Two Pointer

- Sorted array or linked list will be given.
- You will need to calculate some specific numbers that matches some value.
- The set of elements could be a pair, a triplet or even a subarray.
- Two Pointer
    - Q.1 Pair with target sum
        - Approach 1 : Brute Force
        - Code -
        - Approach 2 : Optimize version
        - Code -
    - Q.2 Squaring a sorted array so that it will be sorted array
        - Approach 1 : Brute Force
        - Approach 2 : Optimized
    - Q.3 Triplet sum to zero (Unique Triplets)
        - Approach 1. Brute Force
            - Example of contain duplicate answer
            - Example of not contain duplicate answers
        - Approach 2 : Optimized
    - Q.4 Count no. of triplets whose sum less than given target
        - Approach 1 : Brute Force
        - Approach 2 : Optimized
    - Q.5 You are given an array nums and a range [a, b] of triplets whose sum lies in that range [a, b]
    - Q.6 `Dutch National Flag` Problem
        - Approach 1: Brute Force
        - Approach 2: Optimized
    - Q.7 Backspace String Compare
        - Approach 1: Brute Force
        - Approach 2: Optimized
    - Other Questions Link
- Advance Mix Topic
    - Note :- Prior Knowledge of

Q.1 Pair with target sum

Solve on Leetcode -

S.No	Question	Solution	Related Topics	Difficulty
1.	167. Two Sum II - Input Array Is Sorted			**Easy**

- Given an array of sorted numbers

- and a target sum
- find a pair of indices in the array whose sum is equal to the given target.

2	4	7	8	9	12	14
0	1	2	3	4	5	6

- Target Sum = 13
- Output : [1, 4]

Approach 1 : Brute Force

- Here the length of the array is 7 iterating for each element (pointed by first pointer) we search second element in remaining elements (pointed by second pointer) -
- 7 (Length) : 6 + 5 + 4 + 3 + 2 + 1
- N (Length) : N-1 + N-2 + N-3 + ... + 2 + 1, So the time complexity calculate as -
- Sum of first (N-1) natural numbers :
  - N : N(N+1)/2
  - N-1 : (N-1)(N-1+1)/2
  - = N(N-1)/2
  - = $N^2/2$ - N/2
- **Time Complexity :** O(n^2)
- **Space Complexity :** O(1)

Code -

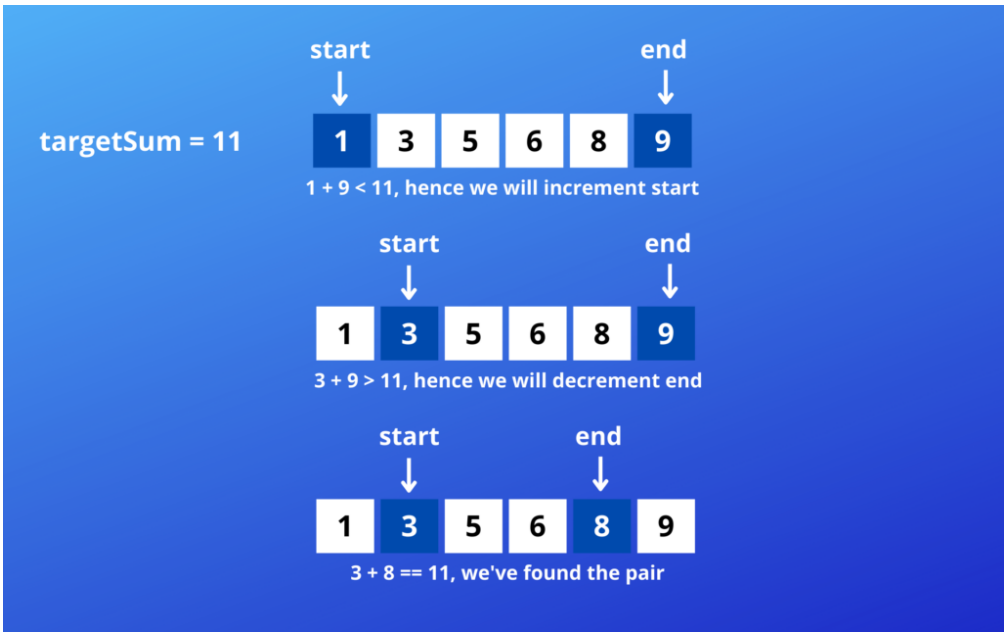
```
def solve(arr,target):
    for i in range(len(arr)):
        for j in range(i+1,len(arr)):
            if arr[i]+arr[j]==target:
                return [i,j]
    return [-1,-1]

arr = [2,4,8,7,9,12,14]
target = 13
print(solve(arr,target))
```

Approach 2 : Optimize version

- Why given array is sorted.
- An efficient way would be to start with one pointer in the beginning and another pointer at the end.
- At every step, we will see if the numbers pointed by the two pointers add up to the target sum. If they do not, we will do one of two things:

    - If the sum of the two numbers pointed by the two pointers is greater than the target sum, this means that we need a pair with a smaller sum. We have to add smaller value for that we have to decrement end pointer index.
    - If the sum of the two numbers pointed by the two pointers is less than the target sum, this means that we need a pair with a greater sum. We have to add greater value for that we have to increment start pointer.
- **Time Complexity :** O(n)
- **Space Complexity :** O(1)



Code -

```
def pairSum(arr,target):
    left = 0
    right = len(arr)-1

    while left < right:
        if arr[left] + arr[right] == target:
            return [left,right]
        elif arr[left] + arr[right] < target:
            left += 1
        else:
            right -= 1
    return [-1, -1]

arr = [1, 3, 5, 6, 8, 9]
target = 11
print(pairSum(arr, target))
```

Q.2 Squaring a sorted array so that it will be sorted array

Solve on Leetcode -

S.No	Question	Solution	Related Topics	Difficulty
1.	977. Squares of a Sorted Array			**Easy**

- You are given a sorted array calculate their squares and the array in sorted.
- Example-1

2	**4**	**7**	**8**	**9**	**12**	**14**
0	1	2	3	4	5	6

- Answer ->

4	**16**	**49**	**64**	**81**	**144**	**196**
0	1	2	3	4	5	6

- Example-2

-5	**-4**	**-2**	**0**	**1**	**3**	**4**
0	1	2	3	4	5	6

- Answer ->

0	**1**	**4**	**9**	**16**	**16**	**25**
0	1	2	3	4	5	6

Approach 1 : Brute Force

- Simply calculate squares and store values into the another `ans` array.
- And then sort the array.
- ***Time Complexity :*** O(nlogn) -> for sorting
- ***Space Complexity :*** O(n)

```
def squareArr(arr):
    ans = []
    for i in arr:
        ans.append(i*i)
    return sorted(ans)

arr = [-5, -4, -1, 0, 2, 3, 4]
print(squareArr(arr))
```

Approach 2 : Optimized

- let us take two pointer at start and end of the array.
- **Time Complexity :** O(n)

- **Space Complexity :** O(n)

```
def square(arr):
    left,right = 0, len(arr)-1
    index = len(arr)-1
    ans = [0]*len(arr)
    while left<=right:
        lsquare = arr[left]**2
        rsquare = arr[right]**2
        if lsquare > rsquare:
            ans[index] = lsquare
            left += 1
        else:
            ans[index] = rsquare
            right -= 1
        index -= 1
    return ans

arr = [-5, -4, -2, 0, 1, 3, 4]
print(square(arr))
```

OR

```
def squareArr(arr):
    ans = []
    left, right = 0, len(arr)-1
    while left<=right:
        l = arr[left]*arr[left]
        r = arr[right]*arr[right]
        if l>r:
            ans.insert(0,l)
            left += 1
        else:
            ans.insert(0,r)
            right -= 1
    return ans

arr = [-5, -4, -1, 0, 2, 3, 4]
print(squareArr(arr))
```

Q.3 Triplet sum to zero (Unique Triplets)

S.No	Question	Solution	Platform	Related Topics	Difficulty
1.	Find triplets with zero sum		GFG	Hash Map	**Easy**
2.	15. 3Sum		Leetcode	Hash Map	**Medium**
3.	3Sum Closest		Leetcode	Hash Map	****

- Given an unsorted array find all unique triplets in the array which gives the sum of zero.
- The solution set must not contain duplicate triplets.

-3	0	1	2	-1	1	-2
0	1	2	3	4	5	6

- **Note :** For answer you must think on pen and paper.
- **Output :** [-3, 1, 2], [-2, 0, 2], [-2, 1, 1], [-1, 0, 1]

Approach 1. Brute Force

- ***Time Complexity :*** O (n^3)
- ***Space Complexity :*** O (1) approx

Example of contain duplicate answer

```
def tripletZero(arr):
    n = len(arr)
    ans = set()
    for i in range(n-2):
        for j in range(i+1,n-1):
            for k in range(j+1,n):
                if arr[i] + arr[j] + arr[k] == 0:
                    ans.add((arr[i], arr[j], arr[k]))
    return ans

arr = [-3, 0, 1, 2, -1, 1, -2]
print(tripletZero(arr))
```

- **Output :** {(0, -1, 1), (-3, 1, 2), (1, 1, -2), (0, 1, -1), (0, 2, -2), (-3, 2, 1)}

Example of not contain duplicate answers

```
a = set()
for i in range(len(arr)-1):
```

- ***Output :***

Approach 2 : Optimized

1. First sort the array.
2. Treat the third element (negative of original) as a target of remaining two element.

-3	0	-2	1	-1	2	1	-3	2
0	1	2	3	4	5	6	7	8

- ***Time Complexity :*** O (n^2)
- ***Space Complexity :*** O (n)

```
def tripletZero(arr):
    triplets = []
    arr.sort()
    for i in range(len(arr)):
        target = -arr[i]
        if i>0 and arr[i]==arr[i-1]:
            continue
        find_pair(arr,i+1,target,triplets)
    return triplets

def find_pair(arr, left,target, triplets):
    right = len(arr)-1
    while left<right:
        arrsum = arr[left] + arr[right]
        if arrsum==target:
            triplets.append([-target, arr[left], arr[right]])
            left += 1
            right -= 1
            # To remove duplicate pair
            while left<right and arr[left]==arr[left-1]:
                left += 1
            while left<right and arr[right]==arr[right+1]:
                right -= 1
        elif arrsum< target:
            left += 1
        else:
            right -= 1

arr = [-3, -3, 0, 1, 2, 2, -1, 1, -2, -2]
print(tripletZero(arr))
```

Q.4 Count no. of triplets whose sum less than given target

-
- **Example -**

-1	4	2	1	3
0	1	2	3	4

- Target = 5
- **Answer :** 4

[-1, 4, 1], [-1, 2, 1], [-1, 2, 3], [-1, 1, 3]

Approach 1 : Brute Force

- ***Time Complexity :*** O (n^3)
- ***Space Complexity :*** O (1)

```
def countTriplet(arr, target):
    count = 0
    for i in range(len(arr)):
        for j in range(i+1, len(arr)):
            for k in range(j+1, len(arr)):
                if arr[i] + arr[j] + arr[k] < target:
                    count += 1
    return count

arr = [-1, 4, 2, 1, 3]
target = 5
print(countTriplet(arr, target))
```

Approach 2 : Optimized

1. Sort the array.

```
def countTriplet(arr, target):
    arr.sort()
    count = 0
    for i in range(len(arr)-2):
        count += find_pair(arr, arr[i], i+1, target)
    return count

def find_pair(arr, first, start, target):
    count = 0
    end = len(arr)-1
    while start<end:
        if first + arr[start] + arr[end] < target:
```

```
                count += (end-start)
                start += 1
            else:
                end -= 1
        return count

    arr = [-1, 4, 2, 1, 3]
    target = 5
    print(countTriplet(arr, target))
```

Q.5 You are given an array nums and a range [a, b] of triplets whose sum lies in that range [a, b]

S.No	Question	Solution	Platform	Related Topics	Difficulty
1.	3Sum Closest		Leetcode	`Hash Map`	**M**

Q.6 `Dutch National Flag` Problem

S.No	Question	Solution	Related Topics	Difficulty
1.	Sort an array of 0s, 1s and 2s			**Easy**
2.	75. Sort Colors			**Medium**
3.	Binary Array Sorting			**Easy**

- The problem was proposed by Edsger Dijkstra.
- This problem is also follows as:
  - Given N balls of color red, white or blue arranged in a line in random order. You have to arrange all the balls such that all red coloured balls come first then the white coloured balls and then the blue coloured balls.

0	**0**	**0**	**1**	**1**	**1**	**1**	**2**	**0**	**1**	**1**	**0**	**2**	**1**	**1**	**0**
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

- If the ith element is 0 then swap the element to the low range.
- Similarly, if the element is 1 then keep it as it is.
- If the element is 2 then swap it with an element in high range.

Approach 1: Brute Force

- Sort the array
- ***Time Complexity :*** O (nlogn)
- ***Space Complexity :*** O (1)

```
def dnf(arr):
    arr.sort()
    return arr

arr = [0,2,0,1,2,1,1,1,0,0,0,2,2,1]
print(dnf(arr))
```

Approach 2: Optimized

- This is `in-place` algorithm
- ***Time Complexity :*** O (n)
- ***Space Complexity :*** O (1)

```

```

Q.7 Backspace String Compare

- ***Time Complexity :***
- ***Space Complexity :***
-

Approach 1: Brute Force

Approach 2: Optimized

Other Questions Link

S.No	Question	Solution	Related Topics	Difficulty
1.	3Sum Closest		`Hash Map`	**Easy**
2.	3Sum Closest		`Hash Map`	
3.	3Sum Closest		`Hash Map`	

Advance Mix Topic

Note :- Prior Knowledge of

3. Linked List

S.No	Question	Solution	Related Topics
1.	Two Sum (Not sorted)		`Linked List`
2.	Two Sum (Not sorted)		`Hash Map`

88. Merge Sorted Array

https://leetcode.com/problems/sort-transformed-array/

https://workat.tech/problem-solving/topics/two-pointers/practice