ICS 104 - Introduction to Programming in Python and C

Functions

Reading Assignment

- Chapter 5 Sections 1, 2, 3, 4, 5 and 8.

Chapter Learning Outcomes

At the end of this chapter, you will be able to

- implement functions
- become familiar with the concept of parameter passing
- develop strategies for decomposing complex tasks into simpler ones
- determine the scope of a variable

Functions as Black Boxes

- A **function** is a sequence of instructions with a name.

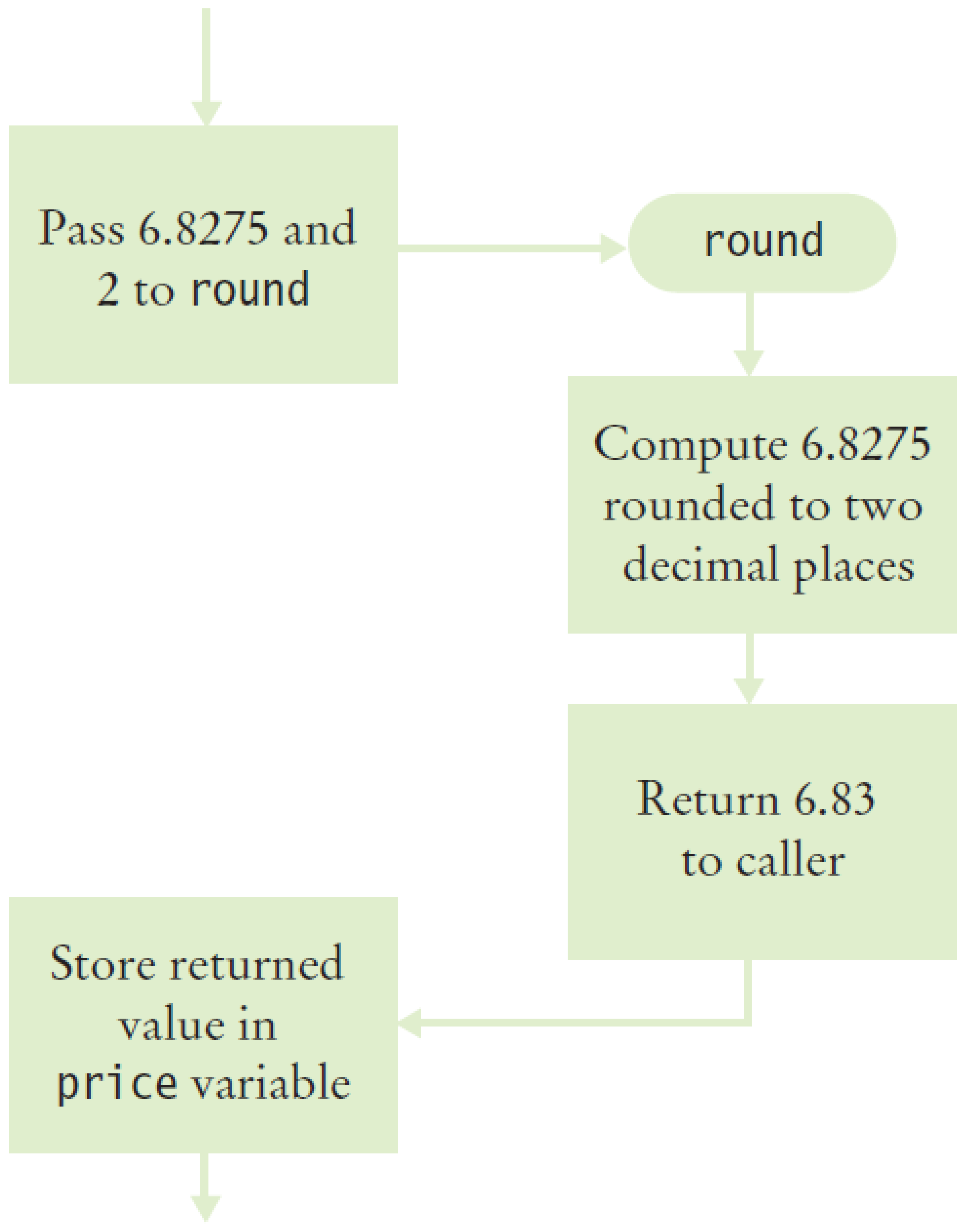
- For example, the **round** function, contains instructions to round a floating point value to a specified number of decimal places.
- You **call** a function in order to execute its instruction.

In [ ]:
```
price = round(6.8275,2) # Sets results to 6.83
print("Price:",price)
```

Functions as Black Boxes

- By using the expression **round(6.8275,2)**, your program **calls** the **round** function, asking it to round 6.8275 to two decimal digits.
- The instructions of the round function execute and compute the result.
- The round function returns its result back to where the function was called and your program resumes execution

Functions as Black Boxes


Pass 6.8275 and 2 to round
round
Compute 6.8275 rounded to two decimal places
Return 6.83 to caller
Store returned value in price variable

Functions as Black Boxes

- When another function calls the round function, it provides **“inputs”**, such as the values 6.8275 and 2 in the call round(6.8275, 2).
- These values are called the **arguments** of the function call.
    - Note that they are not necessarily inputs provided by a human user.
    - They are simply the values for which we want the function to compute a result.

- The **“output”** that the round function computes is called the **return value**.

Functions as Black Boxes

- Functions can receive multiple arguments, but they return only one value.
- It is also possible to have functions with no arguments.
- An example is the **random** function that requires no argument to produce a random number

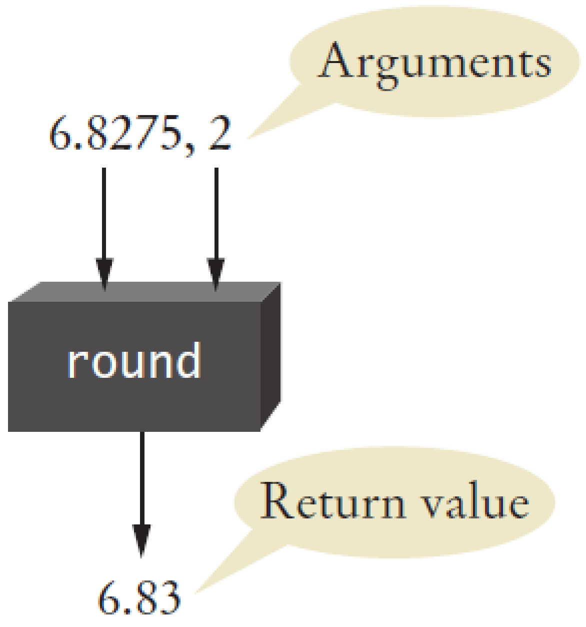
- At this point, you may wonder how the round function performs its job.
- How does round compute that 6.8275 rounded to two decimal digits is 6.83?

In [ ]:
```
price = round(6.8275,2)
print("Price:",price)
```

Functions as Black Boxes

- Fortunately, as a user of the function, you do not need to know how the function is implemented.

- You just need to know the specification of the function:
  - If you provide arguments x and n, the function returns x rounded to n decimal digits.



- We can think of round as a black box.

Functions as Black Boxes

- When you design your own functions, you will want to make them appear as black boxes to other programmers.
- Those programmers want to use your functions without knowing what goes on inside.
- Even if you are the only person working on a program, making each function into a black box pays off: there are fewer details that you need to keep in mind.

Implementing and Testing Functions

Implementing a Function

- When defining a **function**, you provide a **name** for the function and a **variable** for each **argument**.

- Let us start with a very simple example:
    - a function to compute the volume of a cube with a given side length.

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Implementing and Testing Functions

- When writing this function, you need to
    - Pick a **name** for the function (cubeVolume)
    - Define a variable for each **argument** (sideLength). These variables are called the **parameter variables**.
- Put all this information together along with the **def** reserved word to form the first line of the function's definition:
    - **def cubeVolume(sideLength):**

In [ ]:
```
def cubeVolume(sideLength):
    volume = sideLength ** 3
    return volume
```

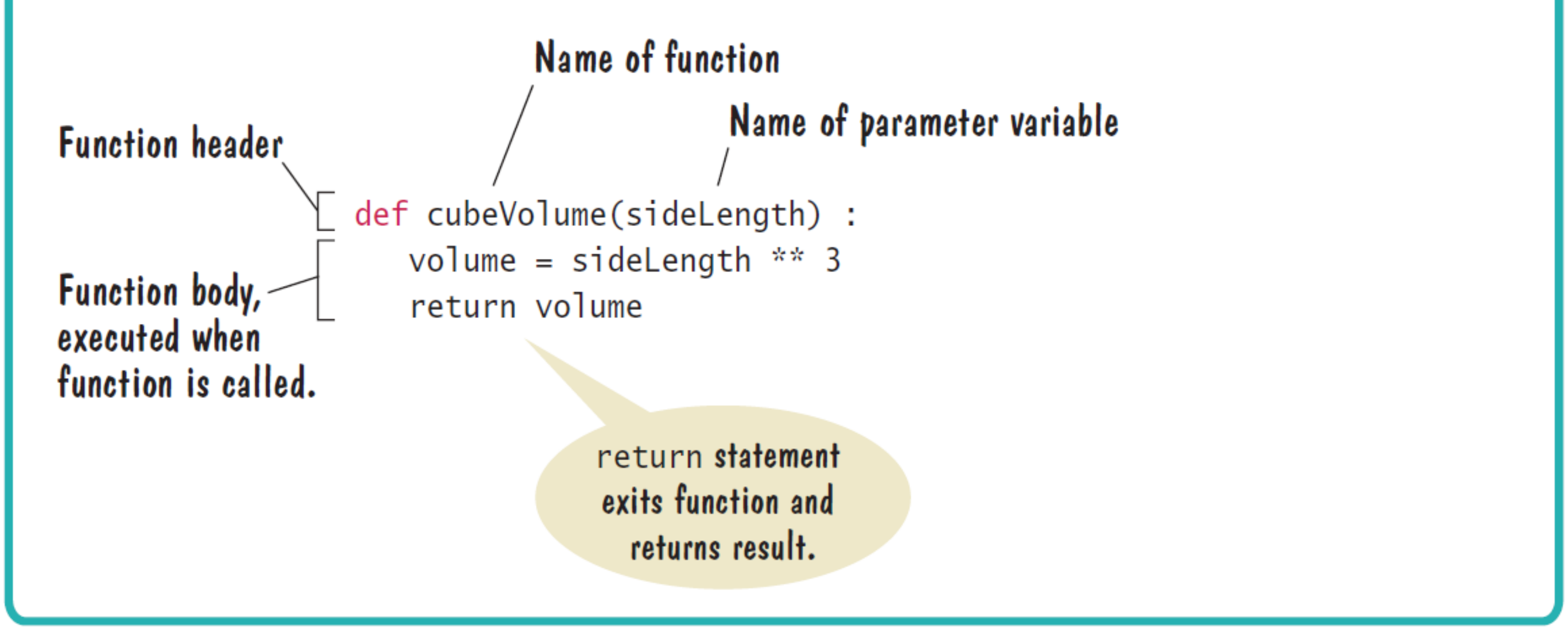
- This line is called the **header** of the function.
- Next, specify the **body** of the function.
    - The body contains the statements that are executed when the function is called.

- In order to return the result of the function, use the **return** statement:
    - **return volume**

Implementing and Testing Functions

Function Definition

Syntax `def` *functionName(parameterName*$_1$*, parameterName*$_2$*, . . .) :*
statements



```
def cubeVolume(sideLength) :
    volume = sideLength ** 3
    return volume
```

Name of function
Name of parameter variable
Function header
Function body, executed when function is called.
return statement exits function and returns result.

Implementing and Testing Functions

Testing a Function

- In order to test the function, your program should contain:
  - The definition of the function.
  - Statements that call the function and print the result.

In [ ]:

```
def cubeVolume(sideLength):
    volume = sideLength ** 3
    return volume
result1 = cubeVolume(2)
result2 = cubeVolume(10)
print("A cube with side length 2 has volume", result1)
print("A cube with side length 10 has volume", result2)
```

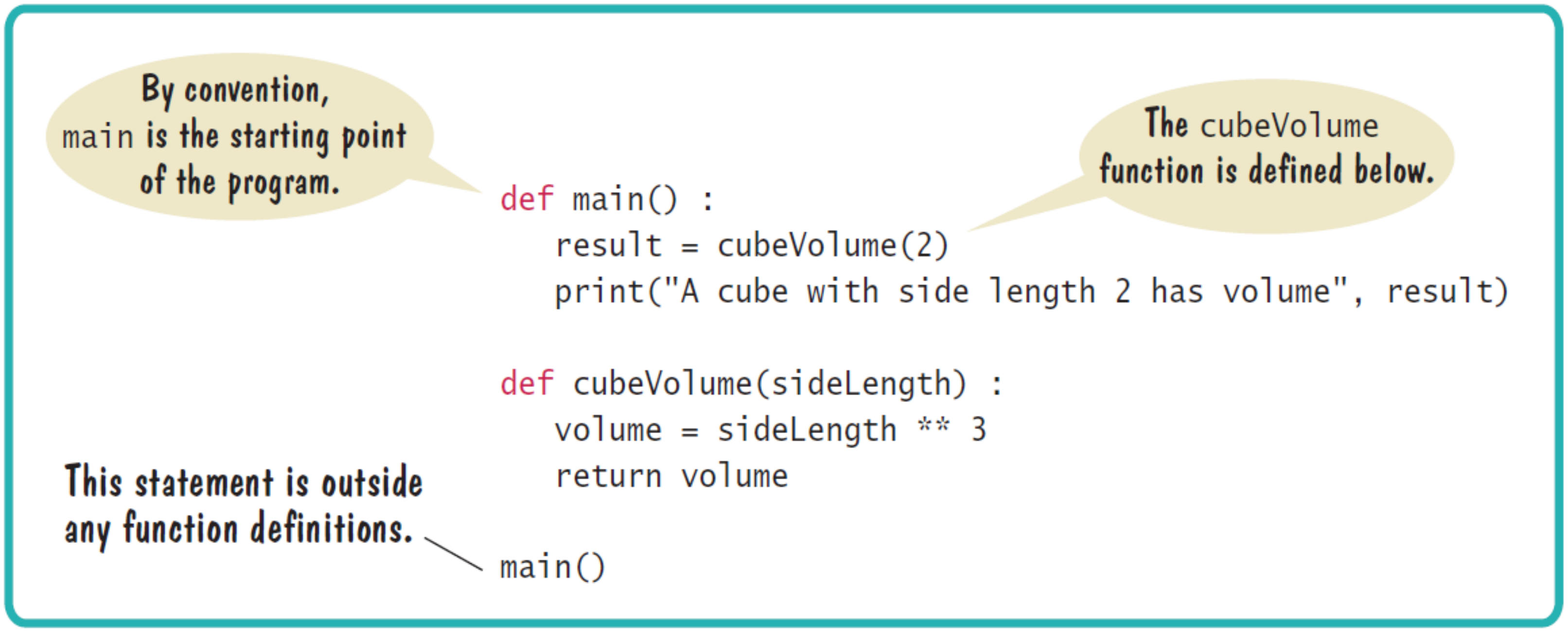
Implementing and Testing Functions

Programs that Contain Functions

- When you write a program that contains one or more functions, you need to pay attention to the order of the function definitions and statements in the program.
- As the Python interpreter reads the source code, it reads each function definition and each statement.
    - The statements in a function definition are not executed until the function is called.
    - Any statement not in a function definition, on the other hand, is executed as it is encountered.
- Therefore, it is important that you define each function before you call it.

Implementing and Testing Functions

Program with Functions


By convention, main is the starting point of the program.
The cubeVolume function is defined below.
This statement is outside any function definitions.

```
def main() :
   result = cubeVolume(2)
   print("A cube with side length 2 has volume", result)

def cubeVolume(sideLength) :
   volume = sideLength ** 3
   return volume

main()
```

Implementing and Testing Functions

In [ ]:
```
#  This program computes the volumes of two cubes.

def main() :
   result1 = cubeVolume(2)
   result2 = cubeVolume(10)
   print("A cube with side length 2 has volume", result1)
   print("A cube with side length 10 has volume", result2)

## Computes the volume of a cube.
#  @param sideLength the length of a side of the cube
#  @return the volume of the cube
#
def cubeVolume(sideLength) :
   volume = sideLength ** 3
   return volume

# Start the program.
main()
```

Implementing and Testing Functions

Student Activity

- Define a function squareArea that computes the area of a square of a given side length.

```
In [ ]:
```

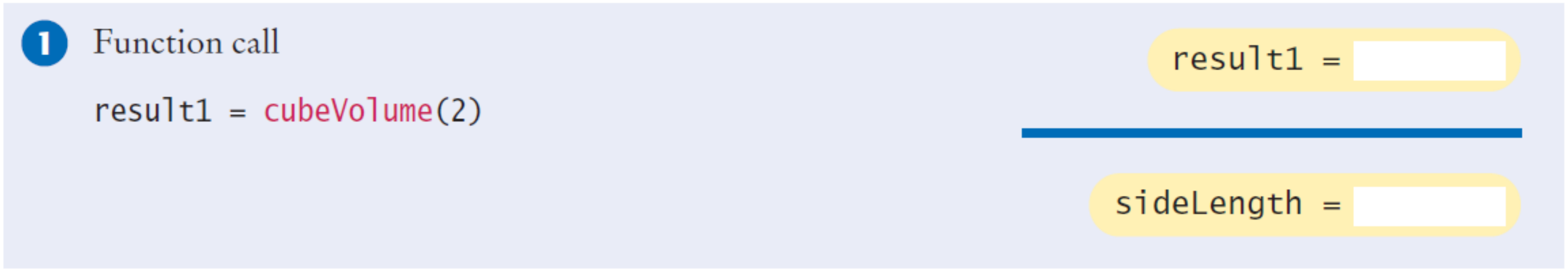
Parameter Passing

- When a function is called, variables are created for receiving the function’s arguments.
- These variables are called **parameter variables**.
    - (Another commonly used term is **formal parameters**.)
- The values that are supplied to the function when it is called are the **arguments** of the call.
    - (These values are also commonly called the **actual parameters**.)

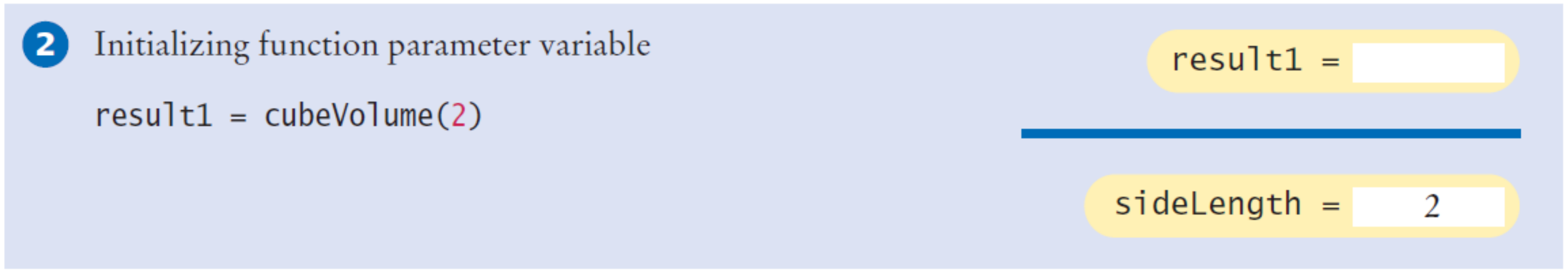
Parameter Passing

In [ ]:

```
#  This program computes the volumes of two cubes.

def main() :
   result1 = cubeVolume(2)
   result2 = cubeVolume(10)
   print("A cube with side length 2 has volume", result1)
   print("A cube with side length 10 has volume", result2)

## Computes the volume of a cube.
#  @param sideLength the length of a side of the cube
#  @return the volume of the cube
#
def cubeVolume(sideLength) :
   volume = sideLength ** 3
   return volume

# Start the program.
main()
```

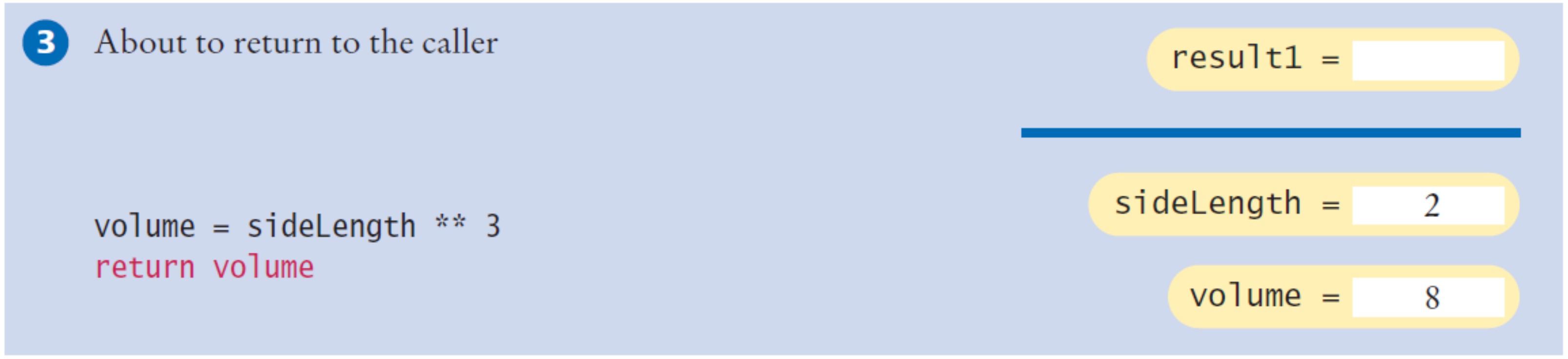


- The parameter variable **sideLength** of the **cubeVolume** function is created when the function is called.



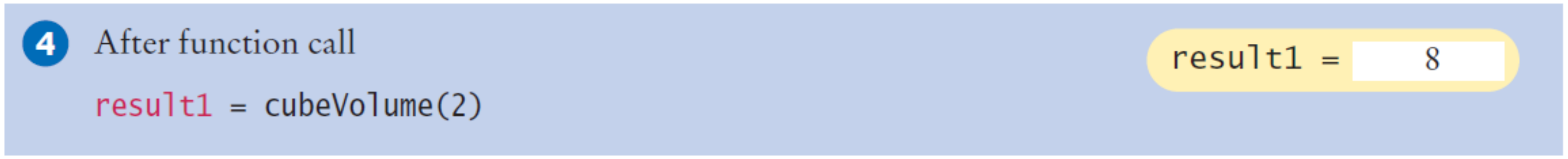
```
result1 = cubeVolume(2)
```

- The parameter variable is initialized with the value of the argument that was passed in the call. In our case, **sideLength** is set to 2.



```
volume = sideLength ** 3
return volume
```

- The function computes the expression **sideLength ** 3**, which has the value 8.
- That value is stored in the variable **volume**.



```
result1 = cubeVolume(2)
```

- The function returns. All of its variables are removed.
- The return value is transferred to the **caller**, that is, the function calling the **cubeVolume** function.
- The caller puts the return value in the **result1** variable.

Parameter Passing

Student Activity

- What does this program print? Use a diagram to find the answer.

In [ ]:

```python
def main():
    a = 5
    b = 7
    print(mystery(a,b))
def mystery(x,y):
    z = x + y
    z = z / 2.0
    return z
main()
```

Return Values

- The **return** statement terminates a function call and yields the function result.
- In the preceding examples, each **return** statement returned a variable.

- However, the **return** statement can return the value of any expression.
- Instead of saving the return value in a variable and returning the variable, it is often possible to eliminate the variable and return the value of a more complex expression:

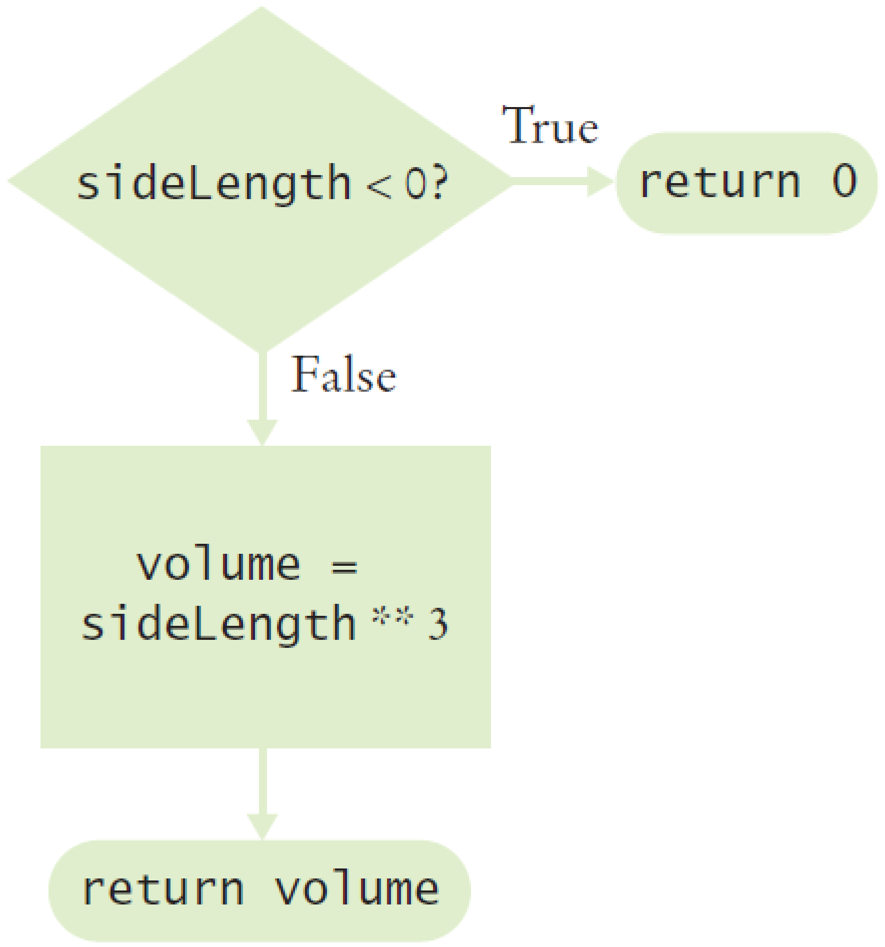
In [ ]:
```
def cubeVolume(sideLength):
    return sideLength ** 3
```

- When the **return** statement is processed, the function exits **immediately**.

Return Values

- Some programmers find this behavior convenient for handling exceptional cases at the beginning of the function:

In [ ]:
```
def cubeVolume(sideLength):
    if sidelength < 0:
        return 0
    # Handle the regular case.
```


sideLength < 0?
True
return 0
False
volume = sideLength ** 3
return volume

Return Values

- Some programmers dislike the use of multiple **return** statements in a function.
- You can avoid multiple returns by storing the function result in a variable that you return in the last statement of the function.
- For example:

In [ ]:
```python
def cubeVolume(sideLength):
    if sideLength >= 0:
        volume = sideLength ** 3
    else:
        volume = 0
    return volume
```

Return Values

Student Activity

- What does this function do?

```
In [ ]:
def mystery(n):
    if n % 2 == 0:
        return True
    else:
        return False
```

Functions Without Return Values

- Some functions may not return a value, but they can produce output.

- Sometimes, you need to carry out a sequence of instructions that does not yield a value.
- If that instruction sequence occurs multiple times, you will want to package it into a function.

Functions Without Return Values

- Here is a typical example: Your task is to print a string in a box, like this:

```
-------
!Hello!
-------
```

In [ ]:
```python
## Prints a string in a box.
# @param contents the string to enclose in a box
#
def boxString(contents):
    n = len(contents)
    if n == 0:
        return #Return immediately
    print("-"*(n+2))
    print("!"+contents+"!")
    print("-"*(n+2))

def main():
    boxString("Hello")
main()
```

Student Activity

- What is wrong with the following statement?

In [ ]:
```
print(boxString("Hello"))
```

Variable Scope

- As your programs get larger and contain more variables, you may encounter problems where you cannot access a variable that is defined in a different part of your program, or where two variable definitions conflict with each other.
- In order to resolve these problems, you need to be familiar with the concept of variable scope.

- The **scope** of a variable is the part of the program in which you can access it.

Variable Scope

In the following code segment, the **scope** of the parameter variable **sideLength** is the entire **cubeVolume** function but **not** the **main** function.

```
def main() :
   print(cubeVolume(10))

def cubeVolume(sideLength) :
   return sideLength ** 3
```

Variable Scope

- A variable that is defined within a function is called a **local variable**.
- When a local variable is defined in a block, it becomes available from that point until the end of the function in which it is defined.

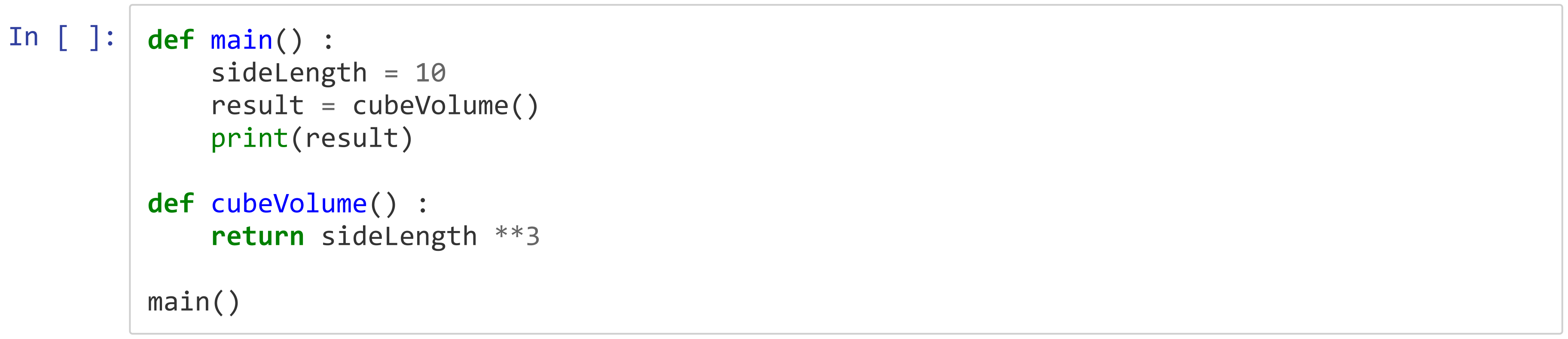
- For example, in the code segment below, the scope of the square variable is highlighted.

```
def main() :
   sum = 0
   for i in range(11) :
      square = i * i
      sum = sum + square

   print(square, sum)
```

```
In [ ]: def main() :
            sum = 0
            for i in range(11) :
                square = i * i
                sum = sum + square
            print(square,sum)

        main()
```

Variable Scope

```
def main() :
    sideLength = 10
    result = cubeVolume()
    print(result)

def cubeVolume() :
    return sideLength ** 3    # Error

main()
```



```
In [ ]: def main() :
            sideLength = 10
            result = cubeVolume()
            print(result)

        def cubeVolume() :
            return sideLength **3

        main()
```

- Note the scope of the variable **sideLength**.
- The **cubeVolume** function attempts to read the variable, but it cannot;
    - The scope of **sideLength** does not extend outside the **main** function.

Variable Scope

- It is possible to use the variable name more than once in a program.
- For example,

```
def main() :
    result = square(3) + square(4)
    print(result)

def square(n) :
    result = n * n
    return result

main()
```

In [ ]:
```
def main() :
    result = square(3) + square(4)
    print(result)

def square(n) :
    result = n * n
    return result

main()
```

- Each **result** variable is defined in a separate function, and their scope do not overlap.

Variable Scope

- A **global variable** is defined outside of a function.
- A **global variable** is visible to all functions defined after it.

- Any function that wishes to update a **global variable** must include a **global** declaration:

In [ ]:
```
balance = 1000 # A global varaible

def withdraw(amount) :
    global balance # This function intends to update the global balance variable
    if balance >= amount:
        balance = balance - amount

withdraw(200)
print(balance)
```

- If you omit the **global** declaration, then the balance variable inside the **withdraw** function is considered a local variable.

Summary

- A function is a named sequence of instructions.
- Arguments are supplied when a function is called.
- The return value is the result that the function computes.
- When declaring a function, you provide a name for the function and a variable for each argument.
- Function comments explain the purpose of the function, the meaning of the parameters and return values, as well as any special requirements.
- Parameter variables hold the arguments supplied in the function call.

Summary

- The return statement terminates a function call and yields the function result.
    - Complete computations that can be reused into functions.
- Use the process of stepwise refinement to decompose complex tasks into simpler ones.
    - When you discover that you need a function, write a description of the parameter variables and return values.
    - A function may require simpler functions to carry out its work.

Summary

- The scope of a variable is the part of the program in which the variable is visible.
    - Two local or parameter variables can have the same name, provided that their scope do not overlap.
    - You can use the same variable name within different functions since their scope does not overlap.
    - Local variable declared inside a function are not visible to code inside other functions.