Programming Assignment 2

Due: 4/17/2023

The objective of this assignment is to explore an interesting algorithm known as k^{th} smallest element in an array.

Problem Definition:

The kth order statistics of an array a of n elements is the k^{th} least element in the array, $k = 0, \dots, n-1$. Moreover, finding the k^{th} order statistics of a can be accomplished by the following solutions

1- Sorting a and returning the k^{th} element in the sorted array. Using any sorting in $O(n\ logn\ )$ would do the task!
2- Using Quicksort and reduce the running time for finding the k^{th} statistics down to $O(n)$.

Assignment

1- Implement two algorithms:
   a. A min heap, that finds the k^{th} smallest element of a given input array and the value k.
   b. Use quicksort (with some modification) to find the k^{th} smallest element of a given input array and the value k.
2- For both algorithms inputs and outputs are similar. Here are some examples:
   a. Example1:
      Input: [8, 4, 1, 2, 10] and k = 3
      Output: 4
   b. Example2:
      Input: [7, 10, 4, 3, 20, 15] and k = 4
      Output: 10

3- The algorithm for MinHeap can be found from class lecture notes.
4- The following pseudocode can be used for 1-a algorithm. This algorithm uses Quicksort concept to find the k^{th} element in an arbitrary array.

```
function kthSmallest(arr, l, r, k)
{
  if  (k > 0 and k <= r – l)
        q = partition(arr, l, r)     // make a partition using the last element
  if (q  == k )                      // if position is same as k
        return arr[pos]
  if (q  > k )                       //if position is more, # recur for left subarray
      return kthSmallest(arr, l, q - 1, k)
  return kthSmallest(arr, q + 1, r, k - q + l)
}
```

Note: You may need to correct the array boundaries for python (e.g. starting from zero)

5- Your program should work for any array, as usual.

What to submit?

1- Write 2 programs for each algorithm. Please name your programs as follows:
   a. minheapfind_yourname.py
   b. quickfind_yourname.py

2- Your programs should be run as follows:
   - minheapfind_youname.py [10,2,3,5] 2 or quickfind_yourname.py [10,2,3,5] 2
     The first input is an array and the second input in the value of k
   - Both programs return an integer indicating the value of kth smallest element in the list.
     Note: make sure test your program for boundary inputs!
3- Please have your name top of your all programs.
4- You should follow general software development rules such as proper and sufficient commenting if it is necessary and proper functions and variables naming.
5- Do not copy any code from online resources!