# takeUforward

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# Trapping Rainwater

**Problem Statement:** Given an array of non-negative integers representation elevation of ground. Your task is to find the water that can be trapped after rain.

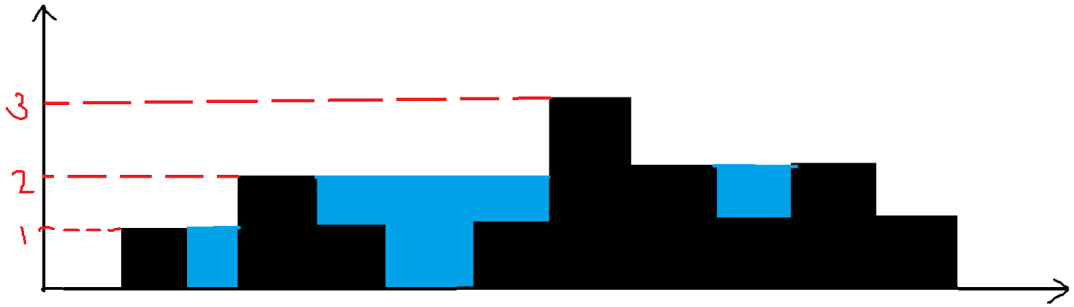
**Examples:**

```
Example 1:

Input: height= [0,1,0,2,1,0,1,3,2,1,2,1]

Output: 6
```

**Explanation:** As seen from the diagram 1+1+2+1+1=6 unit of water can be trapped




**Example 2:**

**Input:** [4,2,0,3,2,5]

**Output:** 9

## Solution

***Disclaimer***: *Don't jump directly to the solution, try it out yourself first.*

**Solution 1: Brute force**

**Approach**: For each index, we have to find the amount of water that can be stored and we have to sum it up.If we observe carefully the amount the water



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stored at a particular index is the minimum of maximum elevation to the left and right of the index minus the elevation at that index.

**Code:**

## C++ Code

```
#include<bits/stdc++.h>

using namespace std;
int trap(vector < int > & arr) {
  int n = arr.size();
  int waterTrapped = 0;
  for (int i = 0; i < n; i++) {
    int j = i;
    int leftMax = 0, rightMax = 0;
    while (j >= 0) {
      leftMax = max(leftMax, arr[j]);
      j--;
    }
    j = i;
    while (j < n) {
      rightMax = max(rightMax, arr[j]);
      j++;
    }
    waterTrapped += min(leftMax, rightMax) - arr[i];
  }
  return waterTrapped;
}
```

```
int main() {
  vector < int > arr;
  arr = {0,1,0,2,1,0,1,3,2,1,2,1};
  cout << "The water that can be trapped is " << trap(arr) << endl;
}
```

**Output:** The water that can be trapped is 6

**Time Complexity:** O(N*N) as for each index we are calculating leftMax and rightMax so it is a nested loop.

**Space Complexity:** O(1).

## Java Code

```
import java.util.*;
class TUF {
    static int trap(int[] arr) {
        int n = arr.length;
        int waterTrapped = 0;
        for (int i = 0; i < n; i++) {
            int j = i;
            int leftMax = 0, rightMax = 0;
            while (j >= 0) {
                leftMax = Math.max(leftMax, arr[j]);
                j--;
            }
            j = i;
            while (j < n) {
```

```
                rightMax = Math.max(rightMax, arr[j]);
                j++;
            }
            waterTrapped += Math.min(leftMax, rightMax) - arr[i];
        }
        return waterTrapped;
    }
    public static void main(String args[]) {
        int arr[] = {0,1,0,2,1,0,1,3,2,1,2,1};
        System.out.println("The duplicate element is " + trap(arr));
    }
}
```

**Output:** The water that can be trapped is 6

**Time Complexity:** O(N*N) as for each index we are calculating leftMax and rightMax so it is a nested loop.

**Space Complexity:** O(1).

## Python Code

```
from typing import List




def trap(arr: List[int]) -> int:
    n = len(arr)
    waterTrapped = 0
```

```
        for i in range(n):
            j = i
            leftMax = 0
            rightMax = 0
            while j >= 0:
                leftMax = max(leftMax, arr[j])
                j -= 1
            j = i
            while j < n:
                rightMax = max(rightMax, arr[j])
                j += 1
            waterTrapped += min(leftMax, rightMax) - arr[i]
        return waterTrapped




if __name__ == "__main__":
    arr = [0, 1, 0, 2, 1, 0, 1, 3, 2, 1, 2, 1]
    print(f"The water that can be trapped is {trap(arr)}")
```

**Output:** The water that can be trapped is 6

**Time Complexity:** O(N*N) as for each index we are calculating leftMax and rightMax so it is a nested loop.

**Space Complexity:** O(1).

**Solution 2:Better solution**

**Intuition:** We are taking O(N) for computing leftMax and rightMax at each index. The complexity can be boiled down to O(1) if we precompute the leftMax and rightMax at each index.

**Approach:** Take 2 array prefix and suffix array and precompute the leftMax and rightMax for each index beforehand. Then use the formula min(prefix[I], suffix[i])-arr[i] to compute water trapped at each index.

**Code:**

## C++ Code

```
#include<bits/stdc++.h>

using namespace std;
int trap(vector < int > & arr) {
  int n = arr.size();
  int prefix[n], suffix[n];
  prefix[0] = arr[0];
  for (int i = 1; i < n; i++) {
    prefix[i] = max(prefix[i - 1], arr[i]);
  }
  suffix[n - 1] = arr[n - 1];
  for (int i = n - 2; i >= 0; i--) {
    suffix[i] = max(suffix[i + 1], arr[i]);
  }
  int waterTrapped = 0;
  for (int i = 0; i < n; i++) {
    waterTrapped += min(prefix[i], suffix[i]) - arr[i];
```

```
    }
    return waterTrapped;
}

int main() {
    vector < int > arr;
    arr = {0,1,0,2,1,0,1,3,2,1,2,1};
    cout << "The water that can be trapped is " << trap(arr) << endl;
}
```

**Output:** The water that can be trapped is 6

**Time Complexity:** O(3*N) as we are traversing through the array only once.

And O(2*N) for computing prefix and suffix array.

**Space Complexity:** O(N)+O(N) for prefix and suffix arrays.

## Java Code

```
import java.util.*;
class TUF {
    static int trap(int[] arr) {
        int n = arr.length;
        int prefix[] = new int[n];
        int suffix[] = new int[n];
        prefix[0] = arr[0];
        for (int i = 1; i < n; i++) {
            prefix[i] = Math.max(prefix[i - 1], arr[i]);
        }
```

```
            suffix[n - 1] = arr[n - 1];
            for (int i = n - 2; i >= 0; i--) {
                suffix[i] = Math.max(suffix[i + 1], arr[i]);
            }
            int waterTrapped = 0;
            for (int i = 0; i < n; i++) {
                waterTrapped += Math.min(prefix[i], suffix[i]) - arr[i];
            }
            return waterTrapped;
        }

        public static void main(String args[]) {
            int arr[] = {0,1,0,2,1,0,1,3,2,1,2,1};
            System.out.println("The duplicate element is " + trap(arr));
        }
    }
```

**Output:** The water that can be trapped is 6

**Time Complexity:** O(3*N) as we are traversing through the array only once.

And O(2*N) for computing prefix and suffix array.

**Space Complexity:** O(N)+O(N) for prefix and suffix arrays.

## Python Code

```
from typing import List
```

```
def trap(arr: List[int]) -> int:
    n = len(arr)
    prefix = [0] * n
    suffix = [0] * n
    prefix[0] = arr[0]
    for i in range(1, n):
        prefix[i] = max(prefix[i - 1], arr[i])
    suffix[n - 1] = arr[n - 1]
    for i in range(n - 2, -1, -1):
        suffix[i] = max(suffix[i + 1], arr[i])
    waterTrapped = 0
    for i in range(n):
        waterTrapped += min(prefix[i], suffix[i]) - arr[i]
    return waterTrapped




if __name__ == "__main__":
    arr = [0, 1, 0, 2, 1, 0, 1, 3, 2, 1, 2, 1]
    print(f"The water that can be trapped is {trap(arr)}")
```

**Output:** The water that can be trapped is 6

**Time Complexity:** O(3*N) as we are traversing through the array only once.

And O(2*N) for computing prefix and suffix array.

**Space Complexity:** O(N)+O(N) for prefix and suffix arrays.

### Solution 3:Optimal Solution(Two pointer approach)

**Approach:** Take 2 pointers l(left pointer) and r(right pointer) pointing to 0th and (n-1)th index respectively. Take two variables leftMax and rightMax and initialize them to 0. If height[l] is less than or equal to height[r] then if leftMax is less than height[l] update leftMax to height[l] else add leftMax-height[l] to your final answer and move the l pointer to the right i.e l++. If height[r] is less than height[l], then now we are dealing with the right block. If height[r] is greater than rightMax, then update rightMax to height[r] else add rightMax-height[r] to the final answer. Now move r to the left. Repeat these steps till l and r crosses each other.

**Intuition:** We need a minimum of leftMax and rightMax.So if we take the case when height[l]<=height[r] we increase l++, so we can surely say that there is a block with a height more than height[l] to the right of l. And for the same reason when height[r]<=height[l] we can surely say that there is a block to the left of r which is at least of height[r]. So by traversing these cases and using two pointers approach the time complexity can be decreased without using extra space.

**Code:**

## C++ Code

```cpp
#include<bits/stdc++.h>

using namespace std;
int trap(vector < int > & height) {
  int n = height.size();
  int left = 0, right = n - 1;
  int res = 0;
  int maxLeft = 0, maxRight = 0;
  while (left <= right) {
    if (height[left] <= height[right]) {
      if (height[left] >= maxLeft) {
        maxLeft = height[left];
      } else {
        res += maxLeft - height[left];
      }
      left++;
    } else {
      if (height[right] >= maxRight) {
        maxRight = height[right];
      } else {
        res += maxRight - height[right];
      }
      right--;
    }
  }
  return res;
}

int main() {
  vector < int > arr;
  arr = {0,1,0,2,1,0,1,3,2,1,2,1};
```

```
    cout << "The water that can be trapped is " << trap(arr) << endl;
}
```

**Output:** The water that can be trapped is 6

**Time Complexity:** O(N) because we are using 2 pointer approach.

**Space Complexity:** O(1) because we are not using anything extra.

## Java Code

```
import java.util.*;
class TUF {
    static int trap(int[] height) {
        int n = height.length;
        int left = 0, right = n - 1;
        int res = 0;
        int maxLeft = 0, maxRight = 0;
        while (left <= right) {
            if (height[left] <= height[right]) {
                if (height[left] >= maxLeft) {
                    maxLeft = height[left];
                } else {
                    res += maxLeft - height[left];
                }
                left++;
            } else {
                if (height[right] >= maxRight) {
                    maxRight = height[right];
```

```
                } else {
                    res += maxRight - height[right];
                }
                right--;
            }
        }
        return res;
    }


    public static void main(String args[]) {
        int arr[] = {0,1,0,2,1,0,1,3,2,1,2,1};
        System.out.println("The duplicate element is " + trap(arr));
    }
}
```

**Output:** The water that can be trapped is 6

**Time Complexity:** O(N) because we are using 2 pointer approach.

**Space Complexity:** O(1) because we are not using anything extra.

## Python Code

```
from typing import List



def trap(height: List[int]) -> int:
```

```
    n = len(height)
    left = 0
    right = n-1
    res = 0
    maxLeft = 0
    maxRight = 0
    while left <= right:
        if height[left] <= height[right]:
            if height[left] >= maxLeft:
                maxLeft = height[left]
            else:
                res += maxLeft - height[left]
            left += 1
        else:
            if height[right] >= maxRight:
                maxRight = height[right]
            else:
                res += maxRight - height[right]
            right -= 1
    return res



if __name__ == "__main__":
    arr = [0, 1, 0, 2, 1, 0, 1, 3, 2, 1, 2, 1]
    print(f"The water that can be trapped is {trap(arr)}")
```

**Output:** The water that can be trapped is 6

**Time Complexity:** O(N) because we are using 2 pointer approach.

**Space Complexity:** O(1) because we are not using anything extra.

> Special thanks to **Pranav Padawe** and **Sudip Ghosh** for contributing to this article on takeUforward. If you also wish to share your knowledge with the takeUforward fam, please check out this article

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