Probem 1

Convert array into heap

In this problem we will convert an array of integers into a heap. This is the crucial step of the sorting algorithm called HeapSort. It has guaranteed worst-case running time of $O(n \log n)$ as opposed to QuickSort's average running time of $O(n \log n)$. QuickSort is usually used in practice, because typically it is faster, but HeapSort is used for external sort when you need to sort huge files that don't fit into memory of your computer.

Problem Description

Task.

The first step of the HeapSort algorithm is to create a heap from the array you want to sort. By the way, did you know that algorithms based on Heaps are widely used for external sort, when you need to sort huge files that don't fit into memory of a computer? . Your task is to implement this first step and convert a given array of integers into a heap. You will do that by applying a certain number of swaps to the array. Swap is an operation which exchanges elements α_i and α_j of the array a for some i and j. You will need to convert the array into a heap using only $O(n)$ swaps, as was described in the lectures.

Note that you will need to use a min-heap instead of a max-heap in this problem.

Input Format.

The first line of the input contains single integer n. The next line contains n space-separated integers ai.

Constraints.

1 ≤ n ≤ 100 000; 0 ≤ i, j ≤ $n-1$; 0 ≤ $a_0, a_1, \ldots, a_{n-1}$ ≤ 10^9. All ai are distinct.

Output Format.

The first line of the output should contain single integer m — the total number of swaps. m must satisfy conditions $0 \le m \le 4n$. The next m lines should contain the swap operations used to convert the array a into a heap. Each swap is described by a pair of integers i, j — the 0-based indices of the elements to be swapped. After applying all the swaps in the specified order the array must become a heap, that is, for each i where $0 \le i \le n-1$ the following conditions must be true:

1. If $2i+1 \le n-1$, then $ai < a2i+1$.
2. If $2i+2 \le n-1$, then $ai < a2i+2$.

Note that all the elements of the input array are distinct. Note that any sequence of swaps that has length at most $4n$ and after which your initial array becomes a correct heap will be graded as correct.

Sample output:

```
Input:
        5
        5 4 3 2 1
Output:
        3
        1 4
        0 1
        1 3
```

In [5]:
```python
count =0
def parent(i):
    return (i-1)/2
def left_child(i):
    return 2*i+1
def right_child(i):
    return 2*i+2

def sift_up(i,H):
    while i>1 and H[parent(i)] > H[i]:

        H[parent(i)],H[i] = H[i],H[parent(i)]
        i = parent(i)

def sift_down(i,H):
    global count # this variable use for couting the number of swap
    max_idx = i
    try:
        l = left_child(i)
        if l <= len(H) and H[l] < H[max_idx]:
            max_idx = l
    except:
        pass
    try:
        r = right_child(i)
        if r <= len(H) and H[r] < H[max_idx]:
            max_idx = r
    except:
        pass
    if i != max_idx:
        H[i],H[max_idx] = H[max_idx],H[i]
#         print("swap: ", i,max_idx)
        count+=1
        sift_down(max_idx,H)
def build_heap(A):
    n = len(A)
    for i in reversed(range(n//2)):
        sift_down(i,A)
    return A
```

In [2]:
```python
count = 0
H = [5, 4, 3, 2, 1]
```

In [3]:
```python
build_heap(H)
```

```
swap:  1 4
swap:  0 1
swap:  1 3
```

Out[3]:
```
[1, 2, 3, 5, 4]
```

In [4]:
```python
count
```

Out[4]:
```
3
```

In [6]:
```python
count = 0
n,t = open("C:/Users/default.DESKTOP-IU77C8K/Desktop/github/Data-structrure/week2_priority_queues_and_disjoint_sets/1_make_heap/tests/04", 'r')
n=int(n.split()[0])
t=list(map(int,t.split()))
```

In [7]:
```
build_heap(t)
```

Out[7]:
```
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