



## 122. Best Time to Buy and Sell Stock II

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Say you have an array `prices` for which the  $i^{\text{th}}$  element is the price of a given stock on day  $i$ .

Design an algorithm to find the maximum profit. You may complete as many transactions as you like (i.e., buy one and sell one share of the stock multiple times).

**Note:** You may not engage in multiple transactions at the same time (i.e., you must sell the stock before you buy again).

**Example 1:**

**Input:** [7,1,5,3,6,4]  
**Output:** 7  
**Explanation:** Buy on day 2 (price = 1) and sell on day 3 (price = 5), profit = 5-1 = 4. Then buy on day 4 (price = 3) and sell on day 5 (price = 6), profit = 6-3 = 3. Total profit = 4 + 3 = 7.

**Example 2:**

**Input:** [1,2,3,4,5]  
**Output:** 4  
**Explanation:** Buy on day 1 (price = 1) and sell on day 5 (price = 5), profit = 5-1 = 4. Note that you cannot buy on day 1, buy on day 2 and sell them later, as you are engaging multiple transactions at the same time. You must sell before buying again.

**Example 3:**

**Input:** [7,6,4,3,1]  
**Output:** 0  
**Explanation:** In this case, no transaction is done, i.e. max profit = 0.

**Constraints:**

- $1 \leq \text{prices.length} \leq 3 \times 10^4$
- $0 \leq \text{prices}[i] \leq 10^4$

## Summary

We have to determine the maximum profit that can be obtained by making the transactions (no limit on the number of transactions done). For this we need to find out those sets of buying and selling prices which together lead to the maximization of profit.

## Solution

### Approach 1: Brute Force

In this case, we simply calculate the profit corresponding to all the possible sets of transactions and find out the maximum profit out of them.

Java

Copy

```
1 class Solution {
2     public int maxProfit(int[] prices) {
3         return calculate(prices, 0);
4     }
5
6     public int calculate(int prices[], int s) {
7         if (s >= prices.length)
8             return 0;
9         int max = 0;
10        for (int start = s; start < prices.length; start++) {
11            int maxprofit = 0;
12            for (int i = start + 1; i < prices.length; i++) {
13                if (prices[start] < prices[i]) {
14                    int profit = calculate(prices, i + 1) + prices[i] - prices[start];
15                    if (profit > maxprofit)
16                        maxprofit = profit;
17                }
18            }
19            if (maxprofit > max)
20                max = maxprofit;
21        }
22        return max;
23    }
24 }
```

**Complexity Analysis**

- Time complexity :  $O(n^n)$ . Recursive function is called  $n^n$  times.
- Space complexity :  $O(n)$ . Depth of recursion is  $n$ .

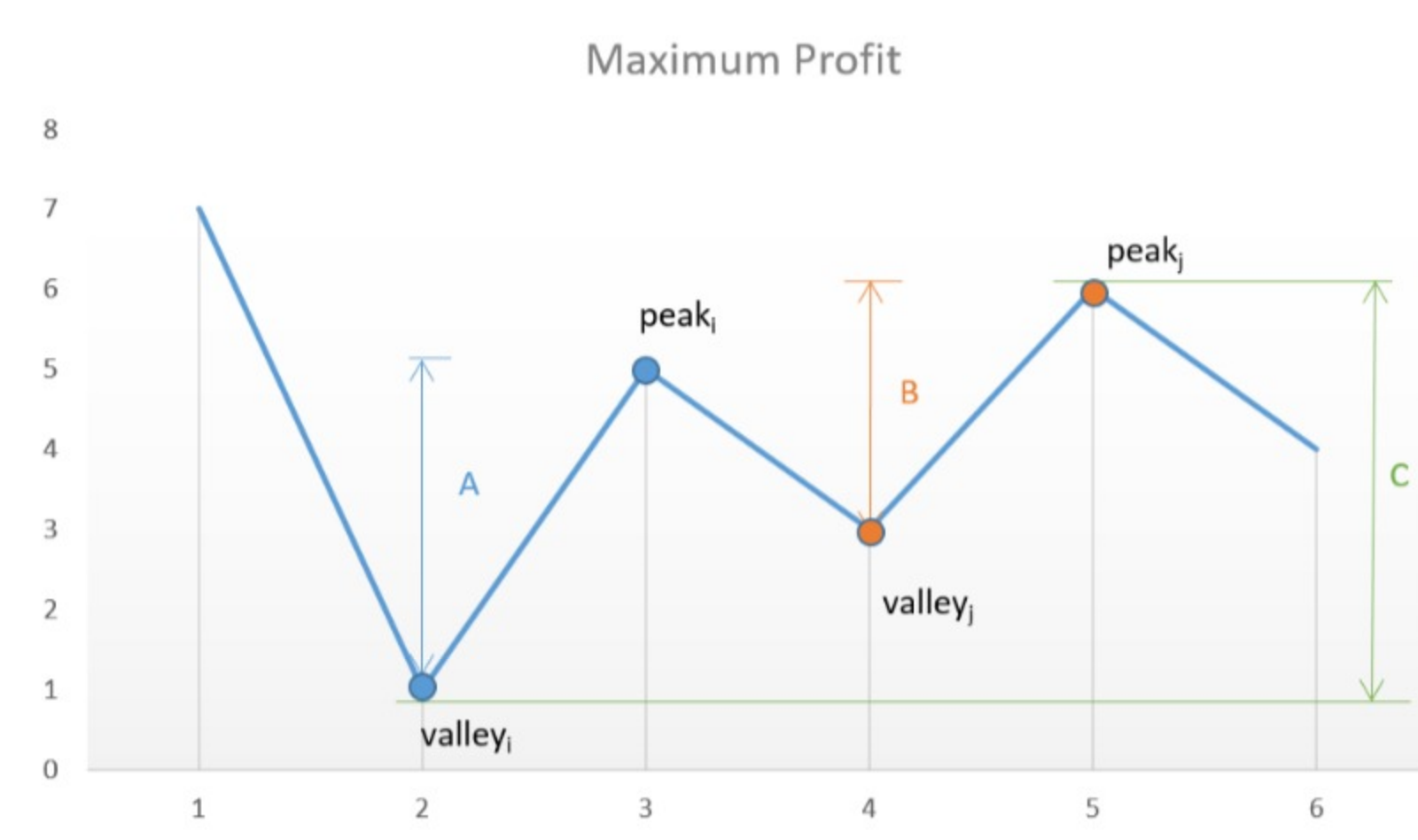
### Approach 2: Peak Valley Approach

**Algorithm**

Say the given array is:

[7, 1, 5, 3, 6, 4].

If we plot the numbers of the given array on a graph, we get:



If we analyze the graph, we notice that the points of interest are the consecutive valleys and peaks.

Mathematically speaking:

$$TotalProfit = \sum_i (height(peak_i) - height(valley_i))$$

The key point is we need to consider every peak immediately following a valley to maximize the profit. In case we skip one of the peaks (trying to obtain more profit), we will end up losing the profit over one of the transactions leading to an overall lesser profit.

For example, in the above case, if we skip  $peak_i$  and  $valley_j$ , trying to obtain more profit by considering points with more difference in heights, the net profit obtained will always be lesser than the one obtained by including them, since  $C$  will always be lesser than  $A + B$ .

Java

Copy

```
1 class Solution {
2     public int maxProfit(int[] prices) {
3         int i = 0;
4         int valley = prices[0];
5         int peak = prices[0];
6         int maxprofit = 0;
7         while (i < prices.length - 1) {
8             while (i < prices.length - 1 && prices[i] >= prices[i + 1])
9                 i++;
10            valley = prices[i];
11            while (i < prices.length - 1 && prices[i] <= prices[i + 1])
12                i++;
13            peak = prices[i];
14            maxprofit += peak - valley;
15        }
16        return maxprofit;
17    }
18 }
```

**Complexity Analysis**

- Time complexity :  $O(n)$ . Single pass.
- Space complexity :  $O(1)$ . Constant space required.

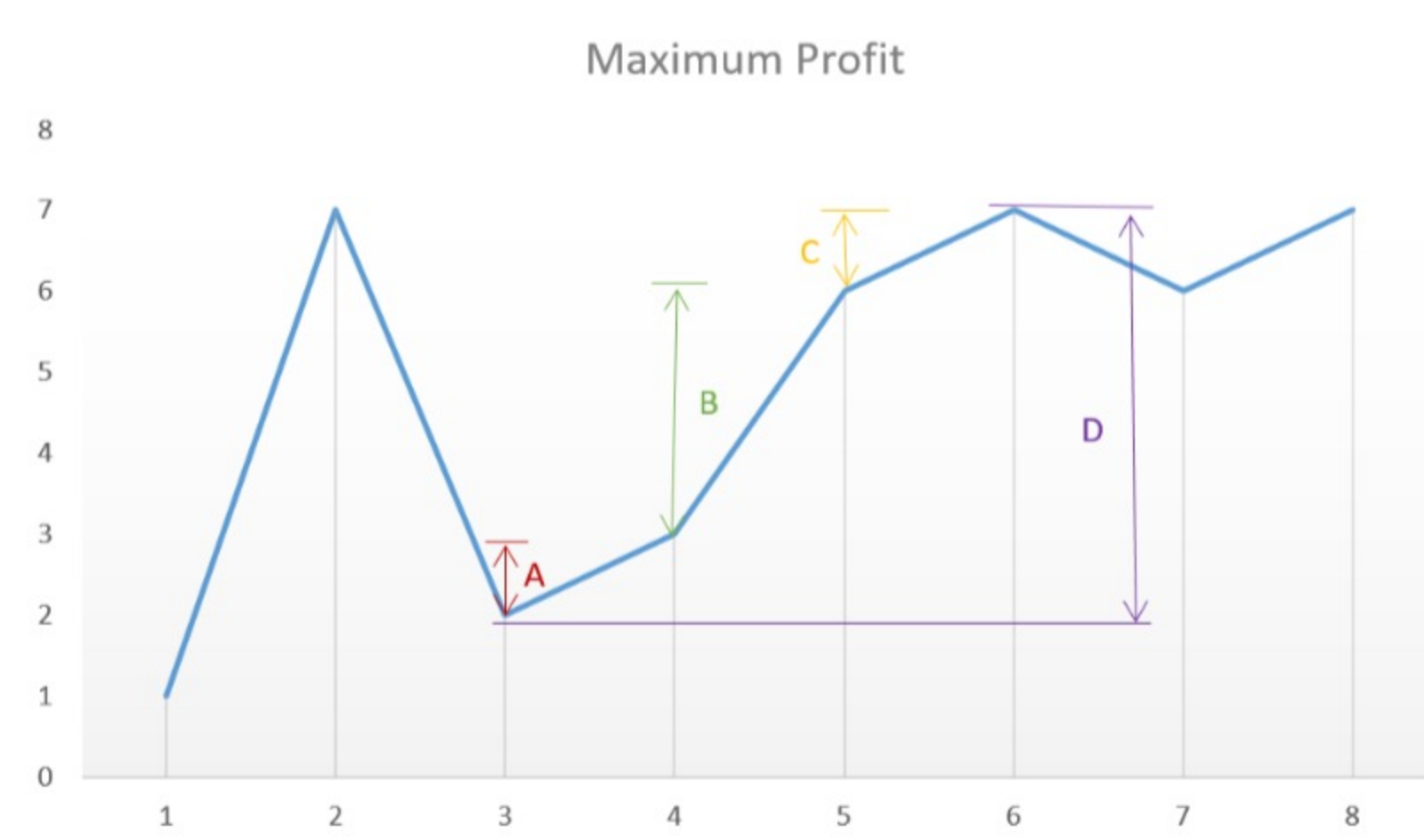
### Approach 3: Simple One Pass

**Algorithm**

This solution follows the logic used in [Approach 2](#) itself, but with only a slight variation. In this case, instead of looking for every peak following a valley, we can simply go on crawling over the slope and keep on adding the profit obtained from every consecutive transaction. In the end, we will be using the peaks and valleys effectively, but we need not track the costs corresponding to the peaks and valleys along with the maximum profit, but we can directly keep on adding the difference between the consecutive numbers of the array if the second number is larger than the first one, and at the total sum we obtain will be the maximum profit. This approach will simplify the solution. This can be made clearer by taking this example:

[1, 7, 2, 3, 6, 7, 6, 7]

The graph corresponding to this array is:



From the above graph, we can observe that the sum  $A + B + C$  is equal to the difference  $D$  corresponding to the difference between the heights of the consecutive peak and valley.

Java

Copy

```
1 class Solution {
2     public int maxProfit(int[] prices) {
3         int maxprofit = 0;
4         for (int i = 1; i < prices.length; i++) {
5             if (prices[i] > prices[i - 1])
6                 maxprofit += prices[i] - prices[i - 1];
7         }
8         return maxprofit;
9     }
10 }
```

**Complexity Analysis**

- Time complexity :  $O(n)$ . Single pass.
- Space complexity :  $O(1)$ . Constant space needed.


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 manitdknda ★ 331 · June 12, 2018 1:11 AM




Third one is surprisingly simple!

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 rayax86 ★ 148 · June 11, 2019 7:54 PM

This is by no means an easy problem





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 tanujain ★ 254 · September 18, 2018 12:49 AM

"You may not engage in multiple transactions at the same time"

I interpreted that as we cannot do both buy and sell on the same day.

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 Gypsophila ★ 69 · March 27, 2019 4:06 PM


One reminder for C++ users who are trying approach #2:

If you just replace Java code "prices.length-1" with C++ code "prices.size()-1", you will fail in the empty testcase. That's because the return type of container.size() is unsigned. So, 0-1 will not be interpreted as -1 but 2^32-1.

[Remember to cast to signed int when you have to do some operation with container.size\(\).](#)

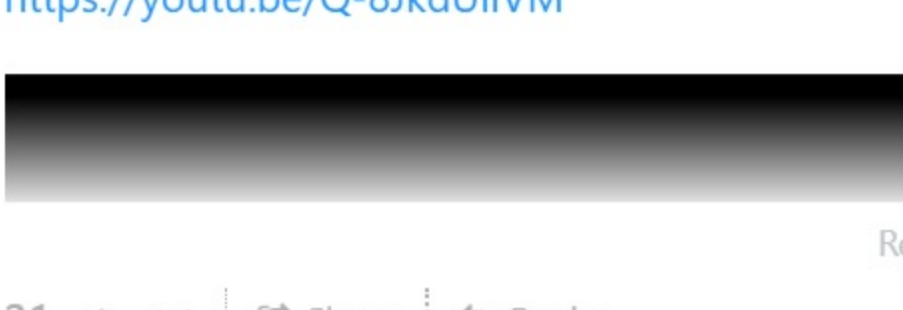
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 terrible\_whiteboard ★ 627 · May 19, 2020 6:20 PM

I made a video if anyone is having trouble understanding the solution (clickable link)





<https://youtu.be/Q-8JkdUjVM>




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 Williiii ★ 22 · June 2, 2019 3:29 AM





Can someone explain why the time complexity is  $n^4$  in Approach 1?

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 KaitouKiddo ★ 21 · January 25, 2019 3:52 PM

In approach 3, you are not allowed to buy and sell at the same time. Who wrote this solution???

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 mocha8lake ★ 8 · March 31, 2018 9:24 PM


my C++ solution:





class Solution {

public:


int maxProfit(vector& prices) {

int len=prices.size();



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


 djchuaner ★ 9 · June 4, 2018 6:08 PM

class Solution {

public int maxProfit(int[] prices) {

if (prices == null || prices.length == 0) {



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 BartSu ★ 20 · February 16, 2019 10:36 AM

In approach 3, we are supposed add "if(prices.length ==0) return 0;" in case of empty array.

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