Q1. Find the first and last occurance of an element in a sorted array.

Approach: Finding First Occurance.

→ Applying binary search, if at any instance mid is such that arr[mid] == key, then:

① Either this is the first occurance itself.
② Or there are more 'key' towards the left of mid.

So we'll temporarily store mid and then search in the left half by making high = mid - 1.

If arr[mid] < key, then search in right half. by making low = mid + 1.

If arr[mid] > key, then search in left half. by making high = mid - 1.

Example: arr[] = {1, 1, 2, 3, 4, 4, 4, 4} key = 4.

① arr[] = {1, 1, 2, 3, 4, 4, 4, 4}
l mid h

arr[mid] < key ⇒ Definitely in the right half.

low = mid + 1. // low = 4

② arr[] = {1, 1, 2, 3, 4, 4, 4, 4}
l mid h

arr[mid] == key ⇒ Either mid or before mid.
store mid in a variable ans. // ans = 5.
Then make high = mid - 1. // high = 4

mid
③ arr[] = {1, 1, 2, 3, 4, 4, 4, 4}

③ arr[] = {1, 1, 2, 3, 4, 4, 4, 4}

mid, l, h

arr[mid] == key ⇒ Either mid or before mid.
store mid in a variable ans. // ans = 4
Then make high = mid - 1. // high = 3

④ arr[] = {1, 1, 2, 3, 4, 4, 4, 4}

h, l

low > high ⇒ break out. Last value of **ans = 4**

Note: low, mid, high and ans are storing the indices and not values.

Finding Last Occurance.

→ Applying binary search, if at any instance mid is such that arr[mid] == key, then:

① Either this is the last occurance itself.
② Or there are more 'key' towards the right of mid.

So we'll temporarily store mid and then search in the right half by making low = mid+1.

If arr[mid] < key, then search in right half. by making low = mid + 1.

If arr[mid] > key, then search in left half. by making high= mid - 1.

Example: arr[] = {1,1,2,3,4,4,4,4} key = 4.

① arr[] = {1, 1, 2, 3, 4, 4, 4, 4}

l, mid, h

arr[mid] < key ⇒ Definitely in the right half.

low = mid + 1. // low = 4

② arr[] = {1, 1, 2, 3, 4, 4, 4, 4}
l mid h

arr[mid] == key ⇒ Either mid or after mid.
store mid in a variable ans. // ans = 5.
Then make low = mid + 1. // low = 6

③ arr[] = {1, 1, 2, 3, 4, 4, 4, 4}
mid
l h

arr[mid] == key ⇒ Either mid or after mid.
store mid in a variable ans. // ans = 6
Then make low = mid + 1. // low = 7

④ arr[] = {1, 1, 2, 3, 4, 4, 4, 4}
mid
l h

arr[mid] == key ⇒ Either the last occurance is at index mid or to the right of mid.
Store mid in a variable ans. // ans = 7
Then make low = mid + 1.

⑤ arr[] = {1, 1, 2, 3, 4, 4, 4, 4}
h l

low > high ⇒ break out. Last value of ans = 7

Code :

```
int firstOcc(int arr[], int n, int key) {

    int s = 0, e = n-1;
    int mid = s + (e-s)/2;
    int ans = -1;
    while(s<=e) {

        if(arr[mid] == key){
            ans = mid;
            e = mid - 1;
        }
        else if(key > arr[mid]) {//Right me jao
            s = mid + 1;
        }
        else if(key < arr[mid]) {//left me jao
            e = mid - 1;
        }

        mid = s + (e-s)/2;
    }
    return ans;
}
```

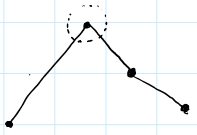
```
int lastOcc(int arr[], int n, int key) {

    int s = 0, e = n-1;
    int mid = s + (e-s)/2;
    int ans = -1;
    while(s<=e) {

        if(arr[mid] == key){
            ans = mid;
            s = mid + 1;
        }
        else if(key > arr[mid]) {//Right me jao
            s = mid + 1;
        }
        else if(key < arr[mid]) {//left me jao
            e = mid - 1;
        }

        mid = s + (e-s)/2;
    }
    return ans;
}
```

Follow - up question :

Q. Count the number of occurances of an element in a sorted array.

→ (Last Occurance Index) - (Fist Occurance Index) + 1

Q. Peak in mountain array.

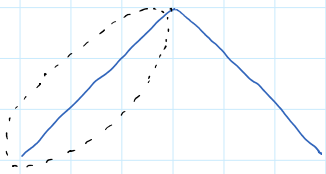
Eg: arr[] : {0, 10, 5, 2} → 

ans = 10.

Approach : If for 'mid' index,

1. arr[mid] < arr[mid+1] :

This element lies in the increasing slope / ascend. Search in the right half. ⇒ low = mid + 1

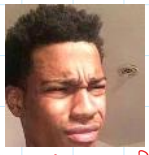


2. In all other cases.

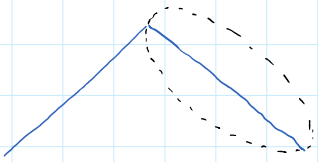
This element lies in the decreasing slope / descend. or is the peak element itself. Since mid can be the peak element, search in the left half including mid.

element, search in the left half including mid.

⇒ high = mid.



Confused?



Example: arr[] : {1, 10, 5, 2, 0}

① low = 0, high = 4, mid = 2

arr[] : {1, 10, 5, 2, 0}
l mid h

arr[mid] is not smaller than arr[mid+1]. ⇒ high = mid

② low = 0, high = 2, mid = 1

arr[] : {1, 10, 5, 2, 0}
l mid h

arr[mid] is not smaller than arr[mid+1]. ⇒ high = mid

③ low = 0, high = 1, mid = 0

arr[] : {1, 10, 5, 2, 0}
mid
l h

arr[mid] is smaller than arr[mid+1] ⇒ low = mid+1.

④ low = 1, high = 1, mid = 1

arr[] : {1, 10, 5, 2, 0}
mid
l h

Do this till **low < high**

Code:

```
int peakIndexInMountainArray(vector<int>& arr) {
    int s = 0;
    int e = arr.size() - 1;

    int mid = s + (e-s)/2;

    while(s<e) {
        if(arr[mid] < arr[mid+1]){
            s = mid + 1;
        }
        else
        {
            e = mid;
        }
        mid = s + (e-s)/2;
    }
    return s;
}
```

Homework: Find pivot in a rotated sorted array.

Discussed in the next Lecture. 😜