



UC Berkeley EECS
Lecturer
Michael Ball

Computational Structures in Data Science



Week 4: HOFs & Environment Diagrams



UC Berkeley EECS
Lecturer
Michael Ball

Computational Structures in Data Science



Higher Order Functions: Returning a New Function



Learning Objectives

- Learn how to use and create higher order functions:
- Functions can be used as data
- Functions can accept a function as an argument
- **Functions can return a new function**



Review: What is a Higher Order Function?

- A function that takes in another function as an argument

OR

- A function that returns a function as a result.



Higher Order Functions

- **A function that returns (makes) a function**

```
1 def leq_maker(c):  
2     def leq(val):  
3         return val <= c  
4     return leq
```

```
>>> leq_maker(3)  
<function leq_maker.<locals>.leq at 0x1019d8c80>
```

```
>>> leq_maker(3)(4)  
False
```

```
>>> [x for x in range(7) if leq_maker(3)(x)]  
[0, 1, 2, 3]
```

Demo





UC Berkeley EECS
Lecturer
Michael Ball

Computational Structures in Data Science



Environment Diagrams



Environment Diagrams

- Organizational tools that help you understand code
- **Terminology:**
 - **Frame:** keeps track of variable-to-value bindings, each function call has a frame
 - **Global Frame:** global for short, the starting frame of all python programs, doesn't correspond to a specific function
 - **Parent Frame:** The frame of where a function is defined (default parent frame is global)
 - **Frame number:** What we use to keep track of frames, f_1 , f_2 , f_3 , etc
 - **Variable vs Value:** $x = 1$. x is the **variable**, 1 is the **value**



Environment Diagrams Reminders

1. Always draw the global frame first
2. When evaluating assignments (lines with single equal), always evaluate right side first
3. When you CALL a function MAKE A NEW FRAME!
4. When assigning a primitive expression (number, boolean, string) write the value in the box
5. When assigning anything else (lists, functions, etc.), draw an arrow to the value
6. When calling a function, name the frame with the intrinsic name – the name of the function that variable points to
7. The parent frame of a function is the frame in which it was defined in (default parent frame is global)
8. If the value for a variable doesn't exist in the current frame, search in the parent frame



Demo

Example 1:

- [Primitives and Functions: Environment Diagram Python Tutor:](#)

Example 2:

- [make_adder Higher Order Function: Environment Diagram Python Tutor Link](#)

Example 3:

- [Compose Python Tutor Link](#)



Example 1

```
a = "chipotle"
```

```
b = 5 > 3
```

```
c = 8
```

```
def foo(c):  
    return c - 5
```

```
def bar():  
    if b:  
        a = "taco bell"
```

```
result1 = foo(10)
```

```
result2 = bar()
```



Example 2

```
def make_adder(n):  
    def adder(k):  
        return k + n  
    return adder
```

```
n = 10  
add_2 = make_adder(2)  
x = add_2(5)
```



Python Tutor Examples

```
add_2 = make_adder(2)
add_3 = make_adder(3)
```

```
x = add_2(2)
def compose(f, g):
    def h(x):
        return f(g(x))
    return h
```

```
add_5 = compose(add_2, add_3)
z = add_5(x)
```



Environment Diagram Tips / Links

- NEVER draw an arrow from one variable to another.
- Useful Resources:
 - http://markmiyashita.com/cs61a/environment_diagrams/rules_of_environment_diagrams/
 - <http://albertwu.org/cs61a/notes/environments.html>