

Topic 6: Functions

What's a function?

How can we use functions to write better software?

Textbook

- Strongly Recommended Exercises
 - The Python Workbook: 85, 86, 98 and 103
- Recommended Exercises
 - The Python Workbook: 84, 88, 92, 93, 101 and 102
- Recommended Readings
 - Starting Out with Python
 - Chapter 3 and Chapter 6 (2nd Ed.) / Chapter 5 (3rd Ed.)

What is a Function?

- What is a function?
 - A named set of statements
 - Perform some task
- Functions:
 - May take parameters
 - May return values
- What functions have you already used?

Motivation

- Ideally, a function should
 - perform a clearly defined specific single purpose
 - hide details from the caller
 - be sufficiently small to be easily understood
 - be well documented

Defining a Function

- Creates a function for later use
 - The function does not execute until it is called
 - Function may be called many times (from different places) after it has been defined
- General form:
 - `def functionName (parameters) :`
 `statement(s)`

Example

- Create a function that draws a music note
 - Head will be a solid oval, 20 pixels wide and 10 pixels high
 - Stem will be 50 pixels tall on the right side
 - Center the head of the note at 100, 100

Calling Our Function

- A function does not execute when it is defined
 - It must be called
- Execution for the entire program begins at the first statement outside of a function

Example

- What's the problem with our function?
- How do we fix it?

Parameters

- Allow us to provide data to a function
 - Data is placed in brackets after the function name when the function is called
 - Parameter variables appear in brackets after the function name in the function definition
 - Values appear in parameter variables when the function executes
 - Parameters are positional

Terminology

- Actual Parameter
 - The value placed in brackets after the function name when the function is called
- Formal Parameter
 - The name of the parameter variable in the function definition

Example

- Extend our note drawing function so that it takes two parameters that control the position of the note

Named Parameters

- Positional parameters assign values to parameter variables in the order that they occur
- Named parameters allow us to assign values in any order
 - Allow for optional parameters / default values for some parameters
 - May still be used in a positional manner

Example

- Extend the note drawing function so that it takes additional parameters that specify the color of the note

Default Parameter Values

- Python permits default values for parameters
 - If the function call does not supply a value then the default is used
 - If the call includes a value for that parameter then the default value is overridden

Functions Can Call Functions

- Create a second function for drawing a note
 - Head will be a solid oval, 20 pixels wide and 10 pixels high
 - Stem will be 50 pixels tall on the right side
 - Flag will be a curve

Functions Can Call Functions

Functions Can Return a Result

- Returning a result allows a value to move from the function to the location where it was called
 - Accomplished using a return statement inside the function
 - When the function is called it is often on the right side of an assignment statement

Functions Can Return a Result

- Write a function that determines the number of real roots of an equation of the form $ax^2 + bx + c = 0$

Variables & Functions

- Variables can be defined inside functions
 - A variable defined inside of a function can only be used inside that function
 - Behaves just like the variables we have used previously

Variables & Functions

- Variables can be defined outside of functions
 - Referred to as global variables
 - Can be read anywhere in the program after it is assigned a value
 - All of the constants we have created are global variables that we choose not to change
 - Use of global variables (other than as constants) is strongly discouraged

Variables & Functions

- Changing global variables
 - By default, an assignment statement inside of a function creates a new variable within that function
 - Even if a global variable with that name already exists
 - Want to change a global variable?
 - Include a global statement at the beginning of the function

Example

- Create a function that computes n-factorial

Returning Multiple Values

- What if we need to return more than one value from a function?
 - Comma separated tuple of values in return statement
 - Comma separated tuple of variables to the left of the equals sign

Scope

- Scope determines the portion of a program where a name can be used
 - Impacts functions, variables, ...
- Functions
 - Functions can't be called before they have been defined
 - Functions in other modules cannot be used until after the import statement for that module

Scope

- Variables
 - Cannot be read before they are given a value
 - Can be used from the point where they are first assigned a value until the end of the function
 - Variables created inside a function are destroyed when the function exits

Formal Parameters

- Formal Parameter variables hold values passed to a function from the calling scope
 - Formal parameters are normally read
 - It is also possible to store a new value into a formal parameter (we don't usually do this!)
 - Value of the variable will change in the called function
 - For the types we have used so far, the value will **not** change in the main program

Why Functions are Useful

- Facilitate Code Reuse
 - Write once, use many times
- Reduce Complexity
 - Low level details are hidden
 - Programmer can concentrate on higher level problems
- Ease Maintenance
 - Bugs only need to be corrected once
 - Functions can be tested separately

Comments

- Every function should begin with a comment
 - Describe the action taken by the function
 - Describe the parameters that need to be provided
 - Describe the value returned by the function

Preconditions / Postconditions

- Function comments may also describe
 - Preconditions:
 - Conditions that must be true before the function executes
 - If any precondition is not met, the function may not behave correctly
 - Postconditions:
 - Conditions that are guaranteed to be true after the function executes
 - If the function doesn't make a post-condition true then the function contains a bug that must be fixed

Example

- Addition and multiplication practice:
 - 10 random questions that involve adding or multiplying 2 integers between 1 and 10

Example

Testing

- Test each function you write individually
 - Errors are easier to find
 - Generally only need to look inside the function being tested
 - Only use the function in the rest of your program once you have tested it thoroughly

Design

- How do functions relate to top down design?
 - Use top down design to break the problem into smaller pieces
 - Each smaller piece is a good candidate for a function
 - Look at each function
 - Is it too big?
 - Does it contain repeated code?
 - Should it call other functions?

Modules

- Functions can be placed in modules to promote reuse
 - Place the functions in a different .py file
 - Import it just like math or SimpleGraphics
 - Add an if statement to prevent the main program from running in the imported file

```
if __name__ == "__main__":  
    main()
```

Wrapping Up

- Functions
 - A named group of statements that perform a task
 - Allow us to break our program into separate units that each have a specific purpose
 - Ease program creation and debugging

Where Are We Going?

- Now that we can write larger programs we want to be able to manage more data
 - How can we work with many values at the same time in a reasonable way?
 - How do we read and write values in files?