CSC180: Lecture 4

Wael Aboulsaadat

wael@cs.toronto.edu

http://portal.utoronto.ca/

Acknowledgement: These slides are partially based on the slides supplied with Prof. Savitch book: Problem Solving with C

Syntax vs. Semantics

- Syntax: how is it written
  - To declare a variable in C

    datatype variable-name;

    datatype variable1-name, variable2-name, variable3-name, ….;

- Semantics: what it means
  - E.g. double is the name of real numbers in C

Functions & machines

- Similarity between a function and a machine
  - Machine has an engine
  - Machine is initialized with input
  - Machine produces an output
  - Machine has a start button

Functions & machines

- Similarity between a function and a machine
  - Machine has an engine == function has an engine (body)
  - Machine is initialized with input == function also takes input (input parameters)
  - Machine produces an output == function also produce an output (returned values or output)
  - Machine has a start button == function has a invocation mechanism

Functions & machines

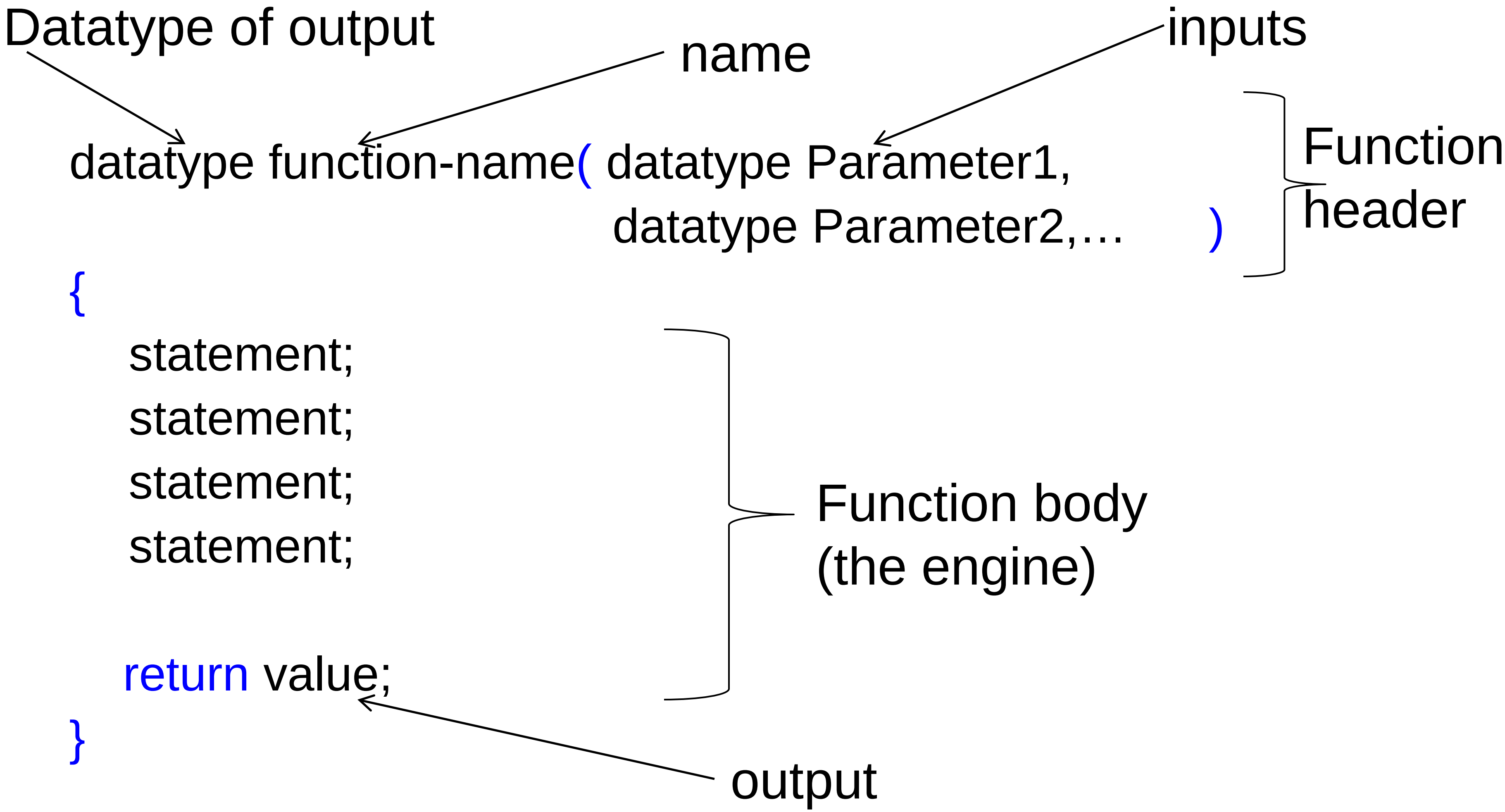
- Similarity between a function and a machine
  - Machine has an engine == function has an engine (body)
  - Machine is initialized with input == function also takes input
  - Machine produces an output == function also produce an output
  - Machine has a start button == function has a start mechanism

- Differences between a function and a machine
  - Machine does not stop unless you press a button while function stops after the last line
  - Machines are often independent of each other while functions are chained somehow

Function Syntax

```
datatype function-name( datatype Parameter1,
                         datatype Parameter2,…      )
{
   statement;
   statement;
   statement;
   statement;

   return value;
}
```

Function Syntax



Datatype of output

name

inputs

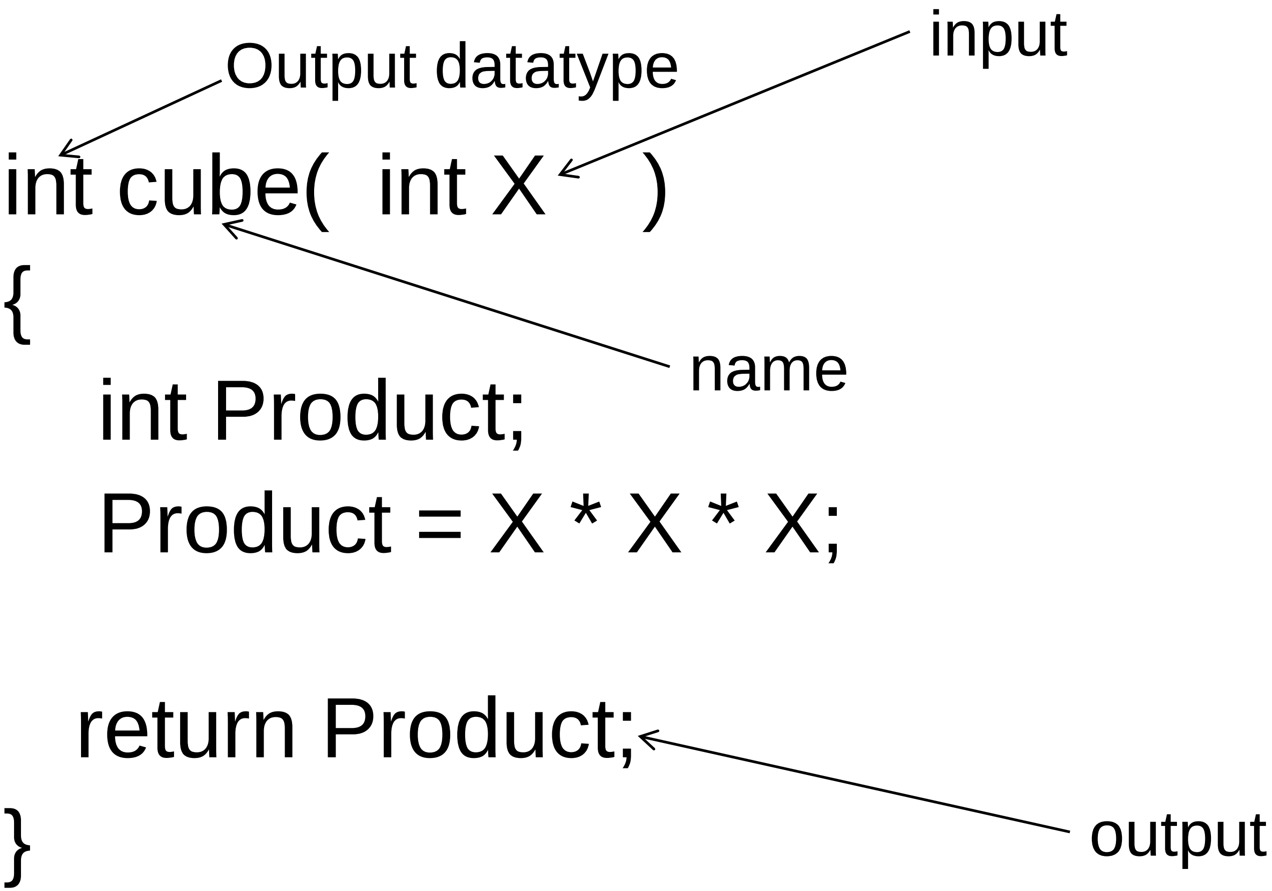
```
datatype function-name( datatype Parameter1,
                         datatype Parameter2,…     )
{
    statement;
    statement;
    statement;
    statement;

   return value;
}
```

Function header

Function body (the engine)

output

Example: a cubing function



```
int cube(  int X    )
{
    int Product;
    Product = X * X * X;

   return Product;
}
```

Output datatype

input

name

output

Example: calculating total price

-

```
double total_cost(int      number_par,
                       double price_par)
  {
     double TAX_RATE = 0.05;
     double subtotal;

     subtotal = price_par * number_par;

     return (subtotal + subtotal * TAX_RATE);
  }
```

The Return Statement

- Ends the function call
- Returns the value calculated by the function
- Syntax:

  return expression;

  - expression performs the calculation

    or
  - expression is a variable containing the calculated value
- Example:

  return subtotal + subtotal * TAX_RATE;

How can you run/execute a function?

- Just call it by the name from some other place in the program, i.e.
  - Tells the name of the function to use
  - Lists the arguments

- Is used in a statement where the returned value makes sense

- Example:

```
double bill = total_cost(number, price);
```

Example: function execution

```
int cube(  int X    )
{
    int Product;
    Produce = X * X * X;

    return Product;
}
….
….
….



int ReturnedValue = cube( 10 );
```

A complete program

```
int cube( int X  )
{
    int Product;
    Produce = X * X * X;

    return Product;
}


int main( )
{
     int ReturnedValue = cube( 10 );
}
```

Why should you fall in love with functions?

- Divide and Conquer
  - A good way to deal with complexity. Divide the problem into smaller tasks and put each in a function

- KISS
  - Not that one ☺
  - Keep it simple and smart

Local Variables

Local Variables

- Variables declared in a function:
  - Are local to that function, they cannot be used from outside the function
  - Have the function as their scope
- Variables declared in the main part of a program:
  - Are local to the main part of the program, they cannot be used from outside the main part
  - Have the main part as their scope

Display 4.11 (1)

Display 4.11 (2)

Global Constants

- Global Named Constant
  - Available to more than one function as well as the main part of the program
  - Declared outside any function body
  - Declared outside the main function body
  - Declared before any function that uses it
- Example:

```
const double PI = 3.14159;
double volume(double);
 int main()
{…}
```

  - PI is available to the main function and to function volume

Display 4.12 (1)

Display 4.12 (2)

Global Variables

- Global Variable -- rarely used when more than one function must use a common variable
  - Declared just like a global constant except const is not used
  - Generally make programs more difficult to understand and maintain

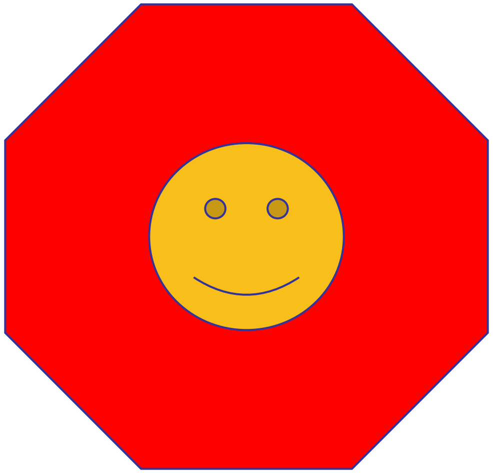
Formal Parameters are Local Variables

- Formal Parameters are actually variables that are local to the function definition
  - They are used just as if they were declared in the function body
  - Do NOT re-declare the formal parameters in the function body, they are declared in the function declaration
- The call-by-value mechanism
  - When a function is called the formal parameters are initialized to the values of the arguments in the function call

Display 4.13 (1)

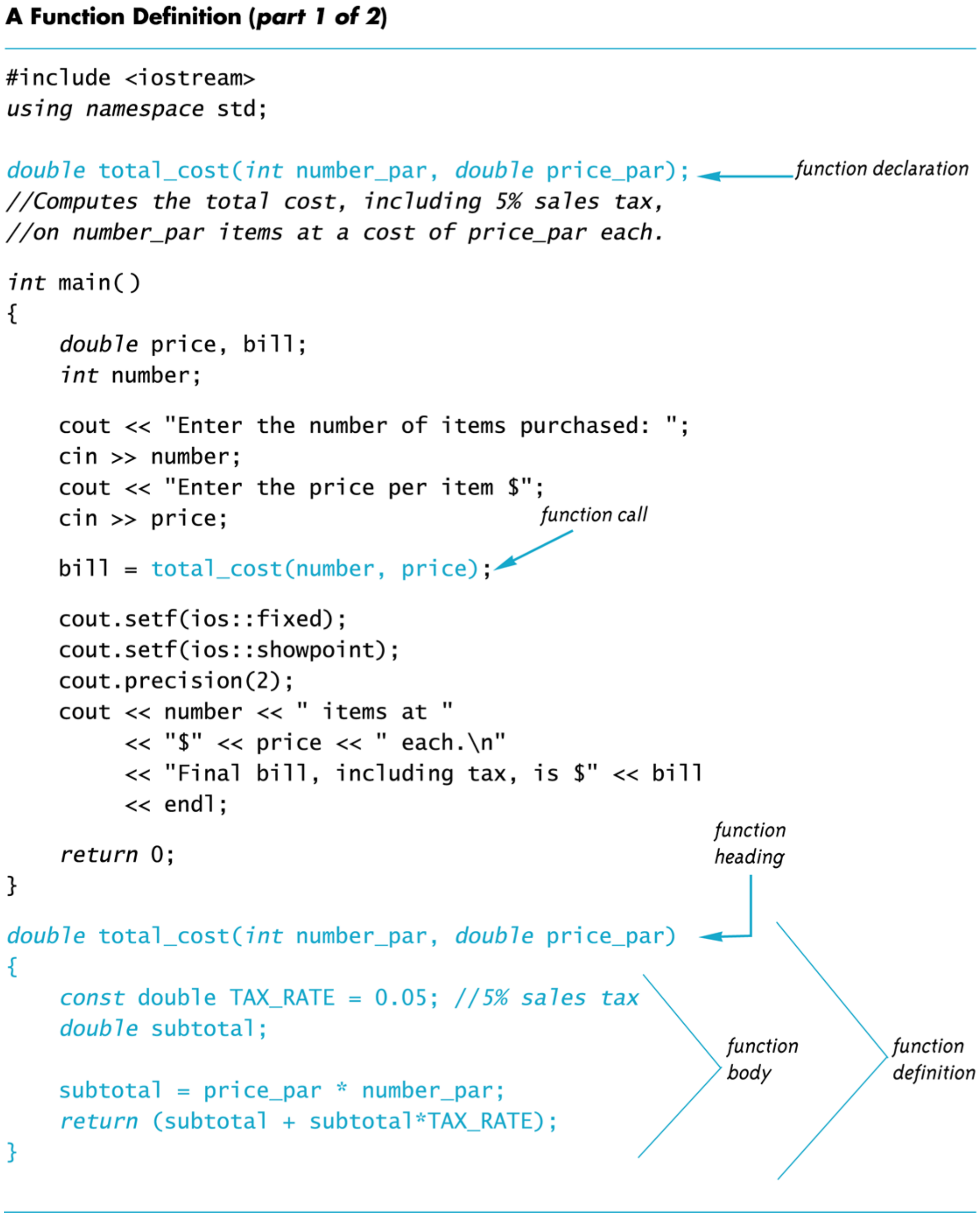
Display 4.13 (2)

Chapter 4 -- End



Display 4.3 (1/2)

Back Next

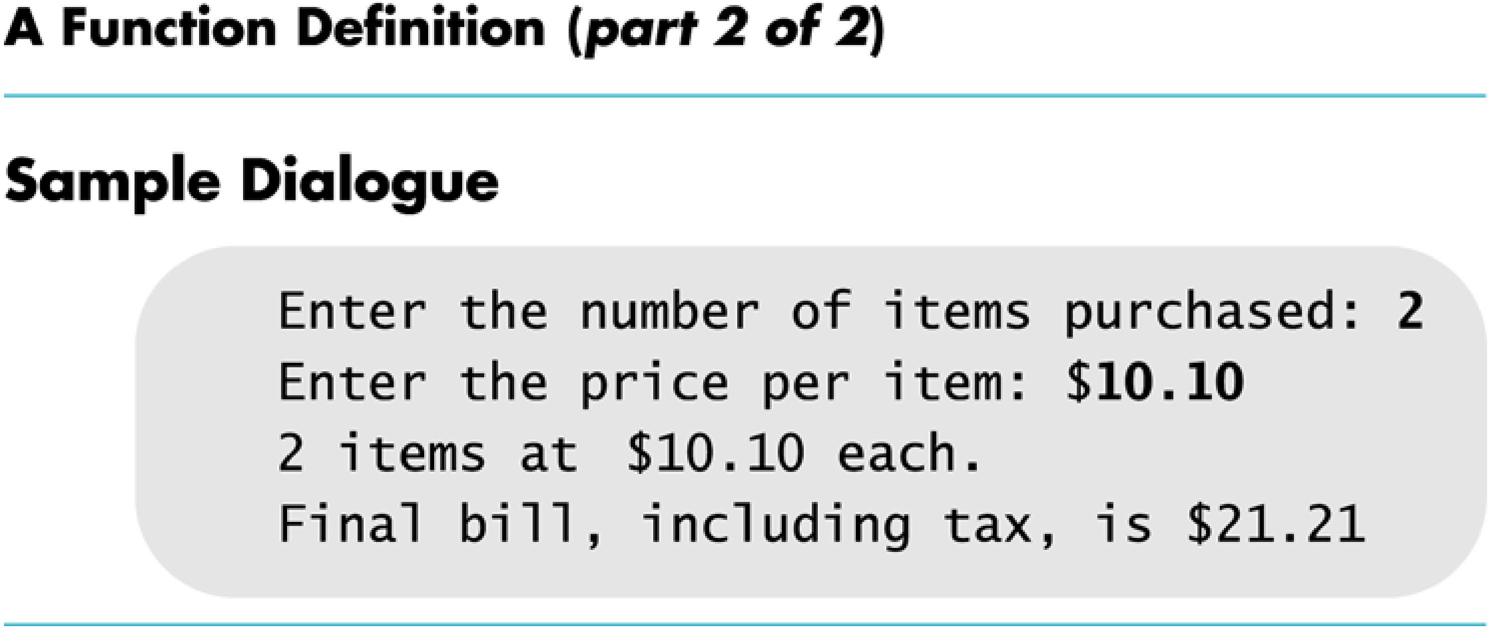


A Function Definition (*part 1 of 2*)

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

double total_cost(int number_par, double price_par);
//Computes the total cost, including 5% sales tax,
//on number_par items at a cost of price_par each.

int main()
{
    double price, bill;
    int number;

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

    bill = total_cost(number, price);

    cout.setf(ios::fixed);
    cout.setf(ios::showpoint);
    cout.precision(2);
    cout << number << " items at "
         << "$" << price << " each.\n"
         << "Final bill, including tax, is $" << bill
         << endl;

    return 0;
}

double total_cost(int number_par, double price_par)
{
    const double TAX_RATE = 0.05; //5% sales tax
    double subtotal;

    subtotal = price_par * number_par;
    return (subtotal + subtotal*TAX_RATE);
}
```

Display 4.3 (2/2)

Back Next



A Function Definition (*part 2 of 2*)

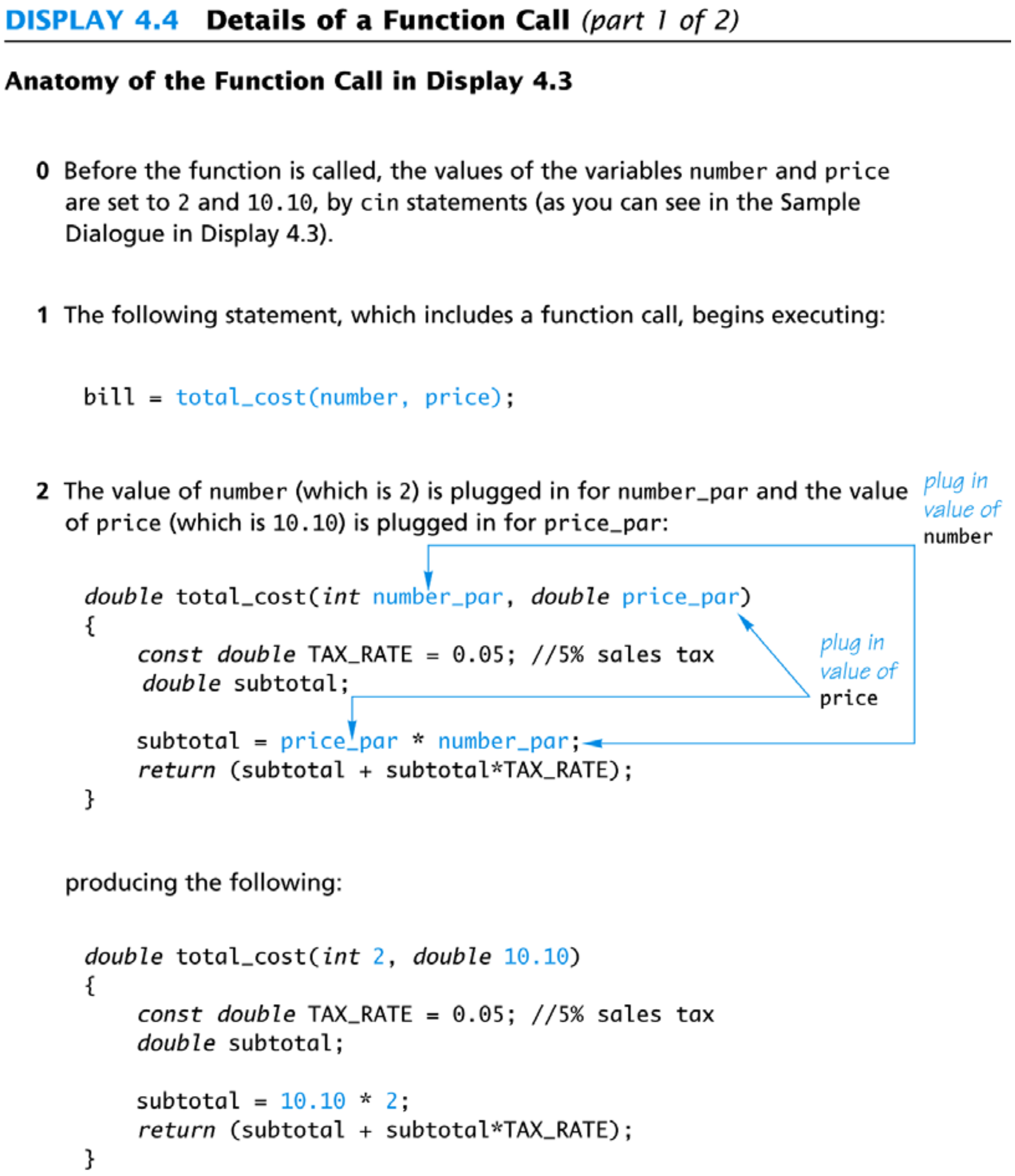
Sample Dialogue

```
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
```

Display 4.4 (1/2)

Back

Next



DISPLAY 4.4 **Details of a Function Call** *(part 1 of 2)*

Anatomy of the Function Call in Display 4.3

0 Before the function is called, the values of the variables number and price are set to 2 and 10.10, by cin statements (as you can see in the Sample Dialogue in Display 4.3).

1 The following statement, which includes a function call, begins executing:

```
bill = total_cost(number, price);
```

2 The value of number (which is 2) is plugged in for number_par and the value of price (which is 10.10) is plugged in for price_par:

plug in value of number

```
double total_cost(int number_par, double price_par)
{
    const double TAX_RATE = 0.05; //5% sales tax
    double subtotal;

    subtotal = price_par * number_par;
    return (subtotal + subtotal*TAX_RATE);
}
```

plug in value of price

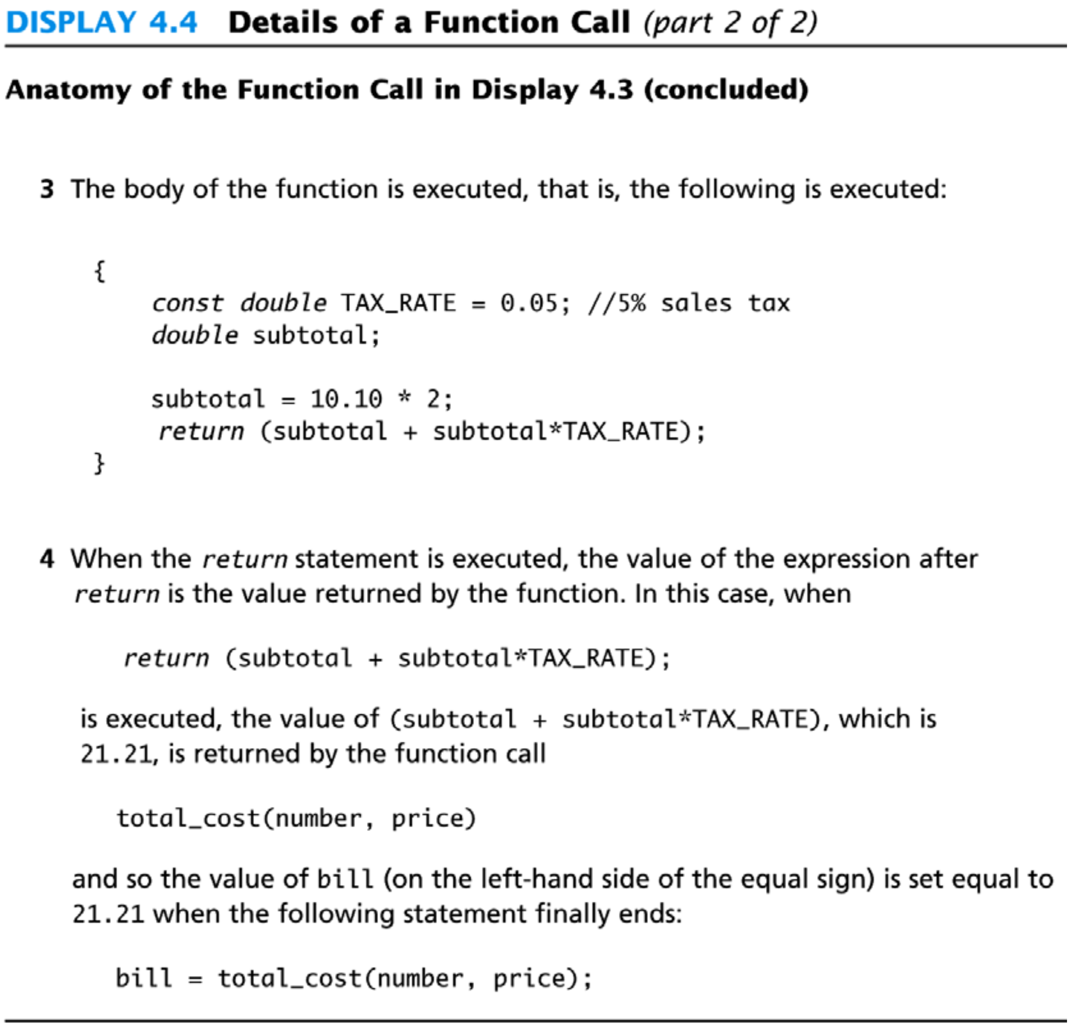
producing the following:

```
double total_cost(int 2, double 10.10)
{
    const double TAX_RATE = 0.05; //5% sales tax
    double subtotal;

    subtotal = 10.10 * 2;
    return (subtotal + subtotal*TAX_RATE);
}
```

Display 4.4 (2/2)

Back

Next



DISPLAY 4.4 Details of a Function Call *(part 2 of 2)*

Anatomy of the Function Call in Display 4.3 (concluded)

3 The body of the function is executed, that is, the following is executed:

```
{
    const double TAX_RATE = 0.05; //5% sales tax
    double subtotal;

    subtotal = 10.10 * 2;
     return (subtotal + subtotal*TAX_RATE);
}
```

4 When the *return* statement is executed, the value of the expression after *return* is the value returned by the function. In this case, when

```
return (subtotal + subtotal*TAX_RATE);
```

is executed, the value of (subtotal + subtotal*TAX_RATE), which is 21.21, is returned by the function call

```
total_cost(number, price)
```

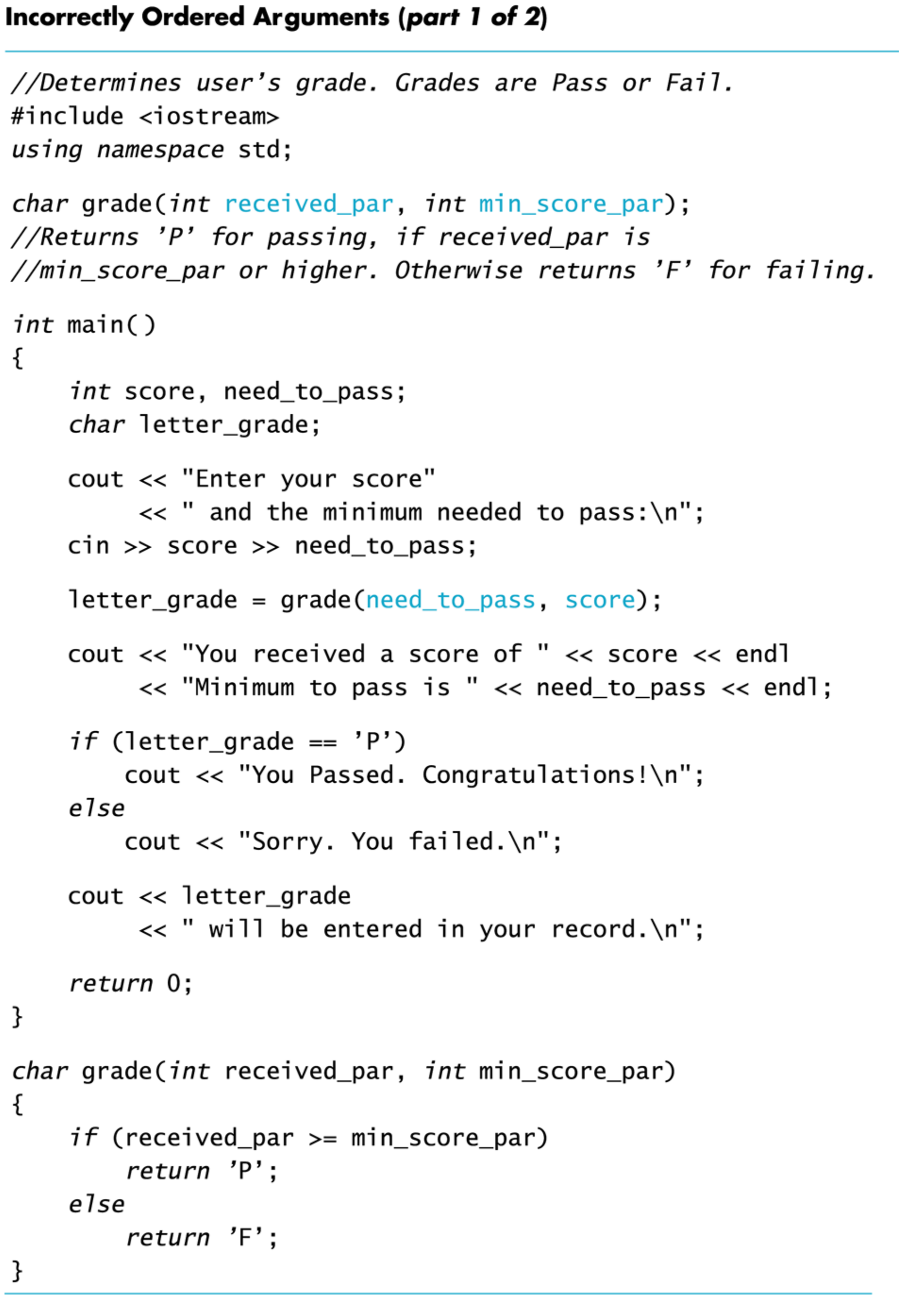
and so the value of bill (on the left-hand side of the equal sign) is set equal to 21.21 when the following statement finally ends:

```
bill = total_cost(number, price);
```

Display 4.5 (1/2)

Back

Next

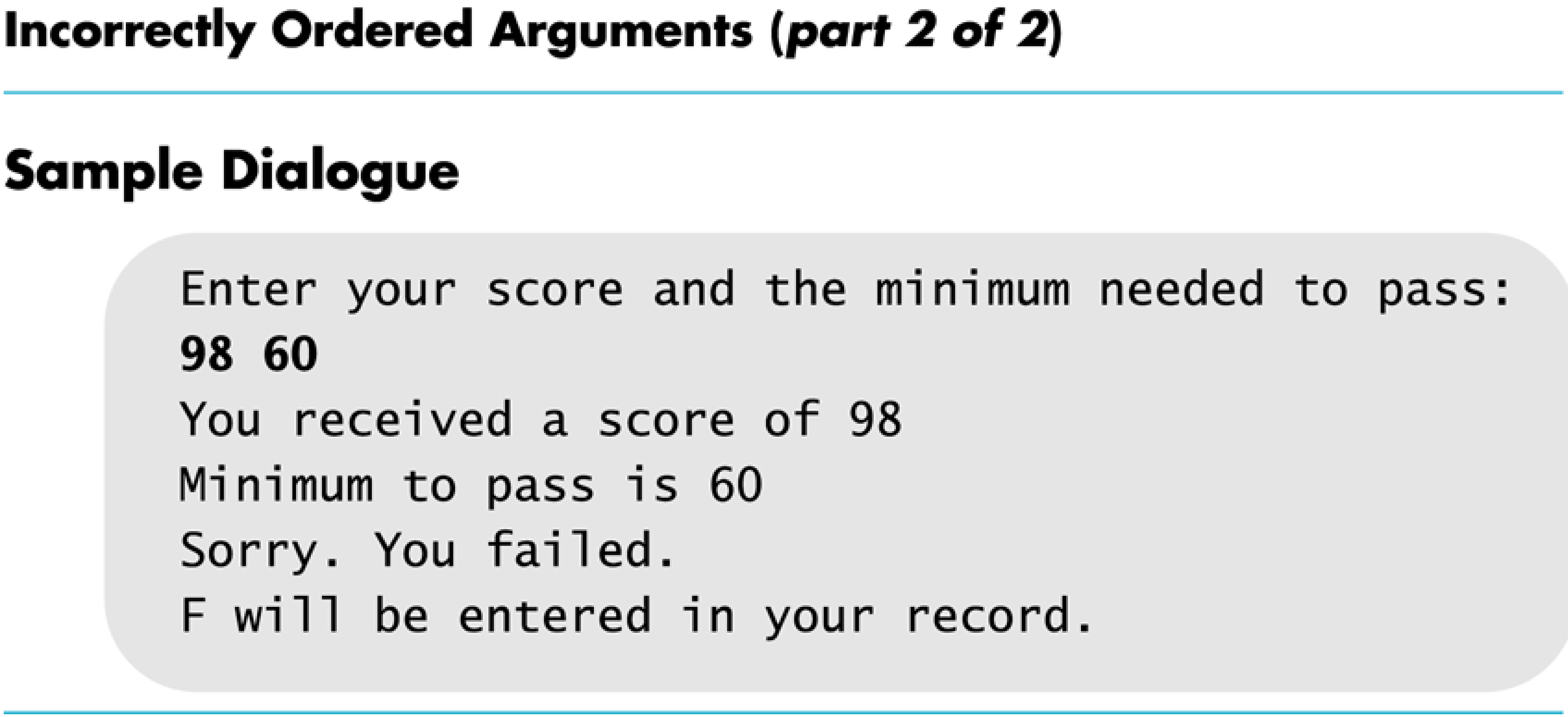


Incorrectly Ordered Arguments (*part 1 of 2*)

```
//Determines user's grade. Grades are Pass or Fail.
#include <iostream>
using namespace std;

char grade(int received_par, int min_score_par);
//Returns 'P' for passing, if received_par is
//min_score_par or higher. Otherwise returns 'F' for failing.

int main()
{
    int score, need_to_pass;
    char letter_grade;

    cout << "Enter your score"
         << " and the minimum needed to pass:\n";
    cin >> score >> need_to_pass;

    letter_grade = grade(need_to_pass, score);

    cout << "You received a score of " << score << endl
         << "Minimum to pass is " << need_to_pass << endl;

    if (letter_grade == 'P')
        cout << "You Passed. Congratulations!\n";
    else
        cout << "Sorry. You failed.\n";

    cout << letter_grade
         << " will be entered in your record.\n";

    return 0;
}

char grade(int received_par, int min_score_par)
{
    if (received_par >= min_score_par)
        return 'P';
    else
        return 'F';
}
```

Display 4.5 (2/2)

Back Next



Incorrectly Ordered Arguments (*part 2 of 2*)

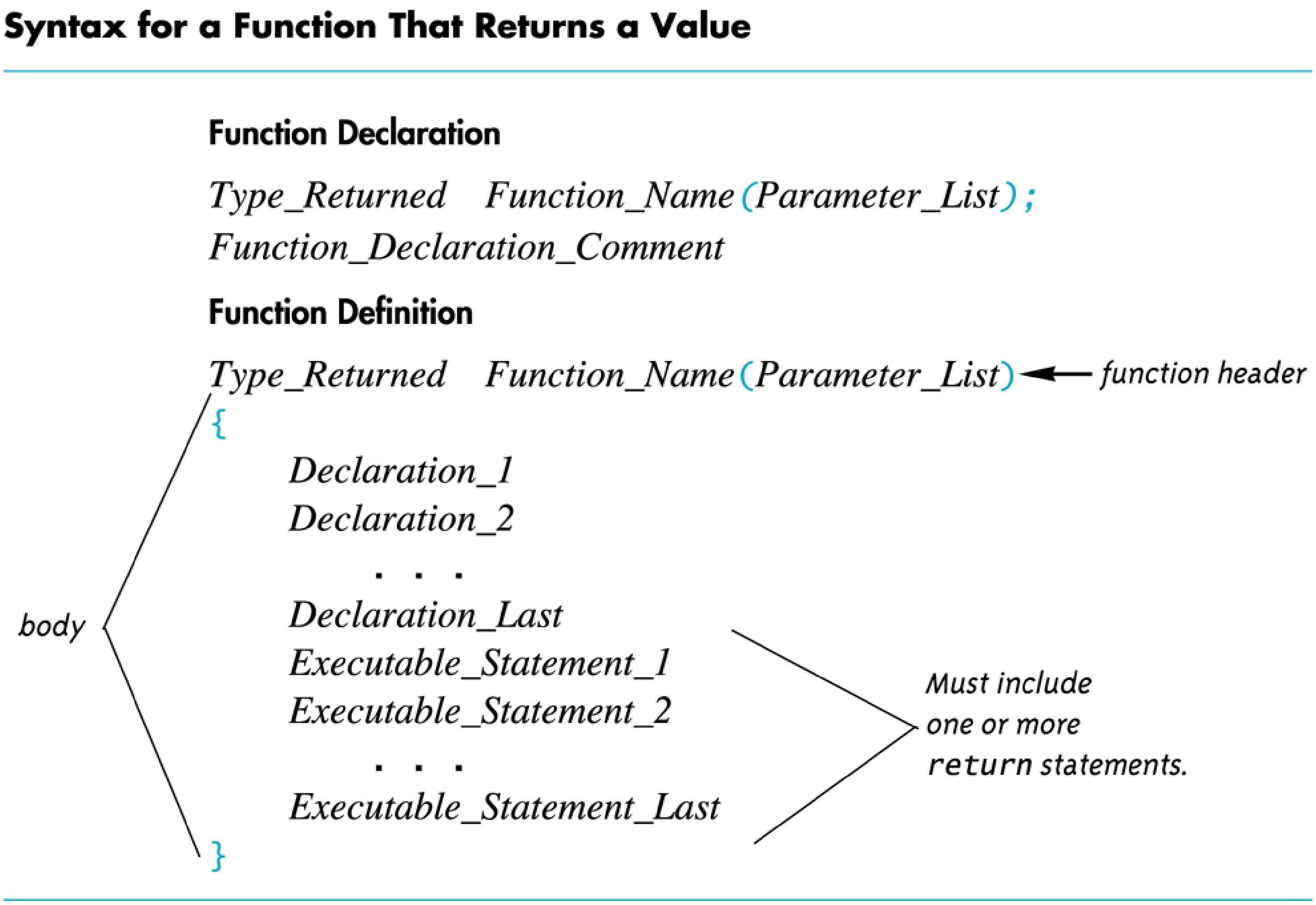
Sample Dialogue

```
Enter your score and the minimum needed to pass:
98 60
You received a score of 98
Minimum to pass is 60
Sorry. You failed.
F will be entered in your record.
```

Display 4.6

Back

Next



Syntax for a Function That Returns a Value

Function Declaration

```
Type_Returned   Function_Name(Parameter_List);
Function_Declaration_Comment
```

Function Definition

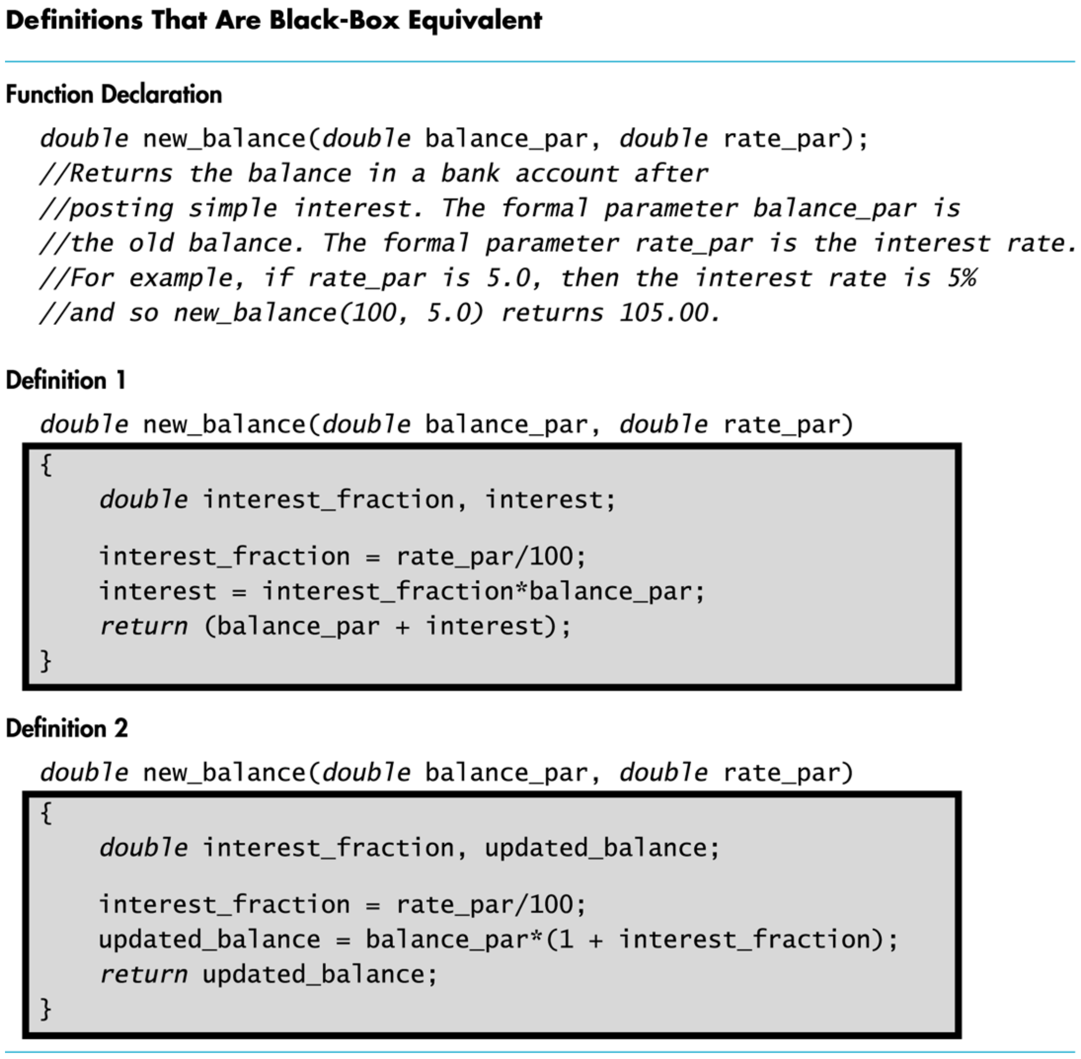
```
Type_Returned   Function_Name(Parameter_List) ←— function header
{
        Declaration_1
        Declaration_2
              . . .
        Declaration_Last
        Executable_Statement_1
        Executable_Statement_2
              . . .
        Executable_Statement_Last
}
```

body
Must include
one or more
return statements.

Display 4.7

Back

Next



Definitions That Are Black-Box Equivalent

Function Declaration

```
double new_balance(double balance_par, double rate_par);
//Returns the balance in a bank account after
//posting simple interest. The formal parameter balance_par is
//the old balance. The formal parameter rate_par is the interest rate.
//For example, if rate_par is 5.0, then the interest rate is 5%
//and so new_balance(100, 5.0) returns 105.00.
```

Definition 1

```
double new_balance(double balance_par, double rate_par)
{
    double interest_fraction, interest;

    interest_fraction = rate_par/100;
    interest = interest_fraction*balance_par;
    return (balance_par + interest);
}
```

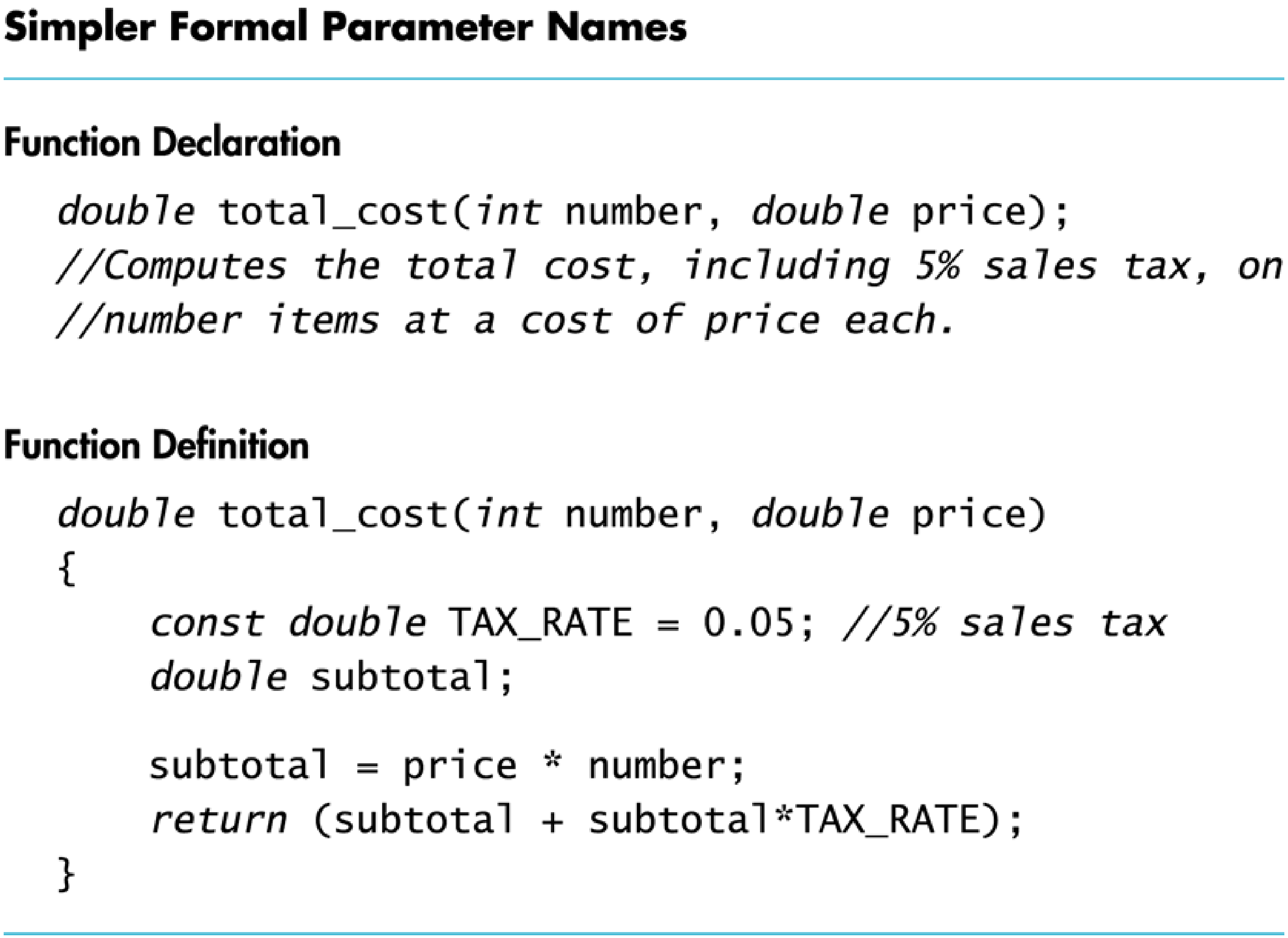
Definition 2

```
double new_balance(double balance_par, double rate_par)
{
    double interest_fraction, updated_balance;

    interest_fraction = rate_par/100;
    updated_balance = balance_par*(1 + interest_fraction);
    return updated_balance;
}
```

Display 4.8

Back

Next



Simpler Formal Parameter Names

Function Declaration

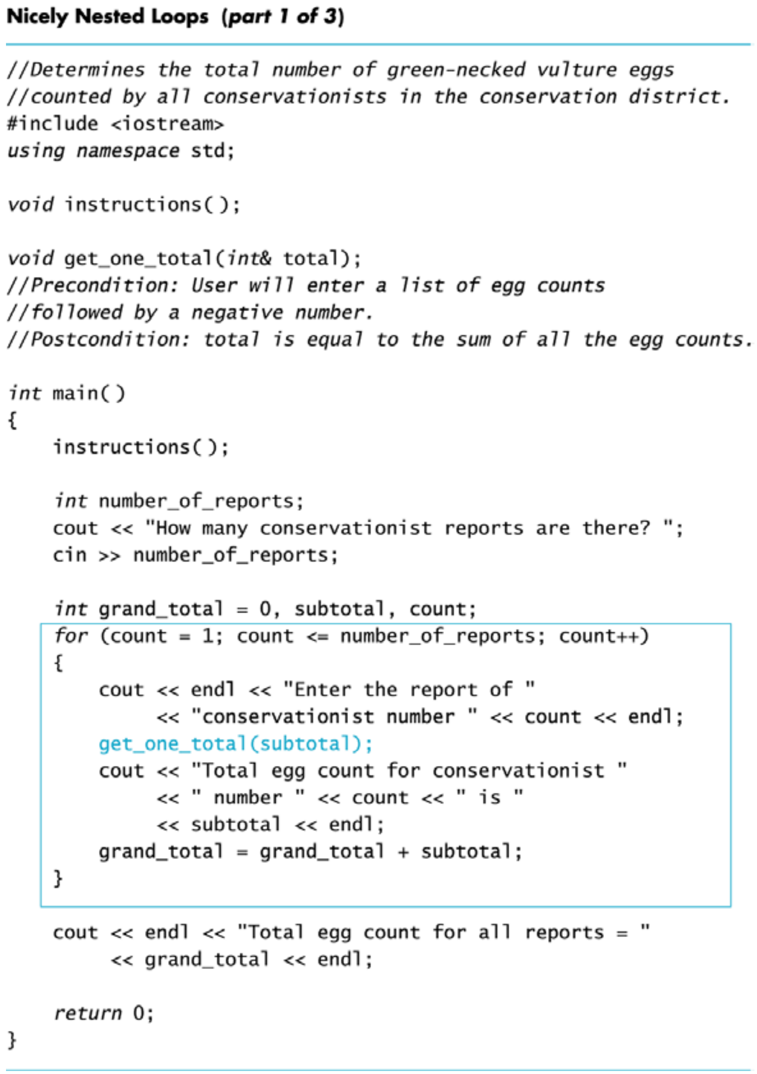
```
double total_cost(int number, double price);
//Computes the total cost, including 5% sales tax, on
//number items at a cost of price each.
```

Function Definition

```
double total_cost(int number, double price)
{
    const double TAX_RATE = 0.05; //5% sales tax
    double subtotal;

    subtotal = price * number;
    return (subtotal + subtotal*TAX_RATE);
}
```

Display 4.9 (1/3)

Back Next

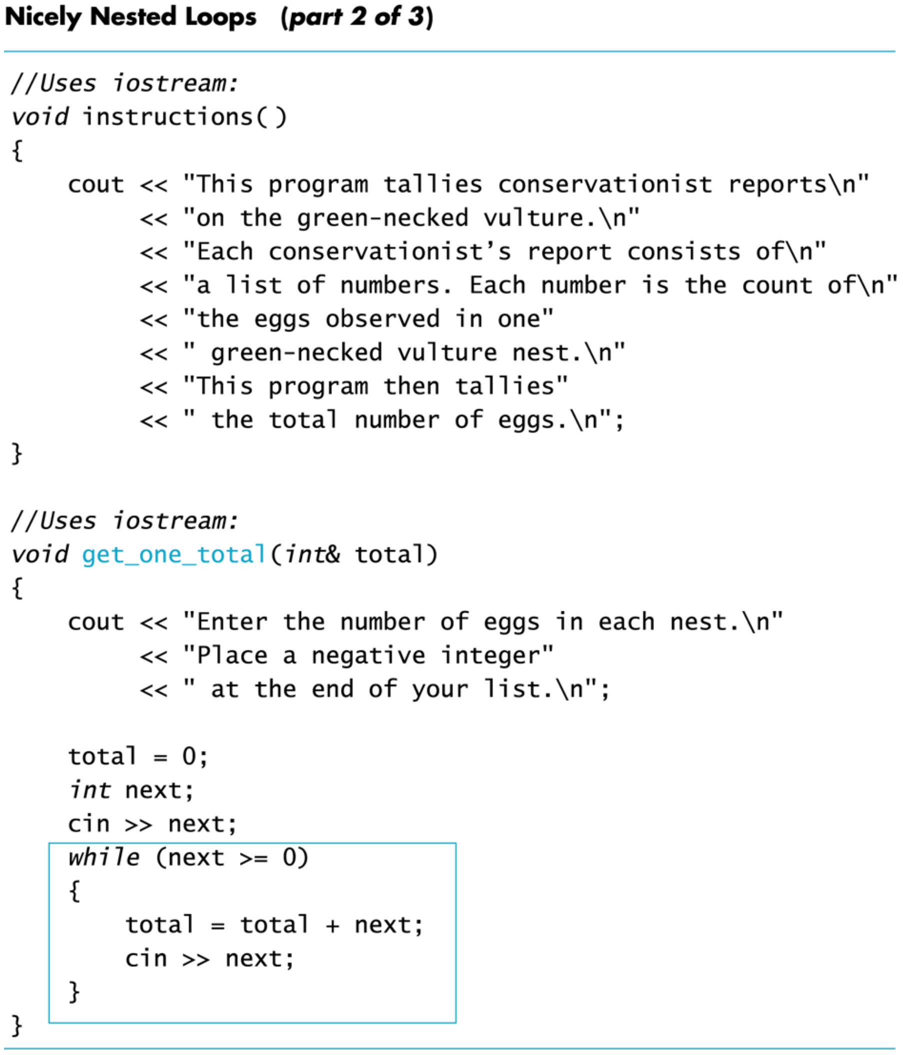


Nicely Nested Loops (*part 1 of 3*)

```
//Determines the total number of green-necked vulture eggs
//counted by all conservationists in the conservation district.
#include <iostream>
using namespace std;

void instructions();

void get_one_total(int& total);
//Precondition: User will enter a list of egg counts
//followed by a negative number.
//Postcondition: total is equal to the sum of all the egg counts.

int main()
{
    instructions();

    int number_of_reports;
    cout << "How many conservationist reports are there? ";
    cin >> number_of_reports;

    int grand_total = 0, subtotal, count;
    for (count = 1; count <= number_of_reports; count++)
    {
        cout << endl << "Enter the report of "
             << "conservationist number " << count << endl;
        get_one_total(subtotal);
        cout << "Total egg count for conservationist "
             << " number " << count << " is "
             << subtotal << endl;
        grand_total = grand_total + subtotal;
    }

    cout << endl << "Total egg count for all reports = "
         << grand_total << endl;

    return 0;
}
```

Display 4.9 (2/3)

Back Next

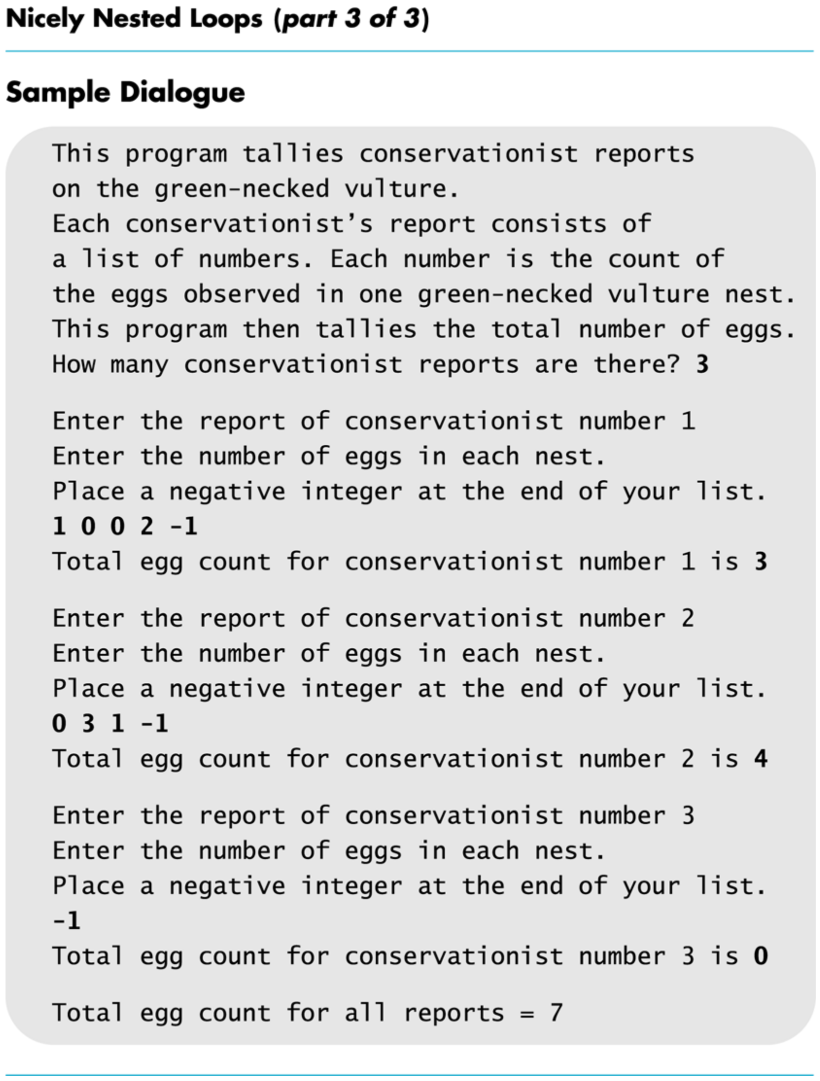


Nicely Nested Loops (*part 2 of 3*)

```
//Uses iostream:
void instructions( )
{
    cout << "This program tallies conservationist reports\n"
         << "on the green-necked vulture.\n"
         << "Each conservationist's report consists of\n"
         << "a list of numbers. Each number is the count of\n"
         << "the eggs observed in one"
         << " green-necked vulture nest.\n"
         << "This program then tallies"
         << " the total number of eggs.\n";
}

//Uses iostream:
void get_one_total(int& total)
{
    cout << "Enter the number of eggs in each nest.\n"
         << "Place a negative integer"
         << " at the end of your list.\n";

    total = 0;
    int next;
    cin >> next;
    while (next >= 0)
    {
        total = total + next;
        cin >> next;
    }
}
```

Display 4.9 (3/3)

Back Next



Nicely Nested Loops (*part 3 of 3*)

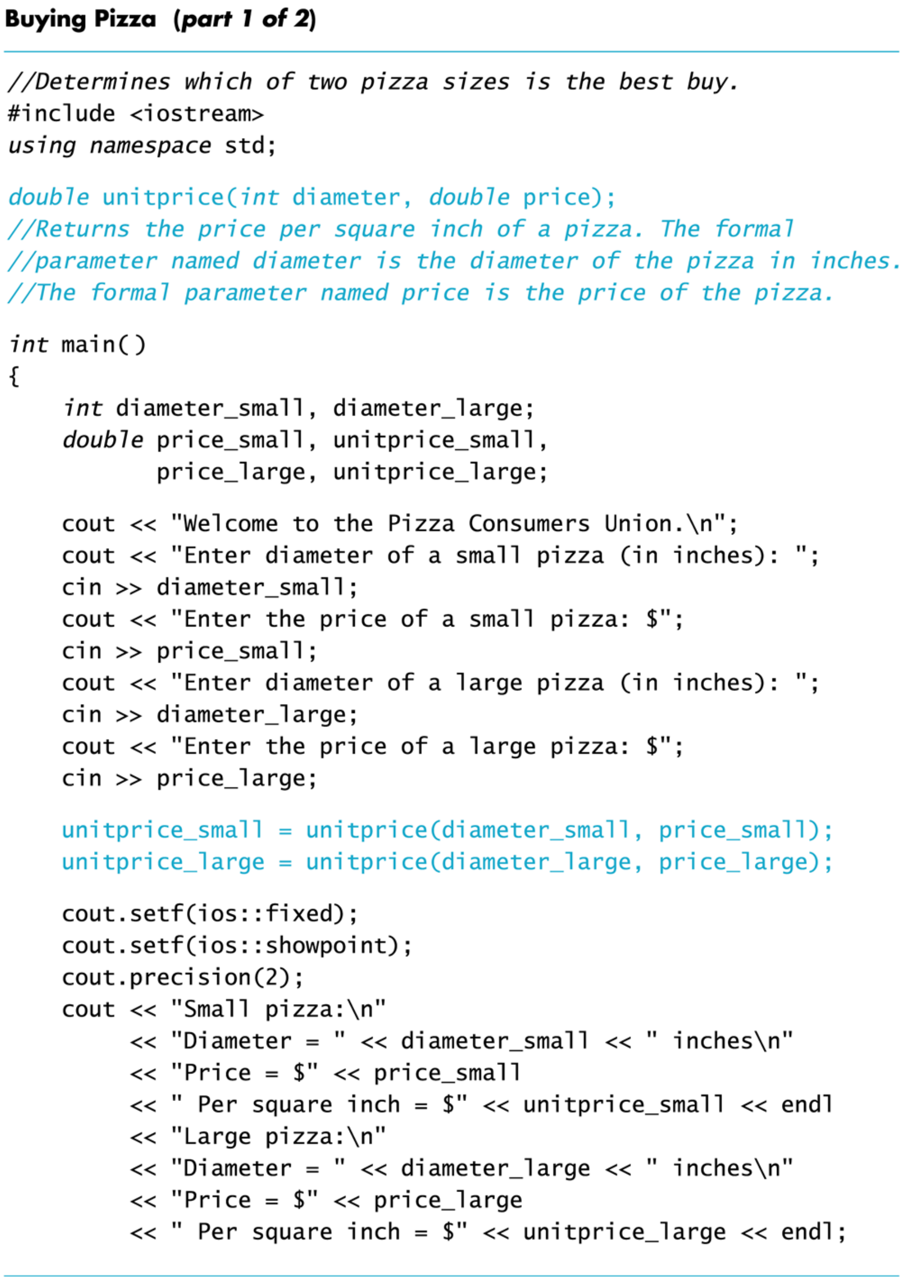
Sample Dialogue

```
This program tallies conservationist reports
on the green-necked vulture.
Each conservationist's report consists of
a list of numbers. Each number is the count of
the eggs observed in one green-necked vulture nest.
This program then tallies the total number of eggs.
How many conservationist reports are there? 3

Enter the report of conservationist number 1
Enter the number of eggs in each nest.
Place a negative integer at the end of your list.
1 0 0 2 -1
Total egg count for conservationist number 1 is 3

Enter the report of conservationist number 2
Enter the number of eggs in each nest.
Place a negative integer at the end of your list.
0 3 1 -1
Total egg count for conservationist number 2 is 4

Enter the report of conservationist number 3
Enter the number of eggs in each nest.
Place a negative integer at the end of your list.
-1
Total egg count for conservationist number 3 is 0

Total egg count for all reports = 7
```

Display 4.10 (1/2)

Back

Next



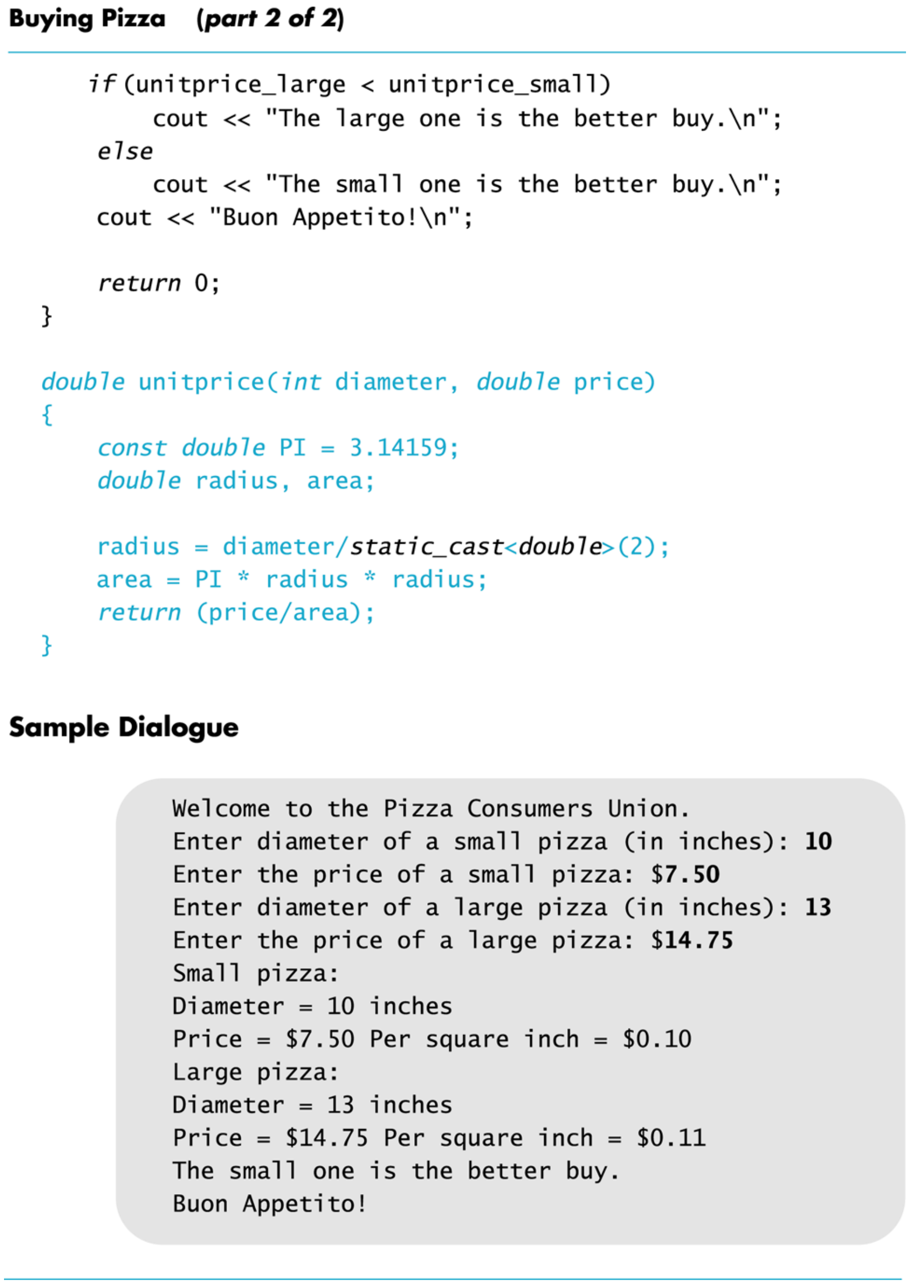
Buying Pizza ***(part 1 of 2)***

```
//Determines which of two pizza sizes is the best buy.
#include <iostream>
using namespace std;

double unitprice(int diameter, double price);
//Returns the price per square inch of a pizza. The formal
//parameter named diameter is the diameter of the pizza in inches.
//The formal parameter named price is the price of the pizza.

int main()
{
    int diameter_small, diameter_large;
    double price_small, unitprice_small,
           price_large, unitprice_large;

    cout << "Welcome to the Pizza Consumers Union.\n";
    cout << "Enter diameter of a small pizza (in inches): ";
    cin >> diameter_small;
    cout << "Enter the price of a small pizza: $";
    cin >> price_small;
    cout << "Enter diameter of a large pizza (in inches): ";
    cin >> diameter_large;
    cout << "Enter the price of a large pizza: $";
    cin >> price_large;

    unitprice_small = unitprice(diameter_small, price_small);
    unitprice_large = unitprice(diameter_large, price_large);

    cout.setf(ios::fixed);
    cout.setf(ios::showpoint);
    cout.precision(2);
    cout << "Small pizza:\n"
         << "Diameter = " << diameter_small << " inches\n"
         << "Price = $" << price_small
         << " Per square inch = $" << unitprice_small << endl
         << "Large pizza:\n"
         << "Diameter = " << diameter_large << " inches\n"
         << "Price = $" << price_large
         << " Per square inch = $" << unitprice_large << endl;
```

Display 4.10 (2/2)

Back

Next



Buying Pizza ***(part 2 of 2)***

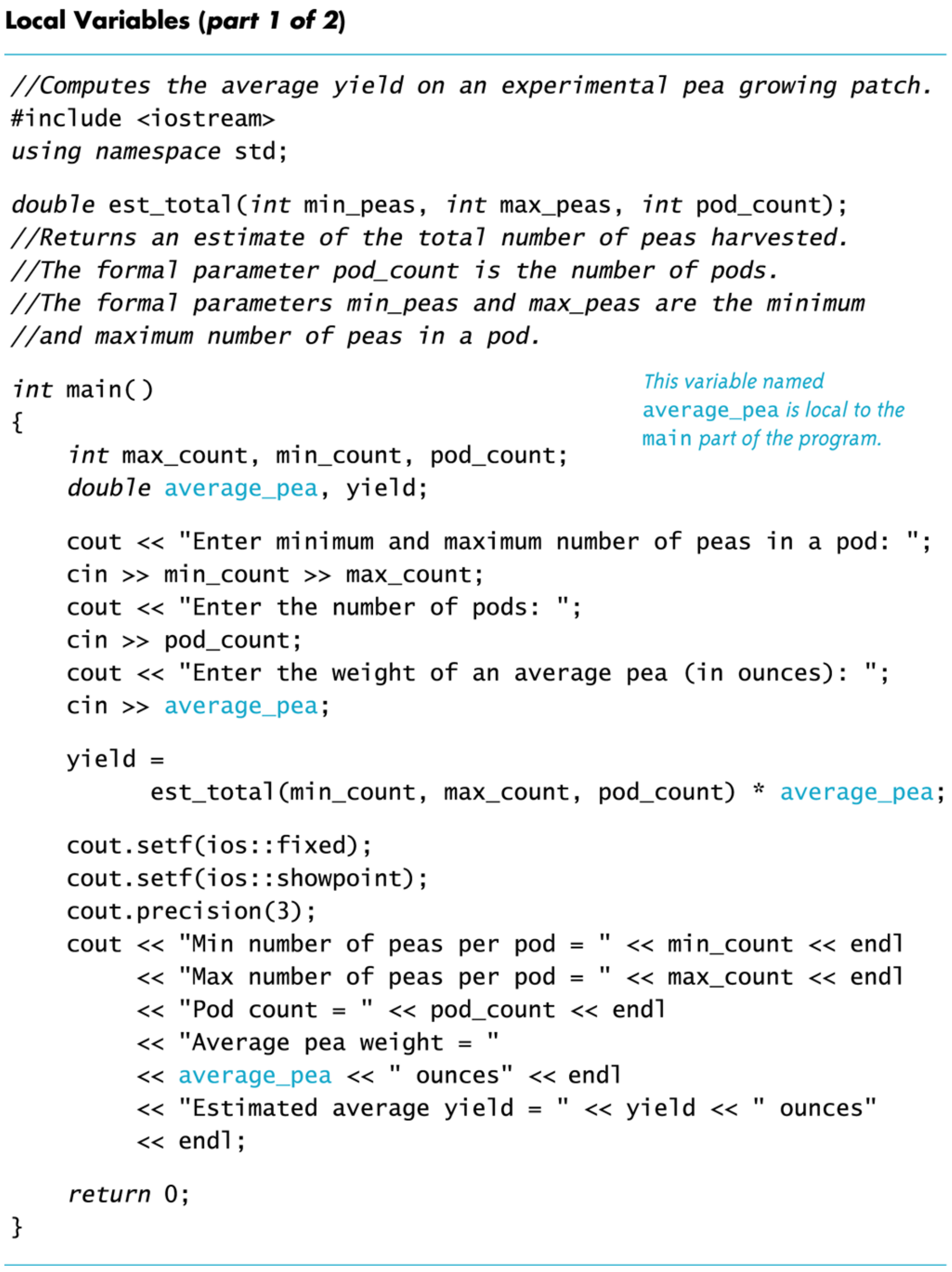
```
    if (unitprice_large < unitprice_small)
        cout << "The large one is the better buy.\n";
    else
        cout << "The small one is the better buy.\n";
    cout << "Buon Appetito!\n";

    return 0;
}

double unitprice(int diameter, double price)
{
    const double PI = 3.14159;
    double radius, area;

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

Sample Dialogue

```
Welcome to the Pizza Consumers Union.
Enter diameter of a small pizza (in inches): 10
Enter the price of a small pizza: $7.50
Enter diameter of a large pizza (in inches): 13
Enter the price of a large pizza: $14.75
Small pizza:
Diameter = 10 inches
Price = $7.50 Per square inch = $0.10
Large pizza:
Diameter = 13 inches
Price = $14.75 Per square inch = $0.11
The small one is the better buy.
Buon Appetito!
```

Display 4.11 (1/2)

Back Next



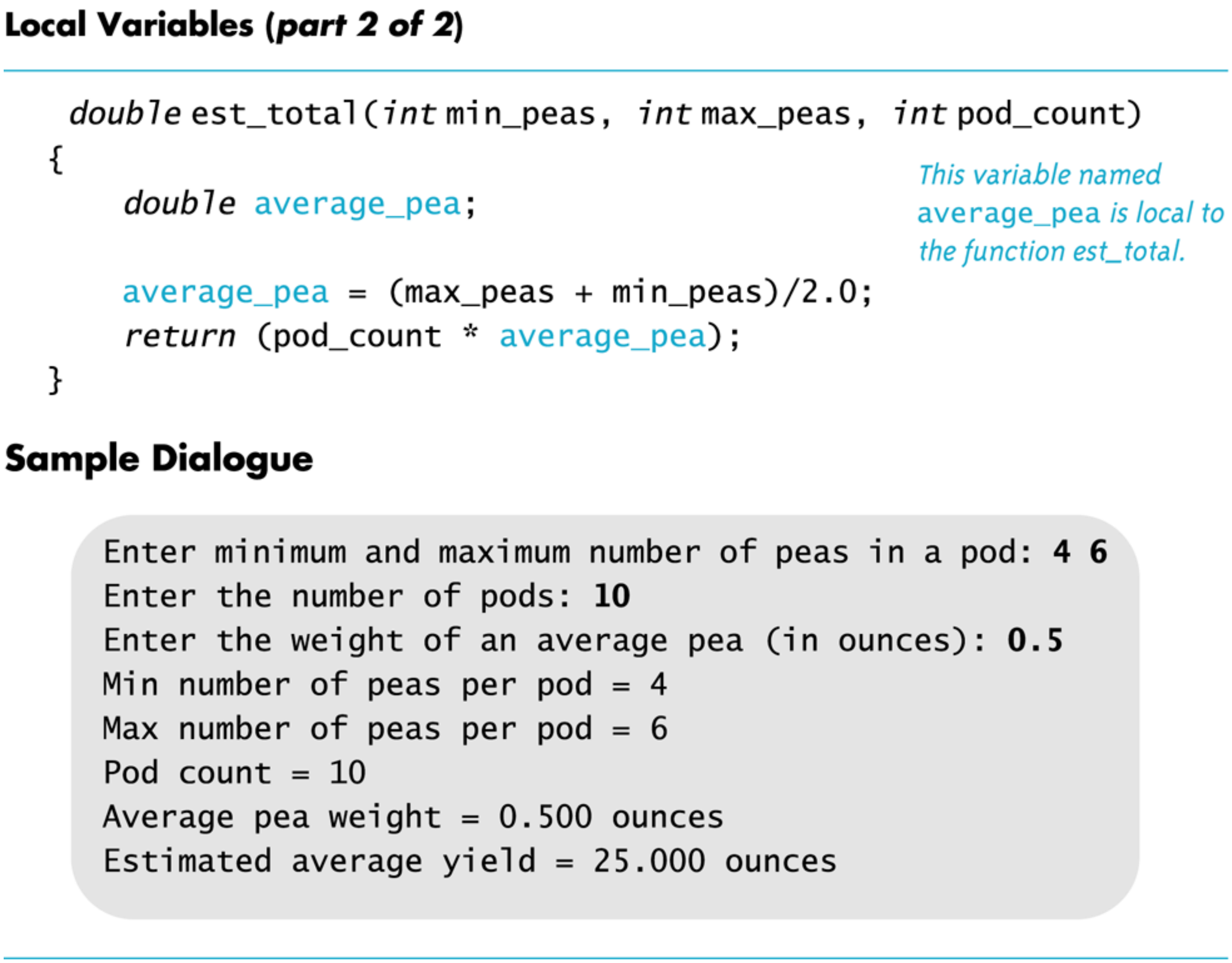
Local Variables (*part 1 of 2*)

```
//Computes the average yield on an experimental pea growing patch.
#include <iostream>
using namespace std;

double est_total(int min_peas, int max_peas, int pod_count);
//Returns an estimate of the total number of peas harvested.
//The formal parameter pod_count is the number of pods.
//The formal parameters min_peas and max_peas are the minimum
//and maximum number of peas in a pod.

int main( )
{
    int max_count, min_count, pod_count;
    double average_pea, yield;

    cout << "Enter minimum and maximum number of peas in a pod: ";
    cin >> min_count >> max_count;
    cout << "Enter the number of pods: ";
    cin >> pod_count;
    cout << "Enter the weight of an average pea (in ounces): ";
    cin >> average_pea;

    yield =
          est_total(min_count, max_count, pod_count) * average_pea;

    cout.setf(ios::fixed);
    cout.setf(ios::showpoint);
    cout.precision(3);
    cout << "Min number of peas per pod = " << min_count << endl
         << "Max number of peas per pod = " << max_count << endl
         << "Pod count = " << pod_count << endl
         << "Average pea weight = "
         << average_pea << " ounces" << endl
         << "Estimated average yield = " << yield << " ounces"
         << endl;

    return 0;
}
```

This variable named average_pea *is local to the* main *part of the program.*

Display 4.11 (2/2)

Back Next



Local Variables (*part 2 of 2*)

```
 double est_total(int min_peas, int max_peas, int pod_count)
{
    double average_pea;

    average_pea = (max_peas + min_peas)/2.0;
    return (pod_count * average_pea);
}
```

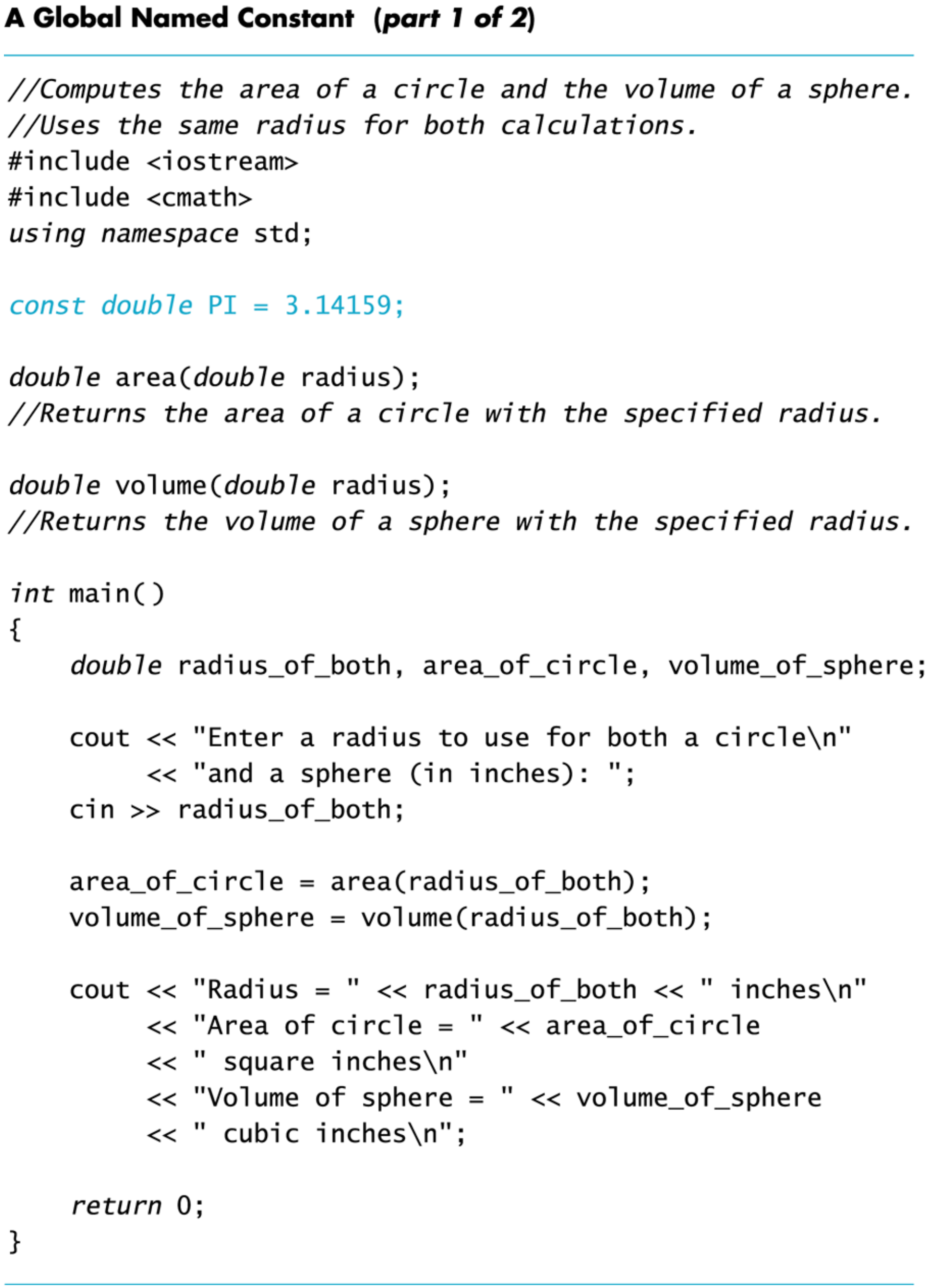
This variable named average_pea is local to the function est_total.

Sample Dialogue

```
Enter minimum and maximum number of peas in a pod: 4 6
Enter the number of pods: 10
Enter the weight of an average pea (in ounces): 0.5
Min number of peas per pod = 4
Max number of peas per pod = 6
Pod count = 10
Average pea weight = 0.500 ounces
Estimated average yield = 25.000 ounces
```

Display 4.12 (1/2)

Back Next

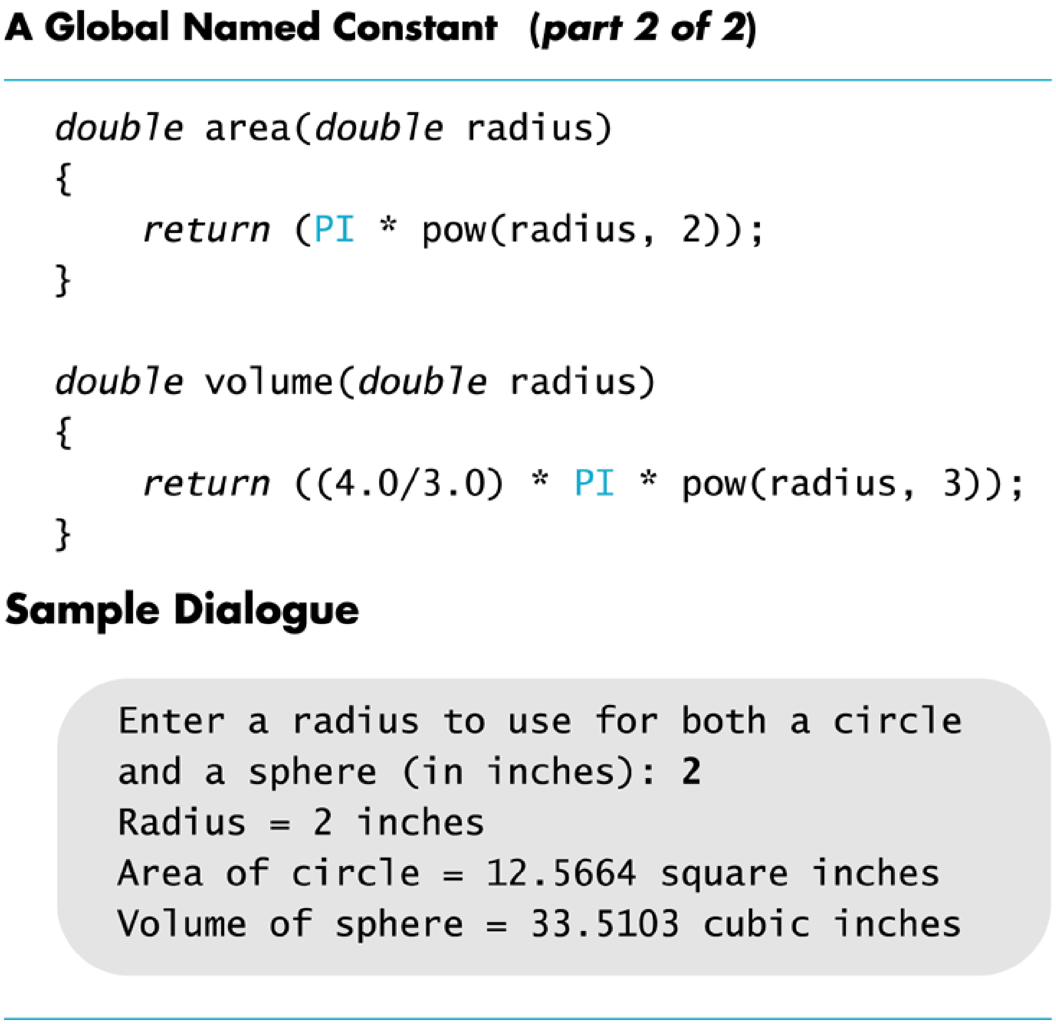


A Global Named Constant *(part 1 of 2)*

```
//Computes the area of a circle and the volume of a sphere.
//Uses the same radius for both calculations.
#include <iostream>
#include <cmath>
using namespace std;

const double PI = 3.14159;

double area(double radius);
//Returns the area of a circle with the specified radius.

double volume(double radius);
//Returns the volume of a sphere with the specified radius.

int main( )
{
    double radius_of_both, area_of_circle, volume_of_sphere;

    cout << "Enter a radius to use for both a circle\n"
         << "and a sphere (in inches): ";
    cin >> radius_of_both;

    area_of_circle = area(radius_of_both);
    volume_of_sphere = volume(radius_of_both);

    cout << "Radius = " << radius_of_both << " inches\n"
         << "Area of circle = " << area_of_circle
         << " square inches\n"
         << "Volume of sphere = " << volume_of_sphere
         << " cubic inches\n";

    return 0;
}
```

Display 4.12 (2/2)

Back Next



A Global Named Constant *(part 2 of 2)*

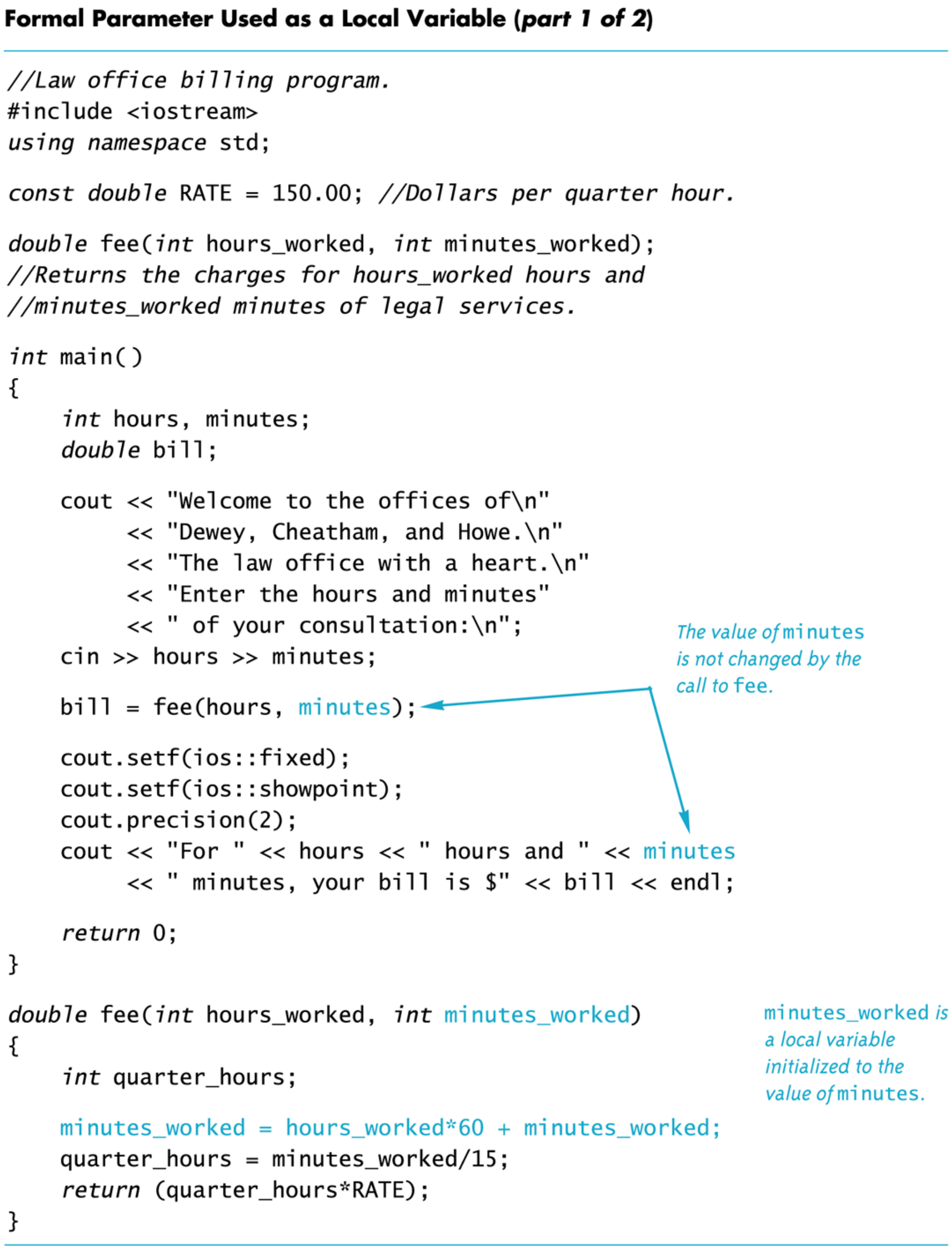
```
double area(double radius)
{
    return (PI * pow(radius, 2));
}

double volume(double radius)
{
    return ((4.0/3.0) * PI * pow(radius, 3));
}
```

Sample Dialogue

```
Enter a radius to use for both a circle
and a sphere (in inches): 2
Radius = 2 inches
Area of circle = 12.5664 square inches
Volume of sphere = 33.5103 cubic inches
```

Display 4.13 (1/2)

Back Next



Formal Parameter Used as a Local Variable (*part 1 of 2*)

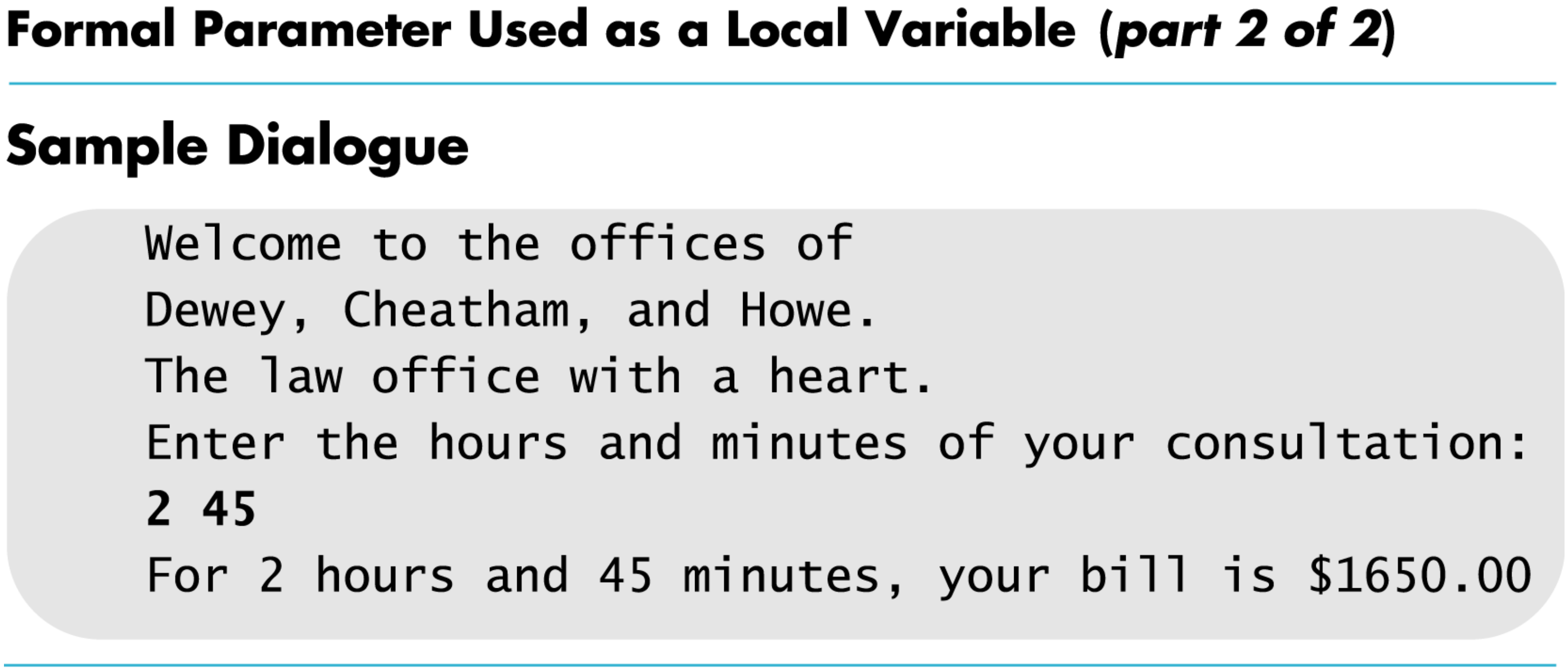
```
//Law office billing program.
#include <iostream>
using namespace std;

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

double fee(int hours_worked, int minutes_worked);
//Returns the charges for hours_worked hours and
//minutes_worked minutes of legal services.

int main()
{
    int hours, minutes;
    double bill;

    cout << "Welcome to the offices of\n"
         << "Dewey, Cheatham, and Howe.\n"
         << "The law office with a heart.\n"
         << "Enter the hours and minutes"
         << " of your consultation:\n";
    cin >> hours >> minutes;

    bill = fee(hours, minutes);

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

    return 0;
}

double fee(int hours_worked, int minutes_worked)
{
    int quarter_hours;

    minutes_worked = hours_worked*60 + minutes_worked;
    quarter_hours = minutes_worked/15;
    return (quarter_hours*RATE);
}
```

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

`minutes_worked` *is a local variable initialized to the value of* `minutes`.

Display 4.13 (2/2)

Back Next



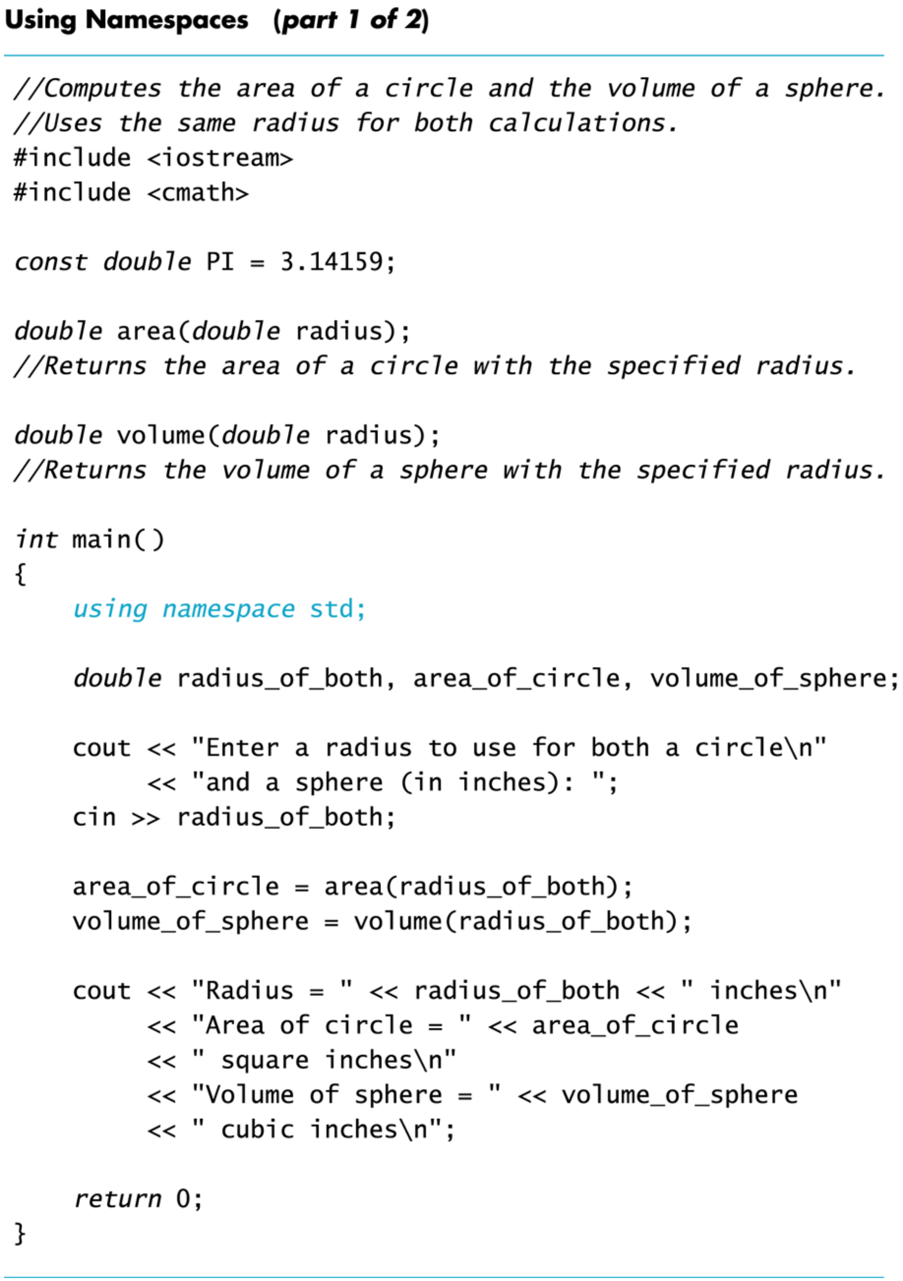
Formal Parameter Used as a Local Variable (*part 2 of 2*)

Sample Dialogue

```
Welcome to the offices of
Dewey, Cheatham, and Howe.
The law office with a heart.
Enter the hours and minutes of your consultation:
2 45
For 2 hours and 45 minutes, your bill is $1650.00
```

Display 4.14 (1/2)

Back Next



Using Namespaces ***(part 1 of 2)***

```
//Computes the area of a circle and the volume of a sphere.
//Uses the same radius for both calculations.
#include <iostream>
#include <cmath>

const double PI = 3.14159;

double area(double radius);
//Returns the area of a circle with the specified radius.

double volume(double radius);
//Returns the volume of a sphere with the specified radius.

int main( )
{
    using namespace std;

    double radius_of_both, area_of_circle, volume_of_sphere;

    cout << "Enter a radius to use for both a circle\n"
         << "and a sphere (in inches): ";
    cin >> radius_of_both;

    area_of_circle = area(radius_of_both);
    volume_of_sphere = volume(radius_of_both);

    cout << "Radius = " << radius_of_both << " inches\n"
         << "Area of circle = " << area_of_circle
         << " square inches\n"
         << "Volume of sphere = " << volume_of_sphere
         << " cubic inches\n";

    return 0;
}
```