Control and Environments

Discussion 1: August 30, 2017

1 Control

Control structures direct the flow of logic in a program. For example, conditionals (if-elif-else) allow a program to skip sections of code, while iteration (while), allows a program to repeat a section.

If statements

Conditional statements let programs execute different lines of code depending on certain conditions. Let's review the if- elif-else syntax.

Recall the following points:

- The else and elif clauses are optional, and you can have any number of elif clauses.
- A conditional expression is a expression that evaluates to either a true value (True, a non-zero integer, etc.) or a false value (False, 0, None, "", [], etc.).
- Only the **suite** that is indented under the first if/elif with a **conditional expression** evaluating to a true value will be executed.
- If none of the **conditional expressions** evaluate to a true value, then the **else** suite is executed. There can only be one **else** clause in a conditional statement!

Boolean Operators

Python also includes the **boolean operators** and, or, and not. These operators are used to combine and manipulate boolean values.

- not returns the opposite truth value of the following expression.
- and stops evaluating any more expressions (short-circuits) once it reaches the first false value and returns it. If all values evaluate to a true value, the last value is returned.
- or short-circuits at the first true value and returns it. If all values evaluate to a false value, the last value is returned.

1.1 Alfonso will only wear a jacket outside if it is below 60 degrees or it is raining. Fill in the function wears_jacket which takes in the current temperature and a Boolean value telling if it is raining and returns True if Alfonso will wear a jacket and False otherwise.

This should only take one line of code!

```
def wears_jacket(temp, raining):
    """
    >>> wears_jacket(90, False)
    False
    >>> wears_jacket(40, False)
    True
    >>> wears_jacket(100, True)
    True
    """
```

1.2 To handle discussion section overflow, TAs may direct students to a more empty section that is happening at the same time. Define handle_overflow, which takes in the number of students in two sections and prints out what to do if either section exceeds 30 students. Note: Don't worry about printing "spot" for singular values and "spots" for multiple values.

```
def handle_overflow(s1, s2):
    """
    >>> handle_overflow(27, 15)
    No overflow.
    >>> handle_overflow(35, 29)
    1 spot left in Section 2.
    >>> handle_overflow(20, 32)
    10 spots left in Section 1.
    >>> handle_overflow(35, 30)
    No space left in either section.
    """
```

While loops

Iteration lets a program repeat statements multiple times. A common iterative block of code is the **while loop**.

As long as <conditional clause> evaluates to a true value, <body of statements> will continue to be executed. The conditional clause gets evaluated each time the body finishes executing.

Questions

1.3 What is the result of evaluating the following code?

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

def so_slow(num):
    x = num
    while x > 0:
        x = x + 1
    return x / 0

square(so_slow(5))
```

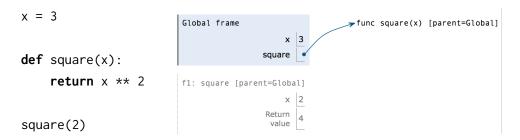
1.4 Fill in the is_prime function, which returns True if n is a prime number and False otherwise. After you have a working solution, think about potential ways to make your solution more *efficient*.

Hint: use the % operator: x % y returns the remainder of x when divided by y.

```
def is_prime(n):
```

2 Environment Diagrams

An **environment diagram** keeps track of all the variables that have been defined and the values they are bound to.



When you execute assignment statements in an environment diagram (like x = 3), you need to record the variable name and the value:

- 1. Evaluate the expression on the right side of the = sign
- 2. Write the variable name and the expression's value in the current frame.

When you execute def *statements*, you need to record the function name and bind the function object to the name.

1. Write the function name (e.g., square) in the frame and point it to a function object (e.g., func square(x) [parent=Global]). The [parent=Global] denotes the frame in which the function was defined.

When you execute a *call expression* (like square(2)), you need to create a new frame to keep track of local variables.

- 1. Draw a new frame. ^a Label it with
 - a unique index (f1, f2, f3 and so on)
 - the **intrinsic name** of the function (square), which is the name of the function object itself. For example, if the function object is func square(x) [parent=Global], the intrinsic name is square.
 - the parent frame ([parent=Global])
- 2. Bind the formal parameters to the arguments passed in (e.g. bind x to 3).
- 3. Evaluate the body of the function.

If a function does not have a return value, it implicitly returns None. Thus, the "Return value" box should contain None.

^aSince we do not know how built-in functions like add(...) or min(...) are implemented, we do *not* draw a new frame when we call built-in functions.

Questions

2.1 Draw the environment diagram that results from running the following code.

```
a = 1
def b(b):
    return a + b
a = b(a)
a = b(a)
```

2.2 Draw the environment diagram so we can visualize exactly how Python evaluates the code. What is the output of running this code in the interpreter?

```
from operator import add
def sub(a, b):
    sub = add
    return a - b
add = sub
sub = min
print(add(2, sub(2, 3)))
```

3 Higher Order Functions

A higher order function (HOF) is a function that manipulates other functions by taking in functions as arguments, returning a function, or both.

Functions as Arguments

One way a higher order function can manipulate other functions is by taking functions as input (an argument). Consider this higher order function called negate.

negate takes in a function f and a number x. It doesn't care what exactly f does, as long as f is a function, takes in a number and returns a number. Its job is simple: call f on x and return the negation of that value.

Questions

3.1 Implement a function keep_ints, which takes in a function cond and a number n, and only prints a number from 1 to n if calling cond on that number returns True:

```
def keep_ints(cond, n):
    """Print out all integers 1..i..n where cond(i) is true

>>> def is_even(x):
    ...  # Even numbers have remainder 0 when divided by 2.
    ...  return x % 2 == 0
    >>> keep_ints(is_even, 5)
2
4
"""
```

Functions as Return Values

Often, we will need to write a function that returns another function. One way to do this is to define a function inside of a function:

The return value of outer is the function inner. This is a case of a function returning a function. In this example, inner is defined inside of outer. Although this is a common pattern, we can also define inner outside of outer and still use the same return statement. However, note that in this second example (unlike the first example), inner doesn't have access to variables defined within the outer function, like x.

Questions

3.2 Use this definition of outer to fill in what Python would display when the following lines are evaluated.

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3.3 Implement a function keep_ints like before, but now it takes in a number n and returns a function that has one parameter cond. The returned function prints out all numbers from $1 \dots i \dots n$ where calling cond(i) returns True.

```
def keep_ints(n):
    """Returns a function which takes one parameter cond and
    prints out all integers 1..i..n where calling cond(i)
    returns True.

>>> def is_even(x):
    ...    # Even numbers have remainder 0 when divided by 2.
    ...    return x % 2 == 0
    >>> keep_ints(5)(is_even)
    2
```