Functional Abstraction

Announcements

Zero-Argument Functions

(Demo)

Dice Functions

In the Hog project, there are multiple zero-argument functions that represent dice.

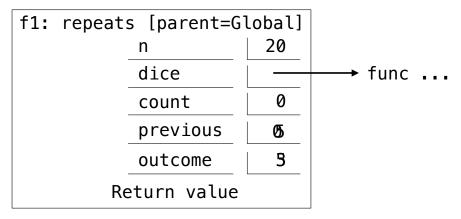A dice function returns an integer that is the outcome of rolling once. (Demo)

Implement repeat, which returns the # of times in n rolls that an outcome repeats.

5 3 3 4 2 1 6 5 3 4 2 2 2 4 4 3 4 3 5 5   repeat(20, six_sided) -> 5

```
def repeats(n, dice):
    count = 0
    previous = 0

    while n:
        outcome = dice()
        if previous == outcome :
            count += 1
        previous = outcome
        n -= 1
    return count
```

```
f1: repeats [parent=Global]
            n         |  20
            dice      |  ──────→ func ...
            count     |  0
            previous  |  0̶5̶
            outcome   |  5̶3̶
          Return value
```

Higher-Order Loops

(Demo)

https://pythontutor.com/cp/composingprograms.html#code=def%20reprint%28n%29%3A%0A%20%20%20%20def%20a%28word%29%3A%0A%20%20%20%20%20%20%20%20k%3D%20n%0A%20%20%20%20%20%20%20%20while%20k%3A%0A%20%20%20%20%20%20%20%20%20%20%20%20print%28word%29%0A%20%20%20%20%20%20%20%20%20%20%20%20k%20-%3D%201%0A%20%20%20%20return%20a%0A%20%20%20%20%0Areprint%282%29%28'hey'%29%0A&cumulative=true&curInstr=0&mode=display&origin=composingprograms.js&py=3&rawInputLstJSON=%5B%5D

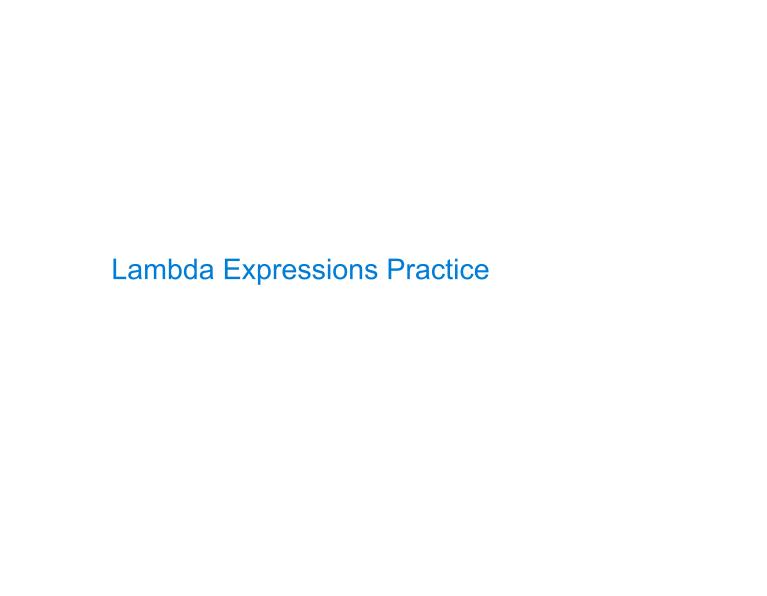# Conditional Expressions Practice

(3 and 4) - 5

True and False Values

The built-in bool(x) returns True for true x and False for false x.

```
>>> bool(0)
False
>>> bool(-1)
True
>>> bool(0.0)
False
>>> bool(' ')
True
>>> bool('')
False
>>> bool(False)
False
>>> bool(print('fool'))
fool
False
```

Lambda Expressions Practice

Lambda and Def

Any program containing lambda expressions can be rewritten using def statements.

```
                        twice                          square
>>> (lambda f: lambda x: f(f(x)))(lambda y: y * y)(3)
81

>>> def twice(f):
...     def g(x):
...         return f(f(x))
...     return g
...
>>> def square(y):
...     return y * y
...
>>> twice(square)(3)
81
```

(2.0 pt) Choose **all** correct implementations of `funsquare`, a function that takes a one-argument function `f`. It returns a one-argument function `f2` such that `f2(x)` has the same behavior as `f(f(x))` for all `x`.

```
>>> triple = lambda x: 3 * x
>>> funsquare(triple)(5)  # Equivalent to triple(triple(5))
45
```

A:
```
def funsquare(f):
    return f(f)
```

B:
```
def funsquare(f):
    return lambda: f(f)
```

C:
```
def funsquare(f, x):
    def g(x):
        return f(f(x))
    return g
```

D:
```
def funsquare(f):
    return lambda x: f(f(x))
```

E:
```
def funsquare(f, x):
    return f(f(x))
```

F:
```
def funsquare(f):
    def g(x):
        return f(f(x))
    return g
```

Spring 2020 Midterm 1 Question 1

```
>>> snap = lambda chat: lambda: snap(chat)
>>> snap, chat = print, snap(2020)
What is displayed here?
>>> chat()
What is displayed here?
```

https://pythontutor.com/cp/composingprograms.html#code=snap%20%3D%20lambda%20chat%3A%20lambda%3A%20snap%28chat%29%0Asnap,%20chat%20%3D%20print,%20snap%282020%29%0Achat%28%29%0A%0A&cumulative=true&curInstr=0&mode=display&origin=composingprograms.js&py=3&rawInputLstJSON=%5B%5D

Call Expressions

Assigning Names to Values

There are three ways of assigning a name to a value:

- Assignment statements (e.g., y = x) assign names in the current frame

- Def statements assign names in the current frame

- Call expressions assign names in a new local frame

```
h = lambda f: lambda x: f(f(x))        f = abs        h = lambda f: f(f(x))
h(abs)(-3)                             x = -3         x = -3
                                       f(f(x))        h(abs)
```

Twenty-One Environment Diagram

Twenty-One Rules

Two players alternate turns, on which they can add 1, 2, or 3 to the current total

The total starts at 0

The game end whenever the total is 21 or more

The last player to add to the total loses

Some states are good; some are bad

21+ ← 20 ← 18 ← 16 ← 14 ← 12 ...
            19 18 17   15 14 13

(Demo)

https://pythontutor.com/cp/composingprograms.html#code=def%20play%28strategy0,%20strategy1,%20goal%3D21%29%3A%0A%20%20%20%20n,
%20who%20%3D%200,%200%0A%20%20%20%20while%20n%20%3C%20goal%3A%0A%20%20%20%20%20%20%20%20if%20who%20%3D%3D%200%3A%0A%20%20%20%20%20%20%20%20%20%20%20%20n%20%3D%20n%20%2B%20strategy0%28n%29%0A%20%20%20%20%20%20%20%20who%20%3D%201%0A%20%20%20%20%20%20%20%20elif%20who%20%3D%3D%201%3A%0A%20%20%20%20%20%20%20%20%20%20%20%20n%20%3D%20n%20%2B%20strategy1%28n%29%0A%20%20%20%20%20%20%20%20who%20%3D%200%0A%20%20%20%20return%20who%0A%0Adef%20two_strat%28n%29%3A%0A%20%20%20%20return%202%0A%0Adef%20noisy_strat%28who,%20s%29%3A%0A%20%20%20%20def%20strat%28n%29%3A%0A%20%20%20%20%20%20%20%20choice%20%3D%20s%28n%29%0A%20%20%20%20%20%20%20%20print%28'Player',%20who,%20'added',%20choice,%20'to',%20n,%20'to%20reach',
%20choice%20%2B%20n%29%0A%20%20%20%20%20%20%20%20return%20choice%0A%20%20%20%20return%20strat%0A%0Aplay%28noisy_strat%280,%20two_strat%29,%20noisy_strat%281,%20two_strat%29%29&cumulative=true&curInstr=0&mode=display&origin=composingprograms.js&py=3&rawInputLstJSON=%5B%5D