1 Learning Goals

- Get exam-level practice with various topics covered thus far
2 Recursion! Take the leap!

"Plaudite, amici, comedia finita est" (Applaud, my friends, the comedy is over).–Beethoven [Said on his deathbed]

This quote is not really relevant to the question, but I (Murtz) found it amusing, even though I did not write the question. Let us write a symphony!

Assume you are given a function, judge, that takes in a list and returns a real number. The list is a representation of a symphony and the number is how good the symphony is. Given this function, use tree recursion to write a function that generates the best symphony of a predetermined length.

```python
def best_symphony(symphony_so_far, possible_notes, length):
    """
    Takes in an incomplete list symphony_so_far, a list of possible notes to add to it, and a maximum length for the symphony. Recursively computes the best possible symphony of that length that can be composed by adding notes from possible_notes to symphony_so_far.
    """

    if ________________:  # base case

        symphonies = []

    for ________________:  # recursive case

        symphony = ________________________________

        symphonies += [(symphony, judge(symphony))]

    return max(______________________, key=____________________)[0]
```

Note: This worksheet is a problem bank—most TAs will not cover all the problems in discussion section.
3 Iterators/Generators! Linked Lists! Trees! Next! Yield! Woohoo!

3.1 To make the `Link` class iterable, implement the `LinkIterator` class.

```python
class Link:
    empty = ()
    def __init__(self, first, rest=empty):
        self.first = first
        self.rest = rest
    def __iter__(self):
        return LinkIterator(self)

class LinkIterator:
    def __init__(self, link):
        pass
    def __iter__(self):
        pass
    def __next__(self):
        pass
```

Note: This worksheet is a problem bank—most TAs will not cover all the problems in discussion section.
3.2 Implement `sum_paths_gen`, which takes in a tree `t` and returns a generator which yields the sum of all the nodes from a path from the root of a tree to a leaf.

You may yield the sums in any order.

```python
def sum_paths_gen(t):
    """
    >>> t1 = tree(5)
    >>> next(sum_paths_gen(t1))
    5
    >>> t2 = tree(1, [tree(2, [tree(3), tree(4)]), tree(9)])
    >>> sorted(sum_paths_gen(t2))
    [6, 7, 10]
    """

    if ____________________________:
        yield ________________

    for ____________________________:
        for ____________________________:
            yield ________________
```

Note: This worksheet is a problem bank—most TAs will not cover all the problems in discussion section.
3.3 Implement long_paths, which returns a list of all paths in a tree with length at least \( n \). A path in a tree is a linked list of node values that starts with the root and ends at a leaf. Each subsequent element must be from a child of the previous value’s node. The length of a path is the number of edges in the path (i.e. one less than the number of nodes in the path). Paths are listed in order from left to right. See the doctests for some examples.

```python
def long_paths(tree, n):
    '''Return a list of all paths in tree with length at least n.'''

    >>> t = Tree(3, [Tree(4), Tree(4), Tree(5)])
    >>> left = Tree(1, [Tree(2), t])
    >>> mid = Tree(6, [Tree(7, [Tree(8)]), Tree(9)])
    >>> right = Tree(11, [Tree(12, [Tree(13, [Tree(14)])]), Tree(9)])
    >>> whole = Tree(0, [left, Tree(13), mid, right])
    >>> for path in long_paths(whole, 2):
    ...     print(path)
    ...
    <0 1 2>
    <0 1 3 4>
    <0 1 3 4>
    <0 1 3 5>
    <0 6 7 8>
    <0 6 9>
    <0 11 12 13 14>
    >>> for path in long_paths(whole, 3):
    ...     print(path)
    ...
    <0 1 3 4>
    <0 1 3 4>
    <0 1 3 5>
    <0 6 7 8>
    <0 11 12 13 14>
    >>> long_paths(whole, 4)
    [Link(0, Link(11, Link(12, Link(13, Link(14, None)))))]
    '''
```

Note: This worksheet is a problem bank—most TAs will not cover all the problems in discussion section.
4 Scheme! Languages! Parentheses!

4.1 Fall 2020 Final, Question 5