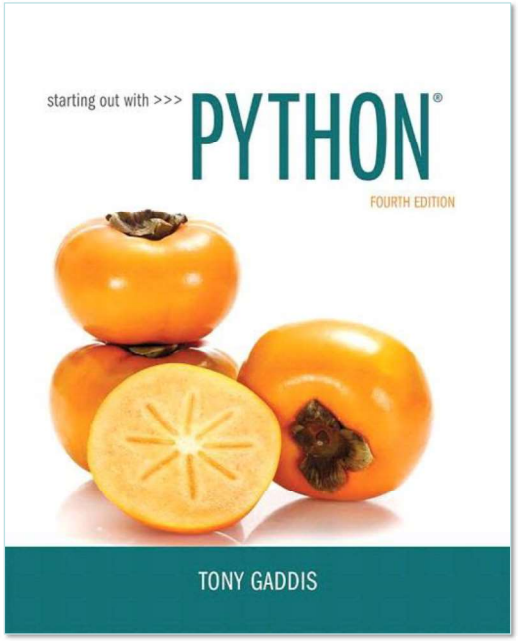
CHAPTER 2

Input, Processing, and Output



Topics

- Designing a Program
- Input, Processing, and Output
- Displaying Output with `print` Function
- Comments
- Variables
- Reading Input from the Keyboard
- Performing Calculations
- More About Data Output
- Named Constants
- Introduction to Turtle Graphics

Designing a Program

- **Programs must be designed before they are written**
- **Program development cycle:**
  - Design the program
  - Write the code
  - Correct syntax errors
  - Test the program
  - Correct logic errors

Designing a Program (cont'd.)

- **Design is the most important part of the program development cycle**
- **Understand the task that the program is to perform**
  - Work with customer to get a sense what the program is supposed to do
  - Ask questions about program details
  - Create one or more software requirements

Designing a Program (cont'd.)

- **Determine the steps that must be taken to perform the task**
  - Break down required task into a series of steps
  - Create an algorithm, listing logical steps that must be taken
- **Algorithm: set of well-defined logical steps that must be taken to perform a task**

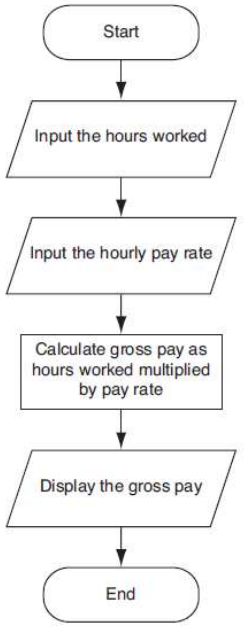
Pseudocode

- **Pseudocode: fake code**
  - Informal language that has no syntax rule
  - Not meant to be compiled or executed
  - Used to create model program
    - No need to worry about syntax errors, can focus on program's design
    - Can be translated directly into actual code in any programming language

Flowcharts

- **Flowchart: diagram that graphically depicts the steps in a program**
  - Ovals are terminal symbols
  - Parallelograms are input and output symbols
  - Rectangles are processing symbols
  - Symbols are connected by arrows that represent the flow of the program

Figure 2-2 Flowchart for the pay calculating program



Input, Processing, and Output

- **Typically, computer performs three-step process**
  - Receive input
    - Input: any data that the program receives while it is running
  - Perform some process on the input
    - Example: mathematical calculation
  - Produce output

Displaying Output with the `print` Function

- **Function: piece of prewritten code that performs an operation**
- **`print` function: displays output on the screen**
- **Argument: data given to a function**
  - Example: data that is printed to screen
- **Statements in a program execute in the order that they appear**
  - From top to bottom

Strings and String Literals

- **String: sequence of characters that is used as data**
- **String literal: string that appears in actual code of a program**
  - Must be enclosed in single (') or double (") quote marks
  - String literal can be enclosed in triple quotes (''' or """)
    - Enclosed string can contain both single and double quotes and can have multiple lines

Comments

- **Comments: notes of explanation within a program**
  - Ignored by Python interpreter
    - Intended for a person reading the program's code
  - Begin with a # character
- **End-line comment: appears at the end of a line of code**
  - Typically explains the purpose of that line

Variables

- **Variable: name that represents a value stored in the computer memory**
  - Used to access and manipulate data stored in memory
  - A variable references the value it represents
- **Assignment statement: used to create a variable and make it reference data**
  - General format is `variable = expression`
    - Example: `age = 29`
    - Assignment operator: the equal sign (=)

Variables (cont'd.)

- **In assignment statement, variable receiving value must be on left side**
- **A variable can be passed as an argument to a function**
  - Variable name should not be enclosed in quote marks
- **You can only use a variable if a value is assigned to it**

Variable Naming Rules

- **Rules for naming variables in Python:**
  - Variable name cannot be a Python key word
  - Variable name cannot contain spaces
  - First character must be a letter or an underscore
  - After first character may use letters, digits, or underscores
  - Variable names are case sensitive
- **Variable name should reflect its use**

Displaying Multiple Items with the `print` Function

- **Python allows one to display multiple items with a single call to `print`**
  - Items are separated by commas when passed as arguments
  - Arguments displayed in the order they are passed to the function
  - Items are automatically separated by a space when displayed on screen

Variable Reassignment

- **Variables can reference different values while program is running**
- **Garbage collection: removal of values that are no longer referenced by variables**
  - Carried out by Python interpreter
- **A variable can refer to item of any type**
  - Variable that has been assigned to one type can be reassigned to another type

Numeric Data Types, Literals, and the `str` Data Type

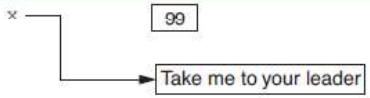
- **Data types: categorize value in memory**
  - e.g., int for integer, float for real number, str used for storing strings in memory
- **Numeric literal: number written in a program**
  - No decimal point considered int, otherwise, considered float
- **Some operations behave differently depending on data type**

Reassigning a Variable to a Different Type

- A variable in Python can refer to items of any type

Figure 2-7 The variable x references an integer

Figure 2-8 The variable x references a string



Reading Input from the Keyboard

- **Most programs need to read input from the user**
- **Built-in `input` function reads input from keyboard**
  - Returns the data as a string
  - Format: *`variable = input(prompt)`*
    - `prompt` is typically a string instructing user to enter a value
  - Does not automatically display a space after the prompt

Reading Numbers with the `input` Function

- **`input` function always returns a string**
- **Built-in functions convert between data types**
  - `int(item)` converts *`item`* to an `int`
  - `float(item)` converts *`item`* to a `float`
  - Nested function call: general format: *`function1`*`(`*`function2`*`(`*`argument`*`))`
    - value returned by function2 is passed to function1
  - Type conversion only works if item is valid numeric value, otherwise, throws exception

Performing Calculations

- **Math expression: performs calculation and gives a value**
  - Math operator: tool for performing calculation
  - Operands: values surrounding operator
    - Variables can be used as operands
  - Resulting value typically assigned to variable
- **Two types of division:**
  - `/` operator performs floating point division
  - `//` operator performs integer division
    - Positive results truncated, negative rounded away from zero

Operator Precedence and Grouping with Parentheses

- **Python operator precedence:**
  1. Operations enclosed in parentheses
     - Forces operations to be performed before others
  2. Exponentiation (**)
  3. Multiplication (*), division (/ and //), and remainder (%)
  4. Addition (+) and subtraction (-)
- **Higher precedence performed first**
  - Same precedence operators execute from left to right

The Exponent Operator and the Remainder Operator

- **Exponent operator (`**`): Raises a number to a power**
  - `x ** y` = x^y
- **Remainder operator (`%`): Performs division and returns the remainder**
  - a.k.a. modulus operator
  - e.g., `4%2=0, 5%2=1`
  - Typically used to convert times and distances, and to detect odd or even numbers

Converting Math Formulas to Programming Statements

- **Operator required for any mathematical operation**
- **When converting mathematical expression to programming statement:**
  - May need to add multiplication operators
  - May need to insert parentheses

Mixed-Type Expressions and Data Type Conversion

- **Data type resulting from math operation depends on data types of operands**
  - Two `int` values: result is an `int`
  - Two `float` values: result is a `float`
  - `int` and `float`: `int` temporarily converted to `float`, result of the operation is a `float`
    - Mixed-type expression
  - Type conversion of `float` to `int` causes truncation of fractional part

Breaking Long Statements into Multiple Lines

- **Long statements cannot be viewed on screen without scrolling and cannot be printed without cutting off**
- **Multiline continuation character (\): Allows to break a statement into multiple lines**

```
result = var1 * 2 + var2 * 3 + \
         var3 * 4 + var4 * 5
```


Breaking Long Statements into Multiple Lines

- **Any part of a statement that is enclosed in parentheses can be broken without the line continuation character.**

```
print("Monday's sales are", monday,
      "and Tuesday's sales are", tuesday,
      "and Wednesday's sales are", Wednesday)

total = (value1 + value2 +
         value3 + value4 +
         value5 + value6)
```

More About Data Output

- **`print` function displays line of output**
  - Newline character at end of printed data
  - Special argument `end='delimiter'` causes `print` to place *`delimiter`* at end of data instead of newline character
- **`print` function uses space as item separator**
  - Special argument `sep='delimiter'` causes `print` to use *`delimiter`* as item separator

More About Data Output (cont'd.)

- **Special characters appearing in string literal**
  - Preceded by backslash (`\`)
    - Examples: newline (`\n`), horizontal tab (`\t`)
  - Treated as commands embedded in string
- **When + operator used on two strings in performs string concatenation**
  - Useful for breaking up a long string literal

Formatting Numbers

- **Can format display of numbers on screen using built-in `format` function**
  - Two arguments:
    - Numeric value to be formatted
    - Format specifier
  - Returns string containing formatted number
  - Format specifier typically includes precision and data type
    - Can be used to indicate scientific notation, comma separators, and the minimum field width used to display the value

Formatting Numbers (cont'd.)

- **The `%` symbol can be used in the format string of `format` function to format number as percentage**
- **To format an integer using `format` function:**
  - Use `d` as the type designator
  - Do not specify precision
  - Can still use `format` function to set field width or comma separator

Magic Numbers

- **A magic number is an unexplained numeric value that appears in a program's code. Example:**

```
amount = balance * 0.069
```

- **What is the value 0.069? An interest rate? A fee percentage? Only the person who wrote the code knows for sure.**

The Problem with Magic Numbers

- **It can be difficult to determine the purpose of the number.**
- **If the magic number is used in multiple places in the program, it can take a lot of effort to change the number in each location, should the need arise.**
- **You take the risk of making a mistake each time you type the magic number in the program's code.**
  - For example, suppose you intend to type 0.069, but you accidentally type .0069. This mistake will cause mathematical errors that can be difficult to find.

Named Constants

- **You should use named constants instead of magic numbers.**
- **A named constant is a name that represents a value that does not change during the program's execution.**
- **Example:**

```
INTEREST_RATE = 0.069
```

- **This creates a named constant named `INTEREST_RATE`, assigned the value 0.069. It can be used instead of the magic number:**

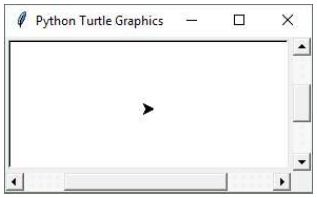
```
amount = balance * INTEREST_RATE
```


Advantages of Using Named Constants

- **Named constants make code self-explanatory (self-documenting)**
- **Named constants make code easier to maintain (change the value assigned to the constant, and the new value takes effect everywhere the constant is used)**
- **Named constants help prevent typographical errors that are common when using magic numbers**

Introduction to Turtle Graphics

- Python's turtle graphics system displays a small cursor known as a *turtle*.



- You can use Python statements to move the turtle around the screen, drawing lines and shapes.

Introduction to Turtle Graphics

- To use the turtle graphics system, you must import the turtle module with this statement:

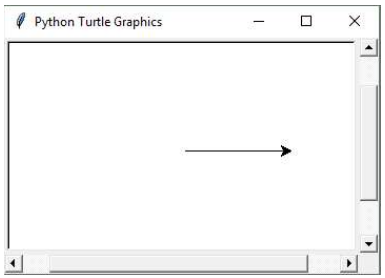
```
import turtle
```

This loads the turtle module into memory

Moving the Turtle Forward

- Use the `turtle.forward(n)` statement to move the turtle forward *n* pixels.

```
>>> import turtle
>>> turtle.forward(100)
>>>
```

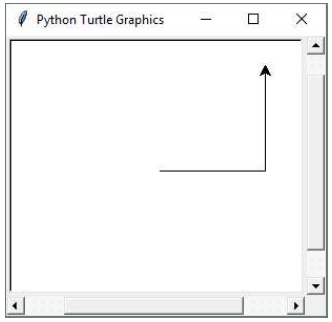


Turning the Turtle

- The turtle's initial heading is 0 degrees (east)
- Use the `turtle.right(angle)` statement to turn the turtle right by *angle* degrees.
- Use the `turtle.left(angle)` statement to turn the turtle left by *angle* degrees.

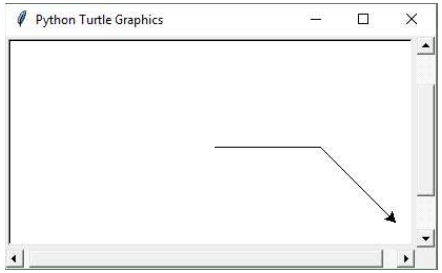
Turning the Turtle

```
>>> import turtle
>>> turtle.forward(100)
>>> turtle.left(90)
>>> turtle.forward(100)
>>>
```



Turning the Turtle

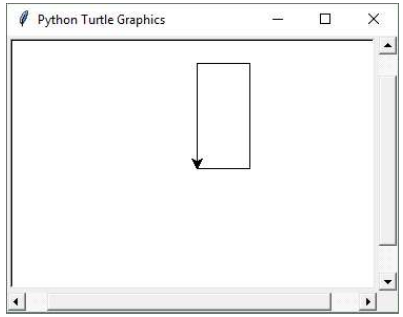
```
>>> import turtle
>>> turtle.forward(100)
>>> turtle.right(45)
>>> turtle.forward(100)
>>>
```



Setting the Turtle's Heading

- **Use the `turtle.setheading(`*`angle`*`)` statement to set the turtle's heading to a specific angle.**

```
>>> import turtle
>>> turtle.forward(50)
>>> turtle.setheading(90)
>>> turtle.forward(100)
>>> turtle.setheading(180)
>>> turtle.forward(50)
>>> turtle.setheading(270)
>>> turtle.forward(100)
>>>
```

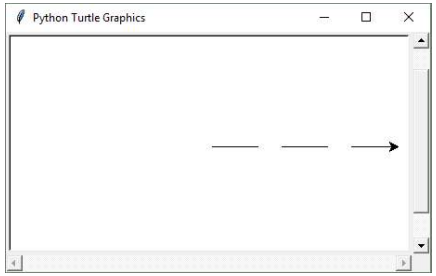


Setting the Pen Up or Down

- **When the turtle's pen is down, the turtle draws a line as it moves. By default, the pen is down.**
- **When the turtle's pen is up, the turtle does not draw as it moves.**
- **Use the `turtle.penup()` statement to raise the pen.**
- **Use the `turtle.pendown()` statement to lower the pen.**

Setting the Pen Up or Down

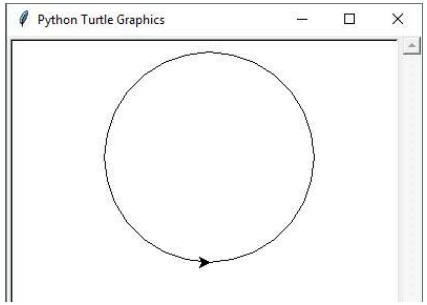
```
>>> import turtle
>>> turtle.forward(50)
>>> turtle.penup()
>>> turtle.forward(25)
>>> turtle.pendown()
>>> turtle.forward(50)
>>> turtle.penup()
>>> turtle.forward(25)
>>> turtle.pendown()
>>> turtle.forward(50)
>>>
```



Drawing Circles

- **Use the `turtle.circle(`*`radius`*`)` statement to draw a circle with a specified radius.**

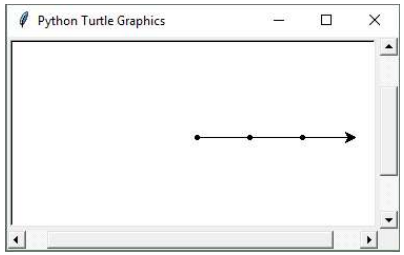
```
>>> import turtle
>>> turtle.circle(100)
>>>
```



Drawing Dots

- **Use the `turtle.dot()` statement to draw a simple dot at the turtle's current location.**

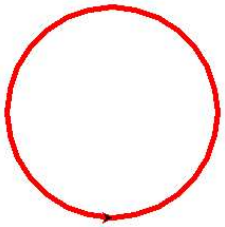
```
>>> import turtle
>>> turtle.dot()
>>> turtle.forward(50)
>>> turtle.dot()
>>> turtle.forward(50)
>>> turtle.dot()
>>> turtle.forward(50)
>>>
```



Changing the Pen Size and Drawing Color

- **Use the `turtle.pensize(`*`width`*`)` statement to change the width of the turtle's pen, in pixels.**
- **Use the `turtle.pencolor(`*`color`*`)` statement to change the turtle's drawing color.**
  - *See Appendix D in your textbook for a complete list of colors.*

```
>>> import turtle
>>> turtle.pensize(5)
>>> turtle.pencolor('red')
>>> turtle.circle(100)
>>>
```



Working with the Turtle's Window

- **Use the `turtle.bgcolor(color)` statement to set the window's background color.**
  - *See Appendix D in your textbook for a complete list of colors.*
- **Use the `turtle.setup(width, height)` statement to set the size of the turtle's window, in pixels.**
  - The *`width`* and *`height`* arguments are the width and height, in pixels.
  - For example, the following interactive session creates a graphics window that is 640 pixels wide and 480 pixels high:

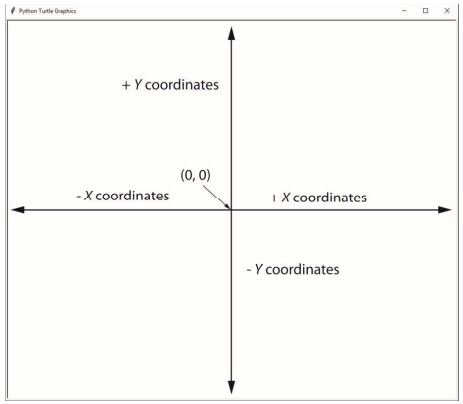
```
>>> import turtle
>>> turtle.setup(640, 480)
>>>
```


Resetting the Turtle's Window

- **The `turtle.reset()` statement:**
  - Erases all drawings that currently appear in the graphics window.
  - Resets the drawing color to black.
  - Resets the turtle to its original position in the center of the screen.
  - Does *not* reset the graphics window's background color.
- **The `turtle.clear()` statement:**
  - Erases all drawings that currently appear in the graphics window.
  - Does *not* change the turtle's position.
  - Does *not* change the drawing color.
  - Does *not* change the graphics window's background color.
- **The `turtle.clearscreen()` statement:**
  - Erases all drawings that currently appear in the graphics window.
  - Resets the drawing color to black.
  - Resets the turtle to its original position in the center of the screen.
  - Resets the graphics window's background color to white.

Working with Coordinates

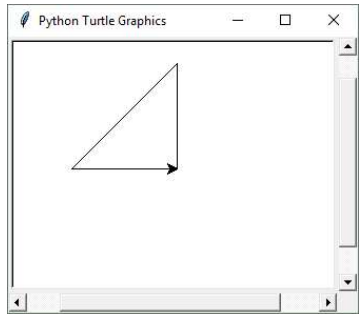
- **The turtle uses Cartesian Coordinates**



Moving the Turtle to a Specific Location

- **Use the `turtle.goto(x, y)` statement to move the turtle to a specific location.**

```
>>> import turtle
>>> turtle.goto(0, 100)
>>> turtle.goto(-100, 0)
>>> turtle.goto(0, 0)
>>>
```



- The `turtle.pos()` statement displays the turtle's current *X*,*Y* coordinates.
- The `turtle.xcor()` statement displays the turtle's current *X* coordinate and the `turtle.ycor()` statement displays the turtle's current *Y* coordinate.

Animation Speed

- **Use the `turtle.speed(speed)` command to change the speed at which the turtle moves.**
  - The *`speed`* argument is a number in the range of 0 through 10.
  - If you specify 0, then the turtle will make all of its moves instantly (animation is disabled).

Hiding and Displaying the Turtle

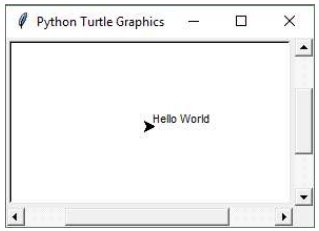
- **Use the `turtle.hideturtle()` command to hide the turtle.**
  - This command does not change the way graphics are drawn, it simply hides the turtle icon.
- **Use the `turtle.showturtle()` command to display the turtle.**

Displaying Text

- **Use the `turtle.write(`*`text`*`)` statement to display text in the turtle's graphics window.**
  - The *`text`* argument is a string that you want to display.
  - The lower-left corner of the first character will be positioned at the turtle's *X* and *Y* coordinates.

Displaying Text

```
>>> import turtle
>>> turtle.write('Hello World')
>>>
```

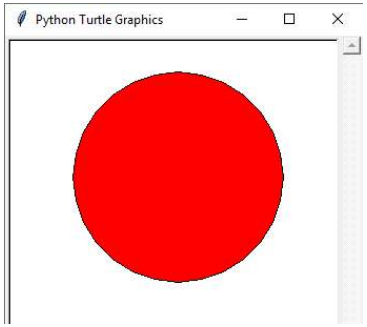


Filling Shapes

- **To fill a shape with a color:**
  - Use the `turtle.begin_fill()` command before drawing the shape
  - Then use the `turtle.end_fill()` command after the shape is drawn.
  - When the `turtle.end_fill()` command executes, the shape will be filled with the current fill color

Filling Shapes

```
>>> import turtle
>>> turtle.hideturtle()
>>> turtle.fillcolor('red')
>>> turtle.begin_fill()
>>> turtle.circle(100)
>>> turtle.end_fill()
>>>
```



Keeping the Graphics Window Open

- **When running a turtle graphics program outside IDLE, the graphics window closes immediately when the program is done.**

- **To prevent this, add the `turtle.done()` statement to the very end of your turtle graphics programs.**
  - This will cause the graphics window to remain open, so you can see its contents after the program finishes executing.

Summary

- **This chapter covered:**
  - The program development cycle, tools for program design, and the design process
  - Ways in which programs can receive input, particularly from the keyboard
  - Ways in which programs can present and format output
  - Use of comments in programs
  - Uses of variables and named constants
  - Tools for performing calculations in programs
  - The turtle graphics system