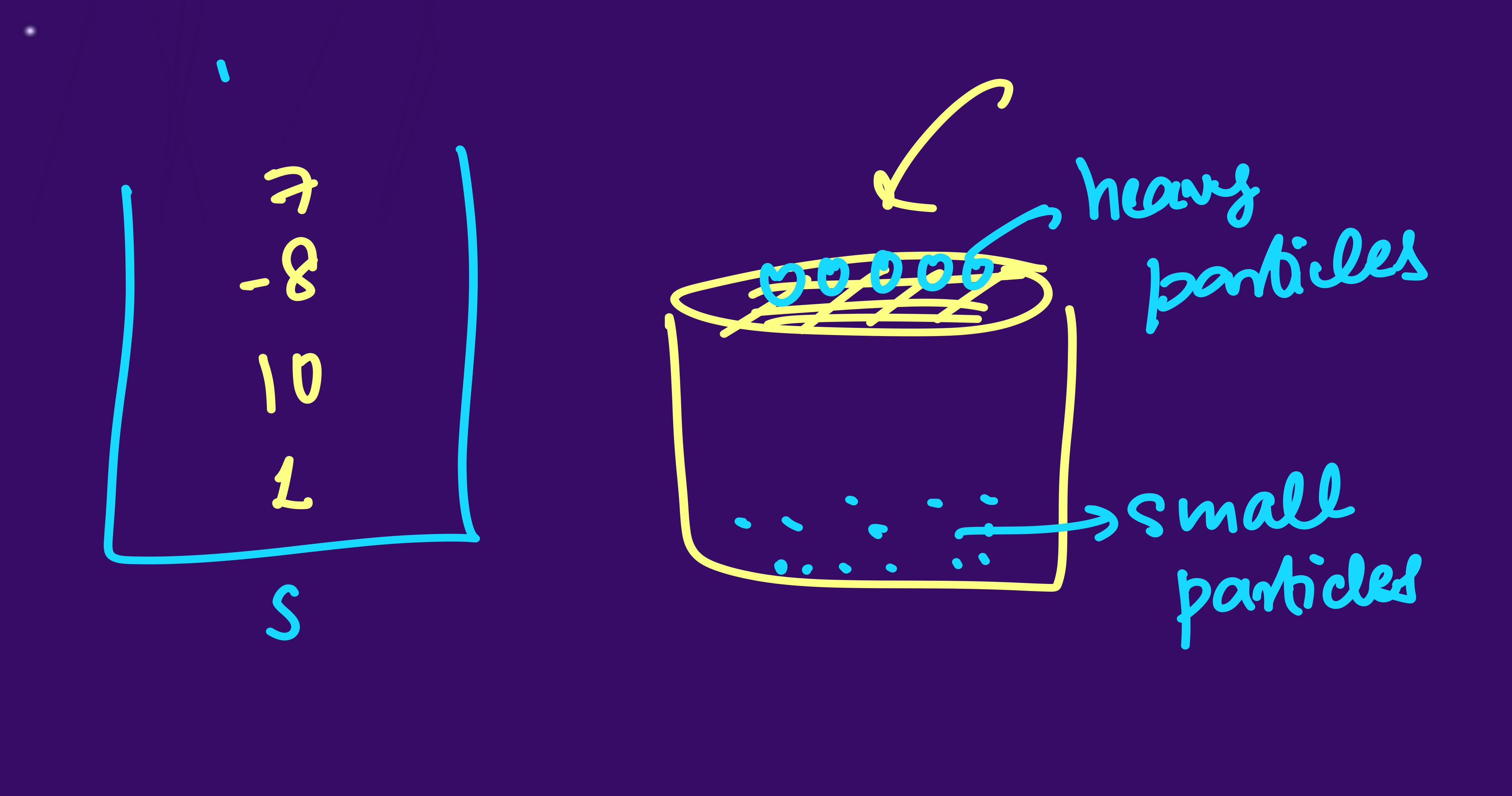


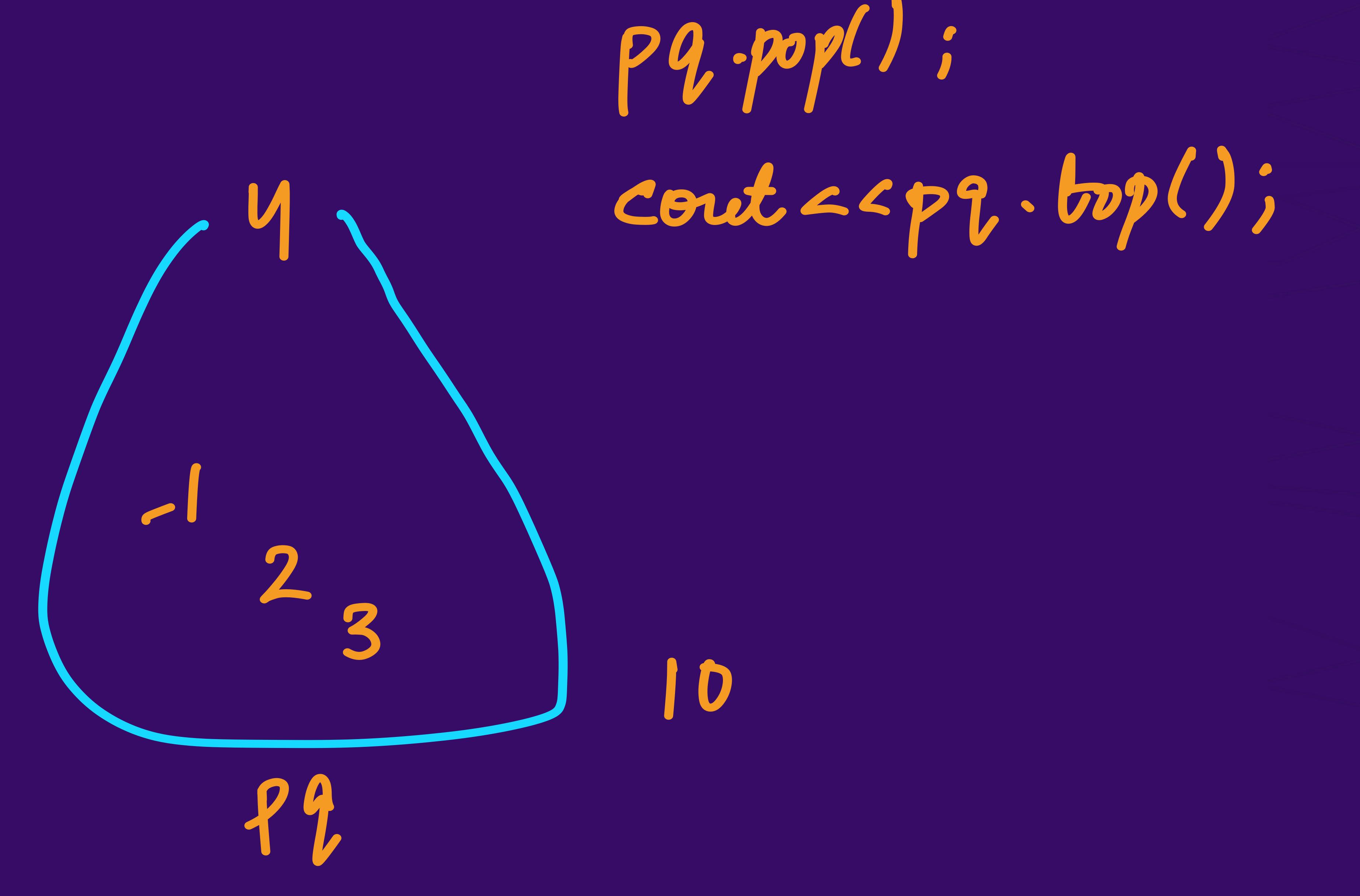
Priority Queues

What and Why?



push, pop, top





What and Why?



```
T.C. current 1

top() \rightarrow 0(1) | 9f we want a DS in which we top() \rightarrow 0(1) | can always get the max<sup>m</sup> or min<sup>m</sup> element push(x) \rightarrow 0(logn) at any pt. of time then we use pqueues (heafe) pop() \rightarrow 0(logn) at any pt. of time then we use pqueues (heafe) \rightarrow n = pq. Size();
```

push (10) pop()

push (2) top()
$$\rightarrow$$
 15

push (18) push (60)

pop()

push (30)

push (15)

2 Types of heaps

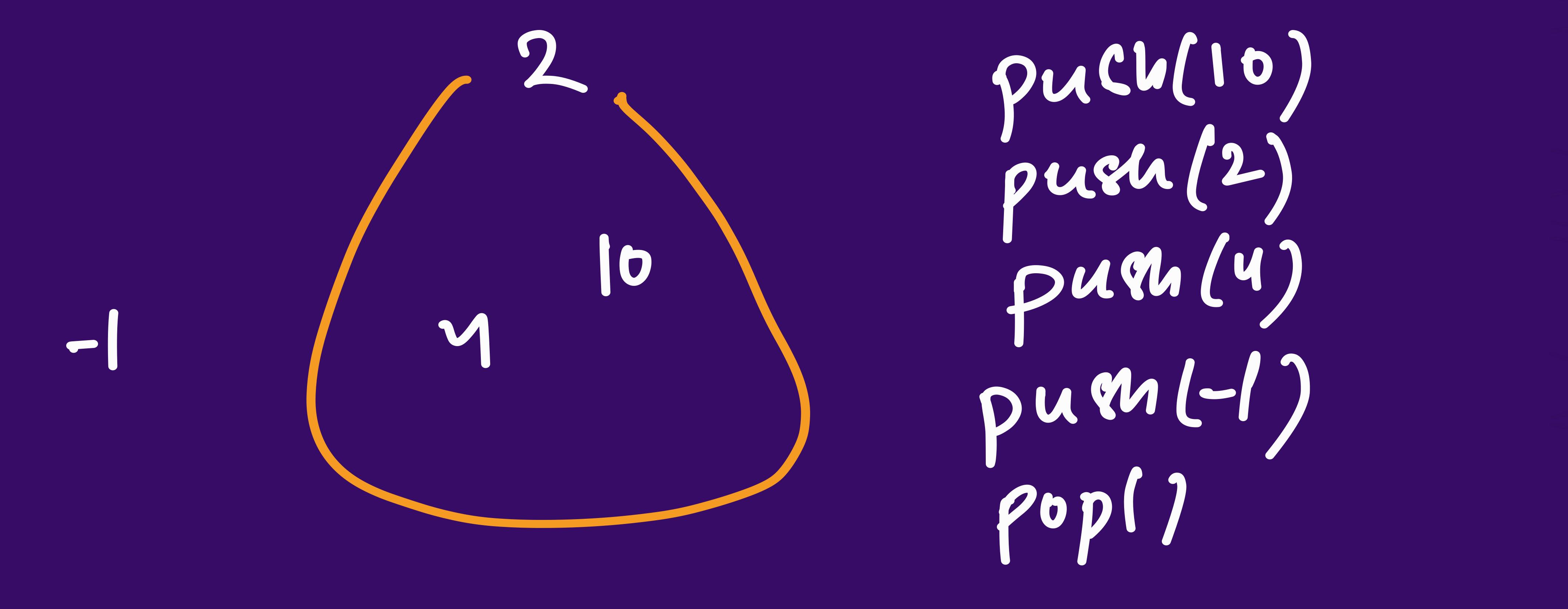


max Meab (default)

max ele is

on the top

min Keap min element is on top



Priority Queue STL



```
#include < queue>
```

```
maxHeap - priority-quene < int > 19
```

min Heap = priority - queue < int, vector < int >, greater = int >> pq

Problem Identification



- 1) Kth Smallest, largest. Top k frequent elements, Clasest K
 - 2) At any fot of time, minimum/max elements are required
- 3) Sorting (cornetimes)



Q1: Find the kth smallest element in a given array.

$$arr = \{10, 20, -4, 6, 18, 24, 105, 118\} \quad k=3$$

$$\underbrace{Method-1}: \text{ BIsort}, \quad arr[k-1] \quad T.C. = O(n\log n) \quad S.C. = O(\log n)$$

$$\underbrace{Method-2}: \quad Selection \quad Sort \rightarrow T.C. = O(k^4n) \quad S.C. = O(1)$$

$$\underbrace{Method-3}: \quad \text{ Quick } \quad \text{ Lelect} \rightarrow \quad T.C. = O(n) \quad \text{ [Not in the worst case]}$$

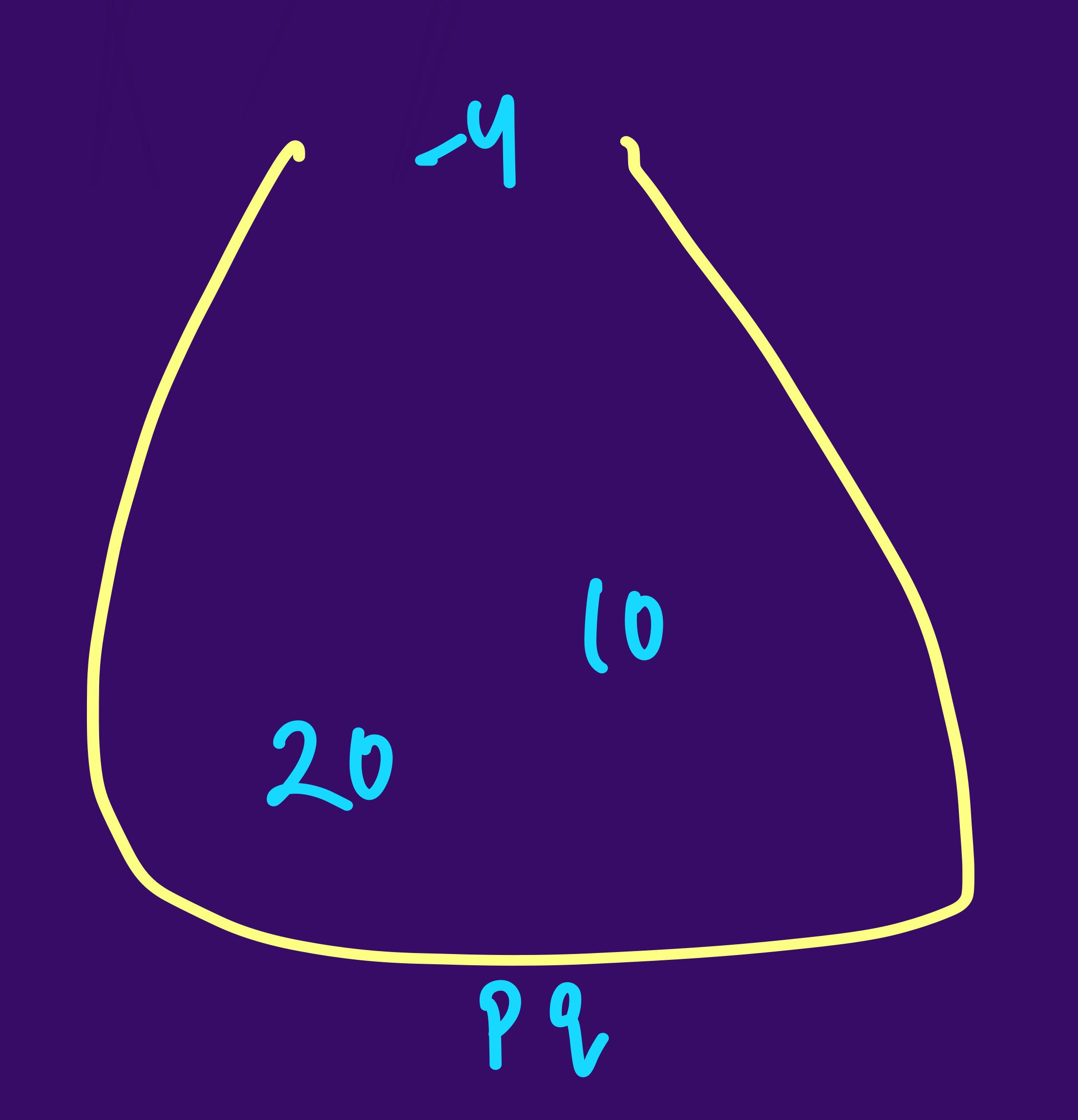
$$\underbrace{Method-4}: \quad \text{ Using } \quad \text{ Heap} \rightarrow \quad T.C. = O(n \cdot \log k)$$



Q1: Find the kth smallest element in a given array.

minkeat

$$arr = \{10, 20, -4, 6, 18, 24, 105, 118\}$$
 $k=3$







Q1: Find the kth smallest element in a given array.

$$arr = \{10, 20, -4, 6, 18, 2, 105, 118\}$$
 $K=3$





Q1: Find the kth smallest element in a given array.

```
for(int i=0;i<n;i++){
    pq.push(arr[i]); -> logk
    if(pq.size()>k) pq.pop(); logk
}
```

$$T \cdot C \cdot = O(n^* \log k)$$

$$S \cdot C \cdot = O(n) \text{ (total space)}$$

$$A \cdot S \cdot = O(k)$$



If 9 insert 'n clements in a heap,





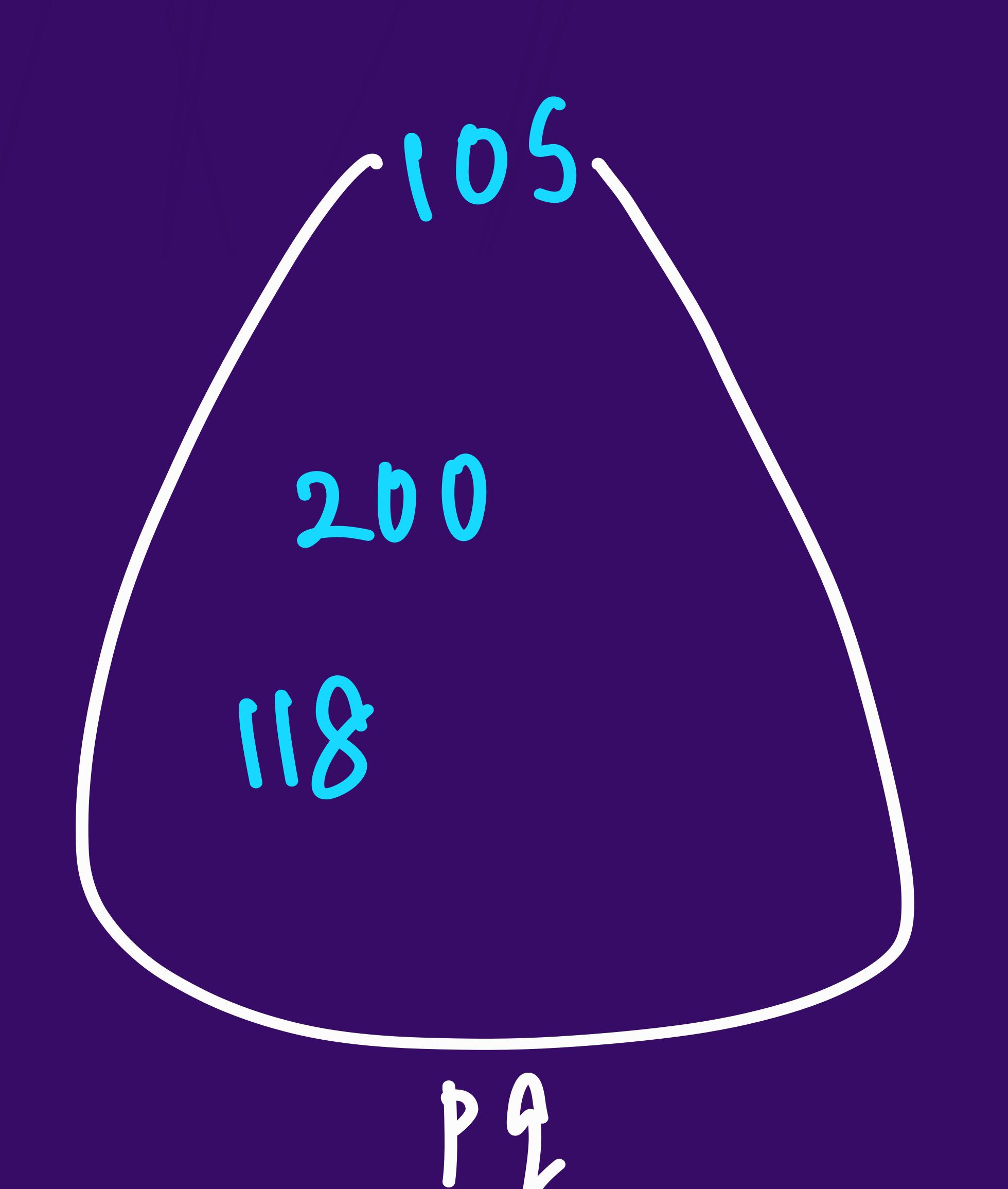


Q2: Find the kth largest element in a given array.

$$arr = \{10, 200, -4, 6, 18, 2, 105, 118\}$$
 $k=3$

T.C. =
$$O(m \log k)$$

S.C. = $o(\kappa)$ (Extra)





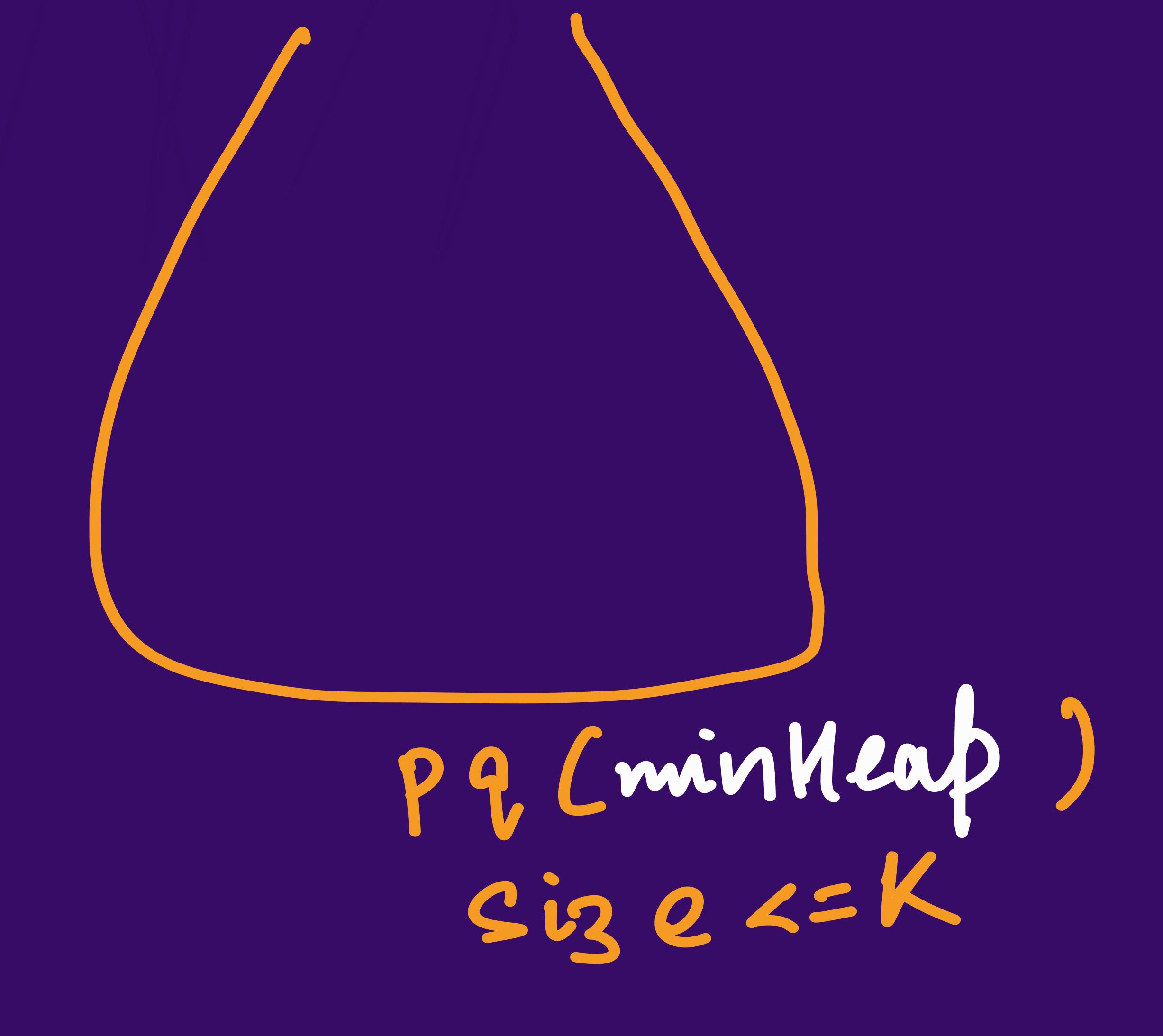
Q3: Sort a 'k' sorted array (sort a nearly sorted array).

minHead



Q3: Sort a 'k' sorted array (sort a nearly sorted array).

arr =
$$[6, 5, 3, 2, 8, 10, 9]$$
 $k=3$
ans = $[2, 3, 5, 6, 8, 9, 10]$



H.W. Leetcode 378

kt Smallest element in a

Sorted Matrix

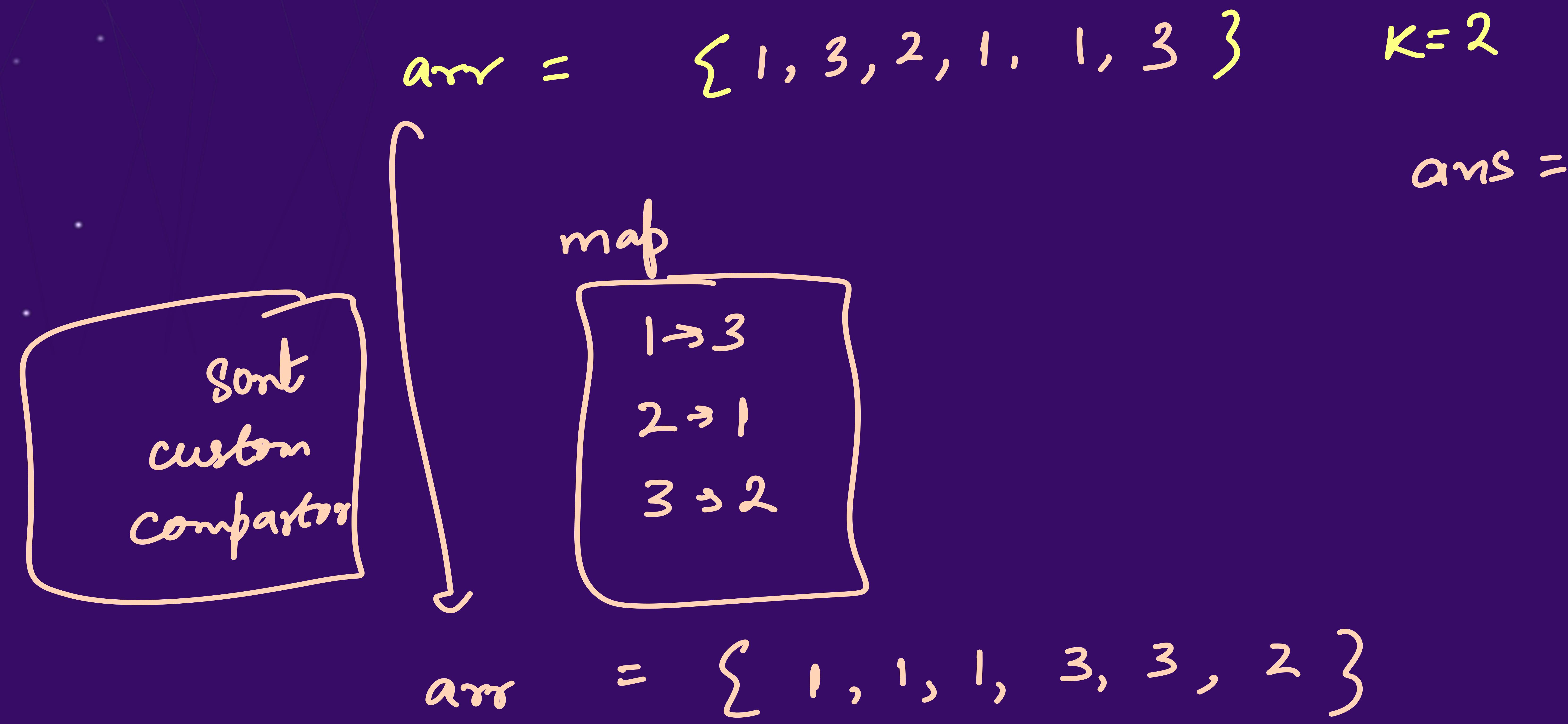


pour ka usage mab





Q4: Top K Frequent Elements



ans =
$$21,33$$

[Leetcode 347]

OUES:

pour ka usage mab



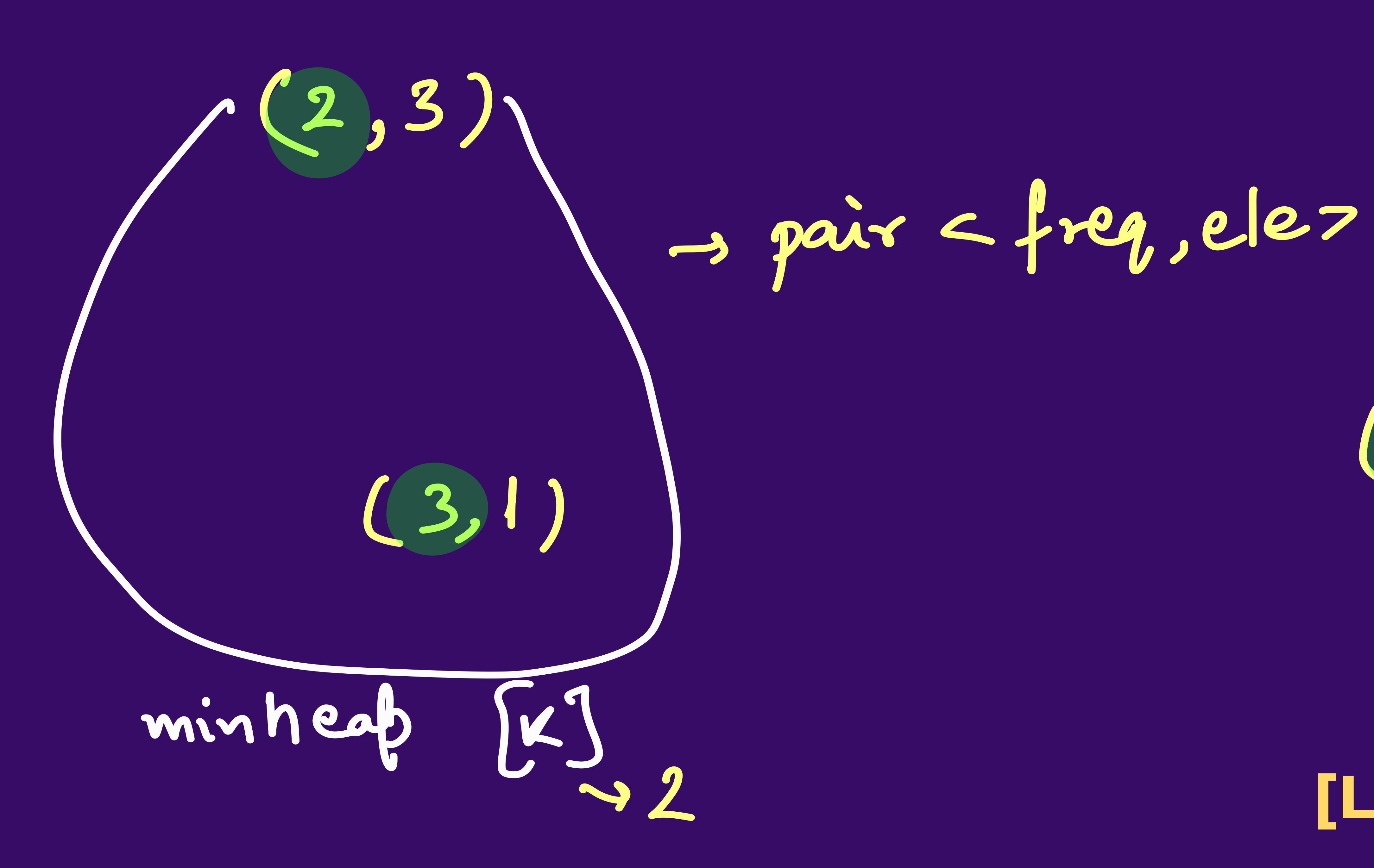


Q4: Top K Frequent Elements

L Klargest Gle nouts

$$arr = \{1, 3, 2, 1, 1, 3\}$$
 $K=2$

minhead



[Leetcode 347]

Homework:



Q: Sort Array by Increasing Frequency.



Q5: Find K Closest Elements

$$x = 3$$
 arr = $\{1, 2, 3, 4, 5, 6\}$ $k = 4$

$$2 | 0 | 2 | 3$$

$$\text{ distances}$$

$$(3, 6)$$

3,6)
(1,4)
(1,2)
(0,3)

VVIMP

maxhead

heap -> L dist, ele >



Q6: K Closest Points to Origin

arr =
$$\{\{3,3\}, \{5,-1\}, \{-2,4\}\}\}$$
 $k=2$ $\{5,3\}, \{-2,4\}\}$ $\{5,3\}, \{-2,4\}\}$ $\{6,3\}, \{-2,4\}\}$ $\{6,4\}, \{6,4\}\}$ $\{6,4\}, \{6,4\}$

[Leetcode 973]

Q7: Last Stone Weight

$$arr = \left\{ 2, 7, 4, 1, 8, 1 \right\}$$

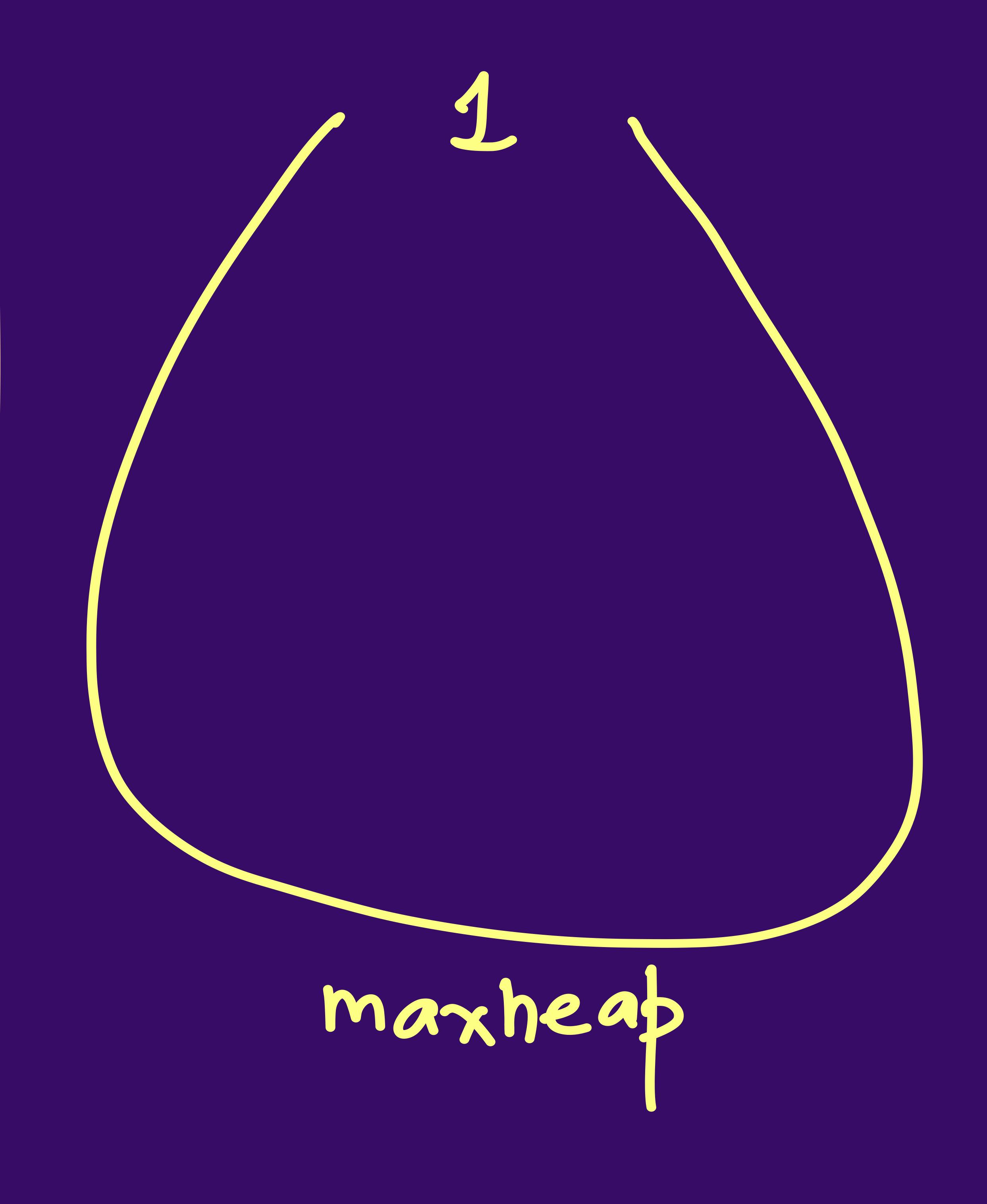
$$\left\{ 2, 4, 1, 1, 1 \right\}$$

$$\left\{ 2, 1, 1, 1 \right\}$$

$$\left\{ 1, 1, 1 \right\}$$

$$\left\{ 1, 2 \right\}$$





$$x = 1$$

$$y = 1$$

$$x - y = 0$$



Q7: Last Stone Weight

$$n \log n + (n-1) \log (n-1) + (n-2) \log (n-2)$$

$$\frac{n-1}{2} (n-1) \log (n-1) + (n-1) \log (n$$

QUES: Very Interesting



Q8: Minimum Cost to Connect all Ropes

$$arr = \{ 2, 7, 4, 1, 8 \}$$

$$9, 4, 1, 8$$

$$13, 1, 8$$

$$14, 8$$

$$22$$

$$cost = 9+13+14+22 = (58)$$

tack is to join all the robes with the nun cost possible You can connect only 2 ropes at a time with the cost being sum of length of twee mbes



Q8: Minimum Cost to Connect all Ropes

$$arr = \{ 2, 7, 4, 1, 8 \}$$

$$6, 7, 1, 8$$

$$6, 8, 8$$

$$cost = 6 + 8 + 16 + 22 = (52)$$



Q8: Minimum Cost to Connect all Ropes

$$\alpha m = \{2, 4, 4, 1, 8\}$$

$$3, 7, 4, 8$$

$$7, 7, 8$$

$$14, 8$$

$$cost = 3 + 7 + 14 + 22 = 46$$



Q8: Minimum Cost to Connect all Ropes

arr =
$$\{6,5,3,2,8,10,9\}$$

 $6,5,5,8,10,9$
 $[14,10,10,9]$
 $[14,10,19]$
 $[14,10,19]$
 $[14,10]$
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JHANK YOU