

CHAPTER 2

Input, Processing, and Output

starting out with >>>

PYTHON®

FOURTH EDITION



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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**

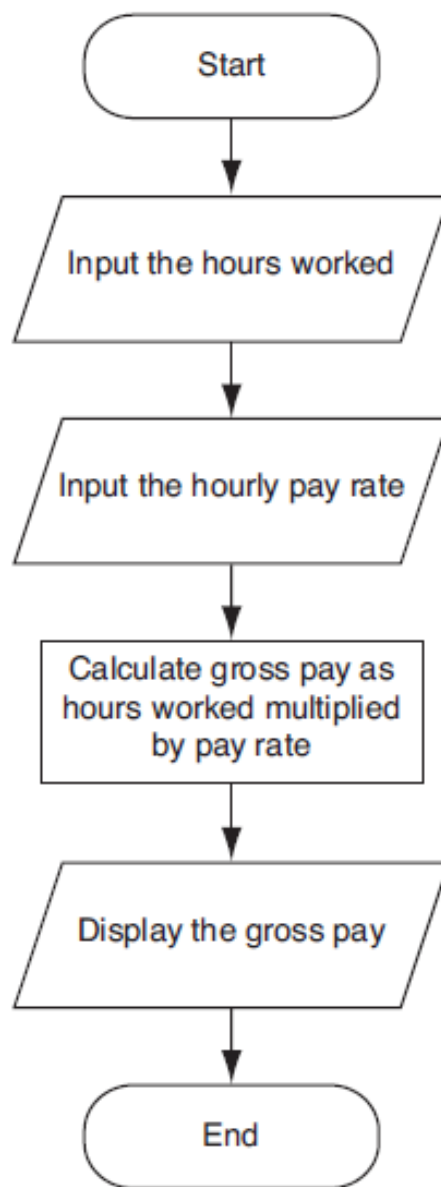
Pseudocode

- **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**

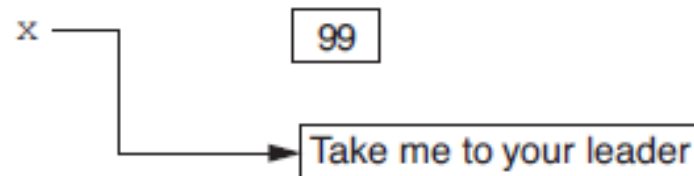
Reassigning a Variable to a Different Type

- 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:

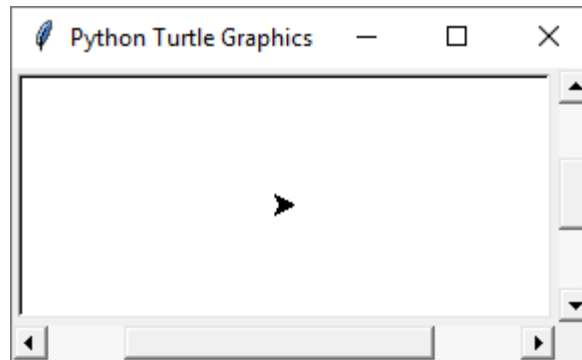
```
amount = balance * INTEREST_RATE
```

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:

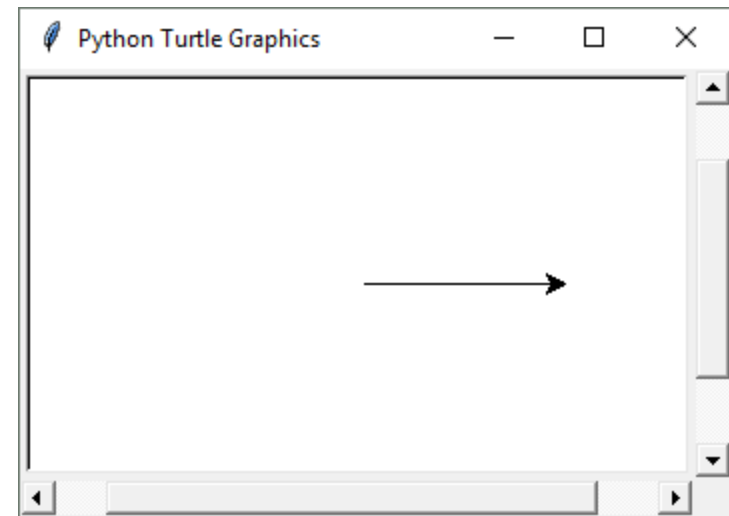
```
import turtle
```

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)
>>>
```

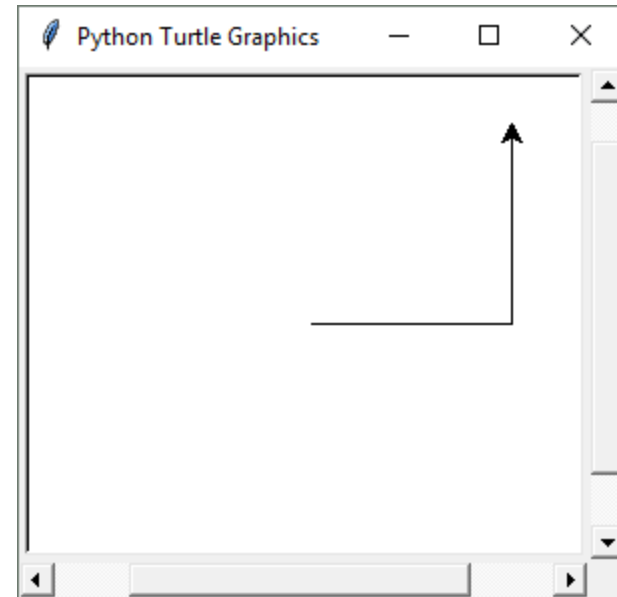


Turning the Turtle

- 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.

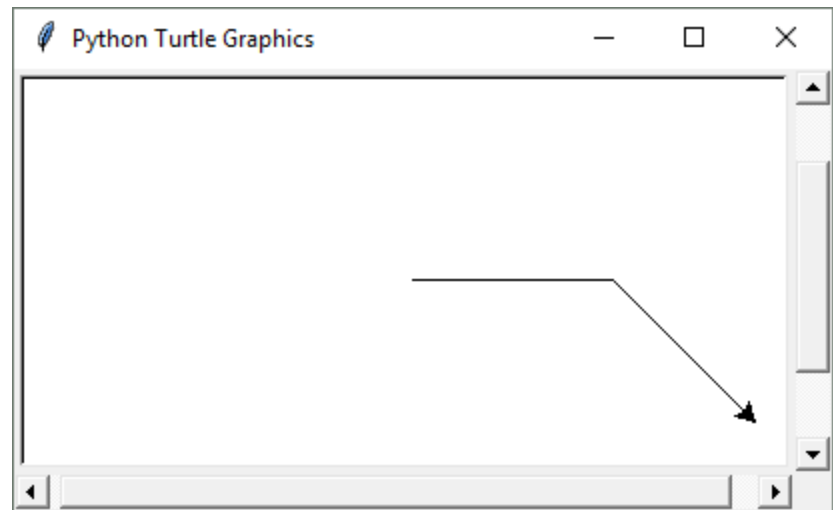
Turning the Turtle

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



Turning the Turtle

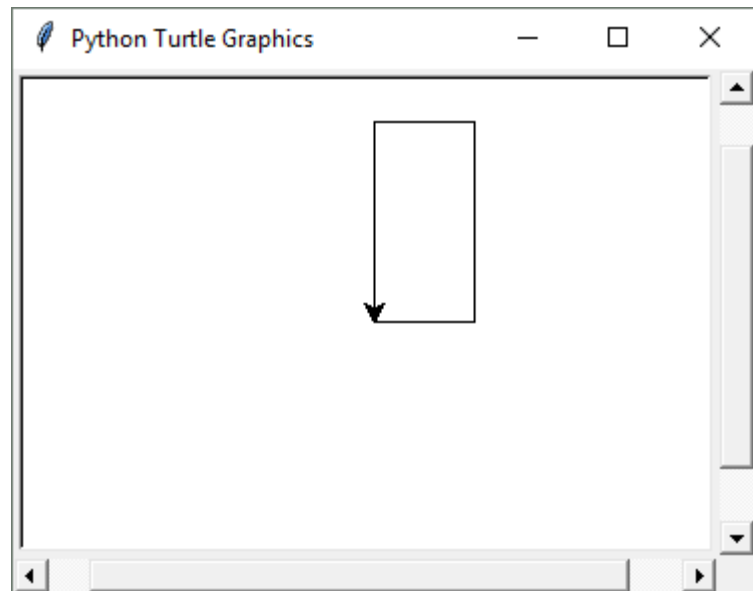
```
>>> import turtle
>>> turtle.forward(100)
>>> turtle.right(45)
>>> turtle.forward(100)
>>>
```



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

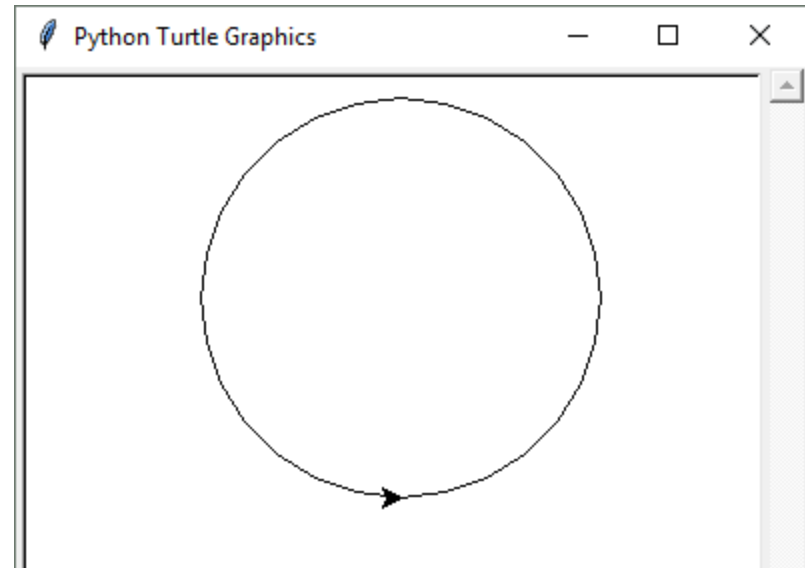
```
>>> import turtle
>>> turtle.forward(50)
>>> turtle.penup()
>>> turtle.forward(25)
>>> turtle.pendown()
>>> turtle.forward(50)
>>> turtle.penup()
>>> turtle.forward(25)
>>> turtle.pendown()
>>> turtle.forward(50)
>>>
```



Drawing Circles

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

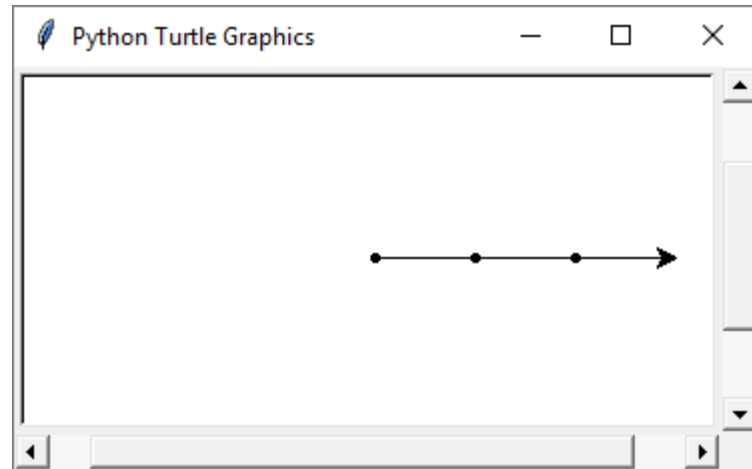
```
>>> import turtle  
>>> turtle.circle(100)  
>>>
```



Drawing Dots

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

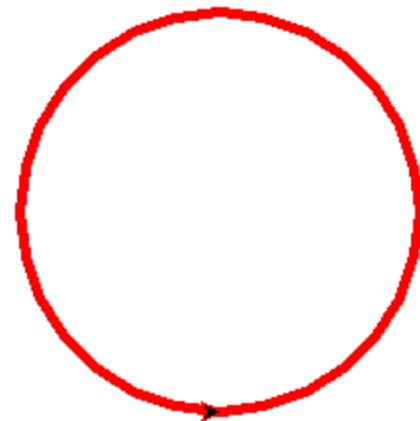
```
>>> import turtle
>>> turtle.dot()
>>> turtle.forward(50)
>>> turtle.dot()
>>> turtle.forward(50)
>>> turtle.dot()
>>> turtle.forward(50)
>>>
```



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:

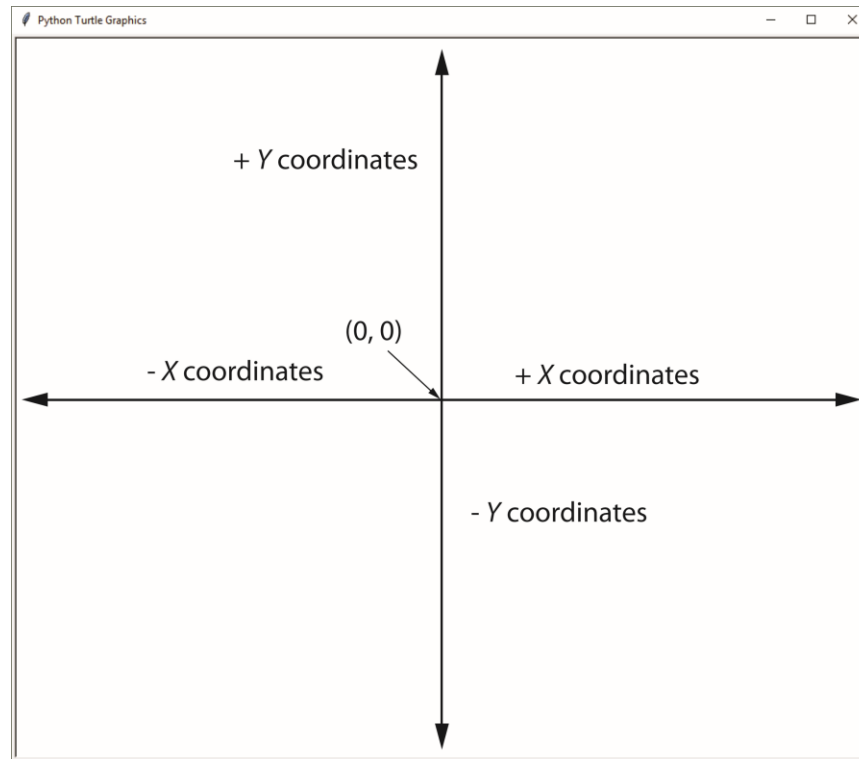
```
>>> import turtle
>>> turtle.setup(640, 480)
>>>
```

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

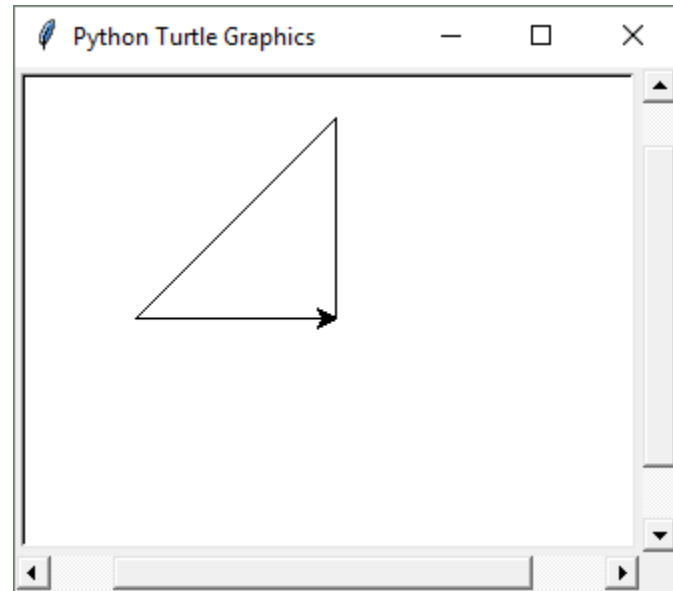
- The turtle uses **Cartesian Coordinates**



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

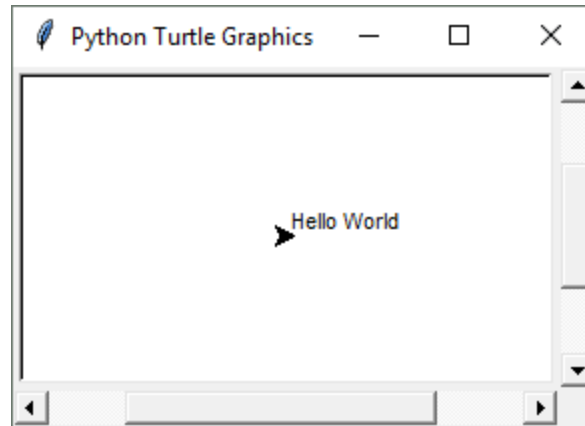
- Use the `turtle.hideturtle()` command to hide the turtle.
 - This command does not change the way graphics are drawn, it simply hides the turtle icon.
- Use the `turtle.showturtle()` command to display the turtle.

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')  
>>>
```

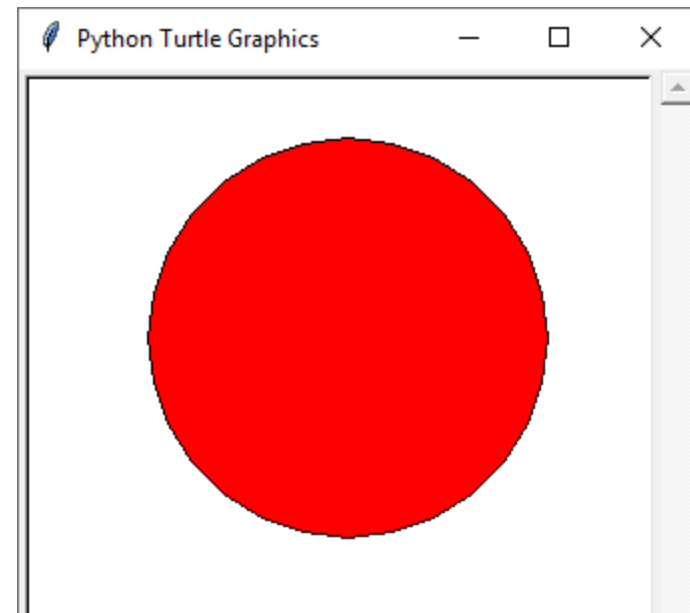


Filling Shapes

- **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