CS2110 Lecture 5 Feb. 3, 2021

- HW1 due tomorrow
- DS1 Assignment graded
- Last time
  - Math functions and the math module
  - Chapter 6: introduction to function calls and defining new functions
  - HW1 information and advice
- Today
  - BeginningCh 7: logical/Boolean expressions, conditional execution – if / else
  - More Ch 6 on functions
    - Execution flow of control
    - Variables and parameters are local
    - Stack diagrams
    - return vs. print
  - More on HW1
    - Floor division (//) and modulus (%) operators (from Ch 2.7)
    - Math.ceil() function
    - String format and controlling number of printed decimal places
    - Fruitful functions, incl return vs. print

From last time: Ch 6 - Defining New Functions

```
def foo(a, b, c):
    temp = a * b
    result = temp + c
    return result
```

IMPORTANT

When executing a function call:

1) first, the function's parameter variables are bound to the *values* of the function call's arguments

2) then, body of the function is executed

```
>>> x = 3
>>> foo(x * x, x + 1, 3)
```

← foo will be executed with variable a bound to 9, b bound to 4, c bound to 3

foo "knows" nothing about x. x *isn't* passed in. 9, 4, and 3 are passed into foo.

Ch 6: Defining New Functions

Functions can have zero parameters:

```
def giveBack1():
    return(1)


>>> giveBack1()
1
```

You can type the function name at interpreter prompt:

```
>>> giveBack1
<function giveBack1 at 0x10367cb70>
>>> type(giveBack1)
<class 'function'>
```

Note: a function name is just like any other variable. It is bound to a value; in this case that value is a function object. Don't try to use that same name as a simple variable (e.g. giveBack1 = 3). You'll "lose" your function. You can even "break" Python – it doesn't prevent you from redefining built-in things:

```
>>> len("hello")   # len is an important standard Python function!
5
>>> len = 23
>>> len("hello")
 ERROR
```

Before looking at functions in more depths, we'll skip to Ch 7: Conditional execution

- Recall list of key programming components: Expressions, variables and assignment, functions, if-then-else (conditional execution), iteration
- We've covered three of them – expressions, variables and assignment, the basics of functions. Can't easily compute a lot yet. Need the last two – conditional execution and iteration.
- Before looking at functions in more depth (more Ch 6), we'll skip to basic "conditional execution" from Ch7 so that I can use if/else in examples

Ch7.1-7.3: Boolean expressions and Logical Operators

- Boolean expressions: have True/False as value

  E.g. 3 == (5 – x).
- Boolean/relational operators:

  <, >, >=, <=, !=

  E.g. (x + y) < 4
- Logical operators

  and, or , not

  E.g. (x < 5) or (z == “foo”)

Understand these well. Critical for conditional execution, decision making in programs!

Ch7.4-7.7: Condition execution - **if**

The most basic conditional statement is **if**

if (Boolean expression):

    …

    … lines of code that execute when Boolean

    … expression evaluates to True

…

… more lines of code. These execute whether or

… not Boolean expression evaluated to True

…

Ch7: Condition execution – **if-else**

if (Boolean expression):

    …

    … code that executes when Boolean expr

    … evaluates to True

else:

    …

    … code that executes when Boolean not true

    …

…

… code that executes after if-else statement, whether

… Boolean expression was True or not

…

Ch7: **if-else**

```
print('before if')
if (a < b):
    print('a is smaller')
else:
    print('a is not smaller')
print('after if')
print('goodbye')
```

NOTE: indentation semantically important. Has execution effect.

Return to Ch 6/Functions: Control Functions

A program consists of a list of instructions, executed (except in certain situations) in top-to-bottom order

```
x = 3                          ←1
y = x + 13                     ←2
z = foo(x, y, 3)               ← 3
newVal = math.sqrt(z)          ←7
result = x + newVal            ←8
print result                   ←9
```

```
def foo(a, b, c):
 temp = a + (b * c)            ← 4
 temp = temp/3.0               ← 5
 return temp                   ← 6
```

As part of 3, foo parameter
a is bound to 3 (not x!)
b is bound to 16 (not y!)
c is bound to 4

Ch 6.4: Variables and parameters are local

- A function's parameters are **local** variables. That is, they exist only during the execution of that function.
- Other variables that are assigned-to within a function body are also local (note: we'll see exception to this later)
- Top-level variables (not within **def**s) are called **global**

```
def foo(a, b):
    c = (a + b) * 2
    return(c)
```

IMPORTANT!

```
>>> foo(3, 4)
    14
>>> a
    Error
>>> c
    Error
```

Ch6: local/global variables

- Another way to say this is that each function has its own **scope** or **namespace**

```
>>> def f(x):
        y = 1
        x = x + y
        print(x)
        return x

>>> x = 3
>>> y = 2
>>> z = f(x)
4
>>> x
?   3
>>> y
?   2
>>>  z
    4
?
```

Function f's variable x. A **local** variable that exists only within scope of definition of f

Two completely different variables!

"Top-level" or **global** variable x

Hint: think of them as, e.g., x_f and x_{global}

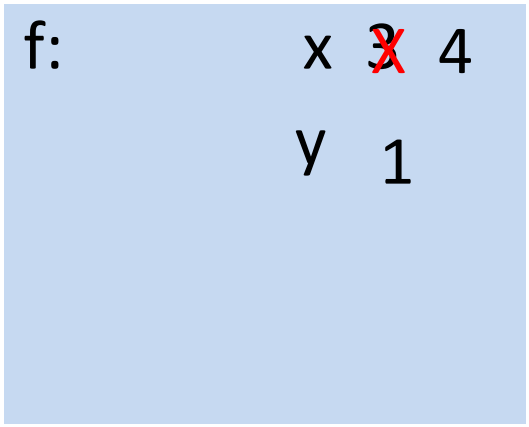
Ch6: Stack frames

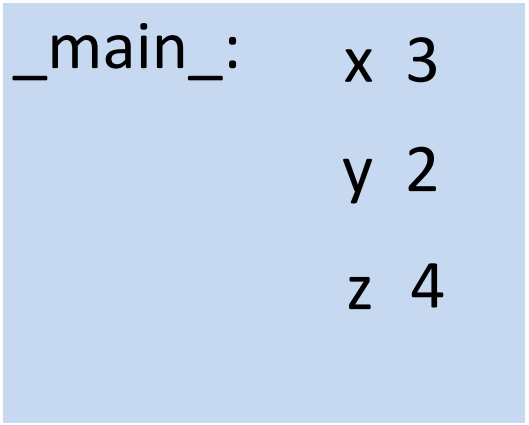
- At top level (the interpreter/shell) a "symbol table" keeps track of all variables (and values bound to them) defined at that level
- When a function is called, a new symbol table , or **stack frame**, is created to keep track of variables defined in the function and the values associated with those names. This includes (1) the function's parameters and (2) any other variables assigned to within the function
  - When the function finishes, the stack frame goes away.
- *Note: this isn't just one level, of course. As functions call other functions that call other functions, the stack (of stack frames) grows deeper …*

Ch6: Stack frames

```
>>> def f(x):
        y = 1
        x = x + y
        print(x)
        return x

>>> x = 3
>>> y = 2
>>> z = f(x)
4
>>> x
>>> y
>>> z
```





Will demo/discuss more complex example Friday

return vs print

print and **return** are very different (and some students never quite get this!)

```
def add1a(number):
    result = number + 1
    return result

def add1b(number):
    result = number + 1
    print(result)
```

Explore difference by using invoking them in shell in a couple of ways.

Ch 6: Why functions?

- Functions let you name a group of statements that make up a meaningful computation.
- Make programs easier to read and debug
  - E.g. debug functions one by one, assemble into whole program
- Make programs shorter (in lines of code) by eliminating duplication. If you start seeing same (or nearly the same) segments of code in various places in your program, consider defining a function and replacing the common segment with function calls.
- Well designed functions often useful in other programs you write.

HW1, including formatting string and outputting numbers with fixed number of decimal digits

- Take baby steps:
  - write a line or two
  - test
  - repeat!
- While debugging, use lots of print statements!
  - Sometimes even worth printing values after every line of code!
  - (remember to comment out/remove such debugging statements before submitting your homework)
- Consider using math.ceil() function for computing nights needed
- Some people have asked me about lastDayFraction in my HW1 suggested outline. There are many ways to do things. That's just how I think about it. Once the number of nights needed is known, what costs can we compute?
  - Hotel costs breakfast cost, dinner cost ✅
  - Lunch cost ❌
  - I calculate a value lastDayFraction to enable lunch cost calculation
- string **format** method makes it easy to print nice complicated strings and to control number of decimal places in printed numbers:

```
>>> item = 'bicycle'
>>> x = 423.1274123
>>> print("The cost of the {} is {:.2f}".format(item, x))
```

https://docs.python.org/3.9/library/string.html#format-string-syntax

Floor Division and Modulus (Ch 2.7) and math.ceil function

- //: “floor division operator. Divides two numbers and truncates (rounds down) to whole number

  14 // 3 yields 4

  8.1 // 2 yields 4.0

% very useful for, e.g., odd/even tests

- %: modulus operator yields remainder

  11 % 3 yields 2

  ((14 // 3) * 3) + (11 % 3) == 14 and in general (except for possible floating point issues), ((n // d) * d) + (n % d) == n

- math.ceil(x) yield nearest integer equal or greater than x. E.g. math.ceil(23.01) -> 24 and math.ceil(16.0) -> 16

Hint: I use this as key part of calculating required hotel nights

HW1: function tripCostData

def tripCostData(distanceKM, vehSpeedMPS, vehKPL, gasCostPerLiter, hotelCostPerNight, breakfastCostPerDay, lunchCostPerDay, dinnerCostPerDay) :

    ….

    …. Lines of code that calculate, in terms of parameters, cost of trip

    ….

    return tripCost, gasCost, foodCost, numLunches, numHotelNights

To the *user* of function, it's a "black box." User sends in values, sees printed answer!

HW1: function tripCostData

```
def tripCostData(distanceKM, vehSpeedMPS, vehKPL, gasCostPerLiter , hotelCostPerNight,
                 breakfastCostPerDay, lunchCostPerDay, dinnerCostPerDay) :
    totalCost = 0
    # compute length of trip in hours
    hours = …
    # compute liters of gas needed
    litersNeeded = …
    # compute gas cost
    gasCost = …

    # compute number of nights (hotel stays) needed
    nights = …                    This should be an integer!
    # perhaps compute a number (0.0->1) representing fraction of final day
    lastDayFraction = …

    # compute breakfast, lunch, and dinner costs
    breakfastCost = …
    # (lunchCost might involve more than one line and an if statement)
    dinnerCost = …

    # sum costs
    totalCost = …

    # return results
    return totalCost, gasCost, …
```

HW1: compareVehiclesForTrip

```
def compareVehiclesForTrip(…) :
    # assign some new variables values based on converting units in input
    …

    # make two calls to tripCostInfo
    veh1Cost, gasCost1, veh1Nights, veh1Lunches, veh1FoodCost = tripCostData(...)
    veh2Cost, gasCost2, veh2Nights, veh2Lunches, veh2FoodCost = tripCostData(…)

    # compare results and print information and recommendation
    if (…):
        print(…)
        ..
    else:
        print(…)
        ..

    return # nothing needs to be returned
```

HW1 Q3 & Q4 - test functions?

- "Write function testQ1() that makes at least five calls to tripCostData(...) with different arguments."
- Students email me – "what's this, dude????"
- You should get in the habit of writing functions that you use to test your code as you are debugging it.
  - When you wrote tripCostInfo, you probably (I hope!) test it by trying
    >>> tripCostData(....)
    multiple times with different values in the interpreter. But that can get tedious, especially for larger, more complicated program.

    It can be better to "package up" the tests, so you can easily run them.
  -
    def testQ1():
      tripCostData(....)
      tripCostData(... different arguments...)
      tripCostData(… different arguments...)

    NOTE: Something is not right here! What? tripCostData doesn't print anything so testQ1() will run but show you nothing
    FIX? *Use print(tripCostData(…))*

    Then, every time you change tripCostInfo, you just run testTripCost and examine the output version what it should be.
- It's important that you choose the arguments of your tests carefully! Think about what sets of argument test the variety of situations that the function should handle
- Similarly, for testP2:
  - def testP2():
      compareVehiclesForTrip(…)
      compareVehiclesForTrip(…)
      compareVehiclesForTrip(…)

    NOTE: unlike for testP1(), no print(…) needed around compareVehiclesForTrip() because compareVehiclesForTrip already prints information (rather than returning it)

HW1 Q3 & Q4 - test functions

- It's important that you choose the arguments of your tests carefully! Think about what sets of argument test the variety of situations that the function should handle
- def testQ1()

  print(tripCostData(100.0, 100.0, 1.0, 1.0, 0.0, 0.0, 0.0, 0.0))

  print(tripCostData(200.0, 100.0, 1.0, 1.0, 0.0, 0.0, 0.0, 0.0))

  …
- from random import random

```
def testP1()
  print(tripCostData(random(),random(),random(),random(),random(),random(), random(), random()))
  print(tripCostData(random(),random(),random(),random(),random(),random(), random(), random()))
  print(tripCostData(random(),random(),random(),random(),random(),random(), random(), random()))
  print(tripCostData(random(),random(),random(),random(),random(),random(), random(), random()))
  print(tripCostData(random(),random(),random(),random(),random(),random(), random(), random()))
```

Not effective for testing!!

- for the random case, would you know the expected results? It's not a good test if you don't know expected results to compare to actual results

A few words on debugging and testing

- For beginning programmers, I'm not a big advocate of using "real" debuggers (the tools that come with IDEs like Wing and even IDLE).
- I'm a fan of *reading code carefully and critically* and
  - Using a lot of carefully placed print statements – print early, print often - see where things go wrong!
    - in HW1, if printed final results don't seem right, print out all your intermediate variables. Most people have variables for, e.g. driving time, gas needed, gas cost, hotel nights needed, etc. – print them all!
- I am also a fan of "baby steps": as I said earlier, write a little bit of code, then test, then a little more, and test again, etc. Small changes to a so-far-working program makes errors much easier to find.
- More to say on this later …

Next time

- Finish conditional execution part of Chapter 7
  - nested conditionals, if-elif-else
- start iteration (the last of the five key programming components). Read Ch 8 (it refers back to introduction to ”for” in 4.4 but you don’t really need to look at 4.4)