Chapter 5

Functions for All Subtasks

Overview

5.1 *void* Functions

5.2 Call-By-Reference Parameters

5.3 Using Procedural Abstraction

5.4 Testing and Debugging

5.5 General Debugging Techniques

5.1

void Functions

void-Functions

- In top-down design, a subtask might produce
  - No value (just input or output for example)
  - One value
  - More than one value
- We have seen how to implement functions that return one value
- A void-function implements a subtask that returns no value or more than one value

void-Function Definition

- Two main differences between void-function definitions and the definitions of functions that return one value
  - Keyword void replaces the type of the value returned
    - void means that no value is returned by the function
  - The return statement does not include and expression
- Example:

```
void show_results(double f_degrees, double c_degrees)
 {
     using namespace std;
     cout << f_degrees
             << " degrees Fahrenheit is euivalent to " << endl
             << c_degrees << " degrees Celsius." << endl;
      return;
}
```

Display 5.1

Syntax for a *void* Function Definition

***void* Function Declaration**

```
void Function_Name(Parameter_List);
Function_Declaration_Comment
```

***void* Function Definition**

```
void Function_Name(Parameter_List)
{
    Declaration_1
    Declaration_2
       . . .
    Declaration_Last
    Executable_Statement_1
    Executable_Statement_2
          . . .
    Executable_Statement_Last
}
```

function header

You may intermix the declarations with the executable statements.

body

May (or may not) include one or more `return` statements.

Using a void-Function

- void-function calls are executable statements
  - They do not need to be part of another statement
  - They end with a semi-colon
- Example:

```
show_results(32.5, 0.3);
```

NOT: `cout << show_results(32.5, 0.3);`

void-Function Calls

- Mechanism is nearly the same as the function calls we have seen
  - Argument values are substituted for the formal parameters
    - It is fairly common to have no parameters in void-functions
      - In this case there will be no arguments in the function call
  - Statements in function body are executed
  - Optional return statement ends the function
    - Return statement does not include a value to return
    - Return statement is implicit if it is not included

Example: Converting Temperatures

- The functions just developed can be used in a program to convert Fahrenheit temperatures to Celcius using the formula

$$C = (5/9)\ (F - 32)$$

  - Do you see the integer division problem?

Display 5.2 (1/2)

***void* Functions (*part 1 of 2*)**

```
//Program to convert a Fahrenheit temperature to a Celsius temperature.
#include <iostream>

void initialize_screen();
//Separates current output from
//the output of the previously run program.

double celsius(double fahrenheit);
//Converts a Fahrenheit temperature
//to a Celsius temperature.

void show_results(double f_degrees, double c_degrees);
//Displays output. Assumes that c_degrees
//Celsius is equivalent to f_degrees Fahrenheit.

int main()
{
    using namespace std;
    double f_temperature, c_temperature;

    initialize_screen();
    cout << "I will convert a Fahrenheit temperature"
         << " to Celsius.\n"
         << "Enter a temperature in Fahrenheit: ";
    cin >> f_temperature;

    c_temperature = celsius(f_temperature);

    show_results(f_temperature, c_temperature);
    return 0;
}

//Definition uses iostream:
void initialize_screen()
{
    using namespace std;
    cout << endl;
    return;
}
```

This `return` *is optional.*

Display 5.2 (2/2)

***void* Functions (*part 2 of 2*)**

```
double celsius(double fahrenheit)
{
    return ((5.0/9.0)*(fahrenheit - 32));
}

//Definition uses iostream:
void show_results(double f_degrees, double c_degrees)
{
    using namespace std;
    cout.setf(ios::fixed);
    cout.setf(ios::showpoint);
    cout.precision(1);
    cout << f_degrees
         << " degrees Fahrenheit is equivalent to\n"
         << c_degrees << " degrees Celsius.\n";
    return;
}
```

This `return` *is optional.*

Sample Dialogue

```
I will convert a Fahrenheit temperature to Celsius.
Enter a temperature in Fahrenheit: 32.5
32.5 degrees Fahrenheit is equivalent to
0.3 degrees Celsius.
```

void-Functions
Why Use a Return?

- Is a return-statement ever needed in a void-function since no value is returned?
  - Yes!
    - What if a branch of an if-else statement requires that the function ends to avoid producing more output, or creating a mathematical error?
    - void-function in Display 5.3, avoids division by zero with a return statement

Display 5.3

Use of *return* in a *void* Function

Function Declaration

```
void ice_cream_division(int number, double total_weight);
//Outputs instructions for dividing total_weight ounces of
//ice cream among number customers.
//If number is 0, nothing is done.
```

Function Definition

```
//Definition uses iostream:
void ice_cream_division(int number, double total_weight)
{
    using namespace std;
    double portion;

    if (number == 0)
        return;
    portion = total_weight/number;
    cout.setf(ios::fixed);
    cout.setf(ios::showpoint);
    cout.precision(2);
    cout << "Each one receives "
         << portion << " ounces of ice cream." << endl;
}
```

If number *is* 0, *then the function execution ends here.*

The Main Function

- The main function in a program is used like a void function…do you have to end the program with a return-statement?
  - Because the main function is defined to return a value of type int, the return is needed
  - C++ standard says the return 0 can be omitted, but many compilers still require it

Section 5.1 Conclusion

- Can you
  - Describe the differences between void-functions and functions that return one value?
  - Tell what happens if you forget the return-statementin a void-function?
  - Distinguish between functions that are used as expressions and those used as statements?

5.2

Call-By-Reference Parameters

Call-by-Reference Parameters

- Call-by-value is not adequate when we need a sub-task to obtain input values
  - Call-by-value means that the formal parameters receive the values of the arguments
  - To obtain input values, we need to change the variables that are arguments to the function
    - Recall that we have changed the values of formal parameters in a function body, but we have not changed the arguments found in the function call
- Call-by-reference parameters allow us to change the variable used in the function call
  - Arguments for call-by-reference parameters must be variables, not numbers

Call-by-Reference Example

- void get_input(double& f_variable)
  {
  using namespace std;
  cout << " Convert a Fahrenheit temperature"
  << " to Celsius.\n"
  << " Enter a temperature in Fahrenheit: ";
  cin >> f_variable;
  }
- '&' symbol (ampersand) identifies f_variable as a call-by-reference parameter
  - Used in both declaration and definition!

Display 5.4 (1/2)

Call-by-Reference Parameters (*part 1 of 2*)

```
//Program to demonstrate call-by-reference parameters.
#include <iostream>

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

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

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

int main( )
{
    int first_num, second_num;

    get_numbers(first_num, second_num);
    swap_values(first_num, second_num);
    show_results(first_num, second_num);
    return 0;
}

//Uses iostream:
void get_numbers(int& input1, int& input2)
{
    using namespace std;
    cout << "Enter two integers: ";
    cin >> input1
        >> input2;
}

void swap_values(int& variable1, int& variable2)
{
    int temp;

    temp = variable1;
    variable1 = variable2;
    variable2 = temp;
}
```

Display 5.4 (2/2)

Call-by-Reference Parameters (*part 2 of 2*)

```
//Uses iostream:
void show_results(int output1, int output2)
{
    using namespace std;
    cout << "In reverse order the numbers are: "
         << output1 << " " << output2 << endl;
}
```

Sample Dialogue

```
Enter two integers: 5 10
In reverse order the numbers are: 10 5
```

Call-By-Reference Details

- Call-by-reference works almost as if the argument variable is substituted for the formal parameter, not the argument's value
- In reality, the memory location of the argument variable is given to the formal parameter
  - Whatever is done to a formal parameter in the function body, is actually done to the value at the memory location of the argument variable

Display 5.5 (1/2)

DISPLAY 5.5 Behavior of Call-by-Reference Arguments *(part 1 of 2)*

Anatomy of a Function Call from Display 5.4 Using Call-by-Reference Arguments

0 Assume the variables `first_num` and `second_num` have been assigned the following memory address by the compiler:

```
first_num  ------> 1010
second_num ------>  1012
```

(We do not know what addresses are assigned and the results will not depend on the actual addresses, but this will make the process very concrete and thus perhaps easier to follow.)

1 In the program in Display 5.4, the following function call begins executing:

```
get_numbers(first_num, second_num);
```

2 The function is told to use the memory location of the variable `first_num` in place of the formal parameter `input1` and the memory location of the `second_num` in place of the formal parameter `input2`. The effect is the same as if the function definition were rewritten to the following (which is not legal C++ code, but does have a clear meaning to us):

```
void get_numbers(int& <the variable at memory location 1010>,
                 int& <the variable at memory location 1012>)
{
    using namespace std;
    cout << "Enter two integers: ";
    cin >> <the variable at memory location 1010>
        >> <the variable at memory location 1012>;
}
```

Display 5.5 (2/2)

DISPLAY 5.5 Behavior of Call-by-Reference Arguments *(part 2 of 2)*

Anatomy of the Function Call in Display 5.4 (*concluded*)

Since the variables in locations 1010 and 1012 are `first_num` and `second_num`, the effect is thus the same as if the function definition were rewritten to the following:

```
void get_numbers(int& first_num, int& second_num)
{
    using namespace std;
    cout << "Enter two integers: ";
    cin >> first_num
        >> second_num;
}
```

3 The body of the function is executed. The effect is the same as if the following were executed:

```
{
    using namespace std;
    cout << "Enter two integers: ";
    cin >> first_num
        >> second_num;
}
```

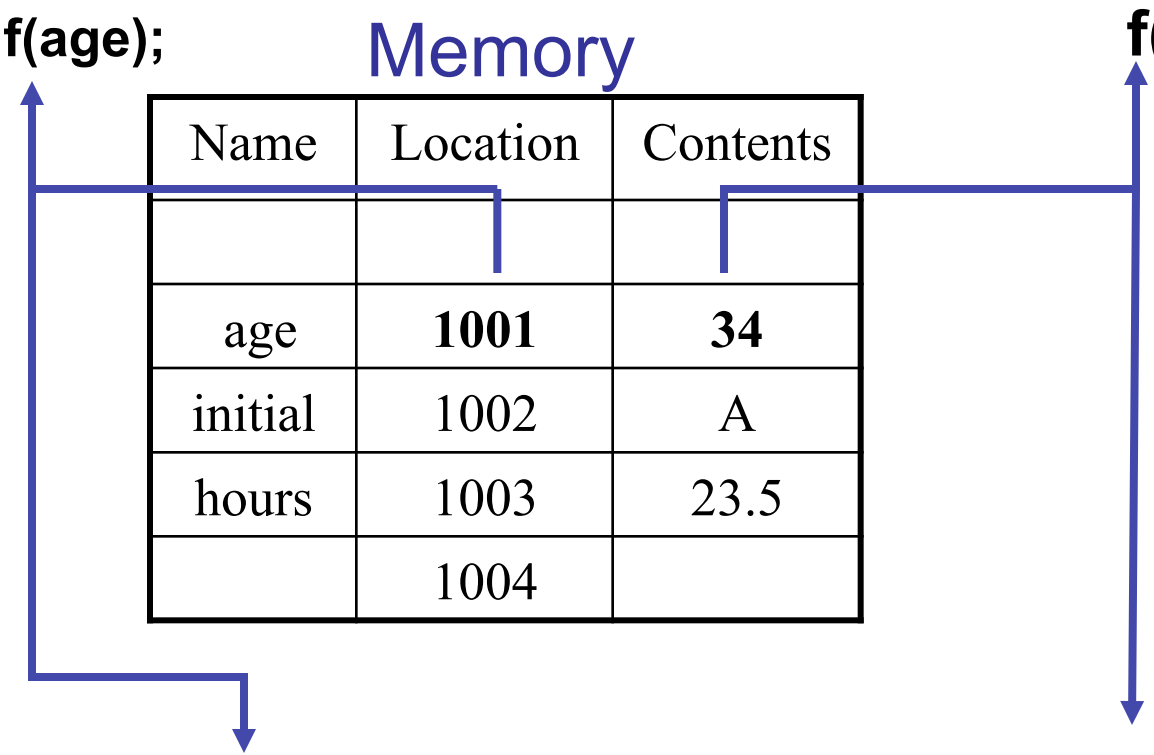
4 When the `cin` statement is executed, the values of the variables `first_num` and `second_num` are set to the values typed in at the keyboard. (If the dialogue is as shown in Display 5.4, then the value of `first_num` is set to `5` and the value of `second_num` is set to `10`.)

5 When the function call ends, the variables `first_num` and `second_num` retain the values that they were given by the `cin` statement in the function body. (If the dialogue is as shown in Display 5.4, then the value of `first_num` is `5` and the value of `second_num` is `10` at the end of the function call.)

Call Comparisons
Call By Reference vs Value

- Call-by-reference
  - The function call:

f(age);



void f(int& ref_par);

- Call-by-value
  - The function call:

f(age);

void f(int var_par);

Example: swap_values

- void swap(int& variable1, int& variable2)
  {
  int temp = variable1;
  variable1 = variable2;
  variable2 = temp;
  }
- If called with swap(first_num, second_num);
  - first_num is substituted for variable1 in the parameter list
  - second_num is substituted for variable2 in the parameter list
  - temp is assigned the value of variable1 (first_num) since the next line will loose the value in first_num
  - variable1 (first_num) is assigned the value in variable2 (second_num)
  - variable2 (second_num) is assigned the original value of variable1 (first_num) which was stored in temp

Mixed Parameter Lists

- Call-by-value and call-by-reference parameters can be mixed in the same function

- Example:
  void good_stuff(int& par1, int par2, double& par3);
  - par1 and par3 are call-by-reference formal parameters
    - Changes in par1 and par3 change the argument variable
  - par2 is a call-by-value formal parameter
    - Changes in par2 do not change the argument variable

Choosing Parameter Types

- How do you decide whether a call-by-reference or call-by-value formal parameter is needed?
  - Does the function need to change the value of the variable used as an argument?
  - Yes? Use a call-by-reference formal parameter
  - No? Use a call-by-value formal parameter

Display 5.6

Comparing Argument Mechanisms

```
//Illustrates the difference between a call-by-value
//parameter and a call-by-reference parameter.
#include <iostream>

void do_stuff(int par1_value, int& par2_ref);
//par1_value is a call-by-value formal parameter and
//par2_ref is a call-by-reference formal parameter.

int main()
{
    using namespace std;
    int n1, n2;

    n1 = 1;
    n2 = 2;
    do_stuff(n1, n2);
    cout << "n1 after function call = " << n1 << endl;
    cout << "n2 after function call = " << n2 << endl;
    return 0;
}

void do_stuff(int par1_value, int& par2_ref)
{
    using namespace std;
    par1_value = 111;
    cout << "par1_value in function call = "
         << par1_value << endl;
    par2_ref = 222;
    cout << "par2_ref in function call = "
         << par2_ref << endl;
}
```

Sample Dialogue

```
par1_value in function call = 111
par2_ref in function call = 222
n1 after function call = 1
n2 after function call = 222
```

Inadvertent Local Variables

- If a function is to change the value of a variable the corresponding formal parameter must be a call-by-reference parameter with an ampersand (&) attached
- Forgetting the ampersand (&) creates a call-by-value parameter
  - The value of the variable will not be changed
  - The formal parameter is a local variable that has no effect outside the function
  - Hard error to find…it looks right!

Display 5.7

Inadvertent Local Variable

```
//Program to demonstrate call-by-reference parameters.
#include <iostream>

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

void swap_values(int variable1, int variable2);
//Interchanges the values of variable1 and variable2.

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

int main( )
{
    using namespace std;
    int first_num, second_num;

    get_numbers(first_num, second_num);
    swap_values(first_num, second_num);
    show_results(first_num, second_num);
    return 0;
}

void swap_values(int variable1, int variable2)
{
    int temp;

    temp = variable1;
    variable1 = variable2;
    variable2 = temp;
}
```

forgot the & here

forgot the & here

inadvertent local variables

<The definitions of get_numbers and show_results are the same as in Display 4.4.>

Sample Dialogue

```
Enter two integers: 5 10
In reverse order the numbers are: 5 10
```

Section 5.2 Conclusion

- Can you
  - Write a void-function definition for a function called zero_both that has two reference parameters, both of which are variables of type int, and sets the values of both variables to 0.
  - Write a function that returns a value and has a call-by-reference parameter?
  - Write a function with both call-by-value and call-by-reference parameters

5.3

Using Procedural Abstraction

Using Procedural Abstraction

- Functions should be designed so they can be used as black boxes
- To use a function, the declaration and comment should be sufficient
- Programmer should not need to know the details of the function to use it

Functions Calling Functions

- A function body may contain a call to another function
  - The called function declaration must still appear before it is called
    - Functions cannot be defined in the body of another function
  - Example:

```
void order(int&  n1, int&  n2)
{
    if (n1 > n2)
        swap_values(n1, n2);
}
```

    - swap_values called if n1 and n2 are not in ascending order
    - After the call to order, n1 and n2 are in ascending order

Display 5.8 (1/2)

Function Calling Another Function (*part 1 of 2*)

```
//Program to demonstrate a function calling another function.
#include <iostream>

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

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

void order(int& n1, int& n2);
//Orders the numbers in the variables n1 and n2
//so that after the function call n1 <= n2.

void give_results(int output1, int output2);
//Outputs the values in output1 and output2.
//Assumes that output1 <= output2


int main( )
{
    int first_num, second_num;

    get_input(first_num, second_num);
    order(first_num, second_num);
    give_results(first_num, second_num);
    return 0;
}


//Uses iostream:
void get_input(int& input1, int& input2)
{
    using namespace std;
    cout << "Enter two integers: ";
    cin >> input1 >> input2;
}
```

Display 5.8 (2/2)

Function Calling Another Function (*part 2 of 2*)

```
void swap_values(int& variable1, int& variable2)
{
    int temp;

    temp = variable1;
    variable1 = variable2;
    variable2 = temp;
}
```

These function definitions can be in any order.

```
void order(int& n1, int& n2)
{
    if (n1 > n2)
        swap_values(n1, n2);
}
```

```
//Uses iostream:
void give_results(int output1, int output2)
{
    using namespace std;
    cout << "In increasing order the numbers are: "
         << output1 << " " << output2 << endl;
}
```

Sample Dialogue

```
Enter two integers: 10 5
In increasing order the numbers are: 5 10
```

Pre and Postconditions

- Precondition
  - States what is assumed to be true when the function is called
    - Function should not be used unless the precondition holds
- Postcondition
  - Describes the effect of the function call
  - Tells what will be true after the function is executed (when the precondition holds)
  - If the function returns a value, that value is described
  - Changes to call-by-reference parameters are described

swap_values revisited

- Using preconditions and postconditions the declaration of swap_values becomes:

```
void swap_values(int& n1, int& n2);
//Precondition:  variable1 and variable 2 have
//                          been given values
// Postcondition:  The values of variable1 and
//                          variable2 have been
//                          interchanged
```

Function celsius

- Preconditions and postconditions make the declaration for celsius:

```
double celsius(double farenheit);
//Precondition:  fahrenheit is a temperature
//                    expressed in degrees Fahrenheit
//Postcondition: Returns the equivalent temperature
//                     expressed in degrees Celsius
```

Why use preconditions and postconditions?

- Preconditions and postconditions
  - should be the first step in designing a function
  - specify what a function should do
    - Always specify what a function should do before designing how the function will do it
  - Minimize design errors
  - Minimize time wasted writing code that doesn't match the task at hand

Case Study
Supermarket Pricing

- Problem definition
  - Determine retail price of an item given suitable input
  - 5% markup if item should sell in a week
  - 10% markup if item expected to take more than a week
    - 5% for up to 7 days, changes to 10% at 8 days
  - Input
    - The wholesale price and the estimate of days until item sells
  - Output
    - The retail price of the item

Supermarket Pricing: Problem Analysis

- Three main subtasks
  - Input the data
  - Compute the retail price of the item
  - Output the results
- Each task can be implemented with a function
  - Notice the use of call-by-value and call-by-reference parameters in the following function declarations

Supermarket Pricing: Function get_input

- void get_input(double& cost, int& turnover);
  //Precondition: User is ready to enter values
  // correctly.
  //Postcondition: The value of cost has been set to
  // the wholesale cost of one item.
  // The value of turnover has been
  // set to the expected number of
  // days until the item is sold.

Supermarket Pricing: Function price

- double price(double cost, int turnover);
  //Precondition: cost is the wholesale cost of one
  //   item. turnover is the expected
  //   number of days until the item is
  //   sold.
  //Postcondition: returns the retail price of the item

Supermarket Pricing: Function give_output

- void give_output(double cost, int turnover, double price);
  //Precondition: cost is the wholesale cost of one item;
  //   turnover is the expected time until sale
  //   of the item; price is the retail price of
  //   the item.
  //Postcondition: The values of cost, turnover, and price
  //   been written to the screen.

Supermarket Pricing: The main function

- With the functions declared, we can write the main function:

```
int main()
{
   double wholesale_cost, retail_price;
   int shelf_time;

   get_input(wholesale_cost, shelf_time);
   retail_price = price(wholesale_cost, shelf_time);
   give_output(wholesale_cost, shelf_time, retail_price);
   return 0;
 }
```

Supermarket Pricing: Algorithm Design -- price

- Implementations of get_input and give_output are straightforward, so we concentrate on the price function
- pseudocode for the price function
  - If turnover <= 7 days then
    return (cost + 5% of cost);
    else
    return (cost + 10% of cost);

Supermarket Pricing: Constants for The price Function

- The numeric values in the pseudocode will be represented by constants
  - Const double LOW_MARKUP = 0.05; // 5%
  - Const double HIGH_MARKUP = 0.10; // 10%
  - Const int THRESHOLD = 7; // At 8 days use //
    HIGH_MARKUP

Supermarket Pricing: Coding The price Function

- The body of the price function
  - {

```
        if (turnover <= THRESHOLD)
            return ( cost + (LOW_MARKUP * cost) ) ;
        else
            return ( cost + ( HIGH_MARKUP *
    cost) ) ;
    }
```

- See the complete program in next slides

Display 5.9 (1/3)

Supermarket Pricing (*part 1 of 3*)

```
//Determines the retail price of an item according to
//the pricing policies of the Quick-Shop supermarket chain.
#include <iostream>

const double LOW_MARKUP = 0.05; //5%
const double HIGH_MARKUP = 0.10; //10%
const int THRESHOLD = 7; //Use HIGH_MARKUP if do not
                         //expect to sell in 7 days or less.

void introduction();
//Postcondition: Description of program is written on the screen.

void get_input(double& cost, int& turnover);
//Precondition: User is ready to enter values correctly.
//Postcondition: The value of cost has been set to the
//wholesale cost of one item. The value of turnover has been
//set to the expected number of days until the item is sold.

double price(double cost, int turnover);
//Precondition: cost is the wholesale cost of one item.
//turnover is the expected number of days until sale of the item.
//Returns the retail price of the item.

void give_output(double cost, int turnover, double price);
//Precondition: cost is the wholesale cost of one item; turnover is the
//expected time until sale of the item; price is the retail price of the item.
//Postcondition: The values of cost, turnover, and price have been
//written to the screen.

int main()
{
    double wholesale_cost, retail_price;
    int shelf_time;

    introduction();
    get_input(wholesale_cost, shelf_time);
    retail_price = price(wholesale_cost, shelf_time);
    give_output(wholesale_cost, shelf_time, retail_price);
    return 0;
}
```

Display 5.9 (2/3)

Supermarket Pricing (*part 2 of 3*)

```
//Uses iostream:
void introduction()
{
    using namespace std;
    cout << "This program determines the retail price for\n"
         << "an item at a Quick-Shop supermarket store.\n";
}

//Uses iostream:
void get_input(double& cost, int& turnover)
{
    using namespace std;
    cout << "Enter the wholesale cost of item: $";
    cin >> cost;
    cout << "Enter the expected number of days until sold: ";
    cin >> turnover;
}

//Uses iostream:
void give_output(double cost, int turnover, double price)
{
    using namespace std;
    cout.setf(ios::fixed);
    cout.setf(ios::showpoint);
    cout.precision(2);
    cout << "Wholesale cost = $" << cost << endl
         << "Expected time until sold = "
         << turnover << " days" << endl
         << "Retail price = $" << price << endl;
}

//Uses defined constants LOW_MARKUP, HIGH_MARKUP, and THRESHOLD:
double price(double cost, int turnover)
{
    if (turnover <= THRESHOLD)
        return ( cost + (LOW_MARKUP * cost) );
    else
        return ( cost + (HIGH_MARKUP * cost) );

}
```

Display 5.9 (3/3)

Supermarket Pricing (*part 3 of 3*)

Sample Dialogue

```
This program determines the retail price for
an item at a Quick-Shop supermarket store.
Enter the wholesale cost of item: $1.21
Enter the expected number of days until sold: 5
Wholesale cost = $1.21
Expected time until sold = 5 days
Retail price = $1.27
```

Supermarket Pricing : Program Testing

- Testing strategies
  - Use data that tests both the high and low markup cases
  - Test boundary conditions, where the program is expected
    to change behavior or make a choice
    - In function price, 7 days is a boundary condition
    - Test for exactly 7 days as well as one day more and one day less

Section 5.3 Conclusion

- Can you
  - Define a function in the body of another function?
  - Call one function from the body of another function?
  - Give preconditions and postconditions for the predefined function sqrt?

5.4

Testing and Debugging

Testing and Debugging Functions

- Each function should be tested as a separate unit
- Testing individual functions facilitates finding mistakes
- Driver programs allow testing of individual functions
- Once a function is tested, it can be used in the driver program to test other functions
- Function get_input is tested in the driver program of Display 5.0 (1) and Display 5.10 (2)

Display 5.10 (1/2)

Driver Program (*part 1 of 2*)

```
//Driver program for the function get_input.
#include <iostream>

void get_input(double& cost, int& turnover);
//Precondition: User is ready to enter values correctly.
//Postcondition: The value of cost has been set to the
//wholesale cost of one item. The value of turnover has been
//set to the expected number of days until the item is sold.

int main( )
{
    using namespace std;
    double wholesale_cost;
    int shelf_time;
    char ans;

    cout.setf(ios::fixed);
    cout.setf(ios::showpoint);
    cout.precision(2);
    do
    {
        get_input(wholesale_cost, shelf_time);

        cout << "Wholesale cost is now $"
             << wholesale_cost << endl;
        cout << "Days until sold is now "
             << shelf_time << endl;

        cout << "Test again?"
             << " (Type y for yes or n for no): ";
        cin >> ans;
        cout << endl;
    } while (ans == 'y' || ans == 'Y');

    return 0;
}
```

Display 5.10 (2/2)

Driver Program (*part 2 of 2*)

```
//Uses iostream:
void get_input(double& cost, int& turnover)
{
    using namespace std;
    cout << "Enter the wholesale cost of item: $";
    cin >> cost;
    cout << "Enter the expected number of days until sold: ";
    cin >> turnover;
}
```

Sample Dialogue

```
Enter the wholesale cost of item: $123.45
Enter the expected number of days until sold: 67
Wholesale cost is now $123.45
Days until sold is now 67
Test again? (Type y for yes or n for no): y

Enter the wholesale cost of item: $9.05
Enter the expected number of days until sold: 3
Wholesale cost is now $9.05
Days until sold is now 3
Test again? (Type y for yes or n for no): n
```

Stubs

- When a function being tested calls other functions that are not yet tested, use a stub
- A stub is a simplified version of a function
  - Stubs are usually provide values for testing rather than perform the intended calculation
  - Stubs should be so simple that you have confidence they will perform correctly
  - Function price is used as a stub to test the rest of the supermarket pricing program in

Display 5.11 (1) and **Display 5.11 (2)**

Display 5.11 (1/2)

Program with a Stub (*part 1 of 2*)

```
//Determines the retail price of an item according to
//the pricing policies of the Quick-Shop supermarket chain.
#include <iostream>

void introduction();
//Postcondition: Description of program is written on the screen.

void get_input(double& cost, int& turnover);
//Precondition: User is ready to enter values correctly.
//Postcondition: The value of cost has been set to the
//wholesale cost of one item. The value of turnover has been
//set to the expected number of days until the item is sold.

double price(double cost, int turnover);
//Precondition: cost is the wholesale cost of one item.
//turnover is the expected number of days until sale of the item.
//Returns the retail price of the item.

void give_output(double cost, int turnover, double price);
//Precondition: cost is the wholesale cost of one item; turnover is the
//expected time until sale of the item; price is the retail price of the item.
//Postcondition: The values of cost, turnover, and price have been
//written to the screen.

int main()
{
    double wholesale_cost, retail_price;
    int shelf_time;

    introduction();
    get_input(wholesale_cost, shelf_time);
    retail_price = price(wholesale_cost, shelf_time);
    give_output(wholesale_cost, shelf_time, retail_price);
    return 0;
}

//Uses iostream:
void introduction()
{
    using namespace std;
    cout << "This program determines the retail price for\n"
         << "an item at a Quick-Shop supermarket store.\n";
}
```

fully tested function

Display 5.11 (2/2)

Program with a Stub (*part 2 of 2*)

```
//Uses iostream:
void get_input(double& cost, int& turnover)
{
    using namespace std;
    cout << "Enter the wholesale cost of item: $";
    cin >> cost;
    cout << "Enter the expected number of days until sold: ";
    cin >> turnover;
}

//Uses iostream:
void give_output(double cost, int turnover, double price)
{
    using namespace std;
    cout.setf(ios::fixed);
    cout.setf(ios::showpoint);
    cout.precision(2);
    cout << "Wholesale cost = $" << cost << endl
         << "Expected time until sold = "
         << turnover << " days" << endl
         << "Retail price= $" << price << endl;
}

//This is only a stub:
double price(double cost, int turnover)
{
    return 9.99; //Not correct, but good enough for some testing.
}
```

fully tested function

function being tested

stub

Sample Dialogue

```
This program determines the retail price for
an item at a Quick-Shop supermarket store.
Enter the wholesale cost of item: $1.21
Enter the expected number of days until sold: 5
Wholesale cost = $1.21
Expected time until sold = 5 days
Retail price = $9.99
```

Rule for Testing Functions

- Fundamental Rule for Testing Functions
  - Test every function in a program in which every other function in that program has already been fully tested and debugged.

Section 5.4 Conclusion

- Can you
  - Describe the fundamental rule for testing functions?
  - Describe a driver program?
  - Write a driver program to test a function?
  - Describe and use a stub?
  - Write a stub?

5.5

General Debugging Techniques

General Debugging Techniques

- Stubs, drivers, test cases as described in the previous section
- Keep an open mind
  - Don’t assume the bug is in a particular location
- Don’t randomly change code without understanding what you are doing until the program works
  - This strategy may work for the first few small programs you write but is doomed to failure for any programs of moderate complexity
- Show the program to someone else

General Debugging Techniques

- Check for common errors, e.g.
  - Local vs. Reference Parameter
  - = instead of ==
- Localize the error
  - This temperature conversion program has a bug Display 5.12
  - Narrow down bug using cout statements Display 5.13

Display 5.12

```
1    #include <iostream>
2    using namespace std;
3
4    int main()
5    {
6        double fahrenheit;
7        double celsius;
8
9        cout << "Enter temperature in Fahrenheit." << endl;
10       cin >> fahrenheit;
11       celsius = (5 / 9) * (fahrenheit - 32);
12       cout << "Temperature in Celsius is " << celsius << endl;
13
14       return 0;
15   }
```

Sample Dialogue

```
Enter temperature in Fahrenheit.
100
Temperature in Celsius is 0
```

Display 5.13 (1 of 2)

```
1    #include <iostream>
2    using namespace std;
3
4    int main()
5    {
6        double fahrenheit;
7        double celsius;
8
9        cout << "Enter temperature in Fahrenheit." << endl;
10       cin >> fahrenheit;
11
12       // Comment out original line of code but leave it
13       // in the program for our reference
14       // celsius = (5 / 9) * (fahrenheit - 32);
15
16       // Add cout statements to verify (5 / 9) and (fahrenheit - 32)
17       // are computed correctly
18       double conversionFactor = 5 / 9;
19       double tempFahrenheit = (fahrenheit - 32);
20
21       cout << "fahrenheit - 32 = " << tempFahrenheit << endl;
```

code that is commented out

debugging with cout statements

Display 5.13 (2 of 2)

```
22          cout << "conversionFactor = " << conversionFactor << endl;
23          celsius = conversionFactor * tempFahrenheit;
24          cout << "Temperature in Celsius is " << celsius << endl;
25
26          return 0;
27      }
```

Sample Dialogue

```
Enter temperature in Fahrenheit.
100
fahrenheit - 32 = 68
conversionFactor = 0
Temperature in Celsius is 0
```

General Debugging Techniques

- Use a debugger
  - Tool typically integrated with a development environment that allows you to stop and step through a program line-by-line while inspecting variables
- The assert macro
  - Can be used to test pre or post conditions

    #include <cassert>

    assert(boolean expression)
  - If the boolean is false then the program will abort

Assert Example

- Denominator should not be zero in Newton's Method

```
// Approximates the square root of n using Newton's
// Iteration.
// Precondition: n is positive, num_iterations is positive
// Postcondition: returns the square root of n
double newton_sqroot(double n, int num_iterations)
{
    double answer = 1;
    int i = 0;

    assert((n > 0) && (num_iterations> 0));
    while (i <num_iterations)
    {
        answer = 0.5 * (answer + n / answer);
        i++;
    }
    return answer;
}
```

Section 5.5 Conclusion

- Can you
  - Recognize common errors?
  - Use the assert macro?
  - Debug a program using cout statements to localize the error?
  - Debug a program using a debugger?

Chapter 5 -- End