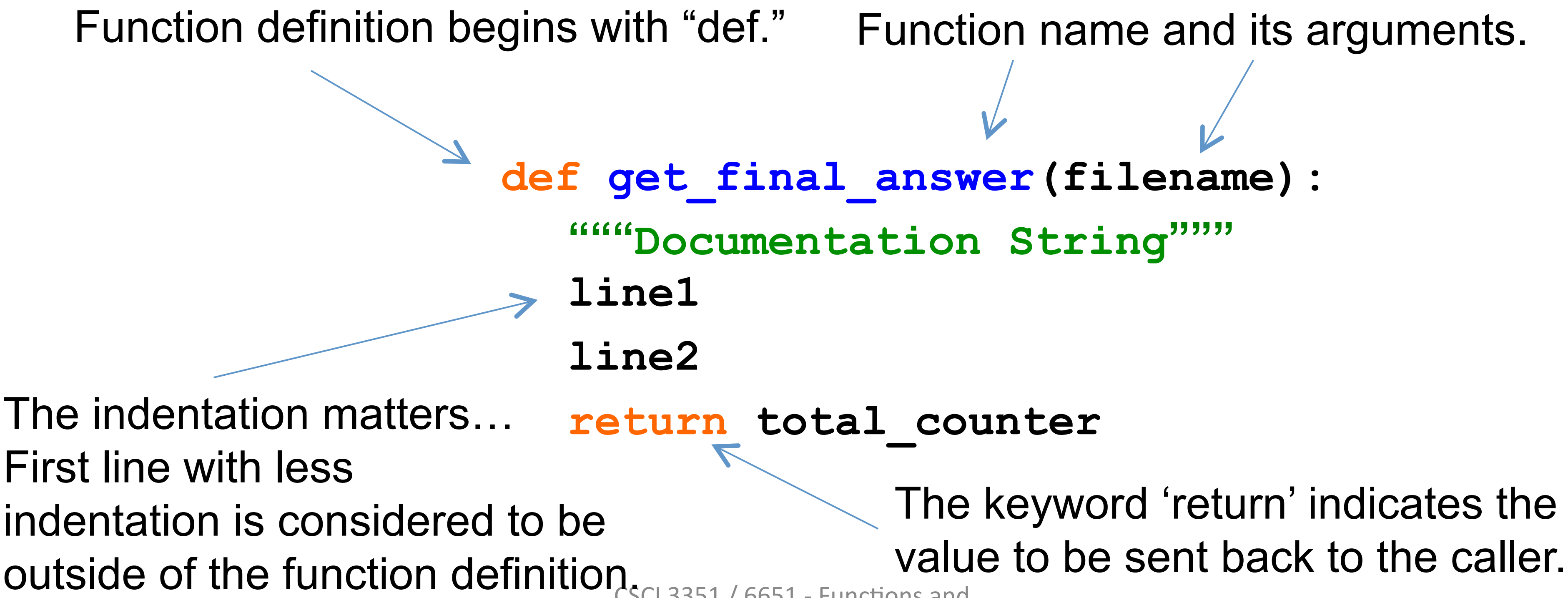
Functions and Sequences

Lecture 2

CSCI 3351 & CSCI 6651
Dr. Frank Breitinger

Defining Functions



Function definition begins with “def.”

Function name and its arguments.

```
def get_final_answer(filename):
    ““““Documentation String””””
    line1
    line2
    return total_counter
```

The indentation matters… First line with less indentation is considered to be outside of the function definition.

The keyword ‘return’ indicates the value to be sent back to the caller.

Functions vs. methods

- Some operations are functions and others methods
  - You just have to learn (and remember or lookup) which operations are functions and which are methods

len() is a function on collections that returns the number of things they contain

```
>>> len(['a', 'b', 'c'])
3
>>> len(('a','b','c'))
3
>>> len("abc")
3
```

index() is a method on collections that returns the index of the 1st occurrence of its arg

```
>>> ['a’,'b’,'c'].index('a')
0
>>> ('a','b','c').index('b')
1
>>> "abc".index('c')
2
```

Python and Types

- **Dynamic typing**: Python determines the data types of variable bindings in a program automatically
- **Strong typing**: But Python’s not casual about types, it enforces the types of objects
- For example, you can’t just append an integer to a string, but must first convert it to a string

```
x = “the answer is ” # x bound to a string
y = 23      # y bound to an integer.
print x + y   # Python will complain!
```

Calling a Function

- The syntax for a function call is:

```
>>> def myfun(x, y):
          return x * y
  >>> myfun(3, 4)
  12
```

Functions without returns

- All functions in Python have a return value, even if no return line inside the code
- Functions without a return, return dthe special value None
  - None is a special constant in the language
  - None is used like NULL, void, or nil in other languages
  - None is not equivalent to False

Function overloading? No.

- There is no function overloading in Python
  - Unlike C++, a Python function is specified by its name alone
  - The number, order, names, or types of arguments cannot be used to distinguish between two functions with the same name
  - Two different functions can't have the same name, even if they have different arguments

Default Values for Arguments

- You can provide default values for a function’s arguments
- These arguments are optional when the function is called

```
>>> def myfun(b, c=3, d=“hello”):
           return b + c
>>> myfun(5,3,”hello”)
>>> myfun(5,3)
>>> myfun(5)
```

- All of the above function calls return 8

Keyword Arguments

- Can call a function with some/all of its arguments out of order as long as you specify their names

```
>>> def foo(x,y,z): return(2*x,4*y,8*z)
>>> foo(2,3,4)
(4, 12, 32)
>>> foo(z=4, y=2, x=3)
(6, 8, 32)
>>> foo(-2, z=-4, y=-3)
(-4, -12, -32)
```

- Can be combined with defaults, too

```
>>> def foo(x=1,y=2,z=3): return(2*x,4*y,8*z)
>>> foo()
(2, 8, 24)
>>> foo(z=100)
(2, 8, 800)
```

*args and **kwargs

- By convention the names are *args and **kwargs.
- One would use *args when you're not sure how many arguments might be passed to your function, i.e. it allows you pass an arbitrary number of arguments to your function:

```
>>> def print_everything(*args):
    for count, thing in enumerate(args):
...         print( '{0}. {1}'.format(count, thing))
...
>>> print_everything('apple', 'banana', 'cabbage')
```

*args and **kwargs

- Similarly, **kwargs allows you to handle named arguments that you have not defined in advance:

```
>>> def table_things(**kwargs):
...     for name, value in kwargs.items():
...         print( '{0} = {1}'.format(name, 
value))
...
>>> table_things(apple = 'fruit', cabbage = 
'vegetable')
```

*args and **kwargs

- One can use these along with named arguments too.
  - The explicit arguments get values first and then everything else is passed to *args and **kwargs. The named arguments come first in the list. For example:

```
def table_things(titlestring, **kwargs)
```

- You can also use both in the same function definition but *args must occur before **kwargs.

*args and **kwargs

- You can also use the * and ** syntax when calling a function. For example:

```
>>> def print_three_things(a, b, c):
...     print( 'a = {0}, b = {1}, c = 
{2}'.format(a,b,c))
...
>>> mylist = ['aardvark', 'baboon', 'cat']
>>> print_three_things(*mylist)
a = aardvark, b = baboon, c = cat
```

- In this case it takes the list (or tuple) of items and unpacks it. By this it matches them to the arguments in the function. Of course, you could have a * both in the function definition and in the function call.

Functions are first-class objects

- Functions can be used as any other datatype, e.g.:
  - Arguments to function
  - Return values of functions
  - Assigned to variables
  - Parts of tuples, lists, etc.

```
>>> def square(x): return x*x

>>> def applier(q, x): return q(x)

>>> applier(square, 7)
49
```

Lambda Notation

- Python’s lambda creates anonymous functions

```
  >>> applier(lambda z: z * 42, 7)
294
```

- Note: only one expression in the lambda body; its value is always returned
- Python supports functional programming idioms: map, filter, closures, continuations, etc.

Lambda Notation

- Be careful with the syntax

```
>>> f = lambda x,y : 2 * x + y
>>> f
<function <lambda> at 0x87d30>
>>> f(3, 4)
10
>>> v = lambda x: x*x(100)
>>> v
<function <lambda> at 0x87df0>
>>> v = (lambda x: x*x)(100)
>>> v
10000
```

Example: composition

```
>>> def square(x):
        return x*x
>>> def twice(f):
        return lambda x: f(f(x))
>>> twice
<function twice at 0x87db0>
>>> quad = twice(square)
>>> quad
<function <lambda> at 0x87d30>
>>> quad(5)
625
```

Lambda Notation Limitations

- Note: only one expression in the lambda body; Its value is always returned
- The lambda expression must fit on one line!
- Lambda will probably be deprecated in future versions of python
  - Guido is not a lambda fanboy

Functional programming

- Python supports functional programming idioms
- Builtins for map, reduce, filter, etc.
- These are often used with lambda

http://book.pythontips.com/en/latest/map_filter.html

map

- Applies a function to all the items in an input_list. Here is the blueprint:

```
map(function_to_apply, list_of_inputs)
```

- **Exercise** – replace this code by using Lambda and map:

```
items = [1, 2, 3, 4, 5]
squared = []
for i in items:
    squared.append(i**2)
```

Example: map

```
>>> def add1(x): return x+1
>>> map(add1, [1,2,3,4])
[2, 3, 4, 5]
>>> map(lambda x: x+1, [1,2,3,4])
[2, 3, 4, 5]
>>> map(+, [1,2,3,4], [100,200,300,400])
map(+,[1,2,3,4],[100,200,300,400])
         ^
SyntaxError: invalid syntax
```

filter

- As the name suggests, filter creates a list of elements for which a function returns true. Here is a short and concise example:

```
number_list = range(-5, 5)
less_than_zero = list(filter(lambda
x: x < 0, number_list))
print(less_than_zero)
```

reduce

- Reduce is a really useful function for performing some computation on a list and returning the result. It applies a rolling computation to sequential pairs of values in a list. For example, if you wanted to compute the product of a list of integers.

```
from functools import reduce
product = reduce((lambda x, y: x * y), [1, 2, 3,
4])
print(product)
>>> 24
```

Global versus Local Scopes

- **Scopes**: Different areas of a program that are separate from each other
- Every function has its own scope
- Functions can't directly access each other's variables
- **But can exchange information through parameters and return values**

Global versus Local Variables

```
def func1():
        local_name1 = "Func1” #local variable
        print local_name1, global_name
        #can access global_name but not local_name2
def func2():
        local_name2 = "Func2"
        print local_name2, global_name
        #but can not access local_name1 here

global_name = "Global” #global variable
#can not access local_name1 & local_name2 here
func1()
func2()
```

Shadowing/Changing a Global Variable from Inside a Function

```
def demo():
    global value1 #full access of global variable value1
    value1 = -value1
    value2 = -20 #a new variable with same name (shadow)
    print("Inside local scope:", value1, value2, value3)
value1 = 10
value2 = 20
value3 = 30
print("In the global scope:", value1, value2, value3)
demo() # value1 is changed; value2 and value3 not
print("Back in the global scope", value1, value2, value3)
```

- **Shadow:** To hide a global variable inside a scope by creating a new local variable of the same name
- Not a good idea to shadow a global variable

Tuples, Lists, and Strings

SEQUENCE TYPES

Sequence Types

- Tuple: (‘john’, 32, [CMSC])
  - A simple **immutable** ordered sequence of items
  - Items can be of mixed types, including collection types
- Strings: “John Smith”
  - **Immutable**
  - Conceptually very much like a tuple
- List: [1, 2, ‘john’, (‘up’, ‘down’)]
  - **Mutable** ordered sequence of items of mixed types

Similar syntax

- All three sequence types (tuples, strings, and lists) share much of the same syntax and functionality.
- Key difference:
  - Tuples and strings are immutable
  - Lists are mutable
- The operations shown in this section can be applied to all sequence types
  - most examples will just show the operation performed on one

Sequence Types 1

- Define tuples using parentheses and commas

```
>>> tu = (23, ‘abc’, 4.56, (2,3), ‘def’)
```

- Define lists are using square brackets and commas

```
>>> li = [“abc”, 34, 4.34, 23]
```

- Define strings using quotes (“, ‘, or “““).

```
>>> st = “Hello World”
>>> st = ‘Hello World’
>>> st = “““This is a multi-line
string that uses triple quotes.”
```

Sequence Types 2

- Access individual members of a tuple, list, or string using square bracket “array” notation
- Note that all are 0 based…

```
>>> tu = (23, ‘abc’, 4.56, (2,3), ‘def’)
>>> tu[1]     # Second item in the tuple.
 ‘abc’

>>> li = [“abc”, 34, 4.34, 23]
>>> li[1]      # Second item in the list.
 34

>>> st = “Hello World”
>>> st[1]   # Second character in string.
 ‘e’
```

Positive and negative indices

```
>>> t = (23, ‘abc’, 4.56, (2,3), ‘def’)
```

Positive index: count from the left, starting with 0

```
 >>> t[1]
‘abc’
```

Negative index: count from right, starting with –1

```
>>> t[-3]
4.56
```

Slicing: return copy of a subset

```
>>> t = (23, ‘abc’, 4.56, (2,3), ‘def’)
```

- Return a copy of the container with a subset of the original members. Start copying at the first index, and stop copying before second.

```
>>> t[1:4]
(‘abc’, 4.56, (2,3))
```

- Negative indices count from end

```
>>> t[1:-1]
(‘abc’, 4.56, (2,3))
```

The ‘in’ Operator

- Boolean test whether a value is inside a container:

```
>>> t = [1, 2, 4, 5]
>>> 3 in t
False
>>> 4 in t
True
>>> 4 not in t
False
```

- For strings, tests for substrings

```
>>> a = 'abcde'
>>> 'c' in a
True
>>> 'cd' in a
True
>>> 'ac' in a
False
```

- Be careful: the in keyword is also used in the syntax of for loops and list comprehensions

The + Operator

- The + operator produces a new tuple, list, or string whose value is the concatenation of its arguments.

```
>>> (1, 2, 3) + (4, 5, 6)
 (1, 2, 3, 4, 5, 6)

>>> [1, 2, 3] + [4, 5, 6]
 [1, 2, 3, 4, 5, 6]

>>> “Hello” + “ ” + “World”
 ‘Hello World’
```

The * Operator

- The * operator produces a new tuple, list, or string that “repeats” the original content.

```
>>> (1, 2, 3) * 3
(1, 2, 3, 1, 2, 3, 1, 2, 3)

>>> [1, 2, 3] * 3
[1, 2, 3, 1, 2, 3, 1, 2, 3]

>>> “Hello” * 3
‘HelloHelloHello’
```

Lists are mutable

```
>>> li = [‘abc’, 23, 4.34, 23]
>>> li[1] = 45
>>> li
  [‘abc’, 45, 4.34, 23]
```

- We can change lists in place.
- Name li still points to the same memory reference when we’re done.

Tuples are immutable

```
>>> t = (23, ‘abc’, 4.56, (2,3), ‘def’)
>>> t[2] = 3.14
```

```
Traceback (most recent call last):
  File "<pyshell#75>", line 1, in -toplevel-
    tu[2] = 3.14
TypeError: object doesn't support item assignment
```

- You can’t change a tuple.
- You can make a fresh tuple and assign its reference to a previously used name.

```
>>> t = (23, ‘abc’, 3.14, (2,3), ‘def’)
```

- The immutability of tuples means they’re faster than lists.

Operations on Lists Only

```
>>> li = [1, 11, 3, 4, 5]

>>> li.append(‘a’)   # Note the method syntax
>>> li
[1, 11, 3, 4, 5, ‘a’]

>>> li.insert(2, ‘i’)
>>>li
[1, 11, ‘i’, 3, 4, 5, ‘a’]
```

The extend method vs +

- + creates a fresh list with a new memory ref
- extend operates on list li in place.

```
>>> li.extend([9, 8, 7])
>>> li
[1, 2, ‘i’, 3, 4, 5, ‘a’, 9, 8, 7]
```

- Potentially confusing:
  - **extend** takes a list as an argument.
  - **append** takes a singleton as an argument.

```
>>> li.append([10, 11, 12])
>>> li
[1, 2, ‘i’, 3, 4, 5, ‘a’, 9, 8, 7, [10, 11, 12]]
```

Operations on Lists Only

- Lists have many methos, including index, count, remove, reverse, sort

```
>>> li = [‘a’, ‘b’, ‘c’, ‘b’]
>>> li.index(‘b’)  # index of 1st occurrence
1
>>> li.count(‘b’)  # number of occurrences
2
>>> li.remove(‘b’) # remove 1st occurrence
>>> li
  [‘a’, ‘c’, ‘b’]
```

https://docs.python.org/3/tutorial/datastructures.html

cont’d

```
>>> li = [5, 2, 6, 8]

>>> li.reverse()     # reverse the list *in place*
>>> li
  [8, 6, 2, 5]

>>> li.sort()        # sort the list *in place*
>>> li
  [2, 5, 6, 8]

>>> li.sort(some_function)
    # sort in place using user-defined comparison
```

Summary

- Strings, lists, tuples, sets and dictionaries all deal with aggregates
- Two big differences
  - Lists and dictionaries are mutable
    - Unlike strings, tuples and sets
  - Strings, lists and tuples are ordered
    - Unlike sets and dictionaries

Assignment 2

- Write a generic converter where the first parameter is “base” (2 <= base <= 16) and then other parameters (flexible amount) are decimal integers. Based on the base, the other integers should be converted. Please also verify that the parameters are integers and not a string / other object. Return a list.
  - 2, 5, 10, 3 will be converted in binary ‘101’, ‘1010’, ‘11’
  - 8, 5, 10 will be converted to octal ‘5’, ’12’
  - 16, 15, 40 will be converted to hex ‘F’, ’28’
  - 10, 12, “foo”, 3.5 will be converted to ’12’, ‘NA’, ‘NA’
  - 17, 12, 15 will be converted to “Wrong base"

Remark

- Any use of code from some source other than yourself has to be cited in the comments.
- You should not use any aspects of the Python language beyond what we have discussed in class.