

04: FUNCTION

Programming Technique I
(SECJ1013)

Modular Programming

- **Modular programming**: breaking a program up into smaller, manageable functions or modules
- **Function**: a collection of statements to perform a task
- Motivation for modular programming:
 - Improves maintainability of programs
 - Simplifies the process of writing programs

This program has one long, complex function containing all of the statements necessary to solve a problem.



```
int main()
{
    statement;
    statement;
}
```

In this program the problem has been divided into smaller problems, each of which is handled by a separate function.



```
int main()
{
    statement;
    statement;
    statement;
}

void function2()
{
    statement;
    statement;
    statement;
}

void function3()
{
    statement;
    statement;
    statement;
}

void function4()
{
    statement;
    statement;
    statement;
}
```

main function

function 2

function 3

function 4

Function

- A **collection of statements** that performs a specific task.
- Commonly used to **break a problem** down into small manageable pieces.
- In C++, there are 2 types of function:
 - Library functions
 - User-defined functions

Library Functions

- “Built-in” functions that **come with the compiler**.
- The source code (definition) for library functions does NOT appear in your program.
- To use a library function, you simply need to **include the proper header file** and know the name of the function that you wish to use.
 - **#include** *compiler directive*

Library Functions (cont.)

- Libraries under discussion at this time:

Compiler directive	Purpose
<code><cctype></code> <small>character manipulation</small>	Character classification and conversion
<code><cmath></code>	Math functions
<code><cstdlib></code>	Data conversion <small>c standard library</small>
<code><ctime></code>	Time functions

Library Functions (cont.)

- A collection of specialized functions.
- C++ promotes code reuse with predefined classes and functions in the standard library
- The functions work as a black box:



Math Functions

- Required header: #include <cmath>
- Example functions

fabs = for float number

Function	Purpose
abs(x)	returns the absolute value of an integer.
pow(x,y)	calculates x to the power of y. If x is negative, y must be an integer. If x is zero, y must be a positive integer. x^y
pow10(x)	calculates 10 to the power of x. 10^x
sqrt(x)	calculates the positive square root of x. (x is ≥ 0)

Library Functions: Example 1

```
#include <iostream>
#include <cmath>
using namespace std;
int main()
{
    double area, radius;

    cout<< "This program calculates the area of a
circle.\n";
    cout<<"What is the radius of the circle? ";
    cin>>radius;
    area=3.14159 * pow(radius,2.0);
    cout<<"The area is " << area << endl;
    system ("pause");
    return 0;
}
```

Library Functions: Example 2

```
#include <iostream>
#include <cmath>
using namespace std;
main() {
    int nom1,nom2, result;
    cout<<"Enter two numbers";
    cin>>nom1>>nom2;
    if ((nom1<0) || (nom2<0))
    {    cout<<"negative number/s";
    }
    else
    {
        result= sqrt(nom1 + nom2);
        cout<<"The square root of "<< nom1+nom2 << "is"
        << result;
    }
}
```

More Mathematical Functions

- Require `cmath` header file
- Take `double` as input, return a `double`
- Commonly used functions:

<code>sin</code>	Sine
<code>cos</code>	Cosine
<code>tan</code>	Tangent
<code>sqrt</code>	Square root
<code>log</code>	Natural (e) log
<code>abs</code>	Absolute value (takes and returns an int)

More Mathematical Functions

Function	Standard Library	Purpose: Example	Argument(s)	Result
abs(x)	<cmath>	Returns the absolute value of its integer argument: if x is -5, abs(x) is 5	int	int
ceil(x)	<cmath>	Returns the smallest integral value that is not less than x: if x is 45.23, ceil(x) is 46.0	double	double
cos(x)	<cmath>	Returns the cosine of angle x: if x is 0.0, cos(x) is 1.0	double (radians)	double
exp(x)	<cmath>	Returns e^x where $e = 2.71828\dots$: if x is 1.0, exp(x) is 2.71828	double	double
fabs(x)	<cmath>	Returns the absolute value of its type double argument: if x is -8.432, fabs(x) is 8.432	double	double
floor(x)	<cmath>	Returns the largest integral value that is not greater than x: if x is 45.23, floor(x) is 45.0	double	double

More Mathematical Functions

<code>log(x)</code>	<code><cmath></code>	Returns the natural logarithm of x for $x > 0.0$: if x is 2.71828, <code>log(x)</code> is 1.0	double	double
<code>log10(x)</code>	<code><cmath></code>	Returns the base-10 logarithm of x for $x > 0.0$: if x is 100.0, <code>log10(x)</code> is 2.0	double	double
<code>pow(x, y)</code>	<code><cmath></code>	Returns x^y . If x is negative, y must be integral: if x is 0.16 and y is 0.5, <code>pow(x, y)</code> is 0.4	double, double	double
<code>sin(x)</code>	<code><cmath></code>	Returns the sine of angle x: if x is 1.5708, <code>sin(x)</code> is 1.0	double (radians)	double
<code>sqrt(x)</code>	<code><cmath></code>	Returns the non-negative square root of x (\sqrt{x}) for $x \geq 0.0$: if x is 2.25, <code>sqrt(x)</code> is 1.5	double	double
<code>tan(x)</code>	<code><cmath></code>	Returns the tangent of angle x: if x is 0.0, <code>tan(x)</code> is 0.0	double (radians)	double

General Purpose Library

- These require `cstdlib` header file
`random`
- `rand()` : returns a random number (`int`) between 0 and the largest int the computer holds. Yields same sequence of numbers each time program is run.
- `srand(x)` : initializes random number generator with `unsigned int x`

Character Manipulation

<cctype>

True or False only

- The C++ library provides several functions for testing characters.
- To use these functions, you must include the `cctype` header file.

FUNCTION	MEANING
<code>isalpha</code>	true if arg. is a letter, false otherwise
<code>isalnum</code>	true if arg. is a letter or digit, false otherwise
<code>isdigit</code>	true if arg. is a digit 0-9, false otherwise
<code>islower</code>	true if arg. is lowercase letter, false otherwise
<code>isprint</code>	true if arg. is a printable character, false otherwise
<code>ispunct</code>	true if arg. is a punctuation character, false otherwise
<code>isupper</code>	true if arg. is an uppercase letter, false otherwise
<code>isspace</code>	true if arg. is a whitespace character, false otherwise

Example – Character Testing

```
#include <iostream>
#include <cctype>
using namespace std;
int main()
{
    char input;
    cout<<"Enter any character: ";
    cin.get(input); accept only other whitespace if use cin only
    if (isalpha(input)){
        cout.put(input);
        cout<<"It is an alphabet";
    }
    if (isdigit(input))
        cout<<"It is a digit";
    if (islower(input))
        cout<<"The letter entered is lowercase";
    if (isupper(input))
        cout<<"The letter entered is uppercase";
    return 0;
}
```

Exercise 01

- Write a program with if statements that will display the word “digit” **if** the variable **ch** contains numeric data, or display the word “letter” if the variable **ch** contains alphabet data. Otherwise, it should display “special character”

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);
cout << toupper(ch2);
cout << toupper(ch3);
```

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);
cout << tolower(ch2);
cout << tolower(ch3);
```

Example – Character Case Conversion

```
#include <iostream>
#include <cctype>
using namespace std;

int main()
{
    char input[15];
    cout<<"Enter a name ";
    cin>>input;
    for(int i=0;input[i] != '\0';i++)
        input[i]=toupper(input[i]);
    cout<<"The name in upper case is:" << input;
    return 0;
}
```

Character Manipulating Functions

Display 9.3 Some Functions in <cctype> (part 1 of 2)

FUNCTION	DESCRIPTION	EXAMPLE
<code>toupper(Char_Exp)</code>	Returns the uppercase version of <i>Char_Exp</i> (as a value of type <code>int</code>).	<pre>char c = toupper('a'); cout << c; Outputs: A</pre>
<code>tolower(Char_Exp)</code>	Returns the lowercase version of <i>Char_Exp</i> (as a value of type <code>int</code>).	<pre>char c = tolower('A'); cout << c; Outputs: a</pre>
<code>isupper(Char_Exp)</code>	Returns <code>true</code> provided <i>Char_Exp</i> is an uppercase letter; otherwise, returns <code>false</code> .	<pre>if (isupper(c)) cout << "Is uppercase."; else cout << "Is not uppercase.";</pre>
<code>islower(Char_Exp)</code>	Returns <code>true</code> provided <i>Char_Exp</i> is a lowercase letter; otherwise, returns <code>false</code> .	<pre>char c = 'a'; if (islower(c)) cout << c << " is lowercase."; Outputs: a is lowercase.</pre>
<code>isalpha(Char_Exp)</code>	Returns <code>true</code> provided <i>Char_Exp</i> is a letter of the alphabet; otherwise, returns <code>false</code> .	<pre>char c = '\$'; if (isalpha(c)) cout << "Is a letter."; else cout << "Is not a letter."; Outputs: Is not a letter.</pre>

Display 9.3 Some Functions in <cctype> (part 2 of 2)

FUNCTION	DESCRIPTION	EXAMPLE
<code>isdigit(Char_Exp)</code>	Returns true provided <i>Char_Exp</i> is one of the digits '0' through '9'; otherwise, returns false.	<pre>if (isdigit('3')) cout << "It's a digit."; else cout << "It's not a digit.";</pre> <p>Outputs: It's a digit.</p>
<code>isalnum(Char_Exp)</code>	Returns true provided <i>Char_Exp</i> is either a letter or a digit; otherwise, returns false.	<pre>if (isalnum('3') && isalnum('a')) cout << "Both alphanumeric."; else cout << "One or more are not.";</pre> <p>Outputs: Both alphanumeric.</p>
<code>isspace(Char_Exp)</code>	Returns true provided <i>Char_Exp</i> is a whitespace character, such as the blank or newline character; otherwise, returns false.	<pre>//Skips over one "word" and sets c //equal to the first whitespace //character after the "word": do { cin.get(c); } while (! isspace(c));</pre>
<code>ispunct(Char_Exp)</code>	Returns true provided <i>Char_Exp</i> is a printing character other than whitespace, a digit, or a letter; otherwise, returns false.	<pre>if (ispunct('?')) cout << "Is punctuation."; else cout << "Not punctuation.";</pre>
<code>isprint(Char_Exp)</code>	Returns true provided <i>Char_Exp</i> is a printing character; otherwise, returns false.	
<code>isgraph(Char_Exp)</code>	Returns true provided <i>Char_Exp</i> is a printing character other than whitespace; otherwise, returns false.	
<code>isctrl(Char_Exp)</code>	Returns true provided <i>Char_Exp</i> is a control character; otherwise, returns false.	

Exercise 02

- Write a program to toggle the contents of a string character from lower to upper case or vice versa.

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!"

H	i		t	h	e	r	e	!	\0
---	---	--	---	---	---	---	---	---	----

Review of the Internal Storage of C-Strings

- Array of chars 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()`

word after whitespace will terminate

(string, character limit)

C-Strings Manipulation Functions

- The C++ library has numerous functions for handling C-strings.
- Requires `cstring` header file be included.
- Functions take one or more C-strings as arguments. Can use:
 - C-string name
 - pointer to C-string
 - literal string

Functions for C-Strings

- Functions: string length

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

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

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

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



Function for C-Strings

- **Functions:**

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

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

```

assign fname value to name

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.

Function for C-Strings

- **Functions:**

- `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);
```

Comparing C-Strings

- Also cannot use operator ==

```
char aString[10] = "Hello";
char anotherString[10] = "Goodbye";
aString == anotherString; // NOT allowed!
```

- Must use library function again:

```
if (strcmp(aString, anotherString) )
    cout << "Strings NOT same.";
else
    cout << "Strings are same.;"
```

same thing will display 0, otherwise positive or negative

Working with C-Strings - Example

```
#include <iostream>
#include <cstring>
using namespace std;
int main()
{   char reply;
    char garment[]="overcoat";
    cout<<"Is it raining outside? Answer y/n\n";
    cin>>reply;
    if(reply=='y')
        strcpy(garment,"raincoat");
    cout<<"before you go out today take your "<<garment;
    return 0;
}
```

Predefined C-String Functions

Display 9.1 Some Predefined C-String Functions in <cstring> (part 1 of 2)

FUNCTION	DESCRIPTION	CAUTIONS
<code>strcpy(Target_String_Var, Src_String)</code>	Copies the C-string value <i>Src_String</i> into the C-string variable <i>Target_String_Var</i> .	Does not check to make sure <i>Target_String_Var</i> is large enough to hold the value <i>Src_String</i> .
<code>strcpy(Target_String_Var, Src_String, Limit)</code>	The same as the two-argument <code>strcpy</code> except that at most <i>Limit</i> characters are copied.	If <i>Limit</i> is chosen carefully, this is safer than the two-argument version of <code>strcpy</code> . Not imple- mented in all versions of C++.
<code>strcat(Target_String_Var, Src_String)</code>	Concatenates the C-string value <i>Src_String</i> onto the end of the C-string in the C-string variable <i>Target_String_Var</i> .	Does not check to see that <i>Target_String_Var</i> is large enough to hold the result of the concatenation.
<code>strcat(Target_String_Var, Src_String, Limit)</code>	The same as the two argument <code>strcat</code> except that at most <i>Limit</i> characters are appended.	If <i>Limit</i> is chosen carefully, this is safer than the two-argument version of <code>strcat</code> . Not imple- mented in all versions of C++.

Predefined C-String Functions

Display 9.1 Some Predefined C-String Functions in <cstring> (part 2 of 2)

FUNCTION	DESCRIPTION	CAUTIONS
<code>strlen(<i>Src_String</i>)</code>	Returns an integer equal to the length of <i>Src_String</i> . (The null character, '\0', is not counted in the length.)	
<code>strcmp(<i>String_1</i>, <i>String_2</i>)</code>	Returns 0 if <i>String_1</i> and <i>String_2</i> are the same. Returns a value < 0 if <i>String_1</i> is less than <i>String_2</i> . Returns a value > 0 if <i>String_1</i> is greater than <i>String_2</i> (that is, returns a nonzero value if <i>String_1</i> and <i>String_2</i> are different). The order is lexicographic.	If <i>String_1</i> equals <i>String_2</i> , this function returns 0, which converts to false. Note that this is the reverse of what you might expect it to return when the strings are equal.
<code>strcmp(<i>String_1</i>, <i>String_2</i>, <i>Limit</i>)</code>	The same as the two-argument <code>strcat</code> except that at most <i>Limit</i> characters are compared.	If <i>Limit</i> is chosen carefully, this is safer than the two-argument version of <code>strcmp</code> . Not implemented in all versions of C++.

String/Numeric Conversion Functions

- These functions convert between string and numeric forms of numbers
- Need to include **cstdlib** header file

FUNCTION	PARAMETER	ACTION
atoi <small>alpha to integer</small>	C-string	converts C-string to an int value, returns the value
atoll <small>to long value</small> strtol	C-string	converts C-string to a long value, returns the value
atof <small>alphabet to float</small> strtod	C-string	converts C-string to a double value, returns the value

String/Numeric Conversion Functions

- **atoi** converts alphanumeric **to int**
- **atol** converts alphanumeric **to long**
- **atof** converts a numeric string to a double
- if C-string being converted contains non-digits, results are undefined
 - function may return result of conversion up to first non-digit
 - function may return 0

String/Numeric Conversion Functions

- Examples:

- int number;
- long lnumber;
- double dnumber;
- number = atoi("57");
- lnumber = atol("50000");
- dnumber = atof("590.55");

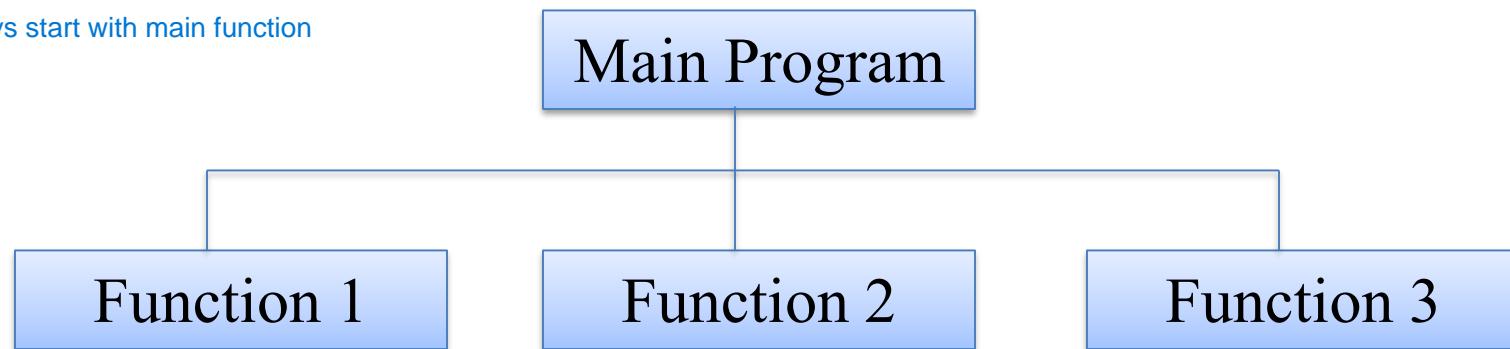


User-Defined Functions

define by user

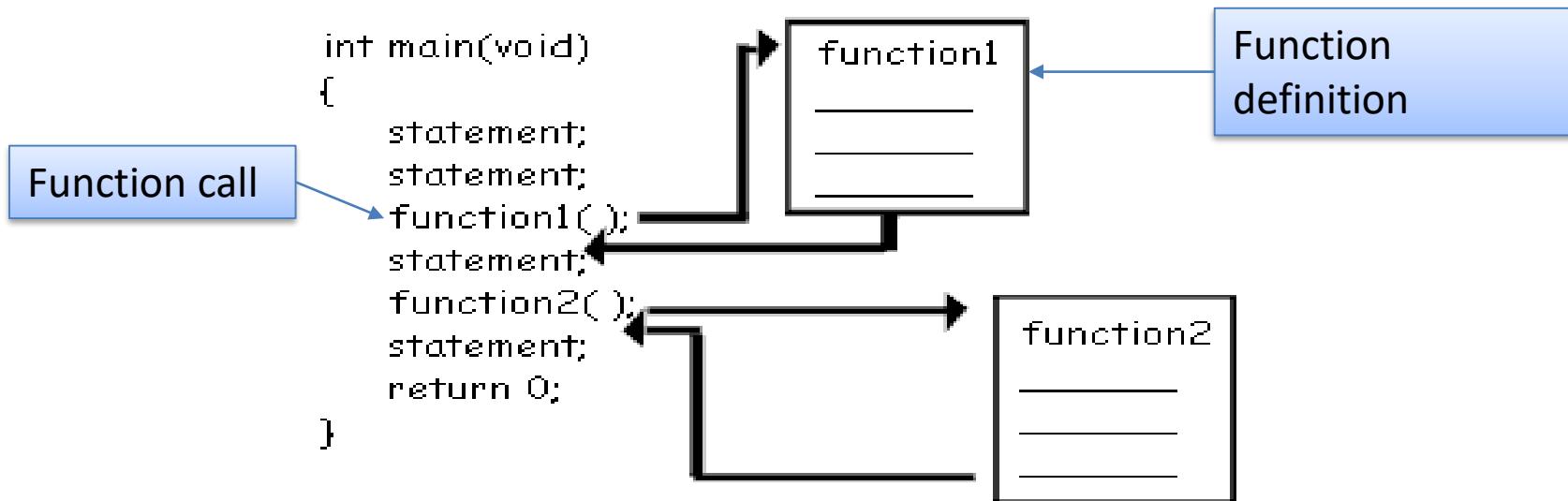
- User-defined functions are created by you, the programmer.
- Commonly used to break a problem down into small **manageable** pieces.
- You are already familiar with the one function that every C++ program possesses: `int main ()`
 - Ideally, your `main ()` function should be very short and should consist primarily of function calls.

always start with main function



Defining and Calling Functions

- Every functions must have:
 - **Function call:** statement causes a function to execute
 - **Function definition:** statements that make up a function



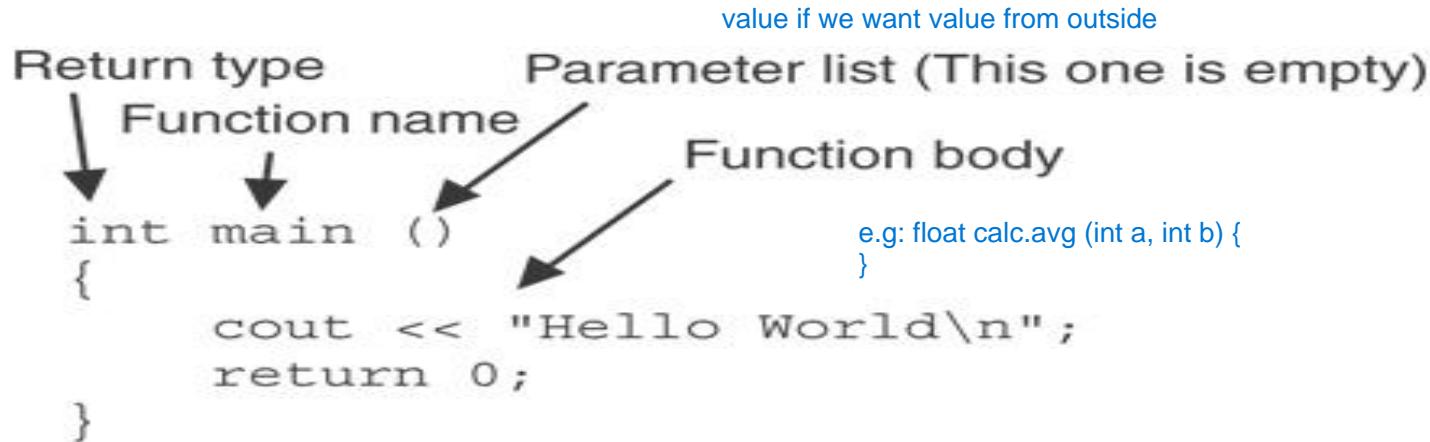
Function Definition

- Definition includes:
 - return type: data type of the value that function returns to the part of the program that calls it
 - name: name of the function. Function names follow same rules as variables
 - parameter list: variables containing values passed to the function
 - body: statements that perform the function's task, enclosed in { }

Function Definition (cont.)

- The general form of a function definition in C++ is as follows:

```
function-returntype function-name( parameter-list )
{
    local-definitions;
    function-implementation;
}
```



Note: The line that reads `int main()` is the function header.

Function Return Type

- If a function returns a value, the type of the value must be indicated:

```
int main()
```

- If a function **does not return a value**, its return type is void: no return value

```
void printHeading()
{
    cout << "Monthly Sales\n";
}
```

Calling a Function

- To call a function, use the function name followed by () and ;

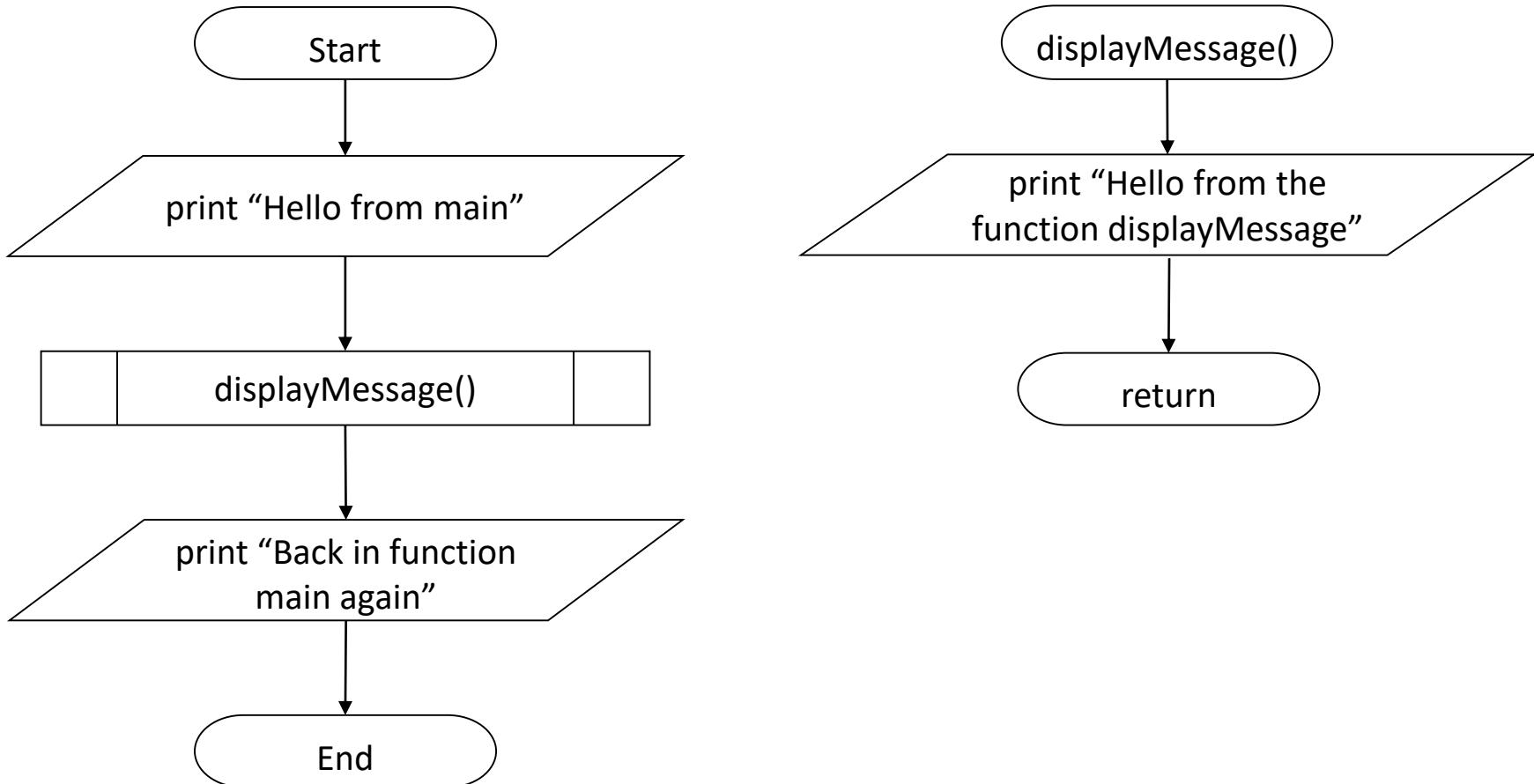
for void

```
printHeading();
```

- When called, program executes the body of the called function
- After the function terminates, execution resumes in the calling function at point of call.

```
otherwise, e.g: float r = calc.avg(5, 7);
@
cout << calc.avg(5, 7);
@
if( a + calc.avg(5, 7) > 10)
```

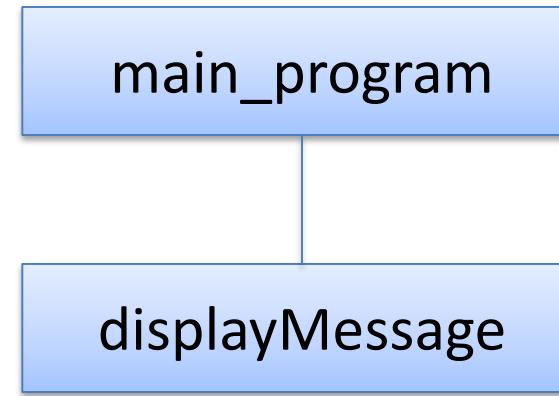
The Flowchart



The Pseudo Code

- Start
 - Print “Hello from main”
 - Call displayMessage()
 - Print “Back in function main again”
 - End
-
- displayMessage():
 - Print “Hello from the function displayMessage”
 - Return

The Structure Chart



Calling a Function - Example

Program 6-1

```
1 // This program has two functions: main and displayMessage
2 #include <iostream>
3 using namespace std;
4
5 //*****
6 // Definition of function displayMessage   *
7 // This function displays a greeting.      *
8 //*****
9
10 void displayMessage()
11 {
12     cout << "Hello from the function displayMessage.\n";
13 }
14
15 //*****
16 // Function main                         *
17 //*****
18
19 int main()
20 {
21     cout << "Hello from main.\n";
22     displayMessage();
23     cout << "Back in function main again.\n";
24     return 0;
25 }
```

Function
definition

Function call

Program Output

```
Hello from main.
Hello from the function displayMessage.
Back in function main again.
```

Flow of Control in Program 6-1

```
void displayMessage()
{
    cout << "Hello from the function displayMessage.\n";
}
```

```
int main()
{
    cout << "Hello from main.\n"
    displayMessage();
    cout << "Back in function main again.\n";
    return;
}
```

User-Defined Functions:

Example 2

```
01 #include <iostream>
02 #include <cmath>
03 using namespace std;
04
05 float distance(float x, float y)
06 {    float dist;
07     dist = sqrt(x * x + y * y);
08     return dist;
09 }
10
11 int main()
12 {
13     float x,y,dist;
14     cout << "Testing function distance(x,y)" << endl;
15     cout << "Enter values for x and y: ";
16     cin >> x >> y;
17     dist = distance(x,y);
18     cout << "Distance of (" << x << ',' << y << ") from origin is "
19     << dist << endl << "Tested" << endl;
20 }
```

Calling Functions

- main can call any number of functions
- Functions can call other functions
- Compiler **must** know the following about a function before it is called:
 - name
 - return type
 - number of parameters
 - data type of each parameter

In-Class Exercise

- Which of the following function headers are valid? If they are invalid, explain why.
 - one (int a, int b)
 - int thisone(char x)
 - char another (int a, b) int a, int b
 - double yetanother

Function Prototypes

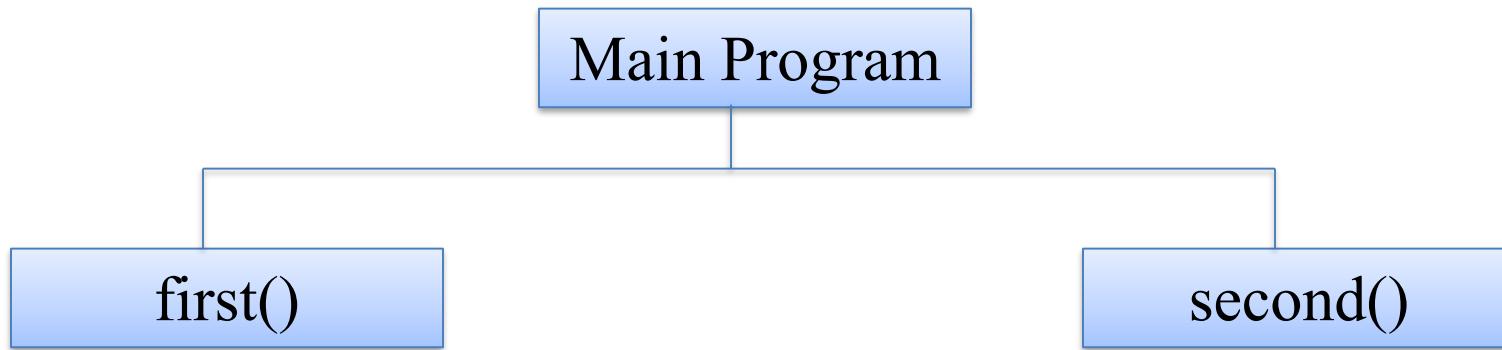
- Ways to **notify the compiler** about a function before a call to the function:
 - Place function definition before calling function's definition
 - Use a function prototype (function declaration) – like the function definition without the body
 - Header: void printHeading()
 - Prototype: void printHeading() ;

User-Defined Functions: Function Prototypes

```
01 #include <iostream>
02
03 void first();      concept is similar to declare variable
04 void second();
05
06 int main()
07 {
08     cout<< "Starting in main function \n";
09     first();
10     second();
11     cout<<"Control back to main\n"; return 0;
12 }
13
14 void first()
15 {   cout<<"Inside the first function\n"; }
16
17 void second()
18 {   cout<<"Inside the second function\n"; }
```

Function prototypes

Structured Chart



Prototype Notes

- Place prototypes near **top** of program
- Program must include either prototype **or** full function definition before any call to the function – compiler error otherwise
- When using prototypes, can place function definitions in any order in source file

User-Defined Functions: Functions with No Parameters

```
01 #include <iostream>
02 using namespace std;
03 void printhi();
04 int main() {
05     cout << "Testing function printhi()" << endl;
06     printhi();
07     cout << "Tested" << endl; return 0;
08 } // End of main
09
10 // Function Definitions
11 void printhi()
12 {
13     cout << "Hi \n";
14 }
```

Sending Data into a Function

- Can **pass values** into a function at time of call:
`c = pow(a, b);`
- Values passed to function are arguments
- Variables in a function that **hold the values passed** as arguments are parameters

A Function with a Parameter Variable

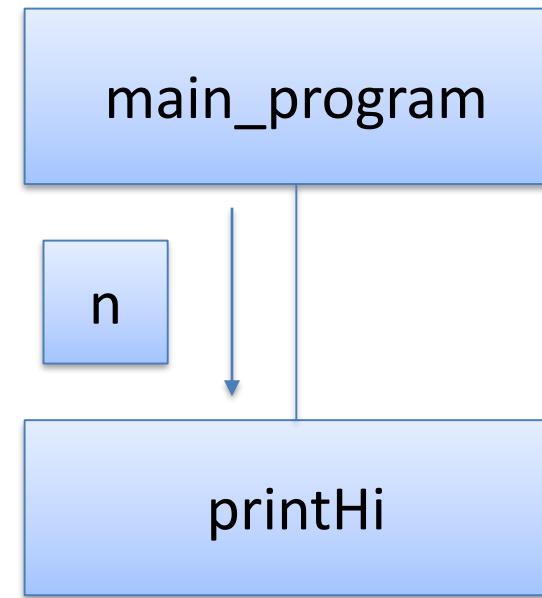
```
01 void displayValue(int num)
02 {
03     cout << "The value is " << num << endl;
04 }
```

The integer variable num is a **parameter**.
It accepts any integer value passed to the function.

User-Defined Functions: Functions with Parameter and No Return Values (1)

```
01 #include <iostream>
02 using namespace std;
03 void printhi(int);
04
05 int main(){
06     int n;
07     cout <<"Enter a value for n: ";
08     cin >> n;
09     printhi(n);
10     cout << "Tested \n"; return 0; }
11
12 void printhi(int n)
13 {
14     int i;
14     for (i = 0; i < n; i++)
15     cout << "Hi \n";
16 }
```

The Structure Chart



User-Defined Functions: Functions with Parameter and No Return Values (2)

```
01 #include <iostream>
02 using namespace std;
03
04 void displayValue(int);
05
06 int main()
07 {
08     cout<<"Passing number 5 to displayValue\n";
09     displayValue(5);
10     cout<<"Back in main\n"; return 0;
11 }
12
13 void displayValue(int n)
14 {
15     cout<<"The value is " << n << endl;
16 }
```

Other Parameter Terminology

- A parameter can also be called a formal parameter or a formal argument
- An argument can also be called an actual parameter or an actual argument

Parameters, Prototypes, and Function Headers

- For each function argument,
 - the **prototype** must include the **data type** of each parameter inside its parentheses
 - the **header** must include a **declaration** for each parameter in its ()

```
void evenOrOdd(int); //prototype  
void evenOrOdd(int num) //header  
evenOrOdd(val); //call
```

parameter name

Function Call Notes

- Value of argument is **copied** into parameter when the function is called
- A parameter's scope is the function which uses it
- Function can have **multiple** parameters
- There **must** be a **data type** listed in the prototype () and an **argument declaration** in the function header () for each parameter
- Arguments will be promoted/demoted as necessary to **match** parameters

In-Class Exercise

- What is the output of this program?

```
01 #include <iostream>
02 using namespace std;
03 // Function prototype
04 void showDouble(int);
05
06 int main(){
07     int num;
08     for (num = 0; num < 10; num++)
09         showDouble(num);
10     system("pause");
11     return 0;
12 }
13
14 //Definition of function
15 void showDouble(int value) {
16     cout<<value <<"\t";
17     cout << (value * 2)<< endl;
18 }
```

User Defined Functions: Passing Multiple Arguments

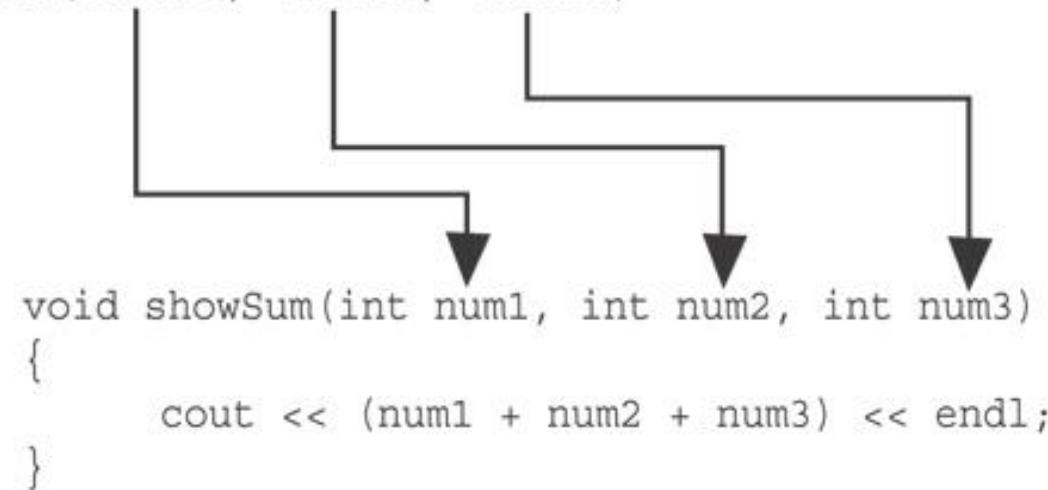
- When calling a function and passing multiple arguments:
 - the number of arguments in the call must match the prototype and definition
 - the first argument will be used to initialize the first parameter, the second argument to initialize the second parameter, etc.

User-Defined Functions: Passing Multiple Arguments (cont.)

```
01 #include <iostream>
02 using namespace std;
03 void showSum(int, int, int);
04
05 int main()
06 {
07     int value1, value2, value3;
08
09     cout<<"Enter 3 integers: ";
10    cin>> value1 >> value2 >> value3;
11    showSum(value1, value2, value3);
12
13    return 0;
14 }
15
16 void showSum(int a, int b, int c)
17 {
18     cout<<"The sum: "<<a+b+c;
19 }
```

Passing Multiple Arguments (cont.)

Function Call → showSum(value1, value2, value3)



The function call in line 18 passes value1, value2, and value3 as arguments to the function.

In-Class Exercise

- What is the output of this program?

```
01 #include <iostream>
02
03 // Function prototype
04 void func1(double, int);
05
06 int main(){
07     int x = 0; double y = 1.5;
08     cout << x << " " <<y<< endl;
09     func1 (y, x);
10     cout << x << " " <<y<< endl;
11     system ("pause");
12     return 0;
13 }
14
15 void func1(double a, int b){
16     cout << a << " " <<b<< endl;
17     a=0.0; b=10;
18     cout << a << " " <<b<< endl;
19 }
```

User-Defined Functions: Passing Data

- Passing by Value
- Passing by Reference

Passing Data by Value

- Pass by value: when an argument is passed to a function, its value is **copied** into the parameter.
- Changes to the parameter in the function do not affect the value of the argument

User-Defined Functions: Passing Data by Value (cont.)

```
01 #include <iostream>
02 using namespace std;
03
04 void f( int n ) {
05     cout << "Inside f( int ), the value of the parameter is "
06     << n << endl;
07     n += 37;
08     cout << "Inside f( int ), the modified parameter is now "
09     << n << endl; }
10
11
12 int main() {
13     int m = 612;
14
15     cout << "The integer m = " << m << endl;
16     cout << "Calling f( m )..." << endl;
17     f( m );
18     cout << "The integer m = " << m << endl;
19     return 0;
20 }
```

User-Defined Functions: Passing Data by Value (cont.)

Inside **main()**:

m  612

Call **f(m)**,
memory allocated for **n**
copy the value **612** to this location

Inside **f(int n)**:

m  612

n  612

f(int) modifies **n**:

n  649

Deallocate memory for **n**
Return to **main()**;

Back in **main()**:

the variable **m** is unchanged:

m  612

Passing Information to Parameters by Value

- Example:

```
int val=5;  
evenOrOdd(val);
```



- `evenOrOdd` can change variable `num`, but it will have no effect on variable `val`

Using Functions in Menu-Driven Programs

- Functions can be used
 - to implement user choices from menu
 - to implement general-purpose tasks:
 - Higher-level functions can call general-purpose functions, minimizing the total number of functions and speeding program development time.

The return Statement

- Used to end execution of a function
- Can be placed anywhere in a function
 - Statements that follow the `return` statement will not be executed
- Can be used to prevent abnormal termination of program
- In a `void` function without a `return` statement, the function ends at its last `}`

Returning a Value from a Function

- A function can return a value back to the statement that called the function.
- You've already seen the `pow` function, which returns a value:

```
double x;  
x = pow(2.0, 10.0);
```

Returning a Value from a Function

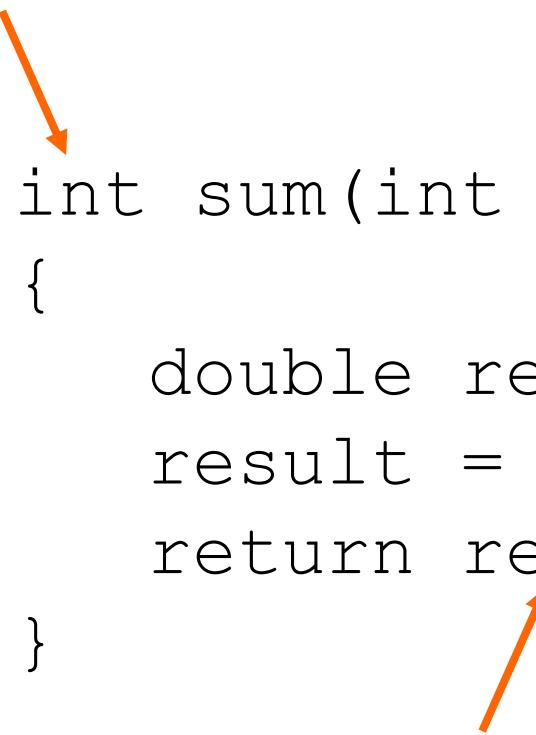
- In a value-returning function, the `return` statement can be used to return a value from function to the point of call.

Example:

```
int sum(int num1, int num2)
{
    double result;
    result = num1 + num2;
    return result;
}
```

A Value-Returning Function

Return Type



```
int sum(int num1, int num2)
{
    double result;
    result = num1 + num2;
    return result;
}
```

Value Being Returned

A Value-Returning Function

```
int sum(int num1, int num2)
{
    return num1 + num2;
}
```

Functions can return the values of expressions,
such as num1 + num2

The return Statement - Example

Program 6-11

```
1 // This program uses a function to perform division. If division
2 // by zero is detected, the function returns.
3 #include <iostream>
4 using namespace std;
5
6 // Function prototype.
7 void divide(double, double);
8
9 int main()
10 {
11     double num1, num2;
12
13     cout << "Enter two numbers and I will divide the first\n";
14     cout << "number by the second number: ";
15     cin >> num1 >> num2;
16     divide(num1, num2);
17     return 0;
18 }
```

The return Statement - Example

Program 6-11(Continued)

```
20 //*****  
21 // Definition of function divide. *  
22 // Uses two parameters: arg1 and arg2. The function divides arg1*  
23 // by arg2 and shows the result. If arg2 is zero, however, the *  
24 // function returns. *  
25 //*****  
26  
27 void divide(double arg1, double arg2)  
28 {  
29     if (arg2 == 0.0)  
30     {  
31         cout << "Sorry, I cannot divide by zero.\n";  
32         return;  
33     }  
34     cout << "The quotient is " << (arg1 / arg2) << endl;  
35 }
```

Return to
called
function



Program Output with Example Input Shown in Bold

Enter two numbers and I will divide the first
number by the second number: **12 0 [Enter]**
Sorry, I cannot divide by zero.

Returning a Value From a Function

Program 6-12

```
1 // This program uses a function that returns a value.
2 #include <iostream>
3 using namespace std;
4
5 // Function prototype
6 int sum(int, int);
7
8 int main()
9 {
10     int value1 = 20,      // The first value
11         value2 = 40,      // The second value
12         total;           // To hold the total
13
14     // Call the sum function, passing the contents of
15     // value1 and value2 as arguments. Assign the return
16     // value to the total variable.
17     total = sum(value1, value2);
18
19     // Display the sum of the values.
20     cout << "The sum of " << value1 << " and "
21         << value2 << " is " << total << endl;
22     return 0;
23 }
```

Returning a Value From a Function

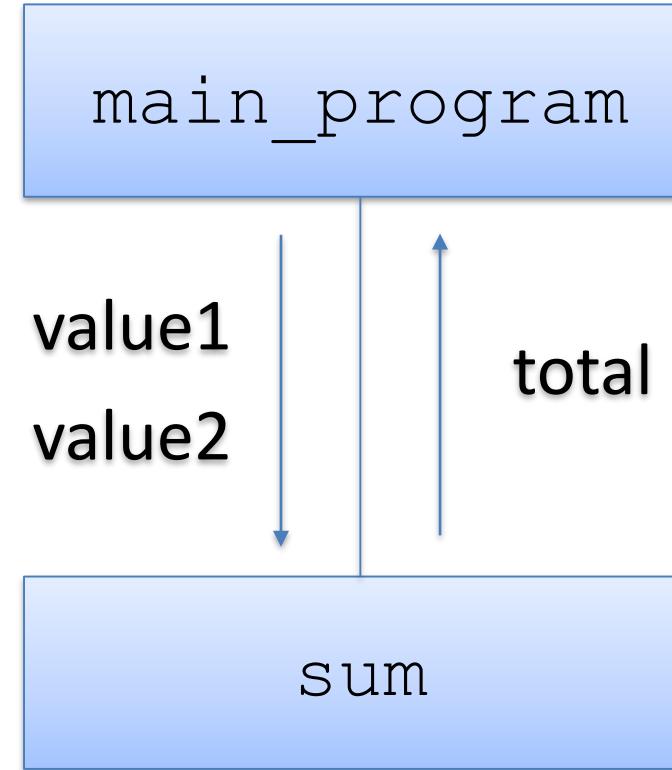
Program 6-12 (Continued)

```
24
25 //*****
26 // Definition of function sum. This function returns *
27 // the sum of its two parameters. *
28 //*****
29
30 int sum(int num1, int num2)
31 {
32     return num1 + num2;
33 }
```

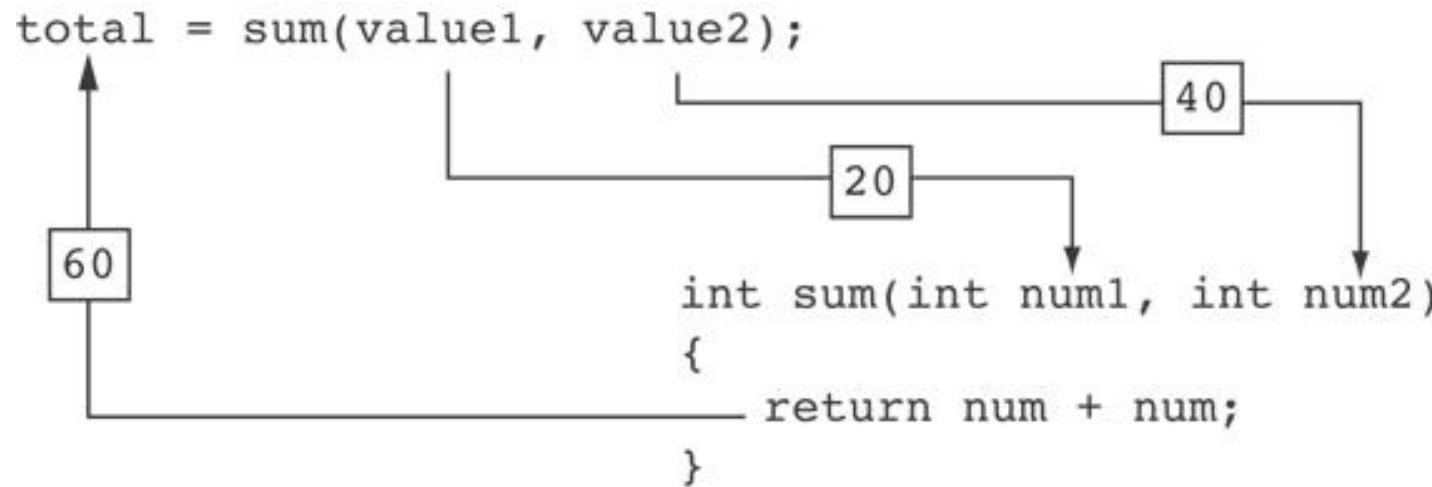
Program Output

The sum of 20 and 40 is 60

The Structure Chart



Returning a Value From a Function



The statement in line 17 calls the **sum** function, passing **value1** and **value2** as arguments.

The return value is assigned to the **total** variable.

Returning a Value From a Function

- The prototype and the definition must indicate the data type of return value (not `void`)
- Calling function should use return value:
 - assign it to a variable
 - send it to `cout`
 - use it in an expression

Returning a Boolean Value

- Function can return true or false
- Declare return type in function prototype and heading as bool
- Function body must contain return statement(s) that return true or false
- Calling function can use return value in a relational expression

Returning a Boolean Value

Program 6-14

```
1 // This program uses a function that returns true or false.  
2 #include <iostream>  
3 using namespace std;  
4  
5 // Function prototype  
6 bool isEven(int);  
7  
8 int main()  
9 {  
10     int val;  
11  
12     // Get a number from the user.  
13     cout << "Enter an integer and I will tell you "  
14     cout << "if it is even or odd: ";  
15     cin >> val;  
16 }
```

Returning a Boolean Value

Program 6-14

(continued)

```
17     // Indicate whether it is even or odd.  
18     if (isEven(val))  
19         cout << val << " is even.\n";  
20     else  
21         cout << val << " is odd.\n";  
22     return 0;  
23 }  
24  
25 //*****  
26 // Definition of function isEven. This function accepts an      *  
27 // integer argument and tests it to be even or odd. The function      *  
28 // returns true if the argument is even or false if the argument      *  
29 // is odd. The return value is an bool.                      *  
30 //*****  
31  
32 bool isEven(int number)  
33 {  
34     bool status;  
35  
36     if (number % 2)  
37         status = false;    // number is odd if there's a remainder.  
38     else  
39         status = true;    // Otherwise, the number is even.  
40     return status;  
41 }
```

Program Output with Example Input Shown in Bold

Enter an integer and I will tell you if it is even or odd: **5 [Enter]**
5 is odd.

In-Class Exercise

```
#include <iostream>
using namespace std;
void try1(int p);
int try3(int r);

int main()
{ int a=2;
  cout << a << endl;
  try1(a);
  cout << a << endl;
  int b=3;
  cout << b << endl;
  int c=4;
  try3(c);
  cout << c << endl;
  c=try3(c);
  cout << c << endl;
  cout << try3(5) << endl;
  return 0; }
```

```
void try1(int p)
{
  p++;
  cout << p << endl;
}

int try3(int r)
{
  return r*r;
}
```

In-Class Exercise

- Write a function prototype and header for a function named `distance`. The function should return a `double` and have two `double` parameters: `rate` and `time`.
- Write a function prototype and header for a function named `days`. The function should return an integer and have three integer parameters: `years`, `months` and `weeks`.
- Examine the following function header, then write an example call to the function.
 - `void showValue(int quantity)`

In-Class Exercise

- The following statement calls a function named half. The half function returns a value that is half that of the argument. Write the function.

```
result = half(number);
```

- A program contains the following function:

```
int cube (int num)
{
    return num*num*num;
}
```

Write a statement that passes the value 4 to this function and assigns its return value to the variable result.

In-Class Exercise

- Write a C++ program to calculate a rectangle's area. The program consists of the following functions:
 - **getLength** – This function should ask the user to enter the rectangle's length, and then returns that value as a double.
 - **getWidth** – This function should ask the user to enter the rectangle's width, and then returns that value as a double.
 - **getArea** – This function should accept the rectangle's length and width as arguments and return the rectangle's area.
 - **displayData** – This function should accept the rectangle's length, width and area as arguments, and display them in an appropriate message on the screen.
 - **main** – This function consists of calls to the above functions.

Local and Global Variables

- Variables defined inside a function are *local* to that function. They are hidden from the statements in other functions, which normally cannot access them.
- Because the variables defined in a function are hidden, other functions may have separate, distinct variables with the same name.

Local and Global Variables - Example

Program 6-15

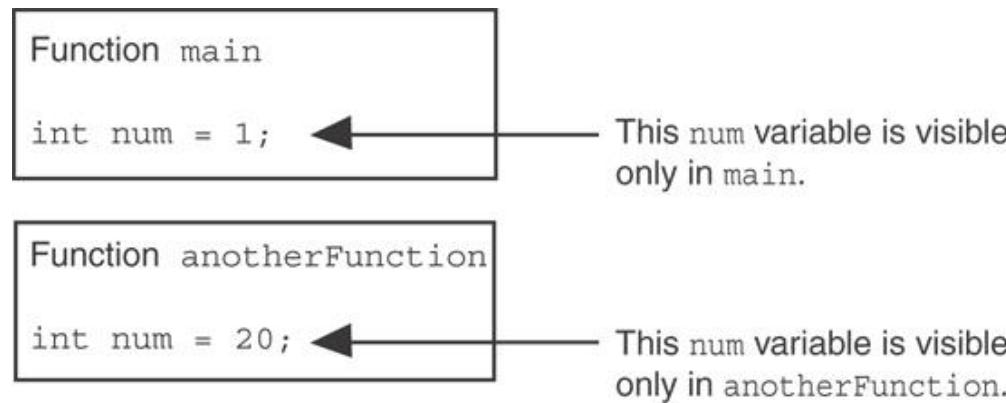
```
1 // This program shows that variables defined in a function
2 // are hidden from other functions.
3 #include <iostream>
4 using namespace std;
5
6 void anotherFunction(); // Function prototype
7
8 int main()
9 {
10     int num = 1;    // Local variable
11
12     cout << "In main, num is " << num << endl;
13     anotherFunction();
14     cout << "Back in main, num is " << num << endl;
15     return 0;
16 }
17
18 //***** Definition of anotherFunction *****
19 // It has a local variable, num, whose initial value
20 // is displayed.
21 //*****
22
23
24 void anotherFunction()
25 {
26     int num = 20;  // Local variable
27
28     cout << "In anotherFunction, num is " << num << endl;
29 }
```

Program Output

```
In main, num is 1
In anotherFunction, num is 20
Back in main, num is 1
```

Local and Global Variables - Example

- When the program is executing in `main`, the `num` variable defined in `main` is visible.
- When `anotherFunction` is called, however, only variables defined inside it are visible, so the `num` variable in `main` is hidden.



Local Variable Lifetime

- A function's local variables exist only while the **function is executing**. This is known as the *lifetime* of a local variable.
- When the function begins, its local variables and its parameter variables are **created** in memory, and when the function ends, the local variables and parameter variables are **destroyed**.
- This means that any value stored in a local variable is lost between calls to the function in which the variable is declared.

Global Variables and Global Constants

- A **global** variable is any variable defined **outside** all the functions in a program.
- The scope of a global variable is the portion of the program from the variable definition to the end.
- This means that a global variable can be accessed by **all** functions that are defined after the global variable is defined

Global Variables and Global Constants

- You should **avoid** using global variables because they make programs difficult to debug.
- Any global that you create should be ***global constants***.

Global Constants – Example

Program 6-18

```
1 // This program calculates gross pay.  
2 #include <iostream>  
3 #include <iomanip>  
4 using namespace std;  
5  
6 // Global constants  
7 const double PAY_RATE = 22.55;      // Hourly pay rate  
8 const double BASE_HOURS = 40.0;     // Max non-overtime hours  
9 const double OT_MULTIPLIER = 1.5;   // Overtime multiplier  
10  
11 // Function prototypes  
12 double getBasePay(double);  
13 double getOvertimePay(double);  
14  
15 int main()  
16 {  
17     double hours,           // Hours worked  
18         basePay,          // Base pay  
19         overtime = 0.0,    // Overtime pay  
20         totalPay;         // Total pay
```

Global constants defined for values that do not change throughout the program's execution.

Global Constants – Example

The constants are then used for those values throughout the program.

```
29     // Get overtime pay, if any.  
30     if (hours > BASE_HOURS)  
31         overtime = getOvertimePay(hours);
```

```
56     // Determine base pay.  
57     if (hoursWorked > BASE_HOURS)  
58         basePay = BASE_HOURS * PAY_RATE;  
59     else  
60         basePay = hoursWorked * PAY_RATE;
```

```
75     // Determine overtime pay.  
76     if (hoursWorked > BASE_HOURS)  
77     {  
78         overtimePay = (hoursWorked - BASE_HOURS) *  
79                         PAY_RATE * OT_MULTIPLIER;  
80     }
```

Initializing Local and Global Variables

- Local variables are not automatically initialized. They must be initialized by programmer.
- Global variables (not constants) are automatically initialized to 0 (numeric) or NULL (character) when the variable is defined.

Static Local Variables

- Local variables only exist while the function is executing. When the function terminates, the contents of local variables are lost.
- static local variables retain their contents between function calls.
- static local variables are defined and initialized only the first time the function is executed. 0 is the default initialization value.

Local Variables - Example

Program 6-20

```
1 // This program shows that local variables do not retain
2 // their values between function calls.
3 #include <iostream>
4 using namespace std;
5
6 // Function prototype
7 void showLocal();
8
9 int main()
10 {
11     showLocal();
12     showLocal();
13     return 0;
14 }
15
```

Local Variables - Example

Program 6-20

(continued)

```
16 //*****  
17 // Definition of function showLocal. *  
18 // The initial value of localNum, which is 5, is displayed. *  
19 // The value of localNum is then changed to 99 before the *  
20 // function returns. *  
21 //*****  
22  
23 void showLocal()  
24 {  
25     int localNum = 5; // Local variable  
26  
27     cout << "localNum is " << localNum << endl;  
28     localNum = 99;  
29 }
```

Program Output

```
localNum is 5  
localNum is 5
```

In this program, each time `showLocal` is called, the `localNum` variable is re-created and initialized with the value 5.

A Different Approach, Using a Static Variable

Program 6-21

```
1 // This program uses a static local variable.  
2 #include <iostream>  
3 using namespace std;  
4  
5 void showStatic(); // Function prototype  
6  
7 int main()  
8 {  
9     // Call the showStatic function five times.  
10    for (int count = 0; count < 5; count++)  
11        showStatic();  
12    return 0;  
13 }  
14
```

Using a Static Variable - Example

Program 6-21

(continued)

```
15 //*****  
16 // Definition of function showStatic. *  
17 // statNum is a static local variable. Its value is displayed *  
18 // and then incremented just before the function returns. *  
19 //*****  
20  
21 void showStatic()  
22 {  
23     static int statNum;  
24  
25     cout << "statNum is " << statNum << endl;  
26     statNum++;  
27 }
```

Program Output

```
statNum is 0  
statNum is 1  
statNum is 2  
statNum is 3  
statNum is 4
```

statNum is automatically initialized to 0. Notice that it retains its value between function calls.

Using a Static Variable - Example

If you do initialize a local static variable, the initialization only happens once. See Program 6-22...

Program 6-22

(continued)

```
16 //*****  
17 // Definition of function showStatic. *  
18 // statNum is a static local variable. Its value is displayed *  
19 // and then incremented just before the function returns. *  
20 //*****  
21  
22 void showStatic()  
23 {  
24     static int statNum = 5;  
25  
26     cout << "statNum is " << statNum << endl;  
27     statNum++;  
28 }
```

Program Output

```
statNum is 5  
statNum is 6  
statNum is 7  
statNum is 8  
statNum is 9
```

In-Class Exercise

- Given the following programs compare the output and reason the output.

```
#include <iostream>
using namespace std;

void showVar();

int main () {
    for (int count=0;count<10; count++)
        showVar();
    system("pause");
    return 0;
}

void showVar() {
    static int var = 10;
    cout << var << endl;
    var++;
}
```

```
#include <iostream>
using namespace std;

void showVar();

int main () {
    for(int count=0;count<10; count++)
        showVar();
    system("pause");
    return 0;
}

void showVar() {
    int var = 10;
    cout << var << endl;
    var++;
}
```

In-Class Exercise

- Identify global variables & local variables in the following program. What is the output?

```
#include <iostream>
using namespace std;
int j = 8;

int main()
{
    int i=0;
    cout<<"i: "<<i<<endl;
    cout<<"j: "<<j<<endl;
    system("pause");
    return 0;
}
```

- Identify global variables, local variables and static local variables in the following program. What is the output?

```
#include <iostream>
using namespace std;
int j = 40;

void p()
{    int i=5;
    static int j=5;
    i++;
    j++;
    cout<<"i: "<<i<<endl;
    cout<<"j: "<<j<<endl;
}
int main()
{    p();
    p();
    return 0; }
```

Using Reference Variables as Parameters

- A mechanism that allows a function to work with the **original argument** from the function call, not a copy of the argument
- Allows the function to **modify values** stored in the calling environment
- Provides a way for the function to ‘return’ more than one value

Passing by Reference

- A reference variable is an alias for another variable
- Defined with an ampersand (&)
`void getDimensions(int&, int&);`
- Changes to a reference variable are made to the variable it refers to
- Use reference variables to implement passing parameters *by reference*

Passing by Reference – Example

The & here in the prototype indicates that the parameter is a reference variable.

Program 6-24

```
1 // This program uses a reference variable as a function
2 // parameter.
3 #include <iostream>
4 using namespace std;
5
6 // Function prototype
7 void doubleNum(int &);The parameter is a reference variable.
8
9 int main()
10 {
11     int value = 4;
12
13     cout << "In main, value is " << value << endl;
14     cout << "Now calling doubleNum..." << endl;
15     doubleNum(value);
16     cout << "Now back in main. value is " << value << endl;
17     return 0;
18 }
19
```

Here we are passing value by reference.

Passing by Reference - Example

Program 6-24 (*Continued*)

The & also appears here in the function header.

```
20 //*****  
21 // Definition of doubleNum. *  
22 // The parameter refVar is a reference variable. The value *  
23 // in refVar is doubled. *  
24 //*****  
25  
26 void doubleNum (int &refVar)  
27 {  
28     refVar *= 2;  
29 }
```

Program Output

```
In main, value is 4  
Now calling doubleNum...  
Now back in main. value is 8
```

Reference Variables Notes

- Each reference parameter must contain &
- Space between type and & is unimportant
- Must use & in both prototype and header
- Argument passed to reference parameter must be a variable – cannot be an expression or constant
- Use when appropriate – don't use when argument should not be changed by function, or if function needs to return only 1 value

```
#include <iostream>
using namespace std;
void test(int, int&);

int main()
{
    int num;
    num=5;
    test(24, num);
    cout<<num<<endl;
    test(num, num);
    cout<<num<<endl;
    test(num*num, num);
    cout<<num<<endl;
    test(num+num, num);
    cout<<num<<endl;
    system("pause");
    return 0;
}

void test(int first, int& second)
{
    int third;
    third=first+second*second+2;
    first=second-first;
    second=2*second;
    cout<<first<<" "<<second<<""
    "<<third<<endl;
}
```

```
#include <iostream>
using namespace std;
void test(int&, int&,int,int&);

int main()
{    int a,b,c,d;
    a=3;    b=4;    c=20;    d=78;
    cout<<a<<" " <<b<<" " <<c<<" "
        " <<d<<endl;
    test(a,b,c,d);
    cout<<a<<" " <<b<<" " <<c<<" "
        " <<d<<endl;
    d=a*b+c-d;
    test(a,b,c,d);
    cout<<a<<" " <<b<<" " <<c<<" "
        " <<d<<endl;
    return 0;
}
```

```
void test(int& a, int& b, int c, int&
          d)
{
    cin>>a >> b>> c>> d;
    c = a* b+d-c;
    c=2*c;
}
```

The input:

6 8 12 35
8 9 30 45

Default Arguments

- A Default argument is an argument that is passed automatically to a parameter if the argument is missing on the function call.
- Must be a constant declared in prototype:

```
void evenOrOdd(int = 0);
```
- Can be declared in header if no prototype
- Multi-parameter functions may have default arguments for some or all of them:

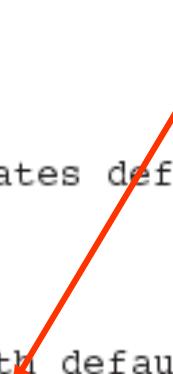
```
int getSum(int, int=0, int=0);
```

Default Arguments – Example

Default arguments specified in the prototype

Program 6-23

```
1 // This program demonstrates default function arguments.  
2 #include <iostream>  
3 using namespace std;  
4  
5 // Function prototype with default arguments  
6 void displayStars(int = 10, int = 1);  
7  
8 int main()  
9 {  
10    displayStars();           // Use default values for cols and rows.  
11    cout << endl;  
12    displayStars(5);         // Use default value for rows.  
13    cout << endl;  
14    displayStars(7, 3);     // Use 7 for cols and 3 for rows.  
15    return 0;  
16 }
```



(Program Continues)

Default Arguments – Example

Program 6-23 (*Continued*)

```
18 //*****  
19 // Definition of function displayStars. *  
20 // The default argument for cols is 10 and for rows is 1.*  
21 // This function displays a square made of asterisks. *  
22 //*****  
23  
24 void displayStars(int cols, int rows)  
25 {  
26     // Nested loop. The outer loop controls the rows  
27     // and the inner loop controls the columns.  
28     for (int down = 0; down < rows; down++)  
29     {  
30         for (int across = 0; across < cols; across++)  
31             cout << "*";  
32         cout << endl;  
33     }  
34 }
```

Program Output

```
*****  
*****  
*****  
*****  
*****
```

Default Arguments

- If not all parameters to a function have default values, the defaultless ones are declared first in the parameter list:

```
int getSum(int, int=0, int=0); // OK
int getSum(int, int=0, int); // NO
```
- When an argument is omitted from a function call, all arguments after it must also be omitted:

```
sum = getSum(num1, num2); // OK
sum = getSum(num1, , num3); // NO
```

Default Arguments

- Consider the following function prototype:

```
void funcExp(int, int, double=55.5, char='A');
```

- The following function calls are legal:

- funcExp(3, 4, 45.5, 'B');
- funcExp(3, 4, 45.5);
- funcExp(3, 4);

- The following function calls are illegal:

- funcExp(3, 4, 'C');

Default Arguments

- The following are illegal function prototypes with default arguments:
 - void funcOne(int, double=23.45, char, int=45);
 - int funcTwo(int=1, int, int=1);
 - void funcThree(int, int&=16, double=34);

Consider the following function prototype & function definition:

```
void testDefaultParam(int , int=5, double=3.2);

void testDefaultParam(int a, int b, double z)
{
    int u;
    a=a+static_cast<int>(2*b+z);
    u=a+b*z;
    cout<<"u = "<<a<<endl;
}
```

What is the output of the following function calls?

- a) testDefaultParam(6);
- b) testDefaultParam(3, 4);
- c) testDefaultParam(3, 4.5);
- d) testDefaultParam(3, 4, 5.5);
- e) testDefaultParam(3.4);

In-Class Exercise

- Write a function prototype and function header for a function called `compute`. The function should have 3 parameters: an `int`, a `double` and a `long`. The `int` parameter should have a default argument of 5, and the `long` parameter should have a default argument of 65536. The `double` parameter should have no default arguments. The parameters no necessarily in the order.
- Write a function prototype and function header for a function called `calculate`. The function should have 3 parameters: an `int`, a reference to a `double` and a `long`. Only the `int` parameter should have a default argument, which is 47. The parameters no necessarily in the order.

Overloading Functions

- Overloaded functions have the same name but different parameter lists
- Can be used to create functions that perform the same task but take **different parameter types or different number of parameters**
- Compiler will determine which version of function to call by argument and parameter lists

Function Overloading Examples

- Using these overloaded functions,

```
void getDimensions(int);           // 1
void getDimensions(int, int);      // 2
void getDimensions(int, double);   // 3
void getDimensions(double, double); // 4
```

- the compiler will use them as follows:

```
int length, width;
double base, height;
getDimensions(length);           // 1
getDimensions(length, width);    // 2
getDimensions(length, height);   // 3
getDimensions(height, base);     // 4
```

Function Overloading – Example

Program 6-26

```
1 // This program uses overloaded functions.  
2 #include <iostream>  
3 #include <iomanip>  
4 using namespace std;  
5  
6 // Function prototypes  
7 int square(int);  
8 double square(double);  
9  
10 int main()  
11 {  
12     int userInt;  
13     double userFloat;  
14  
15     // Get an int and a double.  
16     cout << fixed << showpoint << setprecision(2);  
17     cout << "Enter an integer and a floating-point value: ";  
18     cin >> userInt >> userFloat;  
19  
20     // Display their squares.  
21     cout << "Here are their squares: ";  
22     cout << square(userInt) << " and " << square(userFloat);  
23     return 0;  
24 }
```

The overloaded
functions have different
parameter lists

Passing a double

Passing an int

(Program Continues)

Function Overloading – Example

Program 6-26 (*Continued*)

```
26 //*****
27 // Definition of overloaded function square. *
28 // This function uses an int parameter, number. It returns the *
29 // square of number as an int. *
30 //*****
31
32 int square(int number)
33 {
34     return number * number;
35 }
36
37 //*****
38 // Definition of overloaded function square. *
39 // This function uses a double parameter, number. It returns *
40 // the square of number as a double. *
41 //*****
42
43 double square(double number)
44 {
45     return number * number;
46 }
```

Program Output with Example Input Shown in Bold

Enter an integer and a floating-point value: **12 4.2 [Enter]**

Here are their squares: 144 and 17.64

The exit () Function

- **Terminates** the execution of a program
- Can be called from any function
- Can pass an `int` value to operating system to indicate status of program termination
- Usually used for **abnormal termination** of program
- Requires `cstdlib` header file (Borland)

The `exit()` Function

- Example:

```
exit(0);
```

- The `cstdlib` header defines two constants that are commonly passed, to indicate success or failure:

```
exit(EXIT_SUCCESS);
```

```
exit(EXIT_FAILURE);
```

In-Class Exercise

- What is the output for the following programs

```
#include <iostream>
using namespace std;
void function();
int main(){
    function();
    cout << "Bye from main.\n";
    system ("pause");    return 0;
}

void function(){
    cout << "Bye! from function
before exit\n";
    exit(0);
    cout << "Bye! from function
before exit\n";
}
```

```
#include <iostream>
using namespace std;

int function();
int main(){
    function();
    cout << "Bye from main.\n";
    system ("pause"); return 0;
}

int function(){
    cout << "Bye! from function
before return\n";
    return 0;
    cout << "Bye! from function
before return\n";
}
```

In-Class Exercise

- Write a program that calculates the average of a group of test scores, where the lowest score in the group is dropped. It should use the following functions:
 - `getScore` – This function ask the user for a test score, store it in a reference parameter variable, and validate it. For input validation, do not accept test scores lower than 0 or higher than 100. This function should be called by `main()` once for each of the five scores to be entered.
 - `calcAverage` – This function calculates and display the average of the four highest score. This function should be called just once by `main()`, by should be passed the five scores.
 - `findLowest` – This function finds and returns the lowest of the five scores passed to it. It should be called by `calcAverage` function, which uses the function to determine which of the five scores to drop.