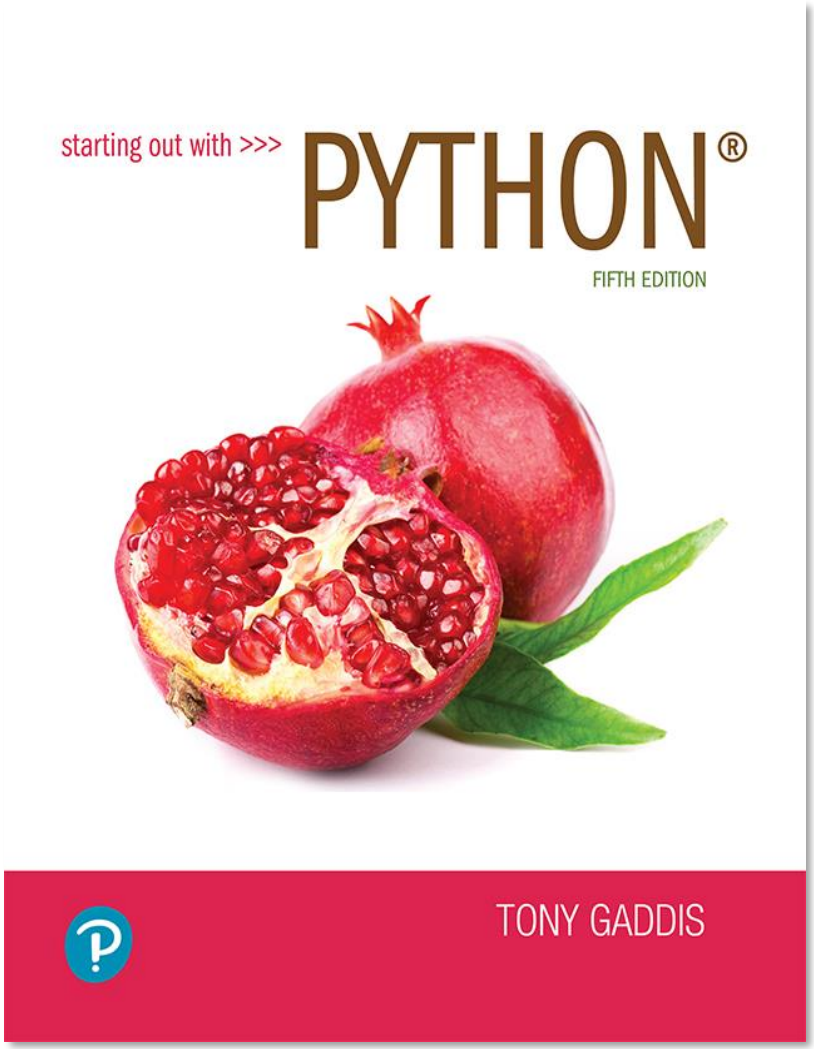
Starting out with Python

Fifth Edition



Chapter 2

Input, Processing, and Output

Topics (1 of 2)

- Designing a Program
- Input, Processing, and Output
- Displaying Output with `print` Function
- Comments
- Variables
- Reading Input from the Keyboard
- Performing Calculations
- String Concatenation

Topics (2 of 2)

- More About The `print` Function
- Displaying Formatted Output
- Named Constants
- Introduction to Turtle Graphics

Designing a Program (1 of 3)

- 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 (2 of 3)

- 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 (3 of 3)

- 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 (1 of 2)

- 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

Flowcharts (2 of 2)

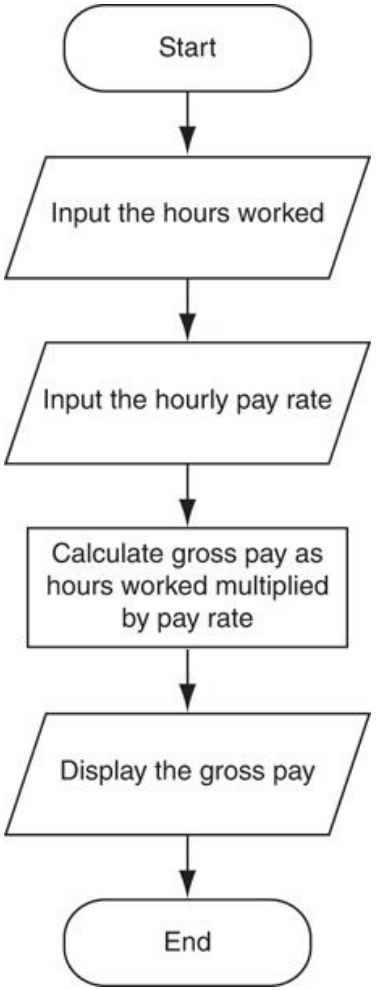


Figure 2-2 The program development cycle

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

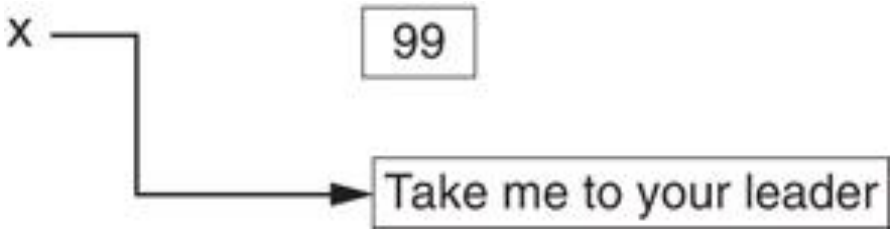


Figure 2-8 The variable x references a string

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 (1 of 2)

- 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 (2 of 2)

- 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)
```

String Concatenation (1 of 2)

- To append one string to the end of another string
- Use the + operator to concatenate strings

```
>>> message = 'Hello ' + 'world'
>>> print(message)
Hello world
>>>
```

String Concatenation (2 of 2)

- You can use string concatenation to break up a long string literal

```
print('Enter the amount of ' +
      'sales for each day and ' +
      'press Enter.')
```

This statement will display the following:

```
Enter the amount of sales for each day and press Enter.
```

Implicit String Literal Concatenation (1 of 2)

- Two or more string literals written adjacent to each other are implicitly concatenated into a single string

```
>>> my_str = 'one' 'two' 'three'
>>> print(my_str)
onetwothree
```

Implicit String Literal Concatenation (2 of 2)

```
print('Enter the amount of '
      'sales for each day and '
      'press Enter.')
```

This statement will display the following:

```
Enter the amount of sales for each day and press Enter.
```

More About The `print` Function (1 of 2)

- `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 The `print` Function (2 of 2)

- Special characters appearing in string literal
  - Preceded by backslash (`\`)
    - Examples: newline (`\n`), horizontal tab (`\t`)
  - Treated as commands embedded in string

Displaying Formatted Output with F-strings (1 of 8)

- An f-string is a special type of string literal that is prefixed with the letter `f`

```
>>> print(f'Hello world')
Hello world
```

- F-strings support placeholders for variables

```
>>> name = 'Johnny'
>>> print(f'Hello {name}.')
Hello Johnny.
```

Displaying Formatted Output with F-strings (2 of 8)

- Placeholders can also be expressions that are evaluated

```
>>> print(f'The value is {10 + 2}.')
The value is 12.
```

```
>>> val = 10
>>> print(f'The value is {val + 2}.')
The value is 12.
```

Displaying Formatted Output with F-strings (3 of 8)

- Format specifiers can be used with placeholders

```
>> num = 123.456789
>> print(f'{num:.2f}')
123.46
>>>
```

- `.2f` means:
  - round the value to 2 decimal places
  - display the value as a floating-point number

Displaying Formatted Output with F-strings (4 of 8)

- Other examples:

```
>> num = 1000000.00
>> print(f'{num:,.2f}')
1,000,000.00


>>> discount = 0.5
>>> print(f'{discount:.0%}')
50%
```

Displaying Formatted Output with F-strings (5 of 8)

- Other examples:

```
>> num = 123456789
>> print(f'{num:,d}')
123,456,789
```

```
>>> num = 12345.6789
>>> print(f'{num:.2e}')
1.23e+04
```

Displaying Formatted Output with F-strings (6 of 8)

- Specifying a minimum field width:

```
>>> num = 12345.6789
>>> print(f'The number is {num:12,.2f}')
The number is   12,345.68
```

Field width = 12

```
The number is   12,345.68
```

Field width = 12

Displaying Formatted Output with F-strings (7 of 8)

- Aligning values within a field
  - Use < for left alignment
  - Use > for right alignment
  - Use ^ for center alignment

- Examples:
  - `print(f'{num:<20.2f}')`
  - `print(f'{num:>20.2f}')`
  - `print(f'{num:^20.2f}')`

Displaying Formatted Output with F-strings (8 of 8)

- The order of designators in a format specifier
  - When using multiple designators in a format specifier, write them in this order:

```
[alignment][width][,][.precision][type]
```

- Example:
  - `print(f'{number:^10,.2f}')`

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:

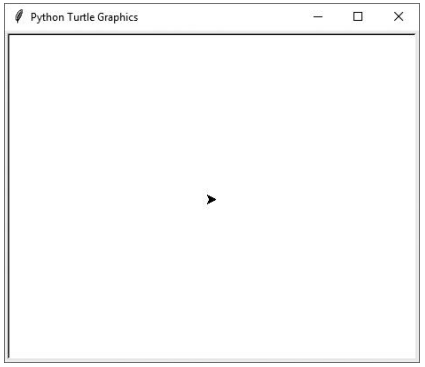
```
amount = balance * INTEREST_RATE
```

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 (1 of 2)

- 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 (2 of 2)

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

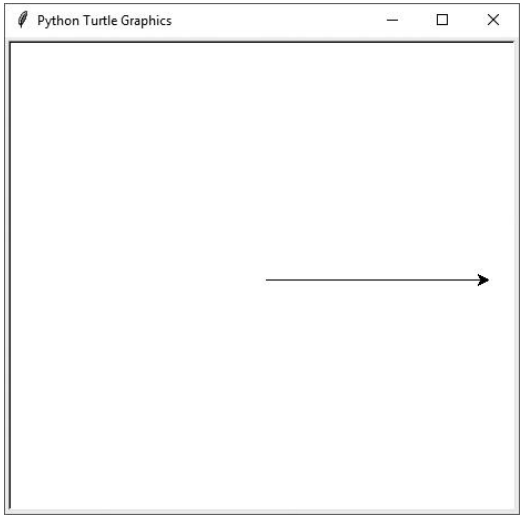
```
import turtle
```

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)
>>>
```

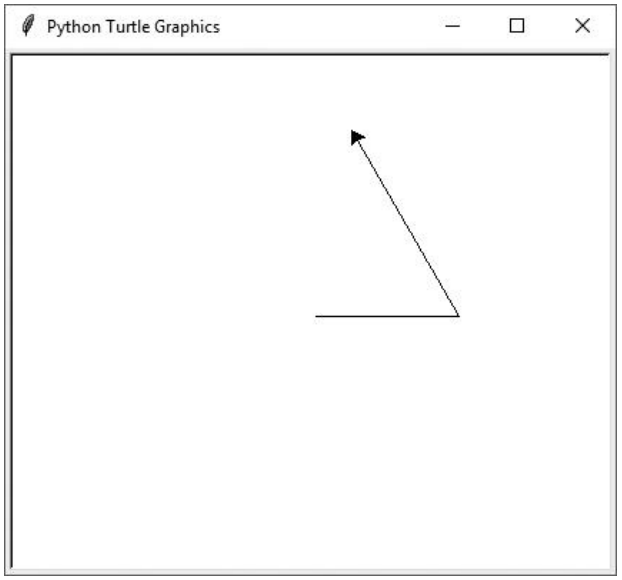


Turning the Turtle (1 of 3)

- 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.

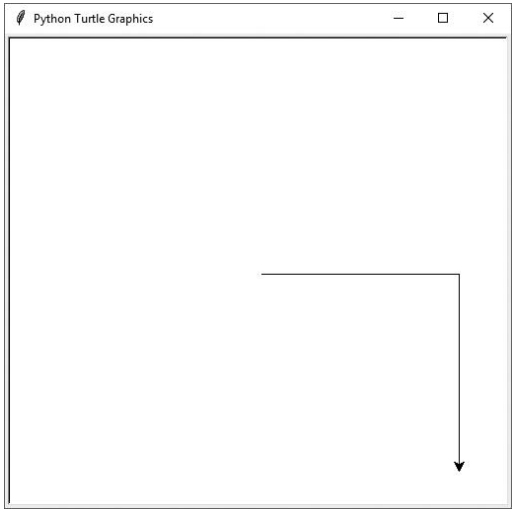
Turning the Turtle (2 of 3)

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



Turning the Turtle (3 of 3)

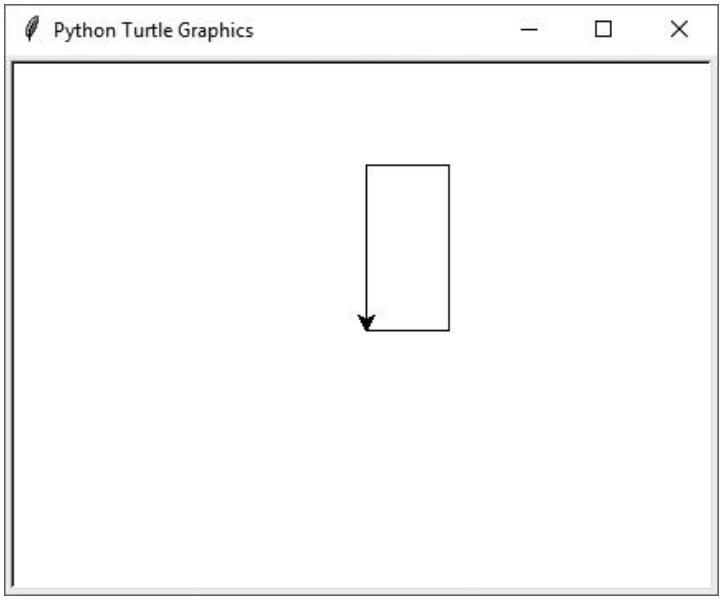
```
>>> import turtle
>>> turtle.forward(100)
>>> turtle.right(45)
>>> turtle.forward(100)
>>>
```



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)
>>>
```

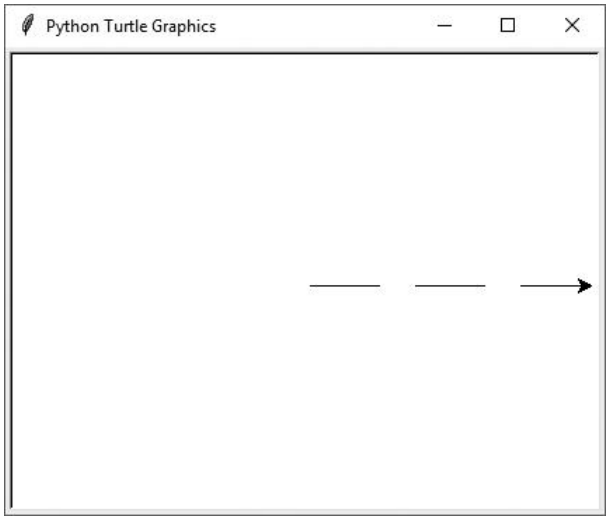


Setting the Pen Up or Down (1 of 2)

- 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 (2 of 2)

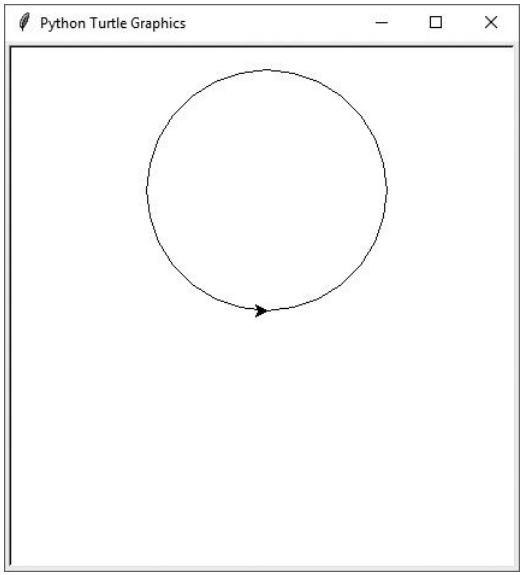
```
>>> import turtle
>>> turtle.forward(50)
>>> turtle.penup()
>>> turtle.forward(25)
>>> turtle.pendown()
>>> turtle.forward(50)
>>> turtle.penup()
>>> turtle.forward(25)
>>> turtle.pendown()
>>> turtle.forward(50)
>>>
```



Drawing Circles

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

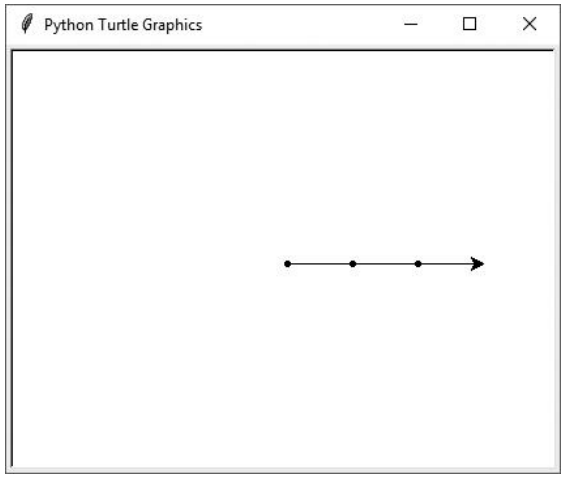
```
>>> import turtle
>>> turtle.circle(100)
>>>
```



Drawing Dots

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

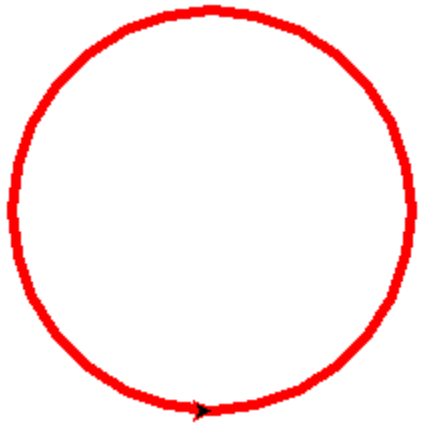
```
>>> import turtle
>>> turtle.dot()
>>> turtle.forward(50)
>>> turtle.dot()
>>> turtle.forward(50)
>>> turtle.dot()
>>> turtle.forward(50)
>>>
```



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 (1 of 3)

- 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.

Resetting the Turtle's Window (2 of 3)

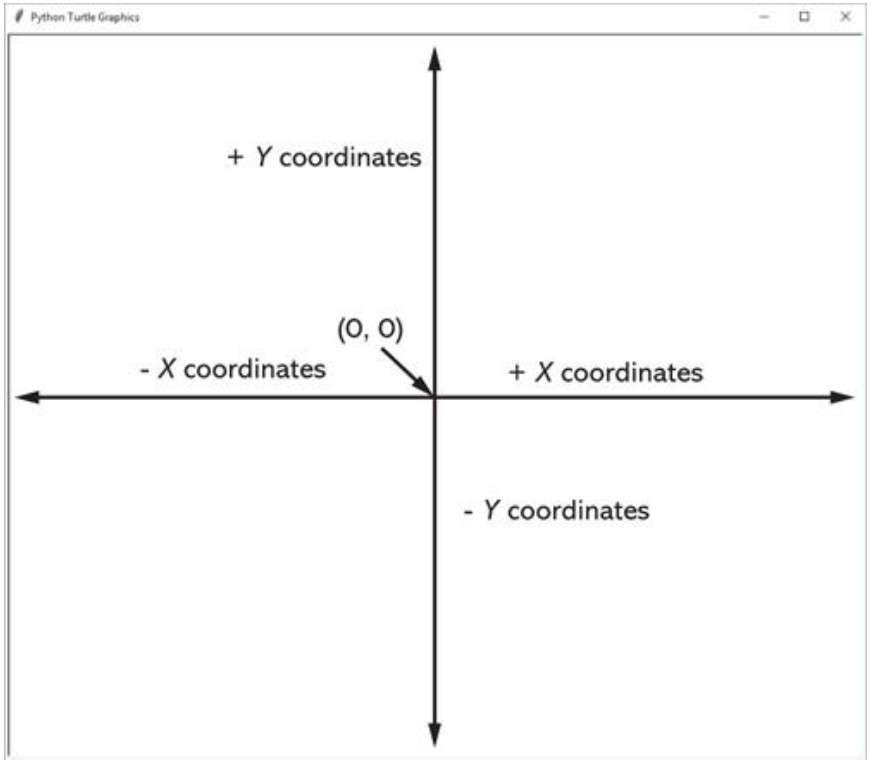
- The `turtle.clear()` statement:
  - Erases all drawings that currently appear in the graphics window.
  - Does *not* change the turtle's position.
  - Does *not* change the drawing color.
  - Does *not* change the graphics window's background color.

Resetting the Turtle's Window (3 of 3)

- 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

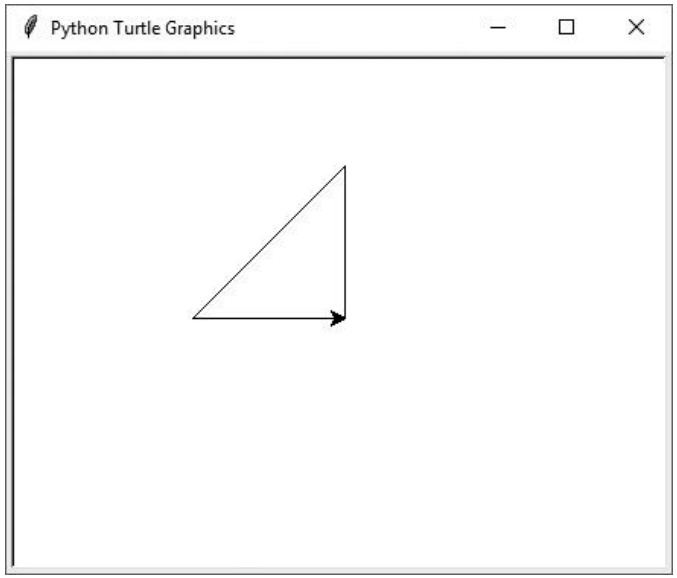
- The turtle uses Cartesian Coordinates



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

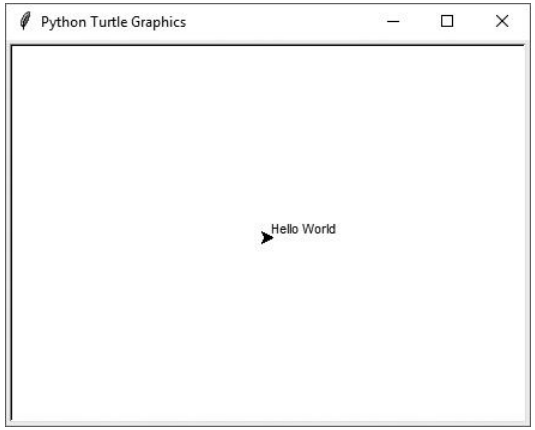
- Use the `turtle.hideturtle()` command to hide the turtle.
  - This command does not change the way graphics are drawn, it simply hides the turtle icon.
- Use the `turtle.showturtle()` command to display the turtle.

Displaying Text (1 of 2)

- 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 (2 of 2)

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

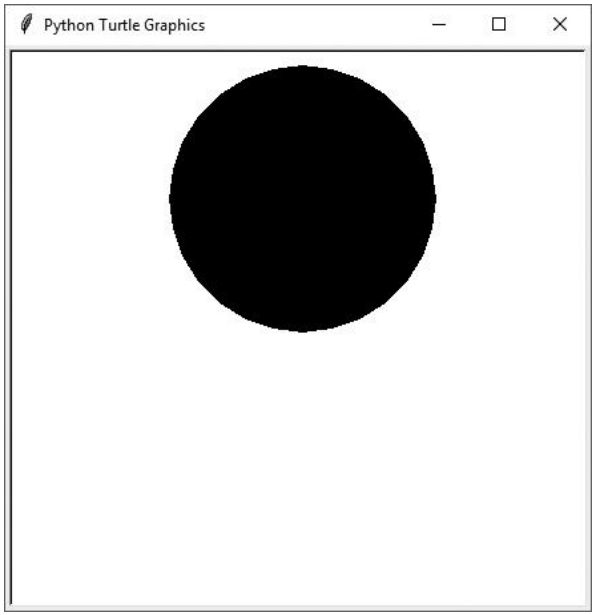


Filling Shapes (1 of 2)

- 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

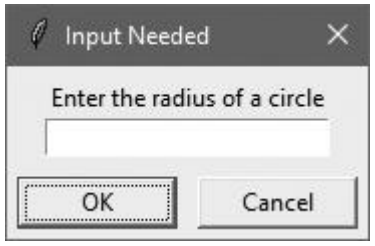
Filling Shapes (2 of 2)

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

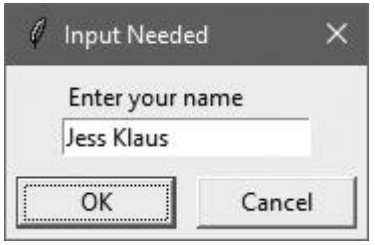


Getting Input With a Dialog Box (1 of 2)

```
>>> import turtle
>>> age = turtle.numinput('Input', 'Enter your age')
```



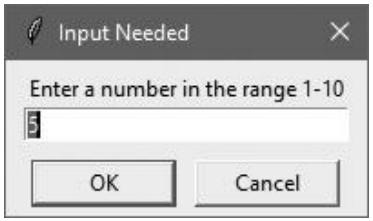

```
>>> import turtle
>>> name = turtle.textinput('Input', 'Enter your name')
```



Getting Input With a Dialog Box (2 of 2)

- Specifying a default value, minimum value, and maximum value with `turtle.numinput`:

```
>>> import turtle
>>> num = turtle.numinput('Input', 'Enter a number',
            default=10, minval=0, maxval=100)
```



- An error message will be displayed if the input is less than `minval` or greater than `maxval`

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