Homework 5: Object-Oriented Programming, Linked Lists, Iterators and Generators hw05.zip (hw05.zip)

Due by 11:59pm on Wednesday, July 28

Instructions

Download hw05.zip (hw05.zip). Inside the archive, you will find a file called hw05.py (hw05.py), along with a copy of the `ok` autograder.

Submission: When you are done, submit with `python3 ok --submit`. You may submit more than once before the deadline; only the final submission will be scored. Check that you have successfully submitted your code on okpy.org (https://okpy.org/). See Lab 0 (/~cs61a/su21/lab/lab00#submitting-the-assignment) for more instructions on submitting assignments.

Using Ok: If you have any questions about using Ok, please refer to this guide. (/~cs61a/su21/articles/using-ok)

Readings: You might find the following references useful:

- Section 2.5 (http://composingprograms.com/pages/25-object-oriented-programming.html)
- Section 2.9 (http://composingprograms.com/pages/29-recursive-objects.html)

Grading: Homework is graded based on correctness. Each incorrect problem will decrease the total score by one point. There is a homework recovery policy as stated in the syllabus. **This homework is out of 3 points.**

Required Questions

Q1: Survey

Please fill out the survey at this link (https://links.cs61a.org/midsemester-survey) and fill in `hw05.py` with the token. The link might not work if you are logged into some google account other than your Berkeley account, so either log out from all other accounts or open the link in a private/incognito window and sign in to your Berkeley account there.

To check that you got the correct token run

Use Ok to test your code:

```
python3 ok -q survey
```

OOP

Q2: Vending Machine

In this question you'll create a vending machine (https://en.wikipedia.org/wiki/Vending_machine) that only outputs a single product and provides change when needed.

Create a class called `VendingMachine` that represents a vending machine for some product. A `VendingMachine` object returns strings describing its interactions. Remember to match **exactly** the strings in the doctests -- including punctuation and spacing!

Fill in the `VendingMachine` class, adding attributes and methods as appropriate, such that its behavior matches the following doctests:

```
class VendingMachine:
    """A vending machine that vends some product for some price.

    >>> v = VendingMachine('candy', 10)
    >>> v.vend()
    'Machine is empty. Please restock.'
    >>> v.add_funds(15)
    'Machine is empty. Please restock. Here is your $15.'
    >>> v.restock(2)
    'Current candy stock: 2'
    >>> v.vend()
    'You must add $10 more funds.'
    >>> v.add_funds(7)
    'Current balance: $7'
    >>> v.vend()
    'You must add $3 more funds.'
    >>> v.add_funds(5)
    'Current balance: $12'
    >>> v.vend()
    'Here is your candy and $2 change.'
    >>> v.add_funds(10)
    'Current balance: $10'
    >>> v.vend()
    'Here is your candy.'
    >>> v.add_funds(15)
    'Machine is empty. Please restock. Here is your $15.'

    >>> w = VendingMachine('soda', 2)
    >>> w.restock(3)
    'Current soda stock: 3'
    >>> w.restock(3)
    'Current soda stock: 6'
    >>> w.add_funds(2)
    'Current balance: $2'
    >>> w.vend()
    'Here is your soda.'
    """
    "*** YOUR CODE HERE ***"
```

> You may find Python's formatted string literals, or f-strings (https://docs.python.org/3/tutorial/inputoutput.html#fancier-output-formatting) useful. A quick example:

```
>>> feeling = 'love'
>>> course = '61A!'
>>> f'I {feeling} {course}'
'I love 61A!'
```

Use Ok to test your code:

```
python3 ok -q VendingMachine
```

> If you're curious about alternate methods of string formatting, you can also check out an older method of Python string formatting (https://docs.python.org/2/library/stdtypes.html#str.format). A quick example:

```
>>> ten, twenty, thirty = 10, 'twenty', [30]
>>> '{0} plus {1} is {2}'.format(ten, twenty, thirty)
'10 plus twenty is [30]'
```

Hint Video

Linked Lists

Q3: Store Digits

Write a function `store_digits` that takes in an integer `n` and returns a linked list where each element of the list is a digit of `n`.

> Note: do not use any string manipulation functions like `str` and `reversed`

```
def store_digits(n):
    """Stores the digits of a positive number n in a linked list.

    >>> s = store_digits(1)
    >>> s
    Link(1)
    >>> store_digits(2345)
    Link(2, Link(3, Link(4, Link(5))))
    >>> store_digits(876)
    Link(8, Link(7, Link(6)))
    >>> # a check for restricted functions
    >>> import inspect, re
    >>> cleaned = re.sub(r"#.*\\n", '', re.sub(r'"{3}[\s\S]*?"{3}', '', inspect.gets
    >>> print("Do not use str or reversed!") if any([r in cleaned for r in ["str", "
    """
    "*** YOUR CODE HERE ***"
```

Use Ok to test your code:

```
python3 ok -q store_digits
```

Hint Video

Trees

Q4: Yield Paths

Define a generator function `path_yielder` which takes in a Tree `t`, a value `value`, and returns a generator object which yields each path from the root of `t` to a node that has label `value`.

`t` is implemented with a class, not as the function-based ADT.

Each path should be represented as a list of the labels along that path in the tree. You may yield the paths in any order.

We have provided a skeleton for you. You do not need to use this skeleton, but if your implementation diverges significantly from it, you might want to think about how you can get it to fit the skeleton.

```
def path_yielder(t, value):
    """Yields all possible paths from the root of t to a node with the label value
    as a list.

    >>> t1 = Tree(1, [Tree(2, [Tree(3), Tree(4, [Tree(6)]), Tree(5)]), Tree(5)])
    >>> print(t1)
    1
      2
        3
        4
          6
        5
      5
    >>> next(path_yielder(t1, 6))
    [1, 2, 4, 6]
    >>> path_to_5 = path_yielder(t1, 5)
    >>> sorted(list(path_to_5))
    [[1, 2, 5], [1, 5]]

    >>> t2 = Tree(0, [Tree(2, [t1])])
    >>> print(t2)
    0
      2
        1
          2
            3
            4
              6
            5
          5
    >>> path_to_2 = path_yielder(t2, 2)
    >>> sorted(list(path_to_2))
    [[0, 2], [0, 2, 1, 2]]
    """

    "*** YOUR CODE HERE ***"

    for _______________ in _________________:
        for _______________ in _________________:

            "*** YOUR CODE HERE ***"
```

> Hint: If you're having trouble getting started, think about how you'd approach this problem if it wasn't a generator function. What would your recursive calls be? With a generator function, what happens if you make a "recursive call" within its body?
>
> Note: Remember that this problem should **yield items** -- do not return a list!

Use Ok to test your code:

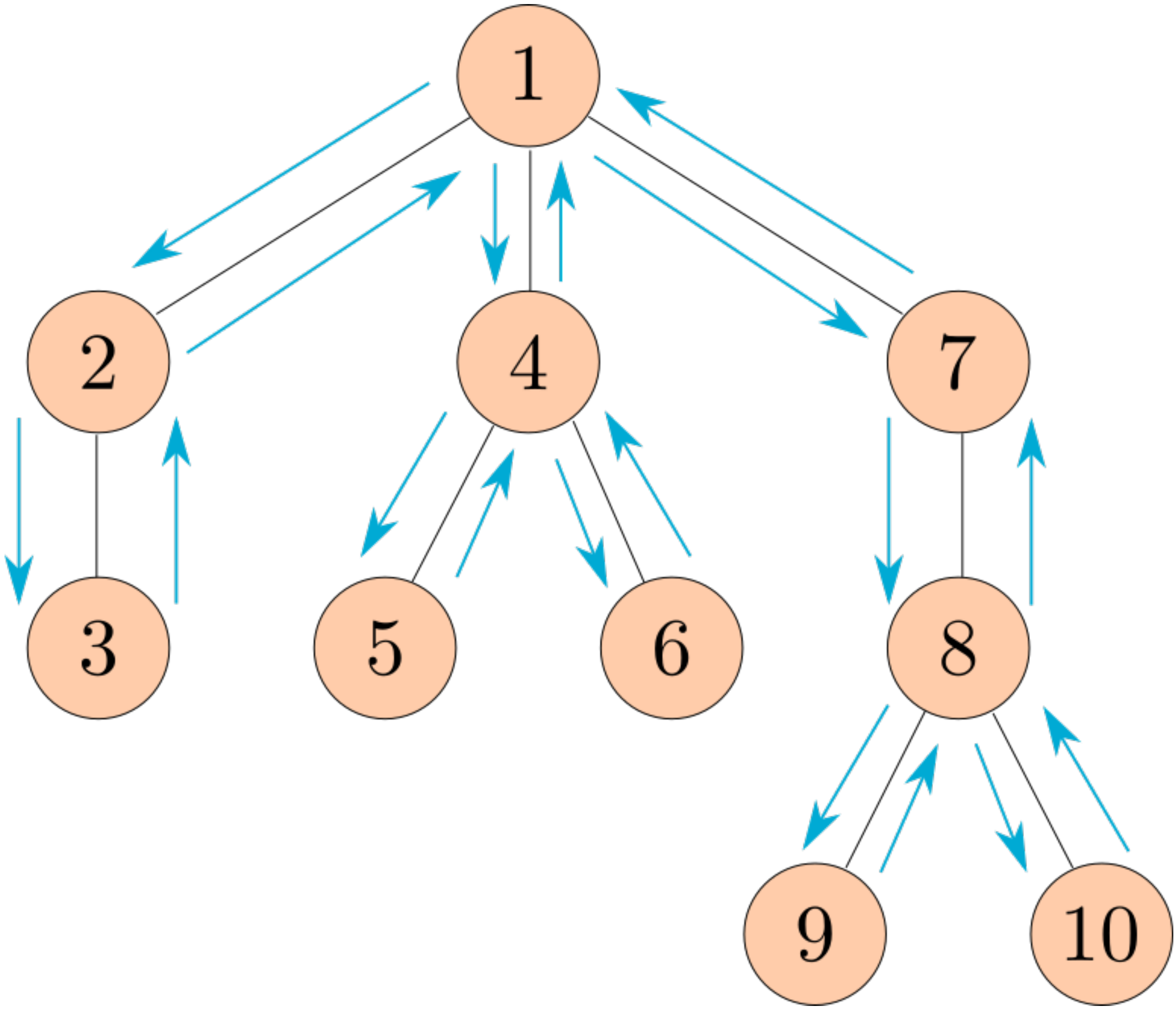
```
python3 ok -q path_yielder
```

Hint Video

Q5: Preorder

Define the function `preorder`, which takes in a tree as an argument and returns a list of all the entries in the tree in the order that `print_tree` would print them.

The following diagram shows the order that the nodes would get printed, with the arrows representing function calls.



> *Note*: This ordering of the nodes in a tree is called a preorder traversal.

```
def preorder(t):
    """Return a list of the entries in this tree in the order that they
    would be visited by a preorder traversal (see problem description).

    >>> numbers = Tree(1, [Tree(2), Tree(3, [Tree(4), Tree(5)]), Tree(6, [Tree(7)])]
    >>> preorder(numbers)
    [1, 2, 3, 4, 5, 6, 7]
    >>> preorder(Tree(2, [Tree(4, [Tree(6)])]))
    [2, 4, 6]
    """
    "*** YOUR CODE HERE ***"
```

Use Ok to test your code:

```
python3 ok -q preorder
```

Hint Video

Extra Questions

OOP

Q6: Mint

A mint is a place where coins are made. In this question, you'll implement a `Mint` class that can output a `Coin` with the correct year and worth.

- Each `Mint` instance has a `year` stamp. The `update` method sets the `year` stamp to the `current_year` class attribute of the `Mint` class.
- The `create` method takes a subclass of `Coin` and returns an instance of that class stamped with the `mint`'s year (which may be different from `Mint.current_year` if it has not been updated.)
- A `Coin`'s `worth` method returns the `cents` value of the coin plus one extra cent for each year of age beyond 50. A coin's age can be determined by subtracting the coin's year from the `current_year` class attribute of the `Mint` class.

```
class Mint:
    """A mint creates coins by stamping on years.

    The update method sets the mint's stamp to Mint.current_year.

    >>> mint = Mint()
    >>> mint.year
    2021
    >>> dime = mint.create(Dime)
    >>> dime.year
    2021
    >>> Mint.current_year = 2101  # Time passes
    >>> nickel = mint.create(Nickel)
    >>> nickel.year     # The mint has not updated its stamp yet
    2021
    >>> nickel.worth()  # 5 cents + (80 - 50 years)
    35
    >>> mint.update()   # The mint's year is updated to 2101
    >>> Mint.current_year = 2176     # More time passes
    >>> mint.create(Dime).worth()    # 10 cents + (75 - 50 years)
    35
    >>> Mint().create(Dime).worth()  # A new mint has the current year
    10
    >>> dime.worth()     # 10 cents + (155 - 50 years)
    115
    >>> Dime.cents = 20  # Upgrade all dimes!
    >>> dime.worth()     # 20 cents + (155 - 50 years)
    125
    """
    current_year = 2021

    def __init__(self):
        self.update()

    def create(self, kind):
        "*** YOUR CODE HERE ***"

    def update(self):
        "*** YOUR CODE HERE ***"

class Coin:
    def __init__(self, year):
        self.year = year

    def worth(self):
        "*** YOUR CODE HERE ***"
```

```
class Nickel(Coin):
    cents = 5

class Dime(Coin):
    cents = 10
```

Use Ok to test your code:

```
python3 ok -q Mint
```

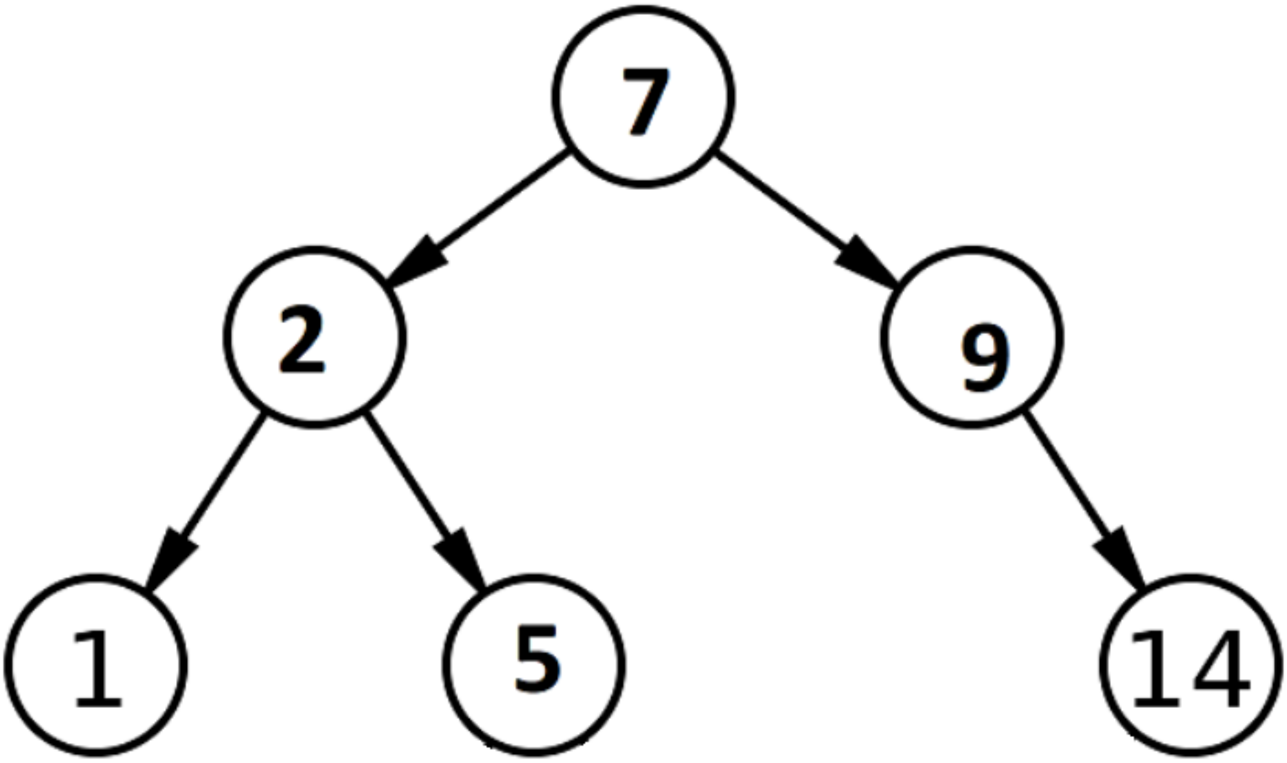
Generators/Trees

Q7: Is BST

Write a function `is_bst`, which takes a Tree `t` and returns `True` if, and only if, `t` is a valid binary search tree, which means that:

- Each node has at most two children (a leaf is automatically a valid binary search tree)
- The children are valid binary search trees
- For every node, the entries in that node's left child are less than or equal to the label of the node
- For every node, the entries in that node's right child are greater than the label of the node

An example of a BST is:



Note that, if a node has only one child, that child could be considered either the left or right child. You should take this into consideration.

Hint: It may be helpful to write helper functions `bst_min` and `bst_max` that return the minimum and maximum, respectively, of a Tree if it is a valid binary search tree.

```
def is_bst(t):
    """Returns True if the Tree t has the structure of a valid BST.

    >>> t1 = Tree(6, [Tree(2, [Tree(1), Tree(4)]), Tree(7, [Tree(7), Tree(8)])])
    >>> is_bst(t1)
    True
    >>> t2 = Tree(8, [Tree(2, [Tree(9), Tree(1)]), Tree(3, [Tree(6)]), Tree(5)])
    >>> is_bst(t2)
    False
    >>> t3 = Tree(6, [Tree(2, [Tree(4), Tree(1)]), Tree(7, [Tree(7), Tree(8)])])
    >>> is_bst(t3)
    False
    >>> t4 = Tree(1, [Tree(2, [Tree(3, [Tree(4)])])])
    >>> is_bst(t4)
    True
    >>> t5 = Tree(1, [Tree(0, [Tree(-1, [Tree(-2)])])])
    >>> is_bst(t5)
    True
    >>> t6 = Tree(1, [Tree(4, [Tree(2, [Tree(3)])])])
    >>> is_bst(t6)
    True
    >>> t7 = Tree(2, [Tree(1, [Tree(5)]), Tree(4)])
    >>> is_bst(t7)
    False
    """
    "*** YOUR CODE HERE ***"
```

Use Ok to test your code:

```
python3 ok -q is_bst
```

Q8: Generate Preorder

Similarly to `preorder` in Question 4, define the function `generate_preorder`, which takes in a tree as an argument and now instead `yield`s the entries in the tree in the order that `print_tree` would print them.

> Hint: How can you modify your implementation of `preorder` to `yield from` your recursive calls instead of returning them?

def generate_preorder(t):

```
    """Yield the entries in this tree in the order that they
    would be visited by a preorder traversal (see problem description).

    >>> numbers = Tree(1, [Tree(2), Tree(3, [Tree(4), Tree(5)]), Tree(6, [Tree(7)])])
    >>> gen = generate_preorder(numbers)
    >>> next(gen)
    1
    >>> list(gen)
    [2, 3, 4, 5, 6, 7]
    """
    "*** YOUR CODE HERE ***"
```

Use Ok to test your code:

```
python3 ok -q generate_preorder
```