Lecture
Functions

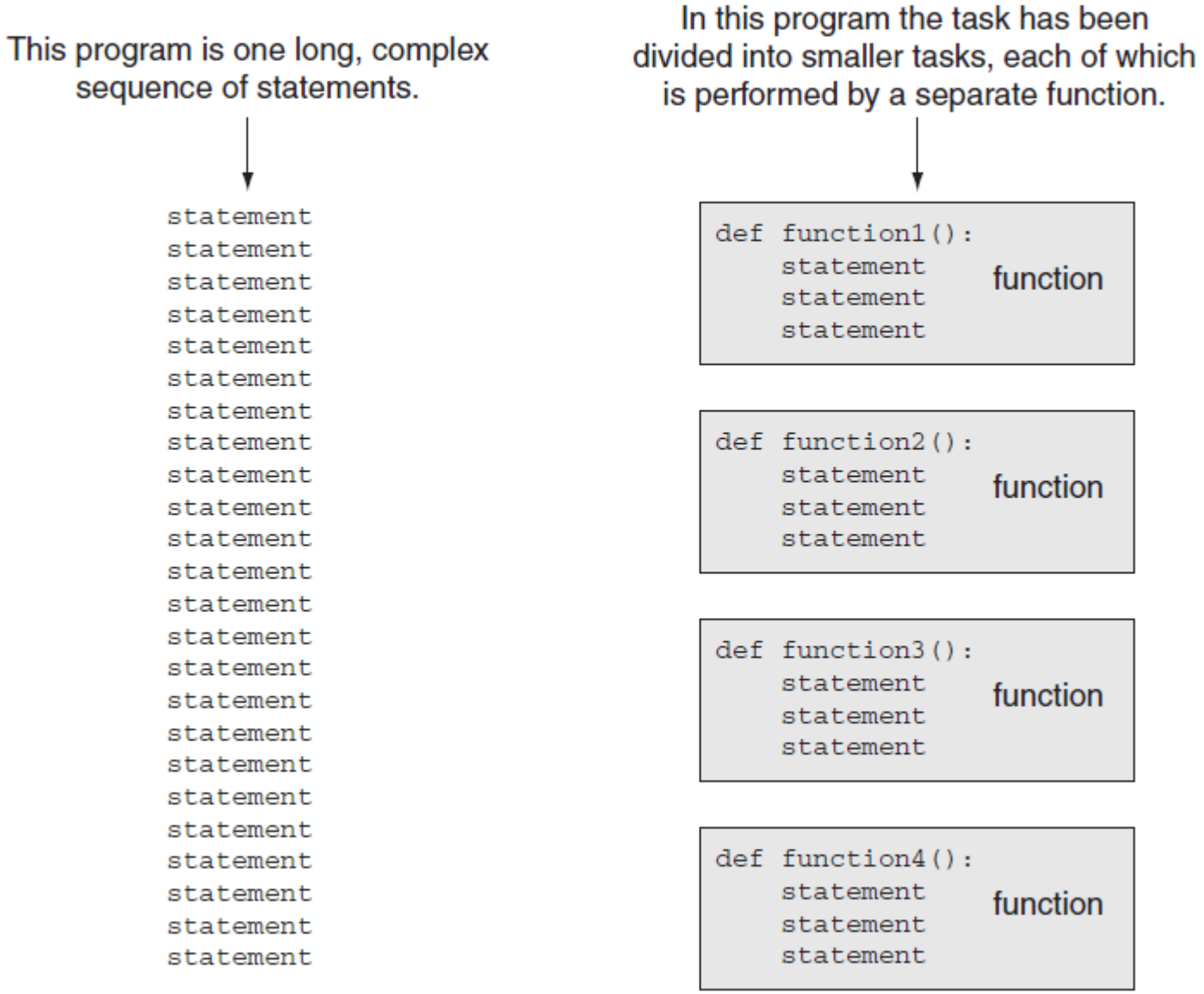
Python

Part 1

Introduction to Functions

- Function: group of statements within a program that perform as specific task
  - Usually one task of a large program
    - Functions can be executed in order to perform overall program task
  - Known as *divide and conquer* approach
- Modularized program: program wherein each task within the program is in its own function

Figure 5-1 Using functions to divide and conquer a large task



Benefits of Modularizing a Program with Functions

- The benefits of using functions include:
  - Simpler code
  - Code reuse
    - write the code once and call it multiple times
  - Better testing and debugging
    - Can test and debug each function individually
  - Faster development
  - Easier facilitation of teamwork
    - Different team members can write different functions

Void Functions and Value-Returning Functions

A void function:

Simply executes the statements it contains and then terminates.

```
# This program demonstrates a function.
# First, we define a function named message.
def message():
    print('I am Arthur')
    print('King of the Britons')

# Call the message function.
message()
```

Void Functions and Value-Returning Functions

A <u>value-returning function</u>:

Executes the statements it contains, returns a value back to the statement that called it

The input, int, and float functions are examples of value-returning functions.

a value returning function named ”message”

a ”void” function named ”main”

```
# This program has two functions. First we
# define the main function.
# This is void function as it hasn't got anything to return
# (no "return" statement)
def main():
    print('================================================================================')
    print('"main()" function executing')
    print('The function message() is going to be called!')
    print('================================================================================')
    # The returned value from message() is assigned to the variable "txt"
    txt = message()
    print('================================================================================')
    print('Back in "main() function" after the function "message()" has been called!')
    print('and execution is continuing in main ()\n\nThe received message is now going to being printed for you :\n')
    print(txt)
    print('Goodbye!')
    print('================================================================================')

# Next we define the message function.
# This is value returning function
def message():
    print('\n********************************************************************************')
    print('"message()" function executing, called from "main()')
    print('and the execution continues in message() function !\n')

    mess = 'I am Arthur\nKing of the Britons'

    print('A message will now be returned to the calling function\nby using the return statement !')
    print('********************************************************************************\n')

    return mess

# Calling the main function.
main()
```

Defining and Calling a Function

- Functions are given names
  - Function naming rules:
    - Cannot use key words as a function name
    - Cannot contain spaces
    - First character must be a letter or underscore
    - All other characters must be a letter, number or underscore
    - Uppercase and lowercase characters are distinct

Defining and Calling a Function (cont'd.)

- Function name should be descriptive of the task carried out by the function
  - Often includes a verb
- Function definition: specifies what function does

```
def function_name():
        statement
        statement
```

Defining and Calling a Function (cont'd.)

- Function header: first line of function
  - Includes keyword `def` and function name, followed by parentheses and colon
- Block: set of statements that belong together as a group
  - Example: the statements included in a function

Defining and Calling a Function (cont'd.)

- Call a function to execute it
  - When a function is called:
    - Interpreter jumps to the function and executes statements in the block
    - Interpreter jumps back to part of program that called the function
      - Known as function return

Defining and Calling a Function (cont'd.)

- `main` function: called when the program starts
  - Calls other functions when they are needed
  - Defines the *mainline logic* of the program

Indentation in Python

- Each block must be indented
  - Lines in block must begin with the same number of spaces
    - Use tabs or spaces to indent lines in a block, but not both as this can confuse the Python interpreter
    - IDLE automatically indents the lines in a block
  - Blank lines that appear in a block are ignored

Designing a Program to Use Functions

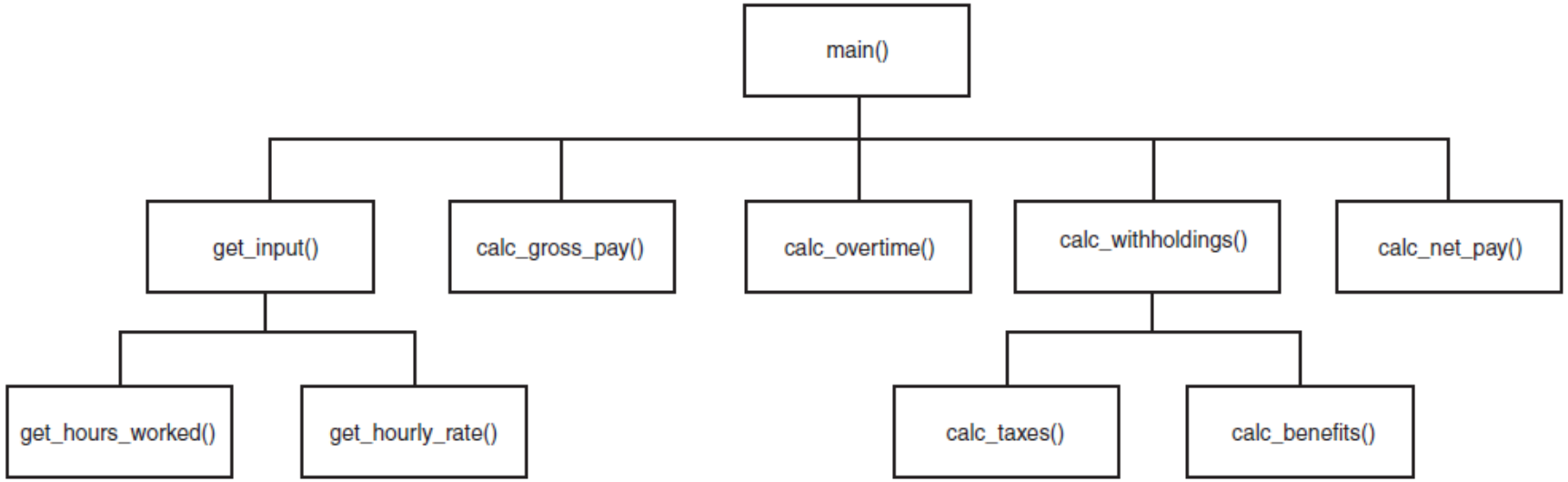
- In a flowchart, function call shown as rectangle with vertical bars at each side
  - Function name written in the symbol
  - Typically draw separate flow chart for each function in the program
    - End terminal symbol usually reads `Return`
- Top-down design: technique for breaking algorithm into functions

Designing a Program to Use Functions (cont'd.)

- Hierarchy chart: depicts relationship between functions
  - AKA structure chart
  - Box for each function in the program, Lines connecting boxes illustrate the functions called by each function
  - Does not show steps taken inside a function
- Use `input` function to have program wait for user to press enter

Designing a Program to Use Functions (cont'd.)

Figure 5-10 A hierarchy chart



Local Variables

- Local variable: variable that is assigned a value inside a function
  - Belongs to the function in which it was created
    - Only statements inside that function can access it, error will occur if another function tries to access the variable
- Scope: the part of a program in which a variable may be accessed
  - For local variable: function in which created

Local Variables (cont’d.)

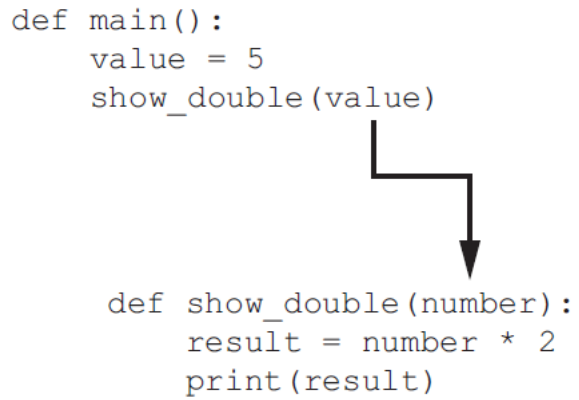
- Local variable cannot be accessed by statements inside its function which precede its creation
- Different functions may have local variables with the same name
  - Each function does not see the other function’s local variables, so no confusion

Passing Arguments to Functions

- Argument: piece of data that is sent into a function
  - Function can use argument in calculations
  - When calling the function, the argument is placed in parentheses following the function name

Passing Arguments to Functions (cont'd.)

Figure 5-13 The `value` variable is passed as an argument



Passing Arguments to Functions (cont'd.)

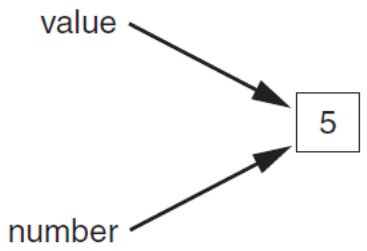
- Parameter variable: variable that is assigned the value of an argument when the function is called
  - The parameter and the argument reference the same value
  - General format:
  - `def function_name(parameter):`
  - Scope of a parameter: the function in which the parameter is used

Passing Arguments to Functions (cont'd.)

Figure 5-14 The `value` variable and the `number` parameter reference the same value

```
def main():
    value = 5
    show_double(value)


def show_double(number):
    result = number * 2
    print(result)
```

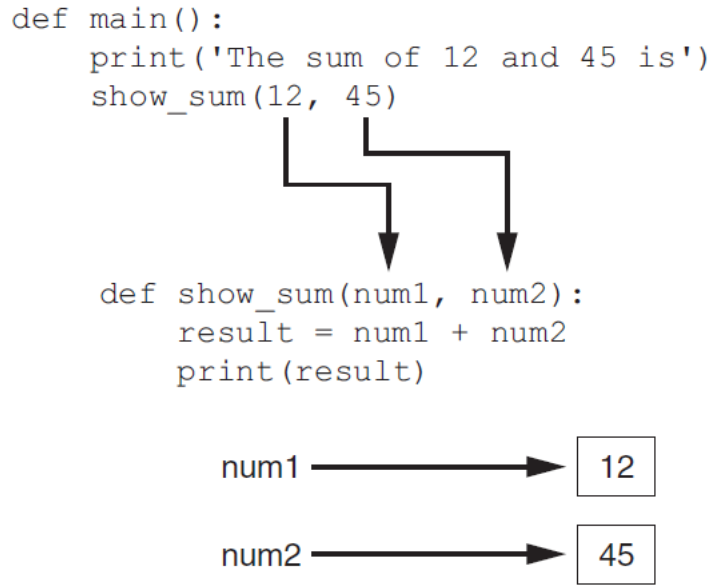


Passing Multiple Arguments

- Python allows writing a function that accepts multiple arguments
  - Parameter list replaces single parameter
    - Parameter list items separated by comma
- Arguments are passed *by position* to corresponding parameters
  - First parameter receives value of first argument, second parameter receives value of second argument, etc.

Passing Multiple Arguments (cont'd.)

Figure 5-16 Two arguments passed to two parameters



Making Changes to Parameters

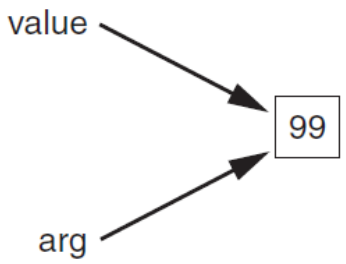
- Changes made to a parameter value within the function do not affect the argument
  - Known as *pass by value*
  - Provides a way for unidirectional communication between one function and another function
    - Calling function can communicate with called function

Making Changes to Parameters (cont'd.)

Figure 5-17 The value variable is passed to the `change_me` function

```
def main():
    value = 99
    print('The value is', value)
    change_me(value)
    print('Back in main the value is', value)


def change_me(arg):
    print('I am changing the value.')
    arg = 0
    print('Now the value is', arg)
```



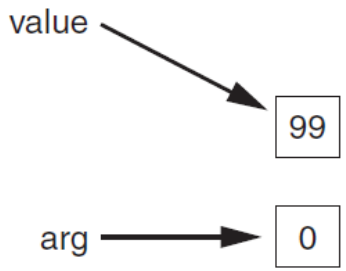
Making Changes to Parameters (cont'd.)

- Figure 5-18
  - The `value` variable passed to the `change_me` function cannot be changed by it

Figure 5-18 The `value` variable is passed to the `change_me` function

```
def main():
    value = 99
    print('The value is', value)
    change_me(value)
    print('Back in main the value is', value)


def change_me(arg):
    print('I am changing the value.')
    arg = 0
    print('Now the value is', arg)
```



Keyword Arguments

- Keyword argument: argument that specifies which parameter the value should be passed to
  - Position when calling function is irrelevant
  - General Format:
  - `function_name(parameter=value)`
- Possible to mix keyword and positional arguments when calling a function
  - Positional arguments must appear first

Lecture
Functions

Python

Part 2

Global Variables and Global Constants

- Global variable: created by assignment statement written outside all the functions
  - Can be accessed by any statement in the program file, including from within a function
  - If a function needs to assign a value to the global variable, the global variable must be redeclared within the function
    - General format: `global` *`variable_name`*

Global Variables and Global Constants (cont'd.)

- Reasons to avoid using global variables:
  - Global variables making debugging difficult
    - Many locations in the code could be causing a wrong variable value
  - Functions that use global variables are usually dependent on those variables
    - Makes function hard to transfer to another program
  - Global variables make a program hard to understand

Global Constants

- Global constant: global name that references a value that cannot be changed
  - Permissible to use global constants in a program
  - To simulate global constant in Python, create global variable and do not re-declare it within functions

Introduction to Value-Returning Functions: Generating Random Numbers

- void function: group of statements within a program for performing a specific task
  - Call function when you need to perform the task
- Value-returning function: similar to void function, returns a value
  - Value returned to part of program that called the function when function finishes executing

Standard Library Functions and the `import` Statement

- Standard library: library of pre-written functions that comes with Python
  - *Library functions* perform tasks that programmers commonly need
    - Example: `print`, `input`, `range`
    - Viewed by programmers as a “black box”
- Some library functions built into Python interpreter
  - To use, just call the function

Standard Library Functions and the `import` Statement (cont'd.)

- Modules: files that stores functions of the standard library
  - Help organize library functions not built into the interpreter
  - Copied to computer when you install Python
- To call a function stored in a module, need to write an `import` statement
  - Written at the top of the program
  - Format: `import` *`module_name`*

Standard Library Functions and the `import` Statement (cont'd.)

Figure 5-19 A library function viewed as a black box

Generating Random Numbers

- Random number are useful in a lot of programming tasks
- `random` module: includes library functions for working with random numbers
- Dot notation: notation for calling a function belonging to a module
  - Format: `module_name.function_name()`

Generating Random Numbers (cont'd.)

- `randint` function: generates a random number in the range provided by the arguments
  - Returns the random number to part of program that called the function
  - Returned integer can be used anywhere that an integer would be used
  - You can experiment with the function in interactive mode

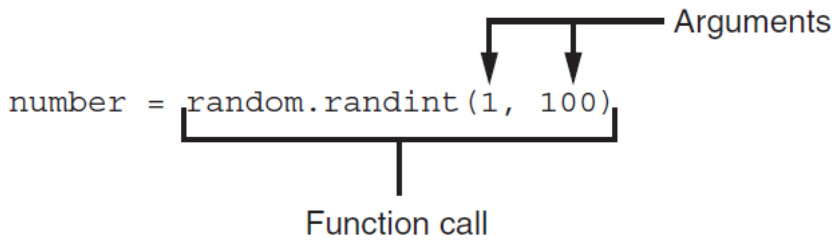
```
# This program displays five random
# numbers in the range of 1 through 100.
import random

def main():
    for count in range(5):
        # Get a random number.
        number = random.randint(1, 100)
        # Display the number.
        print(number)

# Call the main function.
main()
```

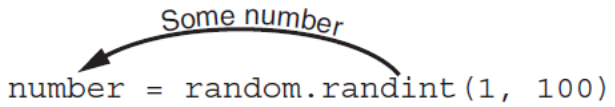
Generating Random Numbers (cont'd.)

Figure 5-20 A statement that calls the `random` function



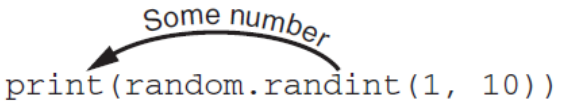
Generating Random Numbers (cont'd.)

Figure 5-21 The `random` function returns a value



A random number in the range of 1 through 100 will be assigned to the `number` variable.

Figure 5-22 Displaying a random number



A random number in the range of 1 through 10 will be displayed.

Generating Random Numbers (cont'd.)

- `randrange` function: similar to `range` function, but returns randomly selected integer from the resulting sequence
  - Same arguments as for the `range` function
- `random` function: returns a random float in the range of 0.0 and 1.0
  - Does not receive arguments
- `uniform` function: returns a random float but allows user to specify range

Random Number Seeds

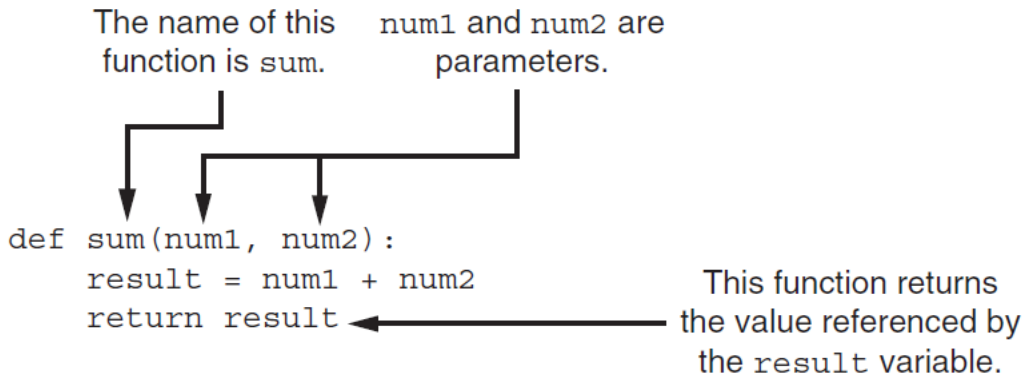
- Random number created by functions in random module are actually pseudo-random numbers
- Seed value: initializes the formula that generates random numbers
  - Need to use different seeds in order to get different series of random numbers
    - By default uses system time for seed
    - Can use `random.seed()` function to specify desired seed value
  - *Read more in chapter 5 about seeds,* "Random Number Seeds"

Writing Your Own Value-Returning Functions

- To write a value-returning function, you write a simple function and add one or more `return` statements
  - Format: `return` *`expression`*
    - The value for *`expression`* will be returned to the part of the program that called the function
  - The expression in the `return` statement can be a complex expression, such as a sum of two variables or the result of another value- returning function

Writing Your Own Value-Returning Functions (cont'd.)

Figure 5-23 Parts of the function



How to Use Value-Returning Functions

- Value-returning function can be useful in specific situations
  - Example: have function prompt user for input and return the user's input
  - Simplify mathematical expressions
  - Complex calculations that need to be repeated throughout the program
- Use the returned value
  - Assign it to a variable or use as an argument in another function

Using IPO Charts

- IPO chart: describes the input, processing, and output of a function
  - Tool for designing and documenting functions
  - Typically laid out in columns
  - Usually provide brief descriptions of input, processing, and output, without going into details
    - Often includes enough information to be used instead of a flowchart

Using IPO Charts (cont'd.)

Figure 5-25 IPO charts for the `getRegularPrice` and `discount` functions

IPO Chart for the `get_regular_price` Function		
Input	Processing	Output
None	Prompts the user to enter an item's regular price	The item's regular price

IPO Chart for the `discount` Function		
Input	Processing	Output
An item's regular price	Calculates an item's discount by multiplying the regular price by the global constant `DISCOUNT_PERCENTAGE`	The item's discount

Returning Strings

- You can write functions that return strings
- For example:

```
def get_name():
    # Get the user's name.
    name = input('Enter your name: ')
    # Return the name.
    return name
```

Returning Boolean Values

- Boolean function: returns either `True` or `False`
  - Use to test a condition such as for decision and repetition structures
    - Common calculations, such as whether a number is even, can be easily repeated by calling a function
  - Use to simplify complex input validation code

Returning Multiple Values

- In Python, a function can return multiple values
  - Specified after the `return` statement separated by commas
    - Format: `return` *`expression1, expression2, etc.`*
  - When you call such a function in an assignment statement, you need a separate variable on the left side of the = operator to receive each returned value

The `math` Module

- `math` module: part of standard library that contains functions that are useful for performing mathematical calculations
  - Typically accept one or more values as arguments, perform mathematical operation, and return the result
  - Use of module requires an `import math` statement

The `math` Module (cont'd.)

Table 5-2 Many of the functions in the `math` module

`math` Module Function	Description
`acos(x)`	Returns the arc cosine of `x`, in radians.
`asin(x)`	Returns the arc sine of `x`, in radians.
`atan(x)`	Returns the arc tangent of `x`, in radians.
`ceil(x)`	Returns the smallest integer that is greater than or equal to `x`.
`cos(x)`	Returns the cosine of `x` in radians.
`degrees(x)`	Assuming `x` is an angle in radians, the function returns the angle converted to degrees.
`exp(x)`	Returns e^x
`floor(x)`	Returns the largest integer that is less than or equal to `x`.
`hypot(x, y)`	Returns the length of a hypotenuse that extends from (0, 0) to (`x`, `y`).
`log(x)`	Returns the natural logarithm of `x`.
`log10(x)`	Returns the base-10 logarithm of `x`.
`radians(x)`	Assuming `x` is an angle in degrees, the function returns the angle converted to radians.
`sin(x)`	Returns the sine of `x` in radians.
`sqrt(x)`	Returns the square root of `x`.
`tan(x)`	Returns the tangent of `x` in radians.

The `math` Module (cont'd.)

- The `math` module defines variables `pi` and `e`, which are assigned the mathematical values for *pi* and *e*
  - Can be used in equations that require these values, to get more accurate results
- Variables must also be called using the dot notation
  - Example:

```
circle_area = math.pi * radius**2
```

Storing Functions in Modules

- In large, complex programs, it is important to keep code organized
- Modularization: grouping related functions in modules
  - Makes program easier to understand, test, and maintain
  - Make it easier to reuse code for multiple different programs
    - Import the module containing the required function to each program that needs it

Storing Functions in Modules (cont'd.)

- Module is a file that contains Python code
  - Contains function definition but does not contain calls to the functions
    - Importing programs will call the functions
- Rules for module names:
  - File name should end in `.py`
  - Cannot be the same as a Python keyword
- Import module using `import` statement

Menu Driven Programs

- Menu-driven program: displays a list of operations on the screen, allowing user to select the desired operation
  - List of operations displayed on the screen is called a *menu*
- Program uses a decision structure to determine the selected menu option and required operation
  - Typically repeats until the user quits