Chapter 10:

Characters, C-Strings, and

More About the `string` Class

starting out with >>>

C++

From Control Structures through Objects

EIGHTH EDITION

TONY GADDIS

10.1

Character Testing

Character Testing

- Requires `cctype` header file
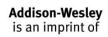
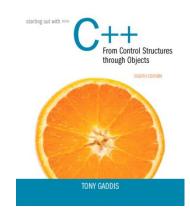| FUNCTION	MEANING
isalpha	true if arg. is a letter, false otherwise
isalnum	true if arg. is a letter or digit, false otherwise
isdigit	true if arg. is a digit 0-9, false otherwise
islower	true if arg. is lowercase letter, false otherwise
isprint	true if arg. is a printable character, false otherwise
ispunct	true if arg. is a punctuation character, false otherwise
isupper	true if arg. is an uppercase letter, false otherwise
isspace	true if arg. is a whitespace character, false otherwise

From Program 10-1

```
10      cout << "Enter any character: ";
11      cin.get(input);
12      cout << "The character you entered is: " << input << endl;
13      if (isalpha(input))
14         cout << "That's an alphabetic character.\n";
15      if (isdigit(input))
16         cout << "That's a numeric digit.\n";
17      if (islower(input))
18         cout << "The letter you entered is lowercase.\n";
19      if (isupper(input))
20         cout << "The letter you entered is uppercase.\n";
21      if (isspace(input))
22         cout << "That's a whitespace character.\n";
```
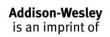
10.2

Character Case Conversion

Character Case Conversion

- Require `cctype` header file

- Functions:

  `toupper`: if `char` argument is lowercase letter, return uppercase equivalent; otherwise, return input unchanged

  ```
  char ch1 = 'H';
  char ch2 = 'e';
  char ch3 = '!';
  cout << toupper(ch1);  // displays 'H'
  cout << toupper(ch2);  // displays 'E'
  cout << toupper(ch3);  // displays '!'
  ```
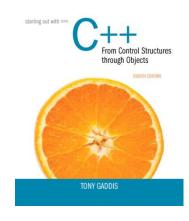
Character Case Conversion

- Functions:

  `tolower`: if `char` argument is uppercase letter, return lowercase equivalent; otherwise, return input unchanged

  ```
  char ch1 = 'H';
  char ch2 = 'e';
  char ch3 = '!';
  cout << tolower(ch1);   // displays 'h'
  cout << tolower(ch2);   // displays 'e'
  cout << tolower(ch3);   // displays '!'
  ```
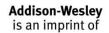
10.3

C-Strings

C-Strings

- C-string: sequence of characters stored in adjacent memory locations and terminated by `NULL` character

- String literal (string constant): sequence of characters enclosed in double quotes " " :

  `"Hi there!"`

H	i		t	h	e	r	e	!	\0

C-Strings

- Array of `char`s can be used to define storage for string:
  ```
  const int SIZE = 20;
  char city[SIZE];
  ```

- Leave room for `NULL` at end
- Can enter a value using `cin` or `>>`
  - Input is whitespace-terminated
  - No check to see if enough space
- For input containing whitespace, and to control amount of input, use `cin.getline()`

Using C-Strings in Program 10-5

Program 10-5

```cpp
1   // This program displays a string stored in a char array.
2   #include <iostream>
3   using namespace std;
4
5   int main()
6   {
7       const int SIZE = 80;   // Array size
8       char line[SIZE];       // To hold a line of input
9       int count = 0;         // Loop counter variable
10
11      // Get a line of input.
12      cout << "Enter a sentence of no more than "
13          << (SIZE - 1) << " characters:\n";
14      cin.getline(line, SIZE);
15
16      // Display the input one character at a time.
17      cout << "The sentence you entered is:\n";
18      while (line[count] != '\0')
19      {
20          cout << line[count];
21          count++;
22      }
23      return 0;
24  }
```
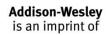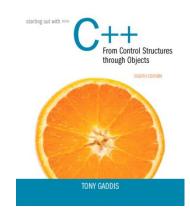
Program Output with Example Input Shown in Bold

Enter a sentence of no more than 79 characters:
C++ is challenging but fun! [Enter]
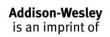The sentence you entered is:
C++ is challenging but fun!

10.4

Library Functions for Working with C-Strings

Library Functions for Working with C-Strings

- Require the `cstring` header file

- Functions take one or more C-strings as arguments. Can use:
  - C-string name
  - pointer to C-string
  - literal string

Library Functions for Working with C-Strings

Functions:

- strlen(str): returns length of C-string str

  ```
  char city[SIZE] = "Missoula";
  cout << strlen(city); // prints 8
  ```

- strcat(str1, str2): appends str2 to the end of str1

  ```
  char location[SIZE] = "Missoula, ";
  char state[3] = "MT";
  strcat(location, state);
  // location now has "Missoula, MT"
  ```

Library Functions for Working with C-Strings

Functions:

- `strcpy(str1, str2)`: copies `str2` to `str1`

```
const int SIZE = 20;
char fname[SIZE] = "Maureen", name[SIZE];
strcpy(name, fname);
```

Note: `strcat` and `strcpy` perform no bounds checking to determine if there is enough space in receiving character array to hold the string it is being assigned.
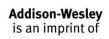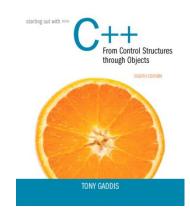
C-string Inside a C-string

Function:

- `strstr(str1, str2)`: finds the first occurrence of `str2` in `str1`. Returns a pointer to match, or `NULL` if no match.

```
char river[] = "Wabash";
char word[] = "aba";
cout << strstr(state, word);
// displays "abash"
```
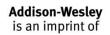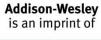
10.5

C-String/Numeric Conversion Functions

String/Numeric Conversion Functions

- Requires `cstdlib` header file

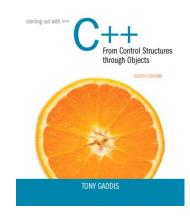| FUNCTION	PARAMETER	ACTION
`atoi`	C-string	converts C-string to an `int` value, returns the value
`atol`	C-string	converts C-string to a `long` value, returns the value
`atof`	C-string	converts C-string to a `double` value, returns the value
`itoa`	`int`, C-string, `int`	converts 1st `int` parameter to a C-string, stores it in 2nd parameter. 3rd parameter is base of converted value

String/Numeric Conversion Functions

```
int iNum;
long lNum;
double dNum;
char intChar[10];
iNum = atoi("1234"); // puts 1234 in iNum
lNum = atol("5678"); // puts 5678 in lNum
dNum = atof("35.7"); // puts 35.7 in dNum
itoa(iNum, intChar, 8); // puts the string
```
$\quad$ // "2322" (base 8 for 1234_{10}) in intChar

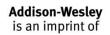# String/Numeric Conversion Functions - Notes

- if C-string contains non-digits, results are undefined
  - function may return result up to non-digit
  - function may return 0

- `itoa` does no bounds checking – make sure there is enough space to store the result

10.6

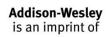## Writing Your Own C-String Handling Functions

Writing Your Own C-String Handling Functions

- Designing C-String Handling Functions
  - can pass arrays or pointers to `char` arrays
  - Can perform bounds checking to ensure enough space for results
  - Can anticipate unexpected user input

From Program 10-9

```
31  void stringCopy(char string1[], char string2[])
32  {
33      int index = 0;   // Loop counter
34
35      // Step through string1, copying each element to
36      // string2. Stop when the null character is encountered.
37      while (string1[index] != '\0')
38      {
39          string2[index] = string1[index];
40          index++;
41      }
42
43      // Place a null character in string2.
44      string2[index] = '\0';
45  }
```

From Program 10-10

```
29  void nameSlice(char userName[])
30  {
31      int count = 0;   // Loop counter
32
33      // Locate the first space, or the null terminator if there
34      // are no spaces.
35      while (userName[count] != ' ' && userName[count] != '\0')
36          count++;
37
38      // If a space was found, replace it with a null terminator.
39      if (userName[count] == ' ')
40          userName[count] = '\0';
41  }
```

10.7

More About the C++ `string` Class

The C++ `string` Class

- Special data type supports working with strings
- `#include <string>`
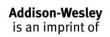- Can define `string` variables in programs:
  ```
  string firstName, lastName;
  ```
- Can receive values with assignment operator:
  ```
  firstName = "George";
  lastName = "Washington";
  ```
- Can be displayed via `cout`
  ```
  cout << firstName << " " << lastName;
  ```

Using the `string` class in Program 10-15

Program 10-15

```cpp
 1   // This program demonstrates the string class.
 2   #include <iostream>
 3   #include <string>      // Required for the string class.
 4   using namespace std;
 5
 6   int main()
 7   {
 8      string movieTitle;
 9
10      movieTitle = "Wheels of Fury";
11      cout << "My favorite movie is " << movieTitle << endl;
12      return 0;
13   }
```

Program Output
```
My favorite movie is Wheels of Fury
```

Input into a `string` Object

- Use `cin >>` to read an item into a string:

```
string firstName;
cout << "Enter your first name: ";
cin >> firstName;
```

Using `cin` and `string` objects in program 10-16

Program 10-16

```cpp
1   // This program demonstrates how cin can read a string into
2   // a string class object.
3   #include <iostream>
4   #include <string>
5   using namespace std;
6
7   int main()
8   {
9      string name;
10
11     cout << "What is your name? ";
12     cin >> name;
13     cout << "Good morning " << name << endl;
14     return 0;
15  }
```

Program Output with Example Input Shown in Bold
```
What is your name? Peggy [Enter]
Good morning Peggy
```

Input into a `string` Object

- Use `getline` function to put a line of input, possibly including spaces, into a string:

```
string address;
cout << "Enter your address: ";
getline(cin,address);
```

`string` Comparison

- Can use relational operators directly to compare string objects:

```
string str1 = "George",
        str2 = "Georgia";
if (str1 < str2)
   cout << str1 << " is less than "
        << str2;
```

- Comparison is performed similar to `strcmp` function. Result is `true` or `false`

Program 10-18

```cpp
1   // This program uses relational operators to alphabetically
2   // sort two strings entered by the user.
3   #include <iostream>
4   #include <string>
5   using namespace std;
6
7   int main ()
8   {
9       string name1, name2;
10
11      // Get a name.
12      cout << "Enter a name (last name first): ";
13      getline(cin, name1);
14
15      // Get another name.
16      cout << "Enter another name: ";
17      getline(cin, name2);
18
19      // Display them in alphabetical order.
20      cout << "Here are the names sorted alphabetically:\n";
21      if (name1 < name2)
22          cout << name1 << endl << name2 << endl;
23      else if (name1 > name2)
24          cout << name2 << endl << name1 << endl;
25      else
26          cout << "You entered the same name twice!\n";
27      return 0;
28  }
```

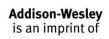**Program Output with Example Input Shown in Bold**

```
Enter a name (last name first): Smith, Richard [Enter]
Enter another name: Jones, John [Enter]
Here are the names sorted alphabetically:
Jones, John
Smith, Richard
```
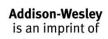
Other Definitions of C++ `strings`

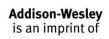| Definition	Meaning
`string name;`	defines an empty string object
`string myname("Chris");`	defines a string and initializes it
`string yourname(myname);`	defines a string and initializes it
`string aname(myname, 3);`	defines a string and initializes it with first 3 characters of `myname`
`string verb(myname,3,2);`	defines a string and initializes it with 2 characters from `myname` starting at position 3
`string noname('A', 5);`	defines string and initializes it to 5 `'A'`s

`string` Operators

OPERATOR	MEANING
>>	extracts characters from stream up to whitespace, insert into string
<<	inserts string into stream
=	assigns string on right to string object on left
+=	appends string on right to end of contents on left
+	concatenates two strings
[]	references character in string using array notation
>, >=, <, <=, ==, !=	relational operators for string comparison. Return `true` or `false`

string Operators

```
string word1, phrase;
string word2 = " Dog";
cin >> word1; // user enters "Hot Tamale"
                // word1 has "Hot"
phrase = word1 + word2; // phrase has
                            // "Hot Dog"
phrase += " on a bun";
for (int i = 0; i < 16; i++)
    cout << phrase[i]; // displays
                    // "Hot Dog on a bun"
```

Program 10-20

```cpp
 1   // This program demonstrates the C++ string class.
 2   #include <iostream>
 3   #include <string>
 4   using namespace std;
 5
 6   int main ()
 7   {
 8      // Define three string objects.
 9      string str1, str2, str3;
10
11      // Assign values to all three.
12      str1 = "ABC";
13      str2 = "DEF";
14      str3 = str1 + str2;
15
16      // Display all three.
17      cout << str1 << endl;
18      cout << str2 << endl;
19      cout << str3 << endl;
20
21      // Concatenate a string onto str3 and display it.
22      str3 += "GHI";
23      cout << str3 << endl;
24      return 0;
25   }
```

Program Output
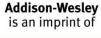
```
ABC
DEF
ABCDEF
ABCDEFGHI
```

`string` Member Functions

- Are behind many overloaded operators
- Categories:
  - assignment: `assign, copy, data`
  - modification: `append, clear, erase, insert, replace, swap`
  - space management: `capacity, empty, length, resize, size`
  - substrings: `find, front, back, at, substr`
  - comparison: `compare`
- See Table 10-8 for a list of functions.

string Member Functions

```
string word1, word2, phrase;
cin >> word1;            // word1 is "Hot"
word2.assign(" Dog");
phrase.append(word1);
phrase.append(word2);   // phrase has "Hot Dog"
phrase.append(" with mustard relish", 13);
          // phrase has "Hot Dog with mustard"
phrase.insert(8, "on a bun ");
cout << phrase << endl; // displays
          // "Hot Dog on a bun with mustard"
```

`string` Member Functions in Program 10-21

Program 10-21

```
1   // This program demonstrates a string
2   // object's length member function.
3   #include <iostream>
4   #include <string>
5   using namespace std;
6
7   int main ()
8   {
9       string town;
10
11      cout << "Where do you live? ";
12      cin >> town;
13      cout << "Your town's name has " << town.length() ;
14      cout << " characters\n";
15      return 0;
16  }
```

Program Output with Example Input Shown in Bold

Where do you live? **Jacksonville [Enter]**
Your town's name has 12 characters