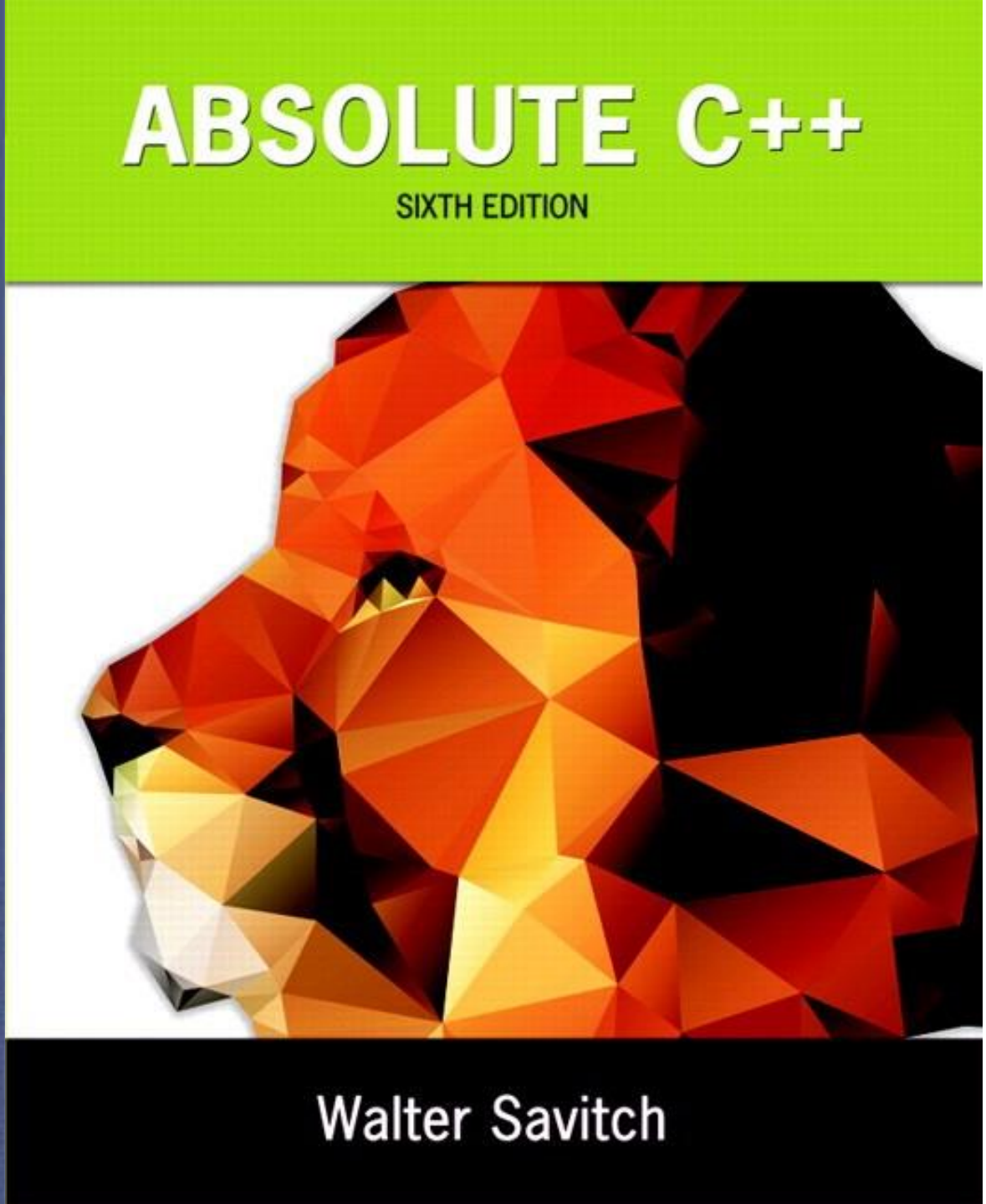


Chapter 3

Function Basics

PEARSON

Learning Objectives

- Predefined Functions
  - Those that return a value and those that don't
- Programmer-defined Functions
  - Defining, Declaring, Calling
  - Recursive Functions
- Scope Rules
  - Local variables
  - Global constants and global variables
  - Blocks, nested scopes

Introduction to Functions

- Building Blocks of Programs
- Other terminology in other languages:
  - Procedures, subprograms, methods
  - In C++: functions
- I-P-O
  - Input – Process – Output
  - Basic subparts to any program
  - Use functions for these "pieces"

Predefined Functions

- Libraries full of functions for our use!
- Two types:
  - Those that return a value
  - Those that do not (void)
- Must "#include" appropriate library
  - e.g.,
    - <cmath>, <cstdlib> (Original "C" libraries)
    - <iostream> (for cout, cin)

Using Predefined Functions

- Math functions very plentiful
  - Found in library <cmath.h>
  - Most return a value (the "answer")
- Example: theRoot = sqrt(9.0);
  - Components:
    sqrt = name of library function
    theRoot = variable used to assign "answer" to
    9.0 = argument or "starting input" for function
  - In I-P-O:
    - I = 9.0
    - P = "compute the square root"
    - O = 3, which is returned & assigned to theRoot

The Function Call

- Back to this assignment:

  theRoot = sqrt(9.0);

  - The expression "sqrt(9.0)" is known as a function *call*, or function *invocation*
  - The argument in a function call (9.0) can be a literal, a variable, or an expression
  - The call itself can be part of an expression:
    - bonus = sqrt(sales)/10;
    - A function call is allowed wherever it's legal to use an expression of the function's return type

A Larger Example:
Display 3.1 A Predefined Function That Returns a Value (1 of 2)

Display 3.1 A Predefined Function That Returns a Value

```
1   //Computes the size of a doghouse that can be purchased
2   //given the user's budget.
3   #include <iostream>
4   #include <cmath>
5   using namespace std;

6   int main( )
7   {
8       const double COST_PER_SQ_FT = 10.50;
9       double budget, area, lengthSide;

10      cout << "Enter the amount budgeted for your doghouse $";
11      cin >> budget;

12      area = budget/COST_PER_SQ_FT;
13      lengthSide = sqrt(area);
```

A Larger Example:
Display 3.1 A Predefined Function That Returns a Value (2 of 2)

```
14      cout.setf(ios::fixed);
15      cout.setf(ios::showpoint);
16      cout.precision(2);
17         cout << "For a price of $" << budget << endl
18           << "I can build you a luxurious square doghouse\n"
19           << "that is " << lengthSide
20           << " feet on each side.\n";

21      return 0;
22  }
```

SAMPLE DIALOGUE

```
Enter the amount budgeted for your doghouse $25.00
For a price of $25.00
I can build you a luxurious square doghouse
that is 1.54 feet on each side.
```

More Predefined Functions

- #include <cstdlib>
  - Library contains functions like:
    - abs() // Returns absolute value of an int
    - labs() // Returns absolute value of a long int
    - *fabs() // Returns absolute value of a float
  - *fabs() is actually in library <cmath>!
    - Can be confusing
    - Remember: libraries were added after C++ was "born," in incremental phases
    - Refer to appendices/manuals for details

More Math Functions

- pow(x, y)
  - Returns x to the power y
    double result, x = 3.0, y = 2.0;
    result = pow(x, y);
    cout << result;
    - Here 9.0 is displayed since $3.0^{2.0} = 9.0$
- Notice this function receives two arguments
  - A function can have any number of arguments, of varying data types

Even More Math Functions: **Display 3.2** Some Predefined Functions (1 of 2)

Display 3.2 Some Predefined Functions

NAME	DESCRIPTION	TYPE OF ARGUMENTS	TYPE OF VALUE RETURNED	EXAMPLE	VALUE	LIBRARY HEADER
sqrt	Square root	double	double	sqrt(4.0)	2.0	cmath
pow	Powers	double	double	pow(2.0,3.0)	8.0	cmath
abs	Absolute value for int	int	int	abs(-7) abs(7)	7 7	cstdlib
labs	Absolute value for long	long	long	labs(-70000) labs(70000)	70000 70000	cstdlib
fabs	Absolute value for double	double	double	fabs(-7.5) fabs(7.5)	7.5 7.5	cmath

Even More Math Functions: **Display 3.2** Some Predefined Functions (2 of 2)

ceil	Ceiling (round up)	double	double	ceil(3.2) ceil(3.9)	4.0 4.0	cmath
floor	Floor (round down)	double	double	floor(3.2) floor(3.9)	3.0 3.0	cmath
exit	End pro-gram	int	void	exit(1);	None	cstdlib
rand	Random number	None	int	rand( )	Varies	cstdlib
srand	Set seed for rand	unsigned int	void	srand(42);	None	cstdlib

Predefined Void Functions

- No returned value
- Performs an action, but sends no "answer"
- When called, it’s a statement itself
  - exit(1); // No return value, so not assigned
    - This call terminates program
    - void functions can still have arguments
- All aspects same as functions that "return a value"
  - They just don’t return a value!

Random Number Generator

- Return "randomly chosen" number
- Used for simulations, games
  - rand()
    - Takes no arguments
    - Returns value between 0 & RAND_MAX
  - Scaling
    - Squeezes random number into smaller range
      rand() % 6
    - Returns random value between 0 & 5
  - Shifting
    rand() % 6 + 1
    - Shifts range between 1 & 6 (e.g., die roll)

Random Number Seed

- Pseudorandom numbers
  - Calls to rand() produce given "sequence" of random numbers
- Use "seed" to alter sequence
  srand(seed_value);
  - void function
  - Receives one argument, the "seed"
  - Can use any seed value, including system time: srand(time(0));
  - time() returns system time as numeric value
  - Library <time> contains time() functions

Random Examples

- Random double between 0.0 & 1.0:
  (RAND_MAX – rand())/static_cast<double>(RAND_MAX)
  - Type cast used to force double-precision division
- Random int between 1 & 6:
  rand() % 6 + 1
  - "%" is modulus operator (remainder)
- Random int between 10 & 20:
  rand() % 10 + 10

Programmer-Defined Functions

- Write your own functions!
- Building blocks of programs
  - Divide & Conquer
  - Readability
  - Re-use
- Your "definition" can go in either:
  - Same file as main()
  - Separate file so others can use it, too

Components of Function Use

- 3 Pieces to using functions:
  - Function Declaration/prototype
    - Information for compiler
    - To properly interpret calls
  - Function Definition
    - Actual implementation/code for what function does
  - Function Call
    - Transfer control to function

Function Declaration

- Also called function prototoype
- An "informational" declaration for compiler
- Tells compiler how to interpret calls
  - Syntax:
    <return_type> FnName(<formal-parameter-list>);
  - Example:
    double totalCost(int numberParameter,
    double priceParameter);
- Placed before any calls
  - In declaration space of main()
  - Or above main() in global space

Function Definition

- Implementation of function
- Just like implementing function main()
- Example:

```
double totalCost(          int numberParameter,
                           double priceParameter)
{
      const double TAXRATE = 0.05;
      double subTotal;
      subtotal = priceParameter * numberParameter;
      return (subtotal + subtotal * TAXRATE);
}
```

- Notice proper indenting

Function Definition Placement

- Placed after function main()
  - NOT "inside" function main()!
- Functions are "equals"; no function is ever "part" of another
- Formal parameters in definition
  - "Placeholders" for data sent in
    - "Variable name" used to refer to data in definition
- return statement
  - Sends data back to caller

Function Call

- Just like calling predefined function
  bill = totalCost(number, price);
- Recall: totalCost returns double value
  - Assigned to variable named "bill"
- Arguments here: number, price
  - Recall arguments can be literals, variables, expressions, or combination
  - In function call, arguments often called "actual arguments"
    - Because they contain the "actual data" being sent

Function Example:
Display 3.5 A Function to Calculate Total Cost (1 of 2)

Display 3.5

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

3  double totalCost(int numberParameter, double priceParameter);
4  //Computes the total cost, including 5% sales tax,
5  //on numberParameter items at a cost of priceParameter each.

6  int main( )
7  {
8      double price, bill;
9      int number;

10     cout << "Enter the number of items purchased: ";
11     cin >> number;
12     cout << "Enter the price per item $";
13     cin >> price;

14     bill = totalCost(number, price);
```

Function declaration; also called the function prototype

Function call

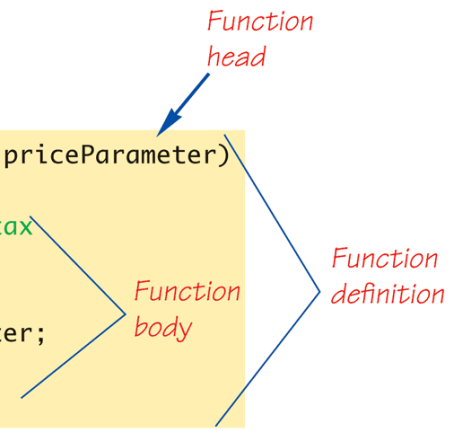
Function Example:
Display 3.5 A Function to Calculate Total Cost (1 of 2)

```
15      cout.setf(ios::fixed);
16      cout.setf(ios::showpoint);
17      cout.precision(2);
18      cout << number << " items at "
19           << "$" << price << " each.\n"
20           << "Final bill, including tax, is $" << bill
21           << endl;

22      return 0;
23  }

24  double totalCost(int numberParameter, double priceParameter)
25  {
26      const double TAXRATE = 0.05; //5% sales tax
27      double subtotal;

28      subtotal = priceParameter * numberParameter;
29      return (subtotal + subtotal*TAXRATE);
30  }
```



SAMPLE DIALOGUE

Enter the number of items purchased: **2**
Enter the price per item: $**10.10**
2 items at $10.10 each.
Final bill, including tax, is $21.21

Alternative Function Declaration

- Recall: Function declaration is "information" for compiler
- Compiler only needs to know:
  - Return type
  - Function name
  - Parameter list
- Formal parameter names not needed:
  double totalCost(int, double);
  - Still "should" put in formal parameter names
    - Improves readability

Parameter vs. Argument

- Terms often used interchangeably
- Formal parameters/arguments
  - In function declaration
  - In function definition's header
- Actual parameters/arguments
  - In function call
- Technically parameter is "formal" piece while argument is "actual" piece*
  - *Terms not always used this way

Functions Calling Functions

- We're already doing this!
  - main() IS a function!
- Only requirement:
  - Function's declaration must appear first
- Function's definition typically elsewhere
  - After main()"s definition
  - Or in separate file
- Common for functions to call many other functions
- Function can even call itself → "Recursion"

Boolean Return-Type Functions

- Return-type can be any valid type
  - Given function declaration/prototype:
    bool appropriate(int rate);
  - And function's definition:

```
bool appropriate (int rate)
{
        return (((rate>=10)&&(rate<20))||(rate==0);
}
```

  - Returns "true" or "false"
  - Function call, from some other function:

```
if (appropriate(entered_rate))
    cout << "Rate is valid\n";
```

Declaring Void Functions

- Similar to functions returning a value
- Return type specified as "void"
- Example:
  - Function declaration/prototype:

```
void showResults(    double fDegrees,
                     double cDegrees);
```

    - Return-type is "void"
    - Nothing is returned

Declaring Void Functions

- Function definition:

```
void showResults(double fDegrees, double cDegrees)
{
        cout.setf(ios::fixed);
        cout.setf(ios::showpoint);
        cout.precision(1);
        cout    << fDegrees
                << " degrees fahrenheit equals \n"
                << cDegrees << " degrees celsius.\n";
}
```

- Notice: no return statement
  - Optional for void functions

Calling Void Functions

- Same as calling predefined void functions
- From some other function, like main():
  - showResults(degreesF, degreesC);
  - showResults(32.5, 0.3);
- Notice no assignment, since no value returned
- Actual arguments (degreesF, degreesC)
  - Passed to function
  - Function is called to "do it's job" with the data passed in

More on Return Statements

- Transfers control back to "calling" function
  - For return type other than void, MUST have return statement
  - Typically the LAST statement in function definition
- return statement optional for void functions
  - Closing } would implicitly return control from void function

Preconditions and Postconditions

- Similar to "I-P-O" discussion
- Comment function declaration:

```
void showInterest(double balance, double rate);
//Precondition: balance is nonnegative account balance
//               rate is interest rate as percentage
//Postcondition: amount of interest on given balance,
//               at given rate …
```

- Often called Inputs & Outputs

main(): "Special"

- Recall: main() IS a function
- "Special" in that:
  - One and only one function called main() will exist in a program
- Who calls main()?
  - Operating system
  - Tradition holds it should have return statement
    - Value returned to "caller" → Here: operating system
  - Should return "int" or "void"

Scope Rules

- Local variables
  - Declared inside body of given function
  - Available only within that function
- Can have variables with same names declared in different functions
  - Scope is local: "that function is it’s scope"
- Local variables preferred
  - Maintain individual control over data
  - Need to know basis
  - Functions should declare whatever local data needed to "do their job"

Procedural Abstraction

- Need to know "what" function does, not "how" it does it!
- Think "black box"
  - Device you know how to use, but not it's method of operation
- Implement functions like black box
  - User of function only needs: declaration
  - Does NOT need function definition
    - Called Information Hiding
    - Hide details of "how" function does it's job

Global Constants and Global Variables

- Declared "outside" function body
  - Global to all functions in that file
- Declared "inside" function body
  - Local to that function
- Global declarations typical for constants:
  - const double TAXRATE = 0.05;
  - Declare globally so all functions have scope
- Global variables?
  - Possible, but SELDOM-USED
  - Dangerous: no control over usage!

Blocks

- Declare data inside compound statement
  - Called a "block"
  - Has "block-scope"
- Note: all function definitions are blocks!
  - This provides local "function-scope"
- Loop blocks:

```
for (int ctr=0;ctr<10;ctr++)
{
      sum+=ctr;
}
```

  - Variable ctr has scope in loop body block only

Nested Scope

- Same name variables declared in multiple blocks
- Very legal; scope is "block-scope"
  - No ambiguity
  - Each name is distinct within its scope

Summary 1

- Two kinds of functions:
  - "Return-a-value" and void functions
- Functions should be "black boxes"
  - Hide "how" details
  - Declare own local data
- Function declarations should self-document
  - Provide pre- & post-conditions in comments
  - Provide all "caller" needs for use

Summary 2

- Local data
  - Declared in function definition
- Global data
  - Declared above function definitions
  - OK for constants, not for variables
- Parameters/Arguments
  - Formal: In function declaration and definition
    - Placeholder for incoming data
  - Actual: In function call
    - Actual data passed to function