Characters, Strings, and the `string` class

Character Testing

Character Testing

- require `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      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";
```

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

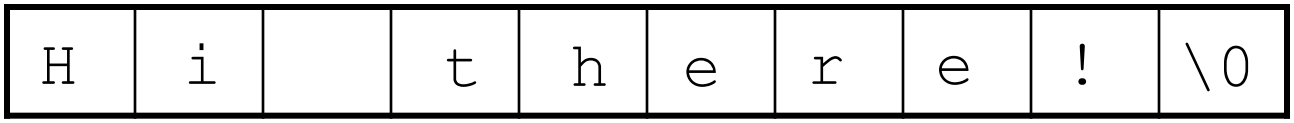
```
char ch1 = 'H';
char ch2 = 'e';
char ch3 = '!';
cout << tolower(ch1);  // displays 'h'
cout << tolower(ch2);  // displays 'e'
cout << tolower(ch3);  // displays '!'
```

Review of the Internal Storage of C-Strings

Review of the Internal Storage of 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!"
```



Review of the Internal Storage of 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()`

Program

```
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!
```

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"
```

String/Numeric Conversion Functions

String/Numeric Conversion Functions

- require `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
   // "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

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

```
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

```
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  }
```

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;
```

Program

```
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;
```

Program

```
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 *Continued*

Program Output with Example Input

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

```
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++ `string`s

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

```
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, substr`
  - comparison: `compare`
- See Table 9-7 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"
```

Program

```
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

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