

ARRAY

Arrays

Characteristics

- **Memory layout:** hold values in a **contiguous** block of memory.
- **Fixed Size:** the size of an array is defined when it is created and cannot be changed.
However, high-level languages have different implementations, making it dynamic.
- **Homogeneous elements:** all elements are of the same data type (int, float, char...)
- **Efficiency:** accessing elements by index is very efficient $O(1)$, since each index maps directly to a memory location. Also, range scans benefit from CPU cache lines since arrays are stored in contiguous blocks of memory.

Arrays – Kadane's algorithm

- Kadane's algorithm is a dynamic programming algorithm to solve **maximum subarray sum**
- At every **index i**:
start a new subarray at **i**
extend the previous subarray to include **array[i]**

- **Algorithm**

1. Initialize:

```
int maxSoFar = array[0];  
int maxEndingHere = array[0];
```

2. Loop through the array

```
for (int i = 1; i < array.size(); ++i) {  
    maxEndingHere = max(array[i], maxEndingHere + array[i]);  
    maxSoFar = max(maxSoFar, maxEndingHere);  
}
```

3. Return maxSoFar;

Problem – Two Sum

Easy



LeetCode

leetcode.com/problems/two-sum

Problem Statement

- Given an **array** of numbers and a **target**, example: **array** [2,7,11,15] and **target** 9
- Return indices of two numbers where they add up to **target**
- **Output:** [0,1]

$\text{array}[0] + \text{array}[1] = 2 + 7 = 9$

Solution – Two Sum

Easy



LeetCode

leetcode.com/problems/two-sum

Solution

- Iterative over each number in the array
- Calculate the difference between target and each number, example:
 $\text{array}[0] = 2, \text{ target } 9, \text{ then } 9 - 2 = 7$
- Now we know we need the number **7** to sum up to **9**
- Check in a *hashmap* if we have 7 in some part of the array
 $\text{hash}[7] \text{ exists?}$
- If yes, return the current index and the index of 7
- If not, store the index of the current number in the hashmap for future evaluation
 $\text{hash}[2] = 0$

Code – Two Sum

Easy



LeetCode

leetcode.com/problems/two-sum

Code Time: $O(n)$ Space: $O(n)$

```
vector<int> twoSum(vector<int>& nums, int target) {
    std::unordered_map<int, int> numMap;
    // n being the size of nums
    for (int i = 0; i < nums.size(); i++) {
        // current number of the array
        int number = nums[i];
        int diff = target - number;

        // check if the difference is in some part of the array
        // by using a hashmap
        if (numMap.find(diff) != numMap.end()) {
            return { numMap[diff], i};
        }

        // register the current number index
        numMap[number] = i;
    }
    // no matches
    return {};
}
```

Problem - Best Time to Buy and Sell Stock

Easy



LeetCode

leetcode.com/problems/best-time-to-buy-and-sell-stock

Problem Statement

- You are given an integer **array** of stock prices
- Choose a **price[i]** to buy and **price[i]** to sell where you achieve maximum profits

- **Example:**

`prices = [9, 1, 3, 4]`

- **Output:** [1,3]

`array[3] - array[1] = 4 - 1 = 3`

Solution - Best Time to Buy and Sell Stock

Easy



LeetCode

leetcode.com/problems/best-time-to-buy-and-sell-stock

Solution

- Initialize **profit = 0**
- Initialize **lowestBuyPrice = prices[0]**
- Loop through the prices
- Track the lowest buy price → **min(lowestBuyPrice, prices[i])**
- Check if selling “today” will make the maximum profit and update profit:
max(prices[i] - buy > profit, profit)
- Update profit
max(prices[i] - buy

Code - Best Time to Buy and Sell Stock

Easy



LeetCode

leetcode.com/problems/best-time-to-buy-and-sell-stock

Code (simplified) Time: $O(n)$ Space: $O(1)$

```
int maxProfit(vector<int>& prices) {  
    int profit = 0;  
    int buy = prices[0];  
    for (auto i = 1; i < prices.size(); i++) {  
        buy = min(buy, prices[i]);  
        profit = max(profit, prices[i] - buy)  
    }  
    return profit;  
}
```

Code - Best Time to Buy and Sell Stock

Easy



LeetCode

leetcode.com/problems/best-time-to-buy-and-sell-stock

Code (optimized) Time: $O(n)$ Space: $O(1)$

- Same logic, but with better branch prediction and less computation

```
int maxProfit(vector<int>& prices) {  
    int profit = 0;  
    int buy = prices[0];  
    for (auto i = 1; i < prices.size(); i++) {  
        if (prices[i] < buy) {  
            buy = prices[i];  
        } else if (prices[i] - buy > profit) {  
            profit = prices[i] - buy;  
        }  
    }  
    return profit;  
}
```

Problem - Best Time to Buy and Sell Stock II

Medium



LeetCode

leetcode.com/problems/best-time-to-buy-and-sell-stock-ii

Problem Statement

- You are given an integer **array** of stock prices
- Choose a **price[i]** to buy and **price[i]** to sell where you achieve maximum profits
- You can buy/sell **multiple times**, but only hold **at most one** transaction at a time
- Output is the **maximum profits**
- **Example:**

`prices = [9, 1, 3, 4]`

Output: $2 + 1 = 3$

`buy (price = 1), sell (price = 3), profit = 2`

`buy (price = 3), sell (price = 4), profit = 1`

Solution - Best Time to Buy and Sell Stock II

Medium

 LeetCode leetcode.com/problems/best-time-to-buy-and-sell-stock-ii

Solution

- Loop through the array starting from index 1
- If current **price[i]** is lower than previous **price[i - 1]**, buy and sell
- **Example:**

`prices = [1, 8, 4]` `prices[0] = 1, prices[1] = 8, prices[2] = 4`

`prices[0] < prices[1] → true, profit = 8 - 1 = 7`

`prices[2] < prices[1] → false, do nothing`

Code - Best Time to Buy and Sell Stock II

Medium



LeetCode

leetcode.com/problems/best-time-to-buy-and-sell-stock-ii

Code Time: $O(n)$ Space: $O(n)$

```
int maxProfit(vector<int>& prices) {  
    int profit = 0;  
    for (int i = 1; i < prices.size(); ++i) {  
        if (prices[i] > prices[i-1]) {  
            profit += prices[i] - prices[i - 1];  
        }  
    }  
    return profit;  
}
```

Problem - Best Time to Buy and Sell Stock IV

Hard



LeetCode

leetcode.com/problems/best-time-to-buy-and-sell-stock-iv

Problem Statement

■ ...

Solution - Best Time to Buy and Sell Stock IV

Hard

 leetcode.com/problems/best-time-to-buy-and-sell-stock-iv

Solution

■ ...

Code - Best Time to Buy and Sell Stock IV

Hard

 leetcode.com/problems/best-time-to-buy-and-sell-stock-iv

Code (simplified) Time: $O(n)$ Space: $O(n)$

```
int maxProfit(vector<int>& prices) {  
    int profit = 0;  
    int buy = prices[0];  
    for (auto i = 1; i < prices.size(); i++) {  
        buy = min(buy, prices[i]);  
        profit = max(profit, prices[i] - buy)  
    }  
    return profit;  
}
```