Generators

Announcements

Tree Practice

Spring 2023 Midterm 2 Question 4(a)

Implement exclude, which takes a tree t and a value x. It returns a tree containing the root node of t as well as each non-root node of t with a label not equal to x. The parent of a node in the result is its nearest ancestor node that is not excluded.

```
def exclude(t, x):
    """Return a tree with the non-root nodes of tree t labeled anything but x.

    >>> t = tree(1, [tree(2, [tree(2), tree(3), tree(4)]), tree(5, [tree(1)])])
    >>> exclude(t, 2)
    [1, [3], [4], [5, [1]]]
    >>> exclude(t, 1)  # The root node cannot be excluded
    [1, [2, [2], [3], [4]], [5]]
    """
    filtered_branches = map(lambda y: ____________, branches(t))
    bs = []
    for b in filtered_branches:
        if ____________:
            bs.________(____________)
        else:
            bs.append(b)
    return tree(label(t), bs)
```

exclude(y, x)

In Spring 2023, 20% of students got this right

label(b) == x

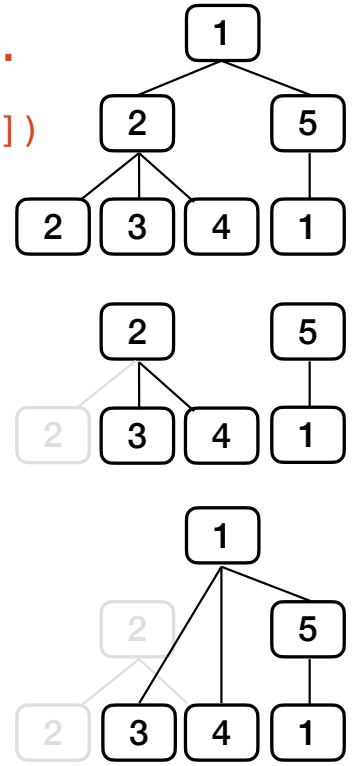
37% of students got this right

30% got it right; 1 of 4 options

extend

branches(b)

24% got it right



Min Practice

Match the description to the code

```
w = {...}  # a dict with unique keys and values

m = {v: k for k, v in w.items()}

Which expression evaluates to?
```

1. The key that has the smallest value in w
2. The value that has the smallest key in w
3. The smallest absolute difference between a key and its value

```
min(w.keys(), key=lambda k: w[k])
min(w.keys(), key=lambda k: m[k])
min(w.values(), key=lambda v: w[v])
min(w.values(), key=lambda v: m[v])
min(w.keys(), key=lambda k: abs(k - w[k]))
min(w.keys(), key=lambda k: abs(k - m[k]))
min(map(lambda k: abs(k - w[k]), w.keys()))
min(map(lambda k: abs(k - m[k]), w.keys()))
```

Generators

Generators and Generator Functions

```
>>> def plus_minus(x):
...     yield x
...     yield -x

>>> t = plus_minus(3)
>>> next(t)
3
>>> next(t)
-3
>>> t
<generator object plus_minus ...>
```

A *generator function* is a function that **yield**s values instead of **return**ing them

A normal function **return**s once; a *generator function* can **yield** multiple times

A *generator* is an iterator created automatically by calling a *generator function*

When a *generator function* is called, it returns a *generator* that iterates over its yields

(Demo)

Spring 2023 Midterm 2 Question 5(b)

Definition. When parking vehicles in a row, a motorcycle takes up 1 parking spot and a car takes up 2 adjacent parking spots. A string of length n can represent n adjacent parking spots using % for a motorcycle, <> for a car, and . for an empty spot.

For example: '.%%.<><>' (Thanks to the Berkeley Math Circle for introducing this question.)

Implement **park**, a generator function that yields all the ways, represented as strings, that vehicles can be parked in n adjacent parking spots for positive integer n.

```
def park(n):
    """Yield the ways to park cars and motorcycles in n adjacent spots.

    >>> sorted(park(1))
    ['%', '.']
    >>> sorted(park(2))
    ['%%', '%.', '.%', '..', '<>']
    >>> len(list(park(4)))  # some examples: '<><>', '.%%.', '%<>%', '%.<>'
    29
    """
```

Example: Call Expressions

Problem Definition

From Discussion 0:

Imagine you can call only the following three functions:

- f(x): Subtracts one from an integer x

- g(x): Doubles an integer x

- h(x, y): Concatenates the digits of two different positive integers x and y. For example, h(789, 12) evaluates to 78912 and h(12, 789) evaluates to 12789.

Definition: A *small expression* is a call expression that contains only f, g, h, the number 5, and parentheses. All of these can be repeated. For example, h(g(5), f(f(5))) is a small expression that evaluates to 103.

What's the shortest *small expression* you can find that evaluates to 2023?

(Demo)

A Simple Restatement:

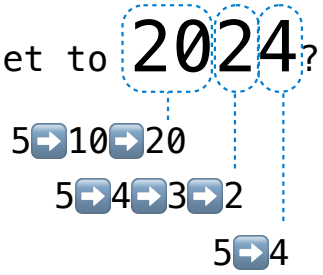
You start with 5. You can:

- Subtract 1 from a number

- Double a number

- Glue two numbers together

How do you get to 2024?



A Computational Approach

```
def f(x):
    return x - 1

def g(x):
    return 2 * x

def h(x, y):
    return int(str(x) + str(y))

def smalls(n):
    """Yield all call expressions involving f, g, h, and 5 that have n calls.

    >>> [exp for exp in smalls(7) if eval(exp) == 2024]
    ['g(h(g(5), g(g(f(f(5))))))']
    """
    if n == 0:
        yield '5'
    else:
        for operand in smalls(n-1):
            yield 'f(' + operand + ')'
            yield 'g(' + operand + ')'
        for k in range(n):
            for first in smalls(k):
                for second in smalls(n-k-1):
                    if eval(first) > 0 and eval(second) > 0:
                        yield 'h(' + first + ', ' + second + ')'
```