characters of string **`s2`** to string **`s1`**. The first character of **`s2`** overwrites the terminating null character of **`s1`**. The value of **`s1`** is returned.
`int strcmp( const char *s1, const char *s2 );`	Compares the string **`s1`** with the string **`s2`**. The function returns a value of zero, less than zero or greater than zero if **`s1`** is equal to, less than or greater than **`s2`**, respectively.

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String Manipulation Functions of the String-handling Library

`int strncmp( const char *s1, const char *s2, size_t n );`	Compares up to **n** characters of the string **s1** with the string **s2**. The function returns zero, less than zero or greater than zero if **s1** is equal to, less than or greater than **s2**, respectively.
`char *strtok( char *s1, const char *s2 );`	A sequence of calls to **strtok** breaks string **s1** into "tokens"—logical pieces such as words in a line of text—delimited by characters contained in string **s2**. The first call contains **s1** as the first argument, and subsequent calls to continue tokenizing the same string contain **NULL** as the first argument. A pointer to the current token is returned by each call. If there are no more tokens when the function is called, **NULL** is returned.
`size_t strlen( const char *s );`	Determines the length of string **s**. The number of characters preceding the terminating null character is returned.

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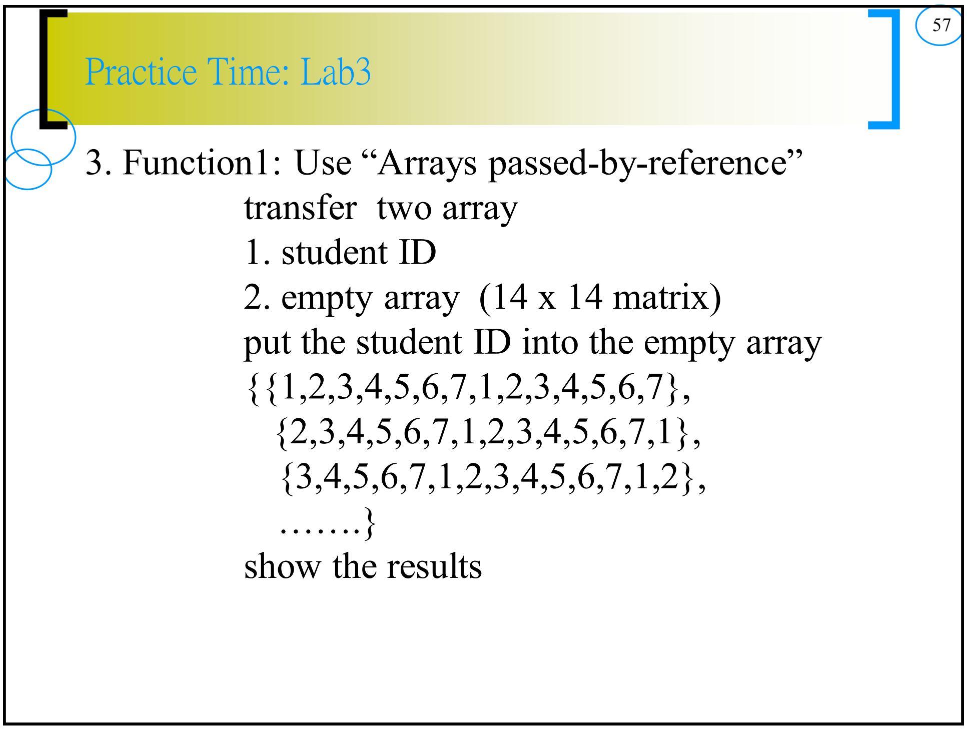
Practice Time: Lab3

1. Write three functions in Lab3
2. Main program:

```
int ID[14]={1,2,3,4,5,6,7,1,2,3,4,5,6,7};
function1();
function2();
function3();
system("pause");
```



Practice Time: Lab3

3. Function1: Use “Arrays passed-by-reference”

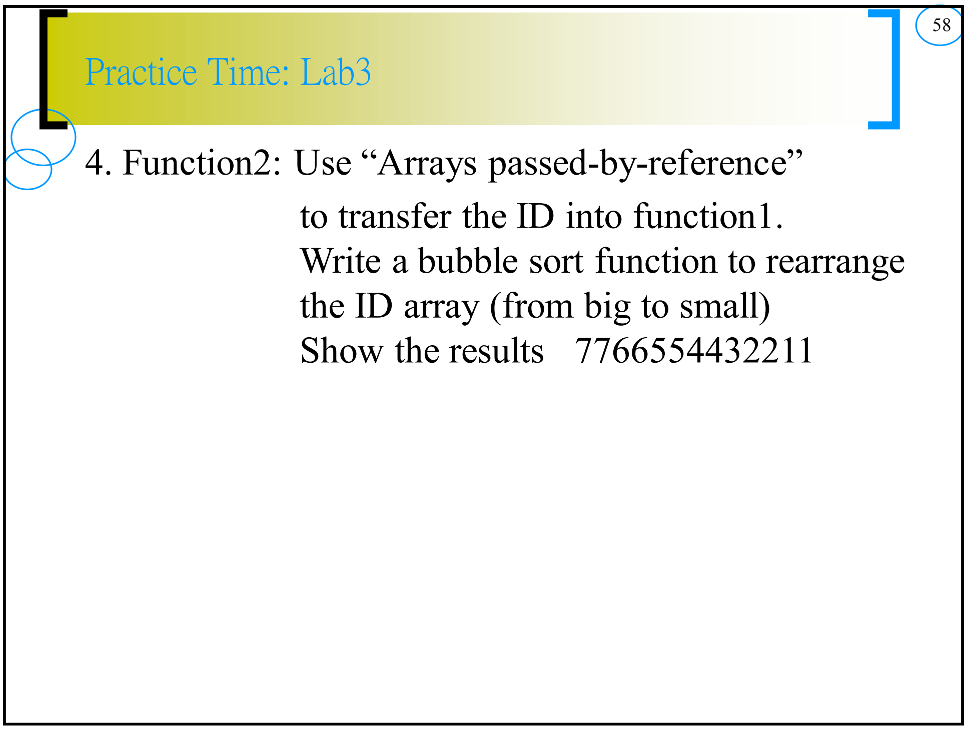
transfer two array

1. student ID
2. empty array (14 x 14 matrix)

put the student ID into the empty array

{{1,2,3,4,5,6,7,1,2,3,4,5,6,7},
{2,3,4,5,6,7,1,2,3,4,5,6,7,1},
{3,4,5,6,7,1,2,3,4,5,6,7,1,2},
…….}

show the results



Practice Time: Lab3

4. Function2: Use “Arrays passed-by-reference”

to transfer the ID into function1.

Write a bubble sort function to rearrange the ID array (from big to small)

Show the results   77665544332211

Practice Time: Lab3

5. Function3: Matrix multiplication
Calculate the 14x14 matrix in function1

If $\mathbf{A}$ is an $n \times m$ matrix and $\mathbf{B}$ is an $m \times p$ matrix,

$$\mathbf{A} = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1m} \\ a_{21} & a_{22} & \cdots & a_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nm} \end{pmatrix}, \quad \mathbf{B} = \begin{pmatrix} b_{11} & b_{12} & \cdots & b_{1p} \\ b_{21} & b_{22} & \cdots & b_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ b_{m1} & b_{m2} & \cdots & b_{mp} \end{pmatrix}$$

the *matrix product* **C** = **AB** (denoted without multiplication signs or dots) is defined to be the $n \times p$ matrix

A.A

Upload the whole project on E3

End