

Ch04-LibraryAndFunction

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1 Library and Function

1.1 Topics

- some common C++ libraries and how to use them
- `iostream`, `string`, `numerics`, `iomanip`, `cmath`, `stdlib`, `sstream`, etc.

1.2 Library

- C++ provides a rich set of standard libraries: <https://en.cppreference.com/w/cpp/header>
- collection of code base that perform various generic and common tasks
 - e.g. input and output, basic math, output formatting, networking and communications, etc.
- C++ program can also use C libraries
- there are other third party libraries as well
 - e.g., boost (<https://www.boost.org/>) - usable across broad spectrum of applications
 - googletest (<https://github.com/google/googletest>) - unittest framework by Google
- syntax to include library in your C++ source files is:

```
#include<libraryName>
```

- C-libraries have `c` prefix before the library name
 - e.g. `cstdio`, `cmath`, etc.
- one can then use the identifiers (typically, functions, operators, and data) defined in the library
- we'll next dive into some libraries and their functions

1.3 `<iostream>` library

- we've already used `<iostream>` library and some of its functionalities
- `iostream` provides identifiers such as `cin`, `cout`, `endl`, etc. that aid in standard input/output (IO)

```
[1]: // standard input example
#include <iostream>
using namespace std;
```

```
[2]: cout << "Hello World!" << endl;
```

Hello World!

```
[3]: // standard output example
float num;
cout << "enter a number: ";
cin >> num;
cout << "you entered " << num << endl;
```

enter a number: 9.99

you entered 9.99

1.4 <string> library

- provides string advanced data types
- we used `to_string()` defined to convert numeric data to string type
- there's a lot of other methods provided in string objects
 - we'll dive into this later in string chapter
- there's also a `<cstring>` library completely different from C++ `<string>` library
 - <http://www.cplusplus.com/reference/cstring/>
 - provides functions for working with c-string (array of char)

```
[4]: #include <string>
using namespace std;
```

```
[5]: string some_name = "John Smith";
// convert float to string
string value = to_string(5324.454);
```

```
[6]: cout << some_name << " " << value << endl;
```

John Smith 5324.454000

```
[7]: value
```

```
[7]: "5324.454000"
```

```
[8]: // convert integer to string
string str_num = to_string(234);
```

```
[10]: // example of c-string (array of characters)
char richest_person[] = "Bill Gates";
```

```
[11]: richest_person
```

```
[11]: "Bill Gates"
```

```
[12]: // convert c-string to C++ string
string some_name1 = string(richest_person);
```

1.5 <cstdlib> library

- provides a bunch of typecasting functions
- originally in the C standard library as `<stdlib.h>`
<https://en.cppreference.com/w/cpp/header/cstdlib>
- must include `<cstdlib>`
- `float()`, `int()`, `double()`, `char()` are built-in functions used to convert data types
- `atof()` - converts a byte string to a floating point value
- `atoi()`, `atol()`, `atoll()` - convert a byte string to corresponding integer value
- the value in parenthesis is called the **argument**

```
[13]: #include <cstdlib> // or
      // include <stdlib.h>
```

```
cout << float(25) << " " << double(20.99f) << " " << int('A') << " " <<
↪char(97) << endl;
```

25 20.99 65 a

```
[14]: cout << atoi("99.99") << " " << atof("89.99");
```

99 89.99

```
[15]: // generate random number between 0 and RAND_MAX
      // run this cell many times to see different pseudo random number
      rand()
```

```
[15]: 1441282327
```

```
[16]: RAND_MAX
```

```
[16]: 2147483647
```

```
[17]: // generate a random number between 1 and 1000
      rand()%1000+1
```

```
[17]: 730
```

1.6 Numerics library

- <https://en.cppreference.com/w/cpp/numeric>
- includes common mathematical functions and types
- we may be familiar with a lot of math functionalities from trigonometrics or algebra
- expressions such as $\sin(\frac{\pi}{2})$, $\log(\frac{1}{x})$, etc.
 - first, we evaluate the expression inside the parenthesis called **argument**
 - then, we apply the function to evaluate the answer

1.7 <cmath> library

- provides functionalities to calculate common mathematical expressions
- `abs()`, `sqrt()`, `sin()`, `cos()`, `pow()`, `sqrt()`, `log()`, etc.
- more: <https://en.cppreference.com/w/cpp/numeric>

```
[18]: #include <cmath>
#include <iostream>

using namespace std;
```

```
[59]: // can use built-in macro M_PI for the value of M_PI
M_PI
```

```
[59]: 3.1415927
```

```
[19]: // sine of (pi/2)
sin(3.141592653589793238/2)
```

```
[19]: 1.0000000
```

```
[20]: cos(0)
```

```
[20]: 1.0000000
```

```
[21]: int x;
```

```
[22]: cout << "Enter a number: ";
cin >> x;
cout << "natural ln (" << x << ") = " << log(x); // returns natural log base e
```

Enter a number:

```
10
natural ln (10) = 2.30259
```

```
[22]: @0x10cd5fec0
```

```
[23]: cout << "base 2 log: log2(" << x << ") = " << log2(x); // returns base 2 log
```

```
base 2 log: log2(10) = 3.32193
```

```
[23]: @0x10cd5fec0
```

```
[24]: cout << "base 10 log: log10(" << x << ") = " << log10(x); // returns base 10 log
```

```
base 10 log: log10(10) = 1
```

[24]: @0x10cd5fec0

```
[25]: pow(2, 4) // returns  $x^y$ 
```

[25]: 16.000000

```
[26]: sqrt(100) // returns square root of x
```

[26]: 10.000000

```
[27]: cbrt(1000) // returns cubic root of x
```

[27]: 10.000000

```
[28]: // returns absolute positive value of an integer  
abs(-7)
```

[28]: 7

```
[29]: // returns rounded up integer  
ceil(5.1)
```

[29]: 6.0000000

```
[30]: // returns the rounded down integer  
floor(5.9)
```

[30]: 5.0000000

```
[31]: // returns the smallest integer larger than argument  
ceil(-5.1)
```

[31]: -5.0000000

```
[32]: // returns the largest integer smaller than argument  
floor(-5.9)
```

[32]: -6.0000000

1.8 <cctype> library

- C library that provides some functionalities to work with character types
- `tolower(x)` : returns the lowercase ASCII value of x character
- `toupper(x)` : returns the uppercase of x character
- `isalpha(x)` : checks if a character is alphabetic
- more on cctype: <https://en.cppreference.com/w/cpp/header/cctype>

```
[33]: #include <cctype>
using namespace std;
```

```
[34]: tolower('A')
```

```
[34]: 97
```

```
[35]: tolower('$')
```

```
[35]: 36
```

```
[36]: // convert lowercase ASCII value to char
char(tolower('A'))
```

```
[36]: 'a'
```

```
[37]: char(toupper('z'))
```

```
[37]: 'Z'
```

```
[38]: char(toupper('1'))
```

```
[38]: '1'
```

```
[39]: // return 1 for true
isalpha('q')
```

```
[39]: 1
```

```
[40]: // returns 0 for false
isalpha('*')
```

```
[40]: 0
```

```
[41]: // TODO: practice with other functions in ctype
```

1.9 <sstream> library

- provides high-level string input/output operations
- basic_istringstream provides functionalities for high-level string stream input operations
 - helps parse string data and extract values as specific types
- basic_ostringstream provides functionalities for high-level string stream output operations
 - helpful in collecting results of different data types
- more: <https://en.cppreference.com/w/cpp/header/ssstream>

```
[1]: #include <sstream> // istringstream and ostringstream
#include <iostream>
```

```
#include <string>

using namespace std;
```

```
[2]: // let's say we've a string data record as: firstName MI lastName age GPA
string mixedData = "John B Doe 20 3.9";
// let's parse it using istringstream
istringstream iss(mixedData);
// now since we created input string stream, we can extract data
// as if we're extracting from standard input stream
```

```
[3]: // let's declare variables to store data into
string firstName, lastName;
char MI;
int age;
float GPA;
```

```
[4]: iss >> firstName >> MI >> lastName >> age >> GPA;
```

```
[5]: cout << "Parsed record: " << firstName << " " << MI << " " << lastName << " "
    << age << " " << GPA;
```

Parsed record: John B Doe 20 3.9

```
[47]: // let's declare an empty output string stream
ostreamstream outstream;
```

```
[48]: // let's write data to outstream just like writing to std output stream
outstream << firstName << MI << lastName << age << GPA;
```

```
[49]: // let's print the outstream as string
cout << outstream.str();
// many objects have methods that can be invoked using . operator
```

JohnBDoe203.9

```
[49]: @0x10cd5fec0
```

1.10 <iomanip> library

- provides functionalities to manipulate or format input and output
- **setfill(char)** - changes the fill character; used in conjunction with setw()
- **setprecision(int)** - changes floating-point precision
- **setw(int)** - changes the width of the next input/output field
- more: <https://en.cppreference.com/w/cpp/header/iomanip>
- syntax:

```
cout << expression << manipulator << expression << manipulator << ...;
```

- some other manipulators are
 - **fixed** - output the floating point in fixed decimal format
 - **showpoint** - displays the trailing zeros
- parameterized manipulator require **iomanip** library
- manipulators without parameters require **iostream** library

1.10.1 Tabular output

- often you have to format your output to look well organized
 - like a tabular report
- let's print the following output

```
=====
First Name      Last Name      Age      GPA
=====
John            Smith          20       3.9
Alice           Wonderland     19       4.0
*****
```

- First Name has width of 20 characters
- Last Name has width of 20 chars
- Age has width of 5 chars
- GPA has width of 5 chars

```
[50]: #include <iomanip>
#include <iostream>

using namespace std;
```

```
[51]: // setw() and setfill() example
// print 50 character long string with '='
cout << setw(50) << setfill('=') << "";
```

```
=====
[52]: cout << setw(20) << "First Name" << setw(20) << "Last Name"
      << setw(5) << "Age" << setw(5) << "GPA" << endl;
      // by default data in setw() column is right aligned!
```

```
=====First Name=====Last Name==Age==GPA
```

```
[52]: @0x10cd5fec0
```

```
[53]: // let's left align the first name and last name columns
// let's right align the Age and GPA numeric columns
cout << setfill(' '); // need to reset the fill character to ' ' space
cout << setw(20) << left << "First Name" << setw(20) << "Last Name"
      << right << setw(5) << "Age" << setw(5) << "GPA" << endl;
      // by default data in setw() column is right aligned!
```


First Name	Last Name	Age	GPA
------------	-----------	-----	-----

[53]: @0x10cd5fec0

```
[54]: // outputting floating point numbers
cout << 1.234567 << endl;
cout << 1.00000 << endl;
// rounds to 5 decimal points or ignores trailing 0s
```

1.23457
1

[54]: @0x10cd5fec0

```
[55]: // force trailing zeros to display
cout << fixed << showpoint << 1.000000 << endl;
```

1.000000

```
[56]: // we can fix this by forcing floating point numbers to print as fixed value
// and then set the precision
cout << fixed << setprecision(6) << 1.123456789 << " " << 1.000000000 << endl;
// do this only once; applies to all the floating points printed onwards..
```

1.123457 1.000000

[56]: @0x10cd5fec0

```
[57]: // let's put it all together
cout << setw(50) << setfill('=') << "" << endl;
cout << setfill(' '); // need to reset the fill character to ' ' space
cout << setw(20) << left << "First Name" << setw(20) << "Last Name"
    << right << setw(5) << "Age" << setw(5) << "GPA" << endl;
cout << setw(50) << setfill('=') << "" << endl;
cout << setfill(' ') << fixed << setprecision(1);
cout << setw(20) << left << "John" << setw(20) << "Smith"
    << right << setw(5) << 20 << setw(5) << 3.9 << endl;
cout << setw(20) << left << "Alice" << setw(20) << "Wonderland"
    << right << setw(5) << 19 << setw(5) << 4.0 << endl;
cout << setw(50) << setfill('*') << "" << endl;
```

```
=====
First Name      Last Name      Age  GPA
=====
John            Smith            20  3.9
Alice           Wonderland      19  4.0
*****
```

1.11 <stdio> library

- C alternative to C++ iostream library is worth learning about
- C library for stdio has many functions for working with standard input/output
 - <https://en.cppreference.com/w/cpp/header/cstdio>
- specially, `printf()` can be very useful in quickly printing integers and floating point numbers with some formatting
- `printf` function prototype:

```
int printf(const char* format, ...);
```

- format strings include format parameter with % symbol to format the given data with
- NOTE: `printf()` is not supported with C++ Jupyter Notebook kernel
- see examples here: [demo_programs/Ch04/printf/printf_demo.cpp](#)

1.12 Exercises

1. Area and perimeter of rectangle
 - Write a C++ program with algorithm that prompts user to enter length and width of a rectangle. Program then computes its area and perimeter and displays the results.
 - Use as many libraries as possible!
 - see this sample solution [exercises/Ch04/rectangle/main.cpp](#)
2. Area and perimeter of a triangle
 - Write a C++ program with algorithm that prompts user to enter three sides of a triangle. Program then computes its area and perimeter and displays the results.
 - Hint: Use Heron's formula: <https://www.mathsisfun.com/geometry/herons-formula.html>
 - Use as many libraries as possible!
3. Area and volume of a right cylinder
 - Write a C++ program with algorithm that prompts user to enter radius and height of a cylinder. Program then computes and displays the area and volume.
 - Use as many libraries as possible (more the better!)
 - [perimeter formula by Google](#)
 - [area formula by Google](#)
 - [volume formula by Google](#)
4. Area and perimeter of a regular hexagon
 - Write a C++ program with algorithm that prompts user to enter a side of the regular hexagon. It then computes and prints the area and perimeter.
 - [area of a regular hexagon by Google](#)
 - Use as many libraries as possible!
5. Average grade
 - Write a C++ program with algorithm that prompts user to enter a student's full name and three test scores in on line. Program then finds the average score and displays the results as a tabular report.
 - must use `sstream` library to read and write data.
 - use as many other libraries as possible.
 - e.g. input: John C Doe 100 95 98
 - e.g. output:

First Name	MI	Last Name	Test1	Test2	Test3	Avg.
#####						
John	C.	Doe	100	95	98	97.66
~~~~~						

### 1.13 Kattis Problems

- almost every Kattis problem requires at least **iostream** or **cstdio** library (cin or cout)
- math problems may require **cmath** library
- string problems may require **string** library
- **iomanip** is required if output results need to be formatted in certain way
- **cctype** is required by any problem that needs to work with **char** type
- **stdlib** has many utility functions that may also be required

### 1.14 Summary

- learned about some common libraries
- purpose of libraries and example usages
- revisited iomanip, string, stdlib
- learned about cmath, sstream, iomanip with some examples
- exercises and sample solution

[ ]: