APR 2024	S	M	T	W	T	F	S
		1	2	3	4	5	6
	7	8	9	10	11	12	13
	14	15	16	17	18	19	20
	21	22	23	24	25	26	27
	28	29	30				

Searching

'24
13th Week
085-281

MARCH
25
MONDAY

→ Finding an element in array/ linked list called searching.

08 → **Linear Search** = A simple approach is to do a linear search. The time complexity of the linear search is O(n).

09

A simple approach is to do a linear search, i.e.,

10 ① Start from the leftmost element of arr[] and one by one compare x with each element of arr[].

11 ② If x matches with an element, return the index.

③ If x doesn't match with any of element, return -1.

12

eg. find [20]

0	1	2	3	4	5	6	7	8
10	50	30	70	80	60	20	90	40

01

```
02  def search (arr, n, x):                  → best case — 1st position element found at
        for i in range (0, n):
03          if (arr[i] == x):                → worst case — at last(or) not available
                return i
04      return -1
```

TC — O(n) [EC]

05

→ **Binary Search**

06

① Begin with the mid element of the whole array as search key.

07 ② If the value of the search key is equal to the item then return index of the search key.

③ Or if the value of the search key is less than the item in the middle of the interval, narrow the interval to the lower half.

④ Otherwise, narrow it to the upper half.

⑤ Repeatedly check for the second point until the value is found or the interval is empty.

⑥ Firstly we have to sort the array/ list then only apply binary search.

MARCH
26
TUESDAY
'24 BS → It only works for sorted arrays. l.sort()
13th Week
086-280

S	M	T	W	T	F	S
31					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

MAR 2024

eg

0	1	2	3	4	5	6
10	20	30	40	50	60	70

low, high

mid = (low + high) // 2 mid = (0 + 6) // 2 = 3

Case 1: (l[mid] == n) , if n = 40 → return mid

Case 2: (l[mid] > n) , if n = 10 → high = mid − 1 [change high]

Case 3: (l[mid] < n) , if n = 60 → low = mid + 1

Iterative

```
def bs(l,n):
    low = 0
    high = len(l) - 1
    while low <= high:
        mid = (low + high) // 2
        if l[mid] == n:
            return mid
        elif l[mid] < n:
            low = mid + 1
        else:
            high = mid - 1
    return -1
```

Recursive

```
def bs(l,n, low, high):
    if low > high:
        return -1
    mid = (low + high) // 2
    if l[mid] == n:
        return mid
    elif l[mid] > n:
        return bs(l,n,low,mid-1)
    else:
        return bs(l,n,mid+1,high)

def bsmain(l,n):
    return bs(l,n,0,len(l)-1)
```

{ — TC — O(log n)
  — SC — O(1) } ⇒ ε then

Searched element left H available
high = mid − 1

Searched element Right H available
low = mid + 1.

{ TC — O(log n)
  SC — O(log n) }

Extra space we don't use recursion

Iterative solution should be preferred when we are having a choice.

→ It is creating binary tree and height of binary tree is $\lceil \log_2 n \rceil$.

→ T.C of binary search for successful search = (log n)

" " " " " unsuccessful search = O(log n)

The happy only are the truly great

Index of first occurrence in sorted array :-

(a)
```
def fo(arr,n):
    for i in range(0,n):
        if(arr[i]==n):
            return i
    return -1
```
TC = O(n)

(b)
```
def fo(arr,n,n):
    low=0
    high=n-1
    while(low<=high):
        mid=(low+high)//2
        if n>arr[mid]:
            low=mid+1
        elif n<arr[mid]:
        else:
            if mid==0 or arr[mid-1]!=arr[mid]:
                return mid
            else:
                high=mid-1
    return -1.
```
TC = O(log n)

Index of last occurrence in sorted array :-

(a)
```
def la(l,n):
    low=0
    high=len(l)-1
    while low<=high:
        mid=(low+high)//2
        if l[mid]<n:
            low=mid+1
        elif l[mid]>n:
            high=mid-1
        else:
            if mid==len(l)-1 or l[mid]!=l[mid+1]:
                return mid
            else:
                low=mid+1
    return -1
```
TC = O(log n)

(b)
```
def la(l,n):
    for i in reversed(range(len(l))):
        if l[i]==n:
            return i
    return -1.
```
TC = O(n)

```
for i in range(len(l)-1,-1,-1):
```

MARCH
28 '24
13th Week
088-278
THURSDAY

S	M	T	W	T	F	S
31					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

MAR 2024

Count occurrence in sorted array

(a) def Count OCC (lin): → first occurrence function of Previous function

```
first = fo (lin)
if first == -1:
    return 0
else:
    return last OCC (lin) - first + 1
```

TC = O(logn)

```
res = 0
for i in range(n): if x == arr[i]:
    res += 1 ; return res
```

lo → function = last occurrence of Previous Page.

(b) l.count( ) — TC = O(n)
any thing which you want

Repeating Element (a) arr(size) ≥ 2 (b) only one element is repeated

(c) All the element from 0 to max(arr) are present ⇒ $0 \le \max(arr) \le n-2$

i/p = l = [0,2,1,3,2,2]
o/p = 2.

i/p = l = [1,2,3,0,3,4,5]
o/p = 3.

We need to solve
O(n), O(1)
No modification to original array

M-1

```
for i in range(0, n-1):
    for j in range(i+1, n):
        if (arr[i] == arr[j]):
            return arr[i]
```

TC = O(n²)
SC = O(1)

M-2 Sort the array.
[0,1,2,2,2,3]

```
for i in range(0,n):
    if (arr[i] == arr[i+1])
        return arr[i]
```

TC = O(nlogn)

M-4

```
def repeat (arr, n):
    slow = arr[0]
    fast = arr[0]
    slow = arr[slow]
    fast = arr[arr[fast]]
    while slow != fast: slow = arr[slow]
        fast = arr[arr[fast]]
    slow = arr[0]
    while slow != fast: slow = arr[slow]
        fast = arr[fast]
return slow.
```

M-3

```
def repeat (arr, n):
    visit = [False]*n
    for i in range(n):
        if visit[arr[i]]:
            return arr[i]
        visit[arr[i]] = True
    return -1
```

Square root

(a)
```
def sqrt(n):
    i = 1
    while i*i <= n:
        i += 1 [क्या ई तो increment]
    return i-1 [नहीं है तो Decrement]
```
TC = O(√n)

(b)
```
def sqrt(n):
    low = 1
    high = n
    ans = -1
    while low <= high:
        mid = (low + high) // 2
        msq = mid*mid
        if msq == n:
            return mid
        elif msq > n:
            high = mid - 1
        else:
            low = mid + 1
            ans = mid
    return ans.
```
TC = O(log n)

Linear search for first & record occurrence.

```
def ls(l, key):
    tl = []
    for i in range(len(l)):
        if key == l[i]:
            tl.append(i)
    return tl[0:2]
```

Search in an Infinite sized array.

i/p = arr = [1, 10, 15, 20, 40, 80, 90, 100, 120, 500, ...]
n = 100 , o/p = 7 ✓

i/p = arr = [20, 40, 100, 300, ...]
n = 50 , o/p = -1.

M1
```
def search(arr, n):
    i = 0
    while True:
        if arr[i] == n:
            return i
        if arr[i] > n:
            return -1
        i += 1.
```
TC = O(n)

M-2
```
def search(arr, n):
    if arr[0] == n:
        return 0
    i = 1
    while arr[i] < n:
        i = i*2
    if arr[i] == n
        return i
    return [arr, i//2+1, i-1, n)
```
TC = O(log n)

Peak Element

Given an array of integers. Find a peak element.
i.e an element that is not smaller than its neighbours.

i/p : l = [5, 10, 20, 15] , o/p = 20
i/p : l = [10, 20, 15, 2, 23, 90, 67] , o/p = 20 (or) 90

M1

```
def peak(arr,n):
    if n==1:
        return arr[0]
    if arr[0] >= arr[1]:
        return arr[0]
    if arr[n-1] >= arr[n-2]:
        return arr[n-1]
    for i in range(1,n-1):
        if arr[i] >= arr[i-1] and arr[i] >= arr[i+1]:
            return arr[i]
```

{TC = O(n), SC = O(1)}

M2

```
def peak(arr,n):
    l=0
    r=n-1
    while(l<=r):
        mid = (l+r)>>1
        if((mid==0 or arr[mid-1]<=arr[mid]) and
           (mid==n-1 or arr[mid+1]<=arr[mid])):
            break
        if(mid>0 and arr[mid-1]>arr[mid]):
            r=mid-1
        else:
            l=mid+1
    return mid
```

{TC = O(log n), SC = O(1)}

Search in a sorted Rotated Array

i/p : arr[] = {10, 20, 30, 40, 50, 8, 9} , n = 30 { You can rotate any No. of times to make it sorted.

o/p : 2

i/p : arr[] = {100, 200, 300, 10, 20} , n = 40

o/p : -1

Naive Approach

```
def search(arr, n, x):
    for i in range(0, n):
        if arr[i] == x:
            return i
    return -1
```

→ It will generate 0 to n No. and in next step we are iterating in array indexing.

TC = O(n)
SC = O(1)

Efficient Approach

```
def search(arr, n, x):
    low = 0
    high = n-1
    while low <= high:
        mid = (low + high) // 2
        if arr[mid] == x:
            return mid
        if arr[low] <= arr[mid]:
            if arr[low] <= x <= arr[mid]:
                high = mid - 1
            else:
                low = mid + 1
        else:
            if arr[mid] <= x <= arr[high]:
                low = mid + 1
            else:
                high = mid - 1
    return -1
```

Normal Binary Search

left half is sorted

right half is sorted

TC = O(log n)

eg

arr = [10, 20, 40, 6, 5, 8] , n = 6

Initially : low = 0 , high = 5

1st iteration : mid = 2 , low = 3

2nd iteration : mid = 4 , return = 4

Allocate minimum No. of Pages.

Given a number of pages in N different books & m student. The books are arranged in ascending order of the No. of pages. Every student is assigned to read some consecutive books. The task is to assign book in such a way that the maximum No. of pages assigned to a student is minimum.

i/p : Pages[] = {12, 34, 67, 90} , m = 2 o/p = 113

There are 2 No. of student so books can be distributed in following fashion:

(i) [12] and [34, 67, 90] → 34 + 67 + 90 = 191 page maximum.

(ii) [12, 34] and [67, 90] → max No. of pages is allocated to student 2! = 67 + 90 = 157.

(iii) [12, 34, 67] and [90] → Max No. of pages is allocated to student '1' with 12 + 34 + 67 = 113 Pages.

Naive Recursive Soln

$x_0 | x_1 | x_2 | x_3 | x_4 | \dots | x_{i-1} | x_i | \dots | x_{n-1}$

We need to choose $(k-1)$ cuts of $(n-1)$ cuts shown above

Total ways $= {}^{n-1}C_{k-1}$

eg $l = [10, 20, 30, 40]$ $k = 2$

We need to choose 1 cut out of 3 cuts.

```
def minPages(arr, n, k):
    if (k == 1):
        return sum(arr[0:n])
    if (n == 1):
        return arr[0]
    res = float('inf')
    for i in range(1, n):
        res = min(res, max(minPages(
            arr, i, k-1), sum(arr[i:n])))
    return res.
```

Using Binary Search

```
def isFeasible(arr, k, ans):
    req = S = 1, 0
    for i in range(len(arr)):
        if (S + arr[i]) > ans:
            req += 1
            S = arr[i]
        else:
            S += arr[i]
    return (req <= k)

def minPages(arr, k):
    n = len(arr)
    S = sum(arr)
    mx = max(arr)
    low, high = mx, S
    res = 0
    while low <= high:
        mid = (low + high) // 2
        if (isFeasible(arr, k, mid)):
            res = mid
            high = mid - 1
        else:
            low = mid + 1
    return res.
```

TC = $O(n \times \log(\text{sum}))$

Two Pointer Approach

08

Two pointers is really an easy & effective technique that is typically used for searching pairs in a sorted array.

09

eg Given a sorted array A (sorted) having N integers, find if there exist any pair of elements (A[i], A[j]) such that their sum is equal to x.

10

11 i/p: A = [10, 20, 35, 50, 75, 80]
x = 70, o/p: True (pair is (35, 20))

12

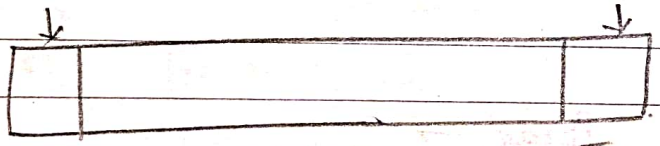
M-1

```
def ispair(arr,n):
    n= len(arr)
    for i in range(n-1):
        for j in range(i+1,n):
            if arr[i] + arr[j]==n:
                return True
    return False
```

TC=O(n^2)
SC=O(1)

arr = [2, 3, 8, 11]
n = 14
i=0, j=1
j=2
j=3
i=1, j=2
j=3
return True

M-2



We move either of them towards each other.

eg [2, 4, 8, 9, 11, 12, 20, 30], n= 23

It is giving smaller than expected so it will not create impact

It is giving larger than expected value pair so it will get impact

i=0, j=7
(2+30) > 23 : i=0, j=6
(2+20) < 23 : i=1, j=6
(4+20) > 23 : i=1, j=5
(4+12) < 23 : i=2, j=5
(8+12) < 23 : i=3, j=5
(9+12) < 23 : i=4, j=5
(11+12) == 23 : return True

APRIL
01
MONDAY
'24
14th Week
092-274

This technique will work well when you have sorted array, for unsorted array we will have to first sort the array.

	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

APR 2024

We take two pointers, one representing the first element and other representing the last element of the array, and then we add the values kept at both the pointers. If their sum is smaller than x then we shift the left pointer to right or if their sum is greater than x then we shift the right pointer to left, in order to get closer to the sum. We keep moving the pointers until we get the sum as x.

```
def Tp(arr, x):
    i = 0
    J = len(arr) - 1
    while i < J:
        if arr[i] + arr[J] == x:
            return True
        elif (arr[i] + arr[J] < x):
            i = i + 1
        else:
            J = J - 1
    return False.
```

TC = O(n log n) because sorting is required.
SC = O(1)

TC = O(n)

Triplet in a sorted Array:—

i/p = l = [2, 3, 14, 8, 9, 20, 40], x = 32
o/p = True. Triplet is (4, 8, 20)

M-1

```
def Triplet(arr, n):
    n = len(arr)
    for i in range(n):
        for J in range(i+1, n):
            for k in range(J+1, n):
                if arr[i] + arr[J] + arr[k] == x:
                    return True
    Return False
```

TC = O(n3)
SC = O(1)

M2

① Traverse the array from left to right
② For every element arr[i], check if there is a pair on right side with sum (x - arr[i])

starting index.

```
def isPair(arr, n, si):
    i = si
    J = len(arr) - 1
    while i < J:
        if arr[i] + arr[J] == n:
            return True
        elif arr[i] + arr[J] < n:
            i = i + 1
        else:
            J = J - 1
    return False
```

```
def Triplet(arr, n):
    for i in range(len(arr) - 2):
        if (isPair(arr, n - arr[i], i+1)):
            return True
    return False
```

TC = $O(n^2)$

Median of two sorted Array.

i/p: a1[] = {10, 20, 30, 40, 50}
a2[] = {5, 15, 25, 35, 45}
o/p: 27.5 // {5, 10, 15, 20, 25, 30, 35, 40, 45, 50}

Naive

n_1: size of a1[], n_2: size of a2[]

① Create an array temp[] of size $(n_1 + n_2)$
② Copy element of a1[] and a2[] to temp[]
③ Sort temp[]
④ If $(n_1 + n_2)$ is odd, then return middle of temp.
⑤ else return average of middle of two element.

TC = $O((n_1 + n_2) \times \log(n_1 + n_2))$

APRIL
03 '24
14th Week
094-272
WEDNESDAY

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

APR 2024

M-2 Using binary search.

```
def getmid(a1, a2):
    n1, n2 = len(a1), len(a2)
    b1, e1 = 0, n1
    while (b1 <= e1):
        x = (b1 + e1) // 2
        y = ((n1 + n2 + 1) // 2 - x)
        minr1 = float('inf') if x == n1 else a1[x]
        maxl1 = float('-inf') if x == 0 else a1[x-1]
        minr2 = a2[y]
        maxl2 = a2[y-1]
        if maxl1 <= minr2 and maxl2 <= minr1:
            if (n1+n2) % 2 == 0:
                return (max(maxl1, maxl2) + min(minr1, minr2))/2
            else:
                return max(maxl1, maxl2)
        elif maxl1 > minr2:
            e1 = x-1
        else:
            b1 = x+1
```

TC = O(log n1)

The highest duty is to respect authority