



GLOBAL
EDITION



Chapter 4

Parameters and Overloading

Absolute C++

SIXTH EDITION
Walter Savitch

ALWAYS LEARNING

PEARSON

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Learning Objectives

- Parameters
 - Call-by-value
 - Call-by-reference
 - Mixed parameter-lists
- Overloading and Default Arguments
 - Examples, Rules
- Testing and Debugging Functions
 - assert Macro
 - Stubs, Drivers

Parameters

- Two methods of passing arguments as parameters
- Call-by-value
 - "copy" of value is passed
- Call-by-reference
 - "address of" actual argument is passed

Call-by-Value Parameters

- Copy of actual argument passed
- Considered "local variable" inside function
- If modified, only "local copy" changes
 - Function has no access to "actual argument" from caller
- This is the default method
 - Used in all examples thus far

Call-by-Value Example:

Display 4.1 Formal Parameter Used as a Local Variable (1 of 3)

Display 4.1 Formal Parameter Used as a Local Variable

```
1 //Law office billing program.
2 #include <iostream>
3 using namespace std;

4 const double RATE = 150.00; //Dollars per quarter hour.

5 double fee(int hoursWorked, int minutesWorked);
6 //Returns the charges for hoursWorked hours and
7 //minutesWorked minutes of legal services.

8 int main()
9 {
10     int hours, minutes;
11     double bill;
```

Call-by-Value Example:

Display 4.1 Formal Parameter Used as a Local Variable (2 of 3)

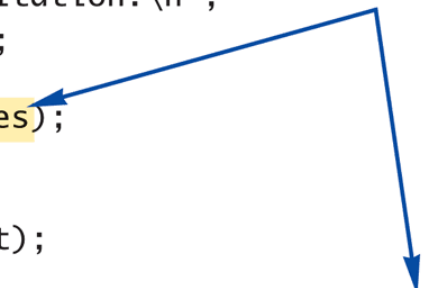
```
12  cout << "Welcome to the law office of\n"
13      << "Dewey, Cheatham, and Howe.\n"
14      << "The law office with a heart.\n"
15      << "Enter the hours and minutes"
16      << " of your consultation:\n";
17  cin >> hours >> minutes;

18  bill = fee(hours, minutes);

19  cout.setf(ios::fixed);
20  cout.setf(ios::showpoint);
21  cout.precision(2);
22  cout << "For " << hours << " hours and " << minutes
23      << " minutes, your bill is $" << bill << endl;

24  return 0;
25 }
```

The value of minutes is not changed by the call to fee.



(continued)

Call-by-Value Example:

Display 4.1 Formal Parameter Used as a Local Variable (3 of 3)

Display 4.1 Formal Parameter Used as a Local Variable

```
26 double fee(int hoursWorked, int minutesWorked)
27 {
28     int quarterHours;

29     minutesWorked = hoursWorked*60 + minutesWorked;
30     quarterHours = minutesWorked/15;
31     return (quarterHours*RATE);
32 }
```

minutesWorked is a local variable initialized to the value of minutes.

SAMPLE DIALOGUE

Welcome to the law office of
Dewey, Cheatham, and Howe.
The law office with a heart.

Enter the hours and minutes of your consultation:

5 46

For 5 hours and 46 minutes, your bill is \$3450.00

Call-by-Value Pitfall

- Common Mistake:
 - Declaring parameter "again" inside function:

```
double fee(int hoursWorked, int minutesWorked)
{
    int quarterHours;           // local variable
    int minutesWorked           // NO!
}
```
 - Compiler error results
 - "Redefinition error..."
- Value arguments ARE like "local variables"
 - But function gets them "automatically"

Call-By-Reference Parameters

- Used to provide access to caller's actual argument
- Caller's data can be modified by called function!
- Typically used for input function
 - To retrieve data for caller
 - Data is then "given" to caller
- Specified by ampersand, &, after type in formal parameter list

Call-By-Reference Example:

Display 4.1 Call-by-Reference Parameters (1 of 3)

Display 4.2 Call-by-Reference Parameters

```
1  //Program to demonstrate call-by-reference parameters.
2  #include <iostream>
3  using namespace std;

4  void getNumbers(int& input1, int& input2);
5  //Reads two integers from the keyboard.

6  void swapValues(int& variable1, int& variable2);
7  //Interchanges the values of variable1 and variable2.

8  void showResults(int output1, int output2);
9  //Shows the values of variable1 and variable2, in that order.

10 int main()
11 {
12     int firstNum, secondNum;

13     getNumbers(firstNum, secondNum);
14     swapValues(firstNum, secondNum);
15     showResults(firstNum, secondNum);
16     return 0;
17 }
```

Call-By-Reference Example:

Display 4.1 Call-by-Reference Parameters (2 of 3)

```
18 void getNumbers(int& input1, int& input2)
19 {
20     cout << "Enter two integers: ";
21     cin >> input1
22     >> input2;
23 }

24 void swapValues(int& variable1, int& variable2)
25 {
26     int temp;

27     temp = variable1;
28     variable1 = variable2;
29     variable2 = temp;
30 }
31
32 void showResults(int output1, int output2)
33 {
34     cout << "In reverse order the numbers are: "
35     << output1 << " " << output2 << endl;
36 }
```

Call-By-Reference Example:

Display 4.1 Call-by-Reference Parameters (3 of 3)

Display 4.2 Call-by-Reference Parameters

SAMPLE DIALOGUE

Enter two integers: 5 6

In reverse order the numbers are: 6 5

Call-By-Reference Details

- What's really passed in?
- A "reference" back to caller's actual argument!
 - Refers to memory location of actual argument
 - Called "address", which is a unique number referring to distinct place in memory

Constant Reference Parameters

- Reference arguments inherently "dangerous"
 - Caller's data can be changed
 - Often this is desired, sometimes not
- To "protect" data, & still pass by reference:
 - Use const keyword
 - `void sendConstRef(const int &par1,
 const int &par2);`
 - Makes arguments "read-only" by function
 - No changes allowed inside function body

Parameters and Arguments

- Confusing terms, often used interchangeably
- True meanings:
 - Formal parameters
 - In function declaration and function definition
 - Arguments
 - Used to "fill-in" a formal parameter
 - In function call (argument list)
 - Call-by-value & Call-by-reference
 - Simply the "mechanism" used in plug-in process

Mixed Parameter Lists

- Can combine passing mechanisms
- Parameter lists can include pass-by-value and pass-by-reference parameters
- Order of arguments in list is critical:
`void mixedCall(int & par1, int par2, double & par3);`
 - Function call:
`mixedCall(arg1, arg2, arg3);`
 - arg1 must be integer type, is passed by reference
 - arg2 must be integer type, is passed by value
 - arg3 must be double type, is passed by reference

Choosing Formal Parameter Names

- Same rule as naming any identifier:
 - Meaningful names!
- Functions as "self-contained modules"
 - Designed separately from rest of program
 - Assigned to teams of programmers
 - All must "understand" proper function use
 - OK if formal parameter names are same as argument names
- Choose function names with same rules

Overloading

- Same function name
- Different parameter lists
- Two separate function definitions
- Function "signature"
 - Function name & parameter list
 - Must be "unique" for each function definition
- Allows same task performed on different data

Overloading Example: Average

- Function computes average of 2 numbers:
`double average(double n1, double n2)`
`{`
 `return ((n1 + n2) / 2.0);`
`}`
- Now compute average of 3 numbers:
`double average(double n1, double n2, double n3)`
`{`
 `return ((n1 + n2) / 2.0);`
`}`
- Same name, two functions

Overloaded Average() Cont'd

- Which function gets called?
- Depends on function call itself:
 - `avg = average(5.2, 6.7);`
 - Calls "two-parameter average()"
 - `avg = average(6.5, 8.5, 4.2);`
 - Calls "three-parameter average()"
- Compiler resolves invocation based on signature of function call
 - "Matches" call with appropriate function
 - Each considered separate function

Overloading Pitfall

- Only overload "same-task" functions
 - A mpg() function should always perform same task, in all overloads
 - Otherwise, unpredictable results
- C++ function call resolution:
 - 1st: looks for exact signature
 - 2nd: looks for "compatible" signature

Overloading Resolution

- 1st: Exact Match
 - Looks for exact signature
 - Where no argument conversion required
- 2nd: Compatible Match
 - Looks for "compatible" signature where automatic type conversion is possible:
 - 1st with promotion (e.g., int→double)
 - No loss of data
 - 2nd with demotion (e.g., double→int)
 - Possible loss of data

Overloading Resolution Example

- Given following functions:
 - 1. `void f(int n, double m);`
 - 2. `void f(double n, int m);`
 - 3. `void f(int n, int m);`
 - These calls:
 - `f(98, 99);` \rightarrow Calls #3
 - `f(5.3, 4);` \rightarrow Calls #2
 - `f(4.3, 5.2);` \rightarrow Calls ???
- Avoid such confusing overloading

Automatic Type Conversion and Overloading

- Numeric formal parameters typically made "double" type
- Allows for "any" numeric type
 - Any "subordinate" data automatically promoted
 - int → double
 - float → double
 - char → double *More on this later!
- Avoids overloading for different numeric types

Automatic Type Conversion and Overloading Example

- `double mpg(double miles, double gallons)`
`{`
 `return (miles/gallons);`
`}`
- Example function calls:
 - `mpgComputed = mpg(5, 20);`
 - Converts 5 & 20 to doubles, then passes
 - `mpgComputed = mpg(5.8, 20.2);`
 - No conversion necessary
 - `mpgComputed = mpg(5, 2.4);`
 - Converts 5 to 5.0, then passes values to function

Default Arguments

- Allows omitting some arguments
- Specified in function declaration/prototype
 - `void showVolume(int length,
 int width = 1,
 int height = 1);`
 - Last 2 arguments are defaulted
 - Possible calls:
 - `showVolume(2, 4, 6);` //All arguments supplied
 - `showVolume(3, 5);` //height defaulted to 1
 - `showVolume(7);` //width & height defaulted to 1

Default Arguments Example:

Display 4.1 Default Arguments (1 of 2)

Display 4.8 Default Arguments

```
1
2  #include <iostream>
3  using namespace std;

4  void showVolume(int length, int width = 1, int height = 1);
5  //Returns the volume of a box.
6  //If no height is given, the height is assumed to be 1.
7  //If neither height nor width is given, both are assumed to be 1.

8  int main( )
9  {
10     showVolume(4, 6, 2);
11     showVolume(4, 6);
12     showVolume(4);

13     return 0;
14 }

15 void showVolume(int length, int width, int height)
```

Default arguments

A default argument should not be given a second time.

Default Arguments Example:

Display 4.1 Default Arguments (2 of 2)

```
16 {  
17     cout << "Volume of a box with \n"  
18         << "Length = " << length << ", Width = " << width << endl  
19         << "and Height = " << height  
20         << " is " << length*width*height << endl;  
21 }
```

SAMPLE DIALOGUE

Volume of a box with
Length = 4, Width = 6
and Height = 2 is 48
Volume of a box with
Length = 4, Width = 6
and Height = 1 is 24
Volume of a box with
Length = 4, Width = 1
and Height = 1 is 4

Testing and Debugging Functions

- Many methods:
 - Lots of cout statements
 - In calls and definitions
 - Used to "trace" execution
 - Compiler Debugger
 - Environment-dependent
 - assert Macro
 - Early termination as needed
 - Stubs and drivers
 - Incremental development

The assert Macro

- Assertion: a true or false statement
- Used to document and check correctness
 - Preconditions & Postconditions
 - Typical assert use: confirm their validity
 - Syntax:
`assert(<assert_condition>);`
 - No return value
 - Evaluates `assert_condition`
 - Terminates if false, continues if true
- Predefined in library `<cassert>`
 - Macros used similarly as functions

An assert Macro Example

- Given Function Declaration:
void computeCoin(int coinValue,
int& number,
int& amountLeft);
//Precondition: $0 < \text{coinValue} < 100$
 $0 \leq \text{amountLeft} < 100$
//Postcondition: number set to max. number
of coins
- Check precondition:
 - assert ((0 < currentCoin) && (currentCoin < 100)
&& (0 <= currentAmountLeft) && (currentAmountLeft < 100));
 - If precondition not satisfied \rightarrow condition is false \rightarrow program execution terminates!

An assert Macro Example Cont'd

- Useful in debugging
- Stops execution so problem can be investigated

assert On/Off

- Preprocessor provides means
- `#define NDEBUG`
`#include <cassert>`
- Add `"#define"` line before `#include` line
 - Turns OFF all assertions throughout program
- Remove `"#define"` line (or comment out)
 - Turns assertions back on

Stubs and Drivers

- Separate compilation units
 - Each function designed, coded, tested separately
 - Ensures validity of each unit
 - Divide & Conquer
 - Transforms one big task → smaller, manageable tasks
- But how to test independently?
 - Driver programs

Driver Program Example:

Display 4.9 Driver Program (1 of 3)

Display 4.9 Driver Program

```
1
2 //Driver program for the function unitPrice.
3 #include <iostream>
4 using namespace std;

5 double unitPrice(int diameter, double price);
6 //Returns the price per square inch of a pizza.
7 //Precondition: The diameter parameter is the diameter of the pizza
8 //in inches. The price parameter is the price of the pizza.

9 int main()
10 {
11     double diameter, price;
12     char ans;

13     do
14     {
15         cout << "Enter diameter and price:\n";
16         cin >> diameter >> price;
```

Driver Program Example:

Display 4.9 Driver Program (2 of 3)

```
17         cout << "unit Price is $"
18         << unitPrice(diameter, price) << endl;

19         cout << "Test again? (y/n)";
20         cin >> ans;
21         cout << endl;
22     } while (ans == 'y' || ans == 'Y');

23     return 0;
24 }
25
26 double unitPrice(int diameter, double price)
27 {
28     const double PI = 3.14159;
29     double radius, area;

30     radius = diameter/static_cast<double>(2);
31     area = PI * radius * radius;
32     return (price/area);
33 }
```

(continued)

Driver Program Example:

Display 4.9 Driver Program (3 of 3)

Display 4.9 Driver Program

SAMPLE DIALOGUE

Enter diameter and price:

13 14.75

Unit price is: \$0.111126

Test again? (y/n): y

Enter diameter and price:

2 3.15

Unit price is: \$1.00268

Test again? (y/n): n

Stubs

- Develop incrementally
- Write "big-picture" functions first
 - Low-level functions last
 - "Stub-out" functions until implementation
 - Example:

```
double unitPrice(int diameter, double price)
{
    return (9.99); // not valid, but noticeably
                  // a "temporary" value
}
```
 - Calls to function will still "work"

Fundamental Testing Rule

- To write "correct" programs
- Minimize errors, "bugs"
- Ensure validity of data
 - Test every function in a program where every other function has already been fully tested and debugged
 - Avoids "error-cascading" & conflicting results

Summary 1

- Formal parameter is placeholder, filled in with actual argument in function call
- Call-by-value parameters are "local copies" in receiving function body
 - Actual argument cannot be modified
- Call-by-reference passes memory address of actual argument
 - Actual argument can be modified
 - Argument **MUST** be variable, not constant

Summary 2

- Multiple definitions of same function name possible: called overloading
- Default arguments allow function call to "omit" some or all arguments in list
 - If not provided → default values assigned
- assert macro initiates program termination if assertions fail
- Functions should be tested independently
 - As separate compilation units, with drivers