

## Solution Review: Problem Challenge 2

### We'll cover the following

- Target Sum (hard)
- \*
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  - Space Optimized Solution

### Target Sum (hard) #

You are given a set of positive numbers and a target sum 'S'. Each number should be assigned either a '+' or '-' sign. We need to find the total ways to assign symbols to make the sum of the numbers equal to the target 'S'.

Example 1: #

```
Input: {1, 1, 2, 3}, S=1
Output: 3
Explanation: The given set has '3' ways to make a sum of '1': {+1-1-2+3} & {-1+1-2+3} & {+1+1+2-3}
```

Example 2: #

```
Input: {1, 2, 7, 1}, S=9
Output: 2
Explanation: The given set has '2' ways to make a sum of '9': {+1+2+7-1} & {-1+2+7+1}
```

### Solution #

This problem follows the **0/1 Knapsack pattern** and can be converted into **Count of Subset Sum**. Let's dig into this.

We are asked to find two subsets of the given numbers whose difference is equal to the given target 'S'. Take the first example above. As we saw, one solution is {+1-1-2+3}. So, the two subsets we are asked to find are {1, 3} & {1, 2} because,

$$(1 + 3) - (1 + 2) = 1$$

Now, let's say 'Sum(s1)' denotes the total sum of set 's1', and 'Sum(s2)' denotes the total sum of set 's2'. So the required equation is:

$$\text{Sum}(s1) - \text{Sum}(s2) = S$$

This equation can be reduced to the subset sum problem. Let's assume that 'Sum(num)' denotes the total sum of all the numbers, therefore:

$$\text{Sum}(s1) + \text{Sum}(s2) = \text{Sum}(\text{num})$$

Let's add the above two equations:

$$\begin{aligned} \Rightarrow \text{Sum}(s1) - \text{Sum}(s2) + \text{Sum}(s1) + \text{Sum}(s2) &= S + \text{Sum}(\text{num}) \\ \Rightarrow 2 * \text{Sum}(s1) &= S + \text{Sum}(\text{num}) \\ \Rightarrow \text{Sum}(s1) &= (S + \text{Sum}(\text{num})) / 2 \end{aligned}$$

Which means that one of the set 's1' has a sum equal to  $(S + \text{Sum}(\text{num})) / 2$ . This essentially converts our problem to: "Find the count of subsets of the given numbers whose sum is equal to  $(S + \text{Sum}(\text{num})) / 2$ "

### Code #

Let's take the dynamic programming code of **Count of Subset Sum** and extend it to solve this problem:

```
1 class TargetSum {
2
3     public int findTargetSubsets(int[] num, int s) {
4         int totalSum = 0;
5         for (int n : num)
6             totalSum += n;
7
8         // if 's + totalSum' is odd, we can't find a subset with sum equal to '(s + totalSum) / 2'
9         if(totalSum < s || (s + totalSum) % 2 == 1)
10             return 0;
11
12         return countSubsets(num, (s + totalSum) / 2);
13     }
14
15     // this function is exactly similar to what we have in 'Count of Subset Sum' problem.
16     private int countSubsets(int[] num, int sum) {
17         int n = num.length;
18         int[][] dp = new int[n][sum + 1];
19
20         // populate the sum=0 columns, as we will always have an empty set for zero sum
21         for(int i=0; i < n; i++)
22             dp[i][0] = 1;
23
24         // with only one number, we can form a subset only when the required sum is equal to the number
25         for(int s=1; s <= sum; s++) {
26             dp[0][s] = (num[0] == s ? 1 : 0);
27         }
28     }
29 }
```

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## Time and Space complexity #

The above solution has time and space complexity of  $O(N * S)$ , where 'N' represents total numbers and 'S' is the desired sum.

We can further improve the solution to use only  $O(S)$  space.

## Space Optimized Solution #

Here is the code for the space-optimized solution, using only a single array:

Java Python3 C++ JS

```
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6             totalSum += n;
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9         if(totalSum < s || (s + totalSum) % 2 == 1)
10             return 0;
11
12         return countSubsets(num, (s + totalSum) / 2);
13     }
14
15     // this function is exactly similar to what we have in 'Count of Subset Sum' problem.
16     private int countSubsets(int[] num, int sum) {
17         int n = num.length;
18         int[] dp = new int[sum + 1];
19         dp[0] = 1;
20
21         // with only one number, we can form a subset only when the required sum is equal to the number
22         for(int s=1; s <= sum; s++) {
23             dp[s] = (num[0] == s ? 1 : 0);
24         }
25
26         // process all subsets for all sums
27         for(int i=1; i < num.length; i++) {
28             for(int s=sum; s >= 0; s--) {
```

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Problem Challenge 2

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