Homework 5: Heaps

Due: Friday, February 28 at 5pm on Canvas

Concepts: sorting, heaps, hypothesis testing

1. (15 points) Implement a min-heap that supports the following operations with the given runtime in parantheses:

   - Initialization - given a (possibly empty) list of elements initialize a heap in-place ($O(n)$)
   - Length - return the number of elements in the heap ($O(1)$)
   - Insert - insert a new element into the heap ($O(\log n)$)
   - Find Min - return the minimum value in the heap ($O(1)$)
   - Delete Min - delete the minimum value element in the heap ($O(\log n)$)
   - Sorted List - returns a new list containing all the elements from min to max ($O(n \log n)$)

   More documentation is given in the file `hw5.py` on Canvas. Your implementation for initialization, insertion, deletion, and returning a sorted list will each count for three points. Additionally, there will be three points for clarity of your explanation at your check-off. You **do not** have to implement unit tests (see the problem below).

2. (6 points) The `hypothesis` library in python is a helpful library to test your code because it generates instances to test your assertions on. Further, this library works with `pytest`. As an example, the code below generates a random list of integers that the test function for length is called on.

   ```
   import pytest
   from hypothesis import given
   import hypothesis.strategies as st

   @given(st.lists(st.integers()))
   def test_heap_len(l):
       h = Heap(l)
       assert len(l) == h.length()
   ```

   If we then run `pytest yourfile.py` the test function `test_heap_len` will be run for many generated lists `l`. For more documentation, see `https://hypothesis.readthedocs.io/en/latest/quickstart.html`.

   You will use this package to test your implementation. At your check-off you should be able to answer: how did you set up the tests? what purpose does each assertion serve? are there any weaknesses to your tests?

   (a) (2 points) Use the `hypothesis` package to test sequentially inserting integers into a heap and then sequentially deleting the minimum until the heap is empty.

   (b) (2 points) Use the `hypothesis` package to test initializing a heap with a list and then sequentially deleting the minimum until the heap is empty.

   (c) (2 points) Use the `hypothesis` package to test initializing a heap with a list and then returning a sorted version of that list.