Binary Search

{
1. define Range (Region of search)
2. try to eliminate half of the region
3. and continue our search in another half.
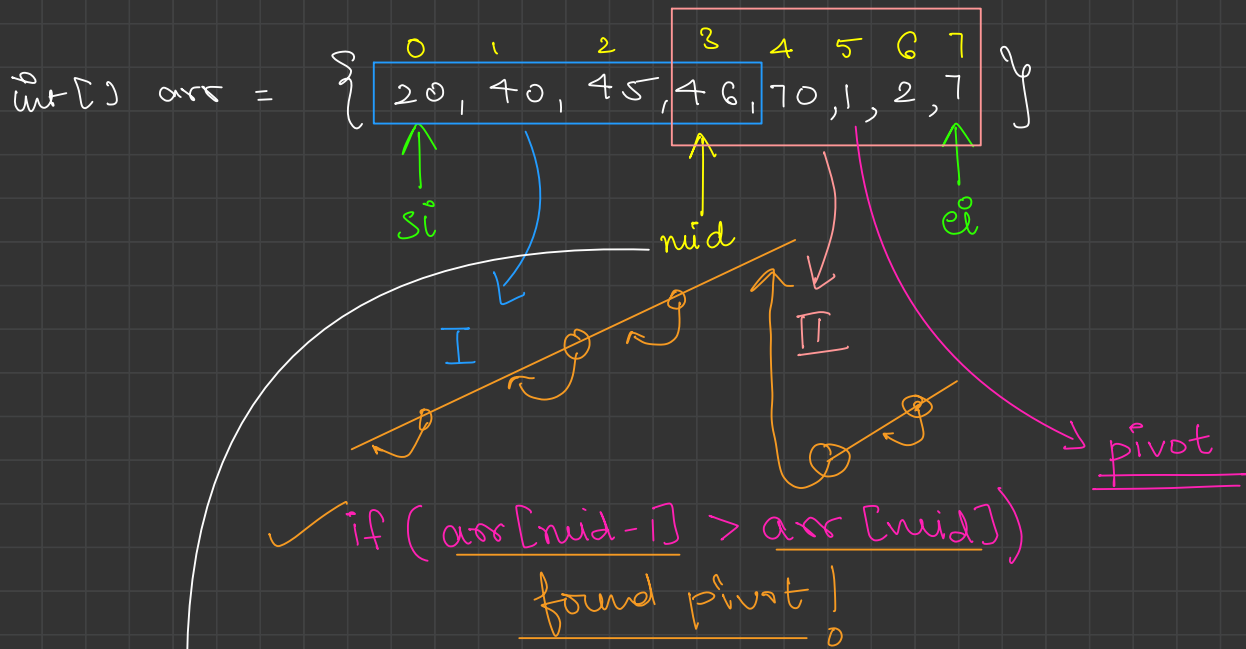
$$\{ \quad TC : O(\log_2 N)$$

$\longrightarrow$ length of search region

$$SC : O(1)$$

Ques. 0   Search minimum in a (Rotated Sorted Array).

Search pivot in a Rotated Sorted Array.

{ Sorted Array
$\longrightarrow$ a array sorted inc/dec order

Non dec array $\rightsquigarrow$ inc. sorted but contains
                                            duplicates

$$\text{int[] arr} = \left\{ \begin{array}{cccccccc} 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ 20, & 40, & 45, & 46, & 70, & 1, & 2, & 7 \end{array} \right\}$$

pivot

rotated sorted array

Brute force

↳ linear search
↳ and find num

TC : O(N)
SC : O(1)

int[] arr = { 20, 40, 45, 46, 70, 1, 2, 7 }

si

mid

ei

I

II

pivot

if (arr[mid-1] > arr[mid])
found pivot !
0

will always cut search space in a sorted & unsorted region

☆ pivot will be towards unsorted region.

```java
static int findMin(int arr[], int low, int high)
{
    // array is not rotated
    if (arr[low] < arr[high]) {
        return arr[low];
    }

    int si = low;
    int ei = high;

    while (si <= ei) {
        int mid = (si + ei) / 2;

        if (arr[mid - 1] > arr[mid]) {
            // found pivot
            return arr[mid];
        } else if (arr[si] <= arr[mid]) {
            // left side is sorted
            // move right
            si = mid + 1;
        } else {
            // left side is not sorted
            // move left
            ei = mid - 1;
        }
    }

    // will never reach this condition
    return -1;
}
```

$$int[] \; arr = \{ \underset{20,}{0} \; \underset{40,}{1} \; \underset{45,}{2} \; \underset{46,}{3} \; \underset{70,}{4} \; \underset{1,}{5} \; \underset{2,}{6} \; \underset{7}{7} \}$$

si   ei

mid

$$\begin{cases} TC : O(\log_2 N) \\ \\ SC : O(1) \end{cases}$$

Search In a rotated Sorted array

$$int[] \ arr = \{ \ \underset{20}{\overset{0}{}}, \ \underset{40}{\overset{1}{}}, \ \underset{45}{\overset{2}{}}, \underset{46}{\overset{3}{}}, \underset{70}{\overset{4}{}}, \underset{1}{\overset{5}{}}, \underset{2}{\overset{6}{}}, \underset{7}{\overset{7}{}} \ \}$$

si ↑   mid ↑   ei ↑

target = 2

Brute force

↳ linear Search   TC : O(N)
                          SC : O(1)

Peak index in a Mountain Array

$$[1, 2, 3, 4, 5, 6, 3, 2, 1]$$

x

6, → peak

5,

4 ,

3 ,

2 ,

1 ,

inc

0   1   2   3   4   5   6   7   8

3

2

dec   1

peak   peak
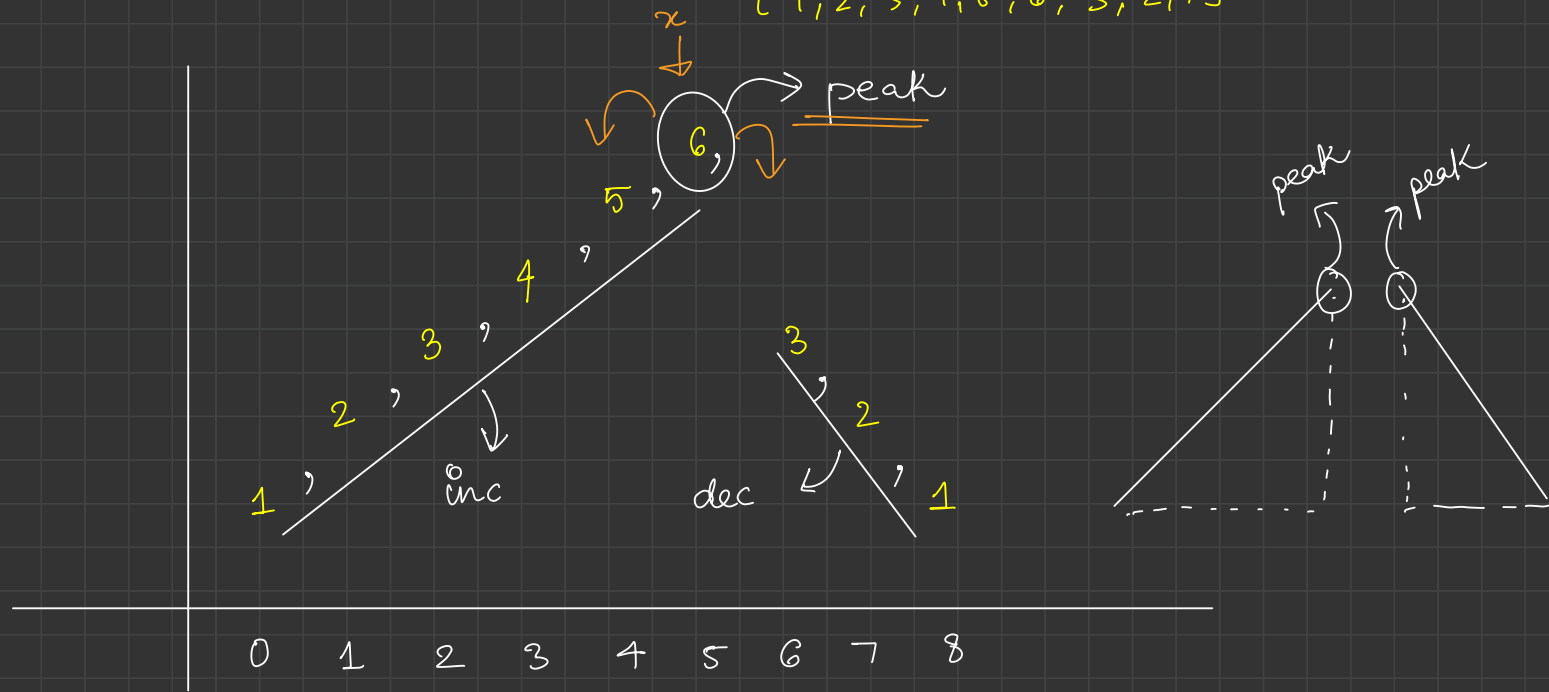
if peak is at index x

if $(arr[x-1] < arr[x]$ && $arr[x+1] < arr[x])$

peak →

5
20
4
5
3
4
2
3
1
3
0
2
1

si

6
4
7
3
8
2

peak

inc   dec
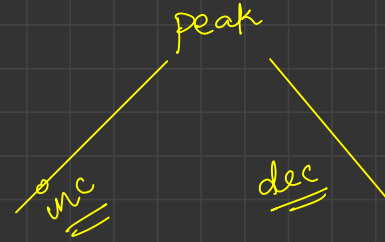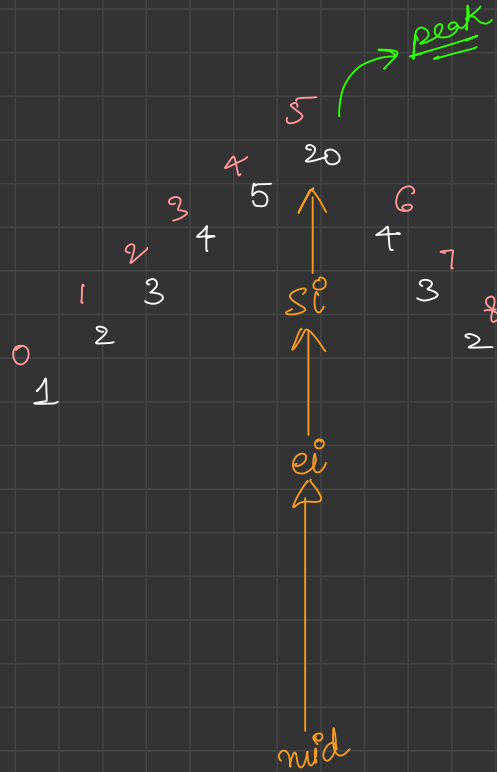
if (mid is peak)

else if (arr[mid-1] < arr[mid])
        move right   left is inc.

else → left is
              not inc
move left

ei

mid

Allocate Min. Number of Pages.

$$\text{book[]} = \left\{ \overset{0}{12}, \overset{1}{34}, \overset{2}{67}, \overset{3}{90} \right\}$$

students = 2

① Each should have min^m 1 book

② Books to student should be in contigeous manner

③ All the books should be given away.

S1 → 12
S2 → 34, 67, 90   191

S1 → 12,34
S2 → 67, 90   157

S1 → 12,34, 67
S2 → 90   113 → return

TC: O(N * log N) ?

$$book[] = \left\{ \overset{0}{12}, \overset{1}{34}, \overset{2}{67}, \overset{3}{90} \right\} \qquad students = 2$$

<u>Case</u>

<u>Students = 1</u>

S1 ⟶ 12, 34, 67, 90 $\Big\}$ ⟶ (203 pages) ⟶ <u>ans</u>

<u>Case</u>

students = N (4)

S1 ⟶ 12
S2 ⟶ 34
S3 ⟶ 67
S4 ⟶ 90
$\Bigg\}$ ⟶ (90 pages) ⟶ <u>ans</u>

N students

1 student

S^i

mid
112

e^i

Students = 2
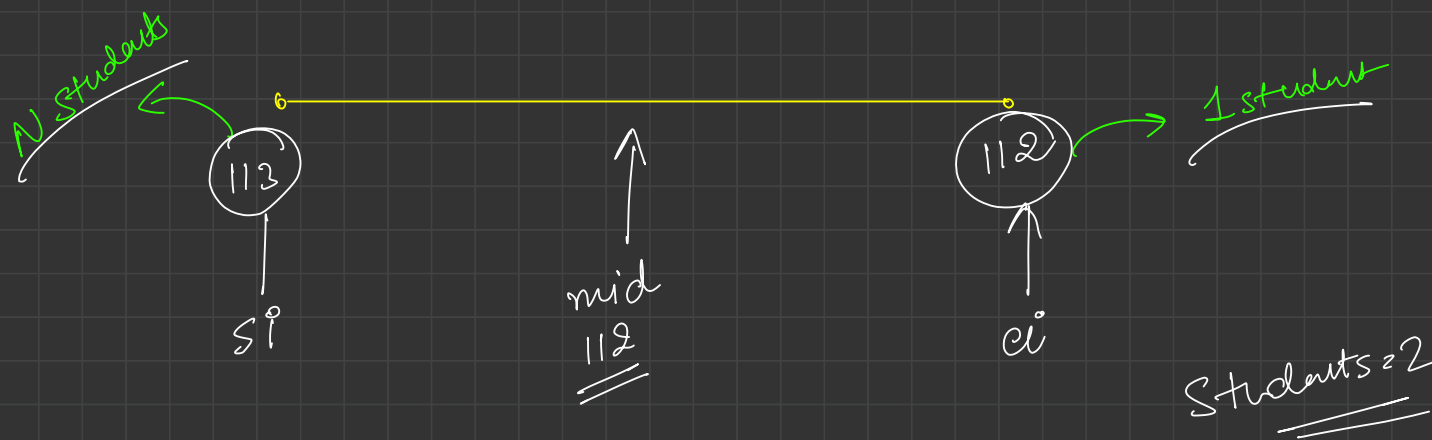
$\underline{minimize}$ your answer = ~~146~~ ~~147~~ (113) ✓

---

book[] = { 12, 34, 67, 90 }
          0   1   2   3

$S1 \rightarrow 12 + 34 + 67$
$S2 \rightarrow 90$

$max^m = 146$

$$book[] = \{\underset{12}{\underset{\times}{\overset{0}{}}}, \underset{34}{\underset{\times}{\overset{1}{}}}, \underset{67}{\underset{\times}{\overset{2}{}}}, \underset{90}{\underset{\uparrow}{\overset{3}{}}}\}$$

$max^m = 117$

$$S1 \longrightarrow 12 + 34 + 67$$
$$S2 \longrightarrow 90$$

$$book[] = \{\underset{12}{\underset{\times}{\overset{0}{}}}, \underset{34}{\underset{\times}{\overset{1}{}}}, \underset{67}{\underset{\times}{\overset{2}{}}}, \underset{90}{\underset{\uparrow}{\overset{3}{}}}\}$$

$max^m = 103$

$$S1 \longrightarrow 12 + 34$$
$$S2 \longrightarrow 67$$
$$S3 \longrightarrow 90$$

$$book[] = \{\underset{12}{\underset{\times}{\overset{0}{}}}, \underset{34}{\underset{\times}{\overset{1}{}}}, \underset{67}{\underset{\times}{\overset{2}{}}}, \underset{90}{\underset{\uparrow}{\overset{3}{}}}\}$$

$max^m = 110$

$$S1 \longrightarrow 12 + 34$$
$$S2 \longrightarrow 67$$
$$S3 \longrightarrow 90$$

$$book[] = \left\{ \begin{matrix} 0 & 1 & 2 & 3 \\ 12, & 34, & 67, & 90 \end{matrix} \right\}$$

$max^m = 113$

$S1 \longrightarrow 12 + 34 + 67$

$S2 \longrightarrow 90$

✓
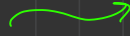
book[] = { 90, 34, 67, 12 }

0 1 2 3

students = 2

Case 1   students = 1

S1 ⟶ 90 + 34 + 67 + 12 ⟶ 203 pages

Case 2   students = 4 (N)
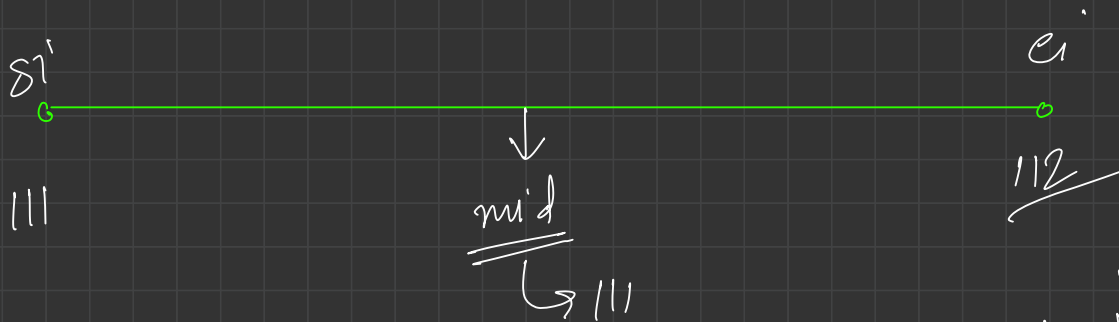
S1 ⟶ 90
S2 ⟶ 34   ⟶ 90 pages
S3 ⟶ 67
S4 ⟶ 12

si

ei

$|||$

112

mid

$\hookrightarrow |||$
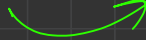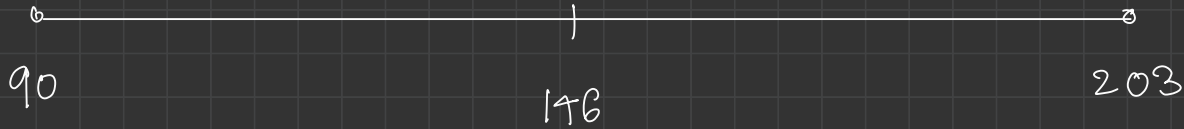
pans = 1~~46~~ ~~117~~ (11)

book[] = { 0   1   2   3 }
          { 90, 34, 67, 12 } $max^m = 11g$

$si \longrightarrow 90$

$s2 \longrightarrow 34 + 67 + 12$

book[] = { 90, 34, 67, 12 }
0   1   2   3

students = 3

90 ———————————|——————————— 203
                        146

pAns = 146

book[] = { 90, 34, 67, 12 }
0   1   2   3

max^m = 146

S1 → 90 + 34
S2 → 67 + 12