Solved Problem - Subarray Sum

In this lesson, we'll see an effective way to compute sum of an subarray.

We'll cover the following

Problem statement

Given an array, A, of N integers, answer Q queries of the type (l, r) - sum of the elements in the subarray $A[l...r]$. Print the sum for each query.

Input format

The first line contains two space-separated integers N and Q $(1 \leq N, Q \leq 10^6)$.

The second line contains N integers representing the array $A[]$ $(1 \leq A[i] \leq 10^6)$.

The next Q lines each contain a pair of integers l and r.

Output format

Print Q integers and answer to the queries.

Sample

Input

```
5 3
1 2 4 8 16
1 5
2 3
3 5
```

Output

```
31 6 28
```

Brute force

The brute force method would be to loop over the subarray in the query and sum all the elements.

I am skipping the code for this solution because it is trivial.

The time for each query would be $O(N)$, the total complexity of the solution would be $O(Q * N)$. This means it is not good enough for the given constraints.

Optimization

First, let’s discuss what the prefix sum array is.

The prefix sum array $sum[]$ of an array $A[]$ is defined as

$sum[i] = \sum_{k=1}^{i} A[k]$

or, ith element of $sum[]$ is sum of first i elements of $A[]$

We can use the prefix sum array to find the sum of a subarray in $O(1)$ time.

$sum[i...j] = A[i] + A[i+1] + ... + A[j]$

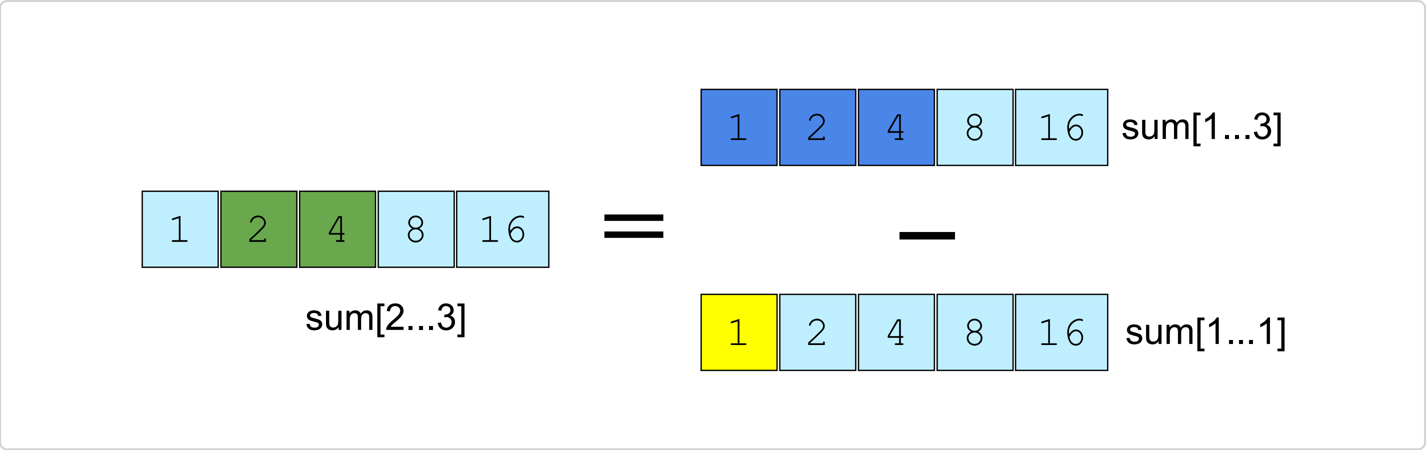
$= (A[1] + A[2] + ... + A[j]) - (A[1] + A[2] + ... + A[i-1])$

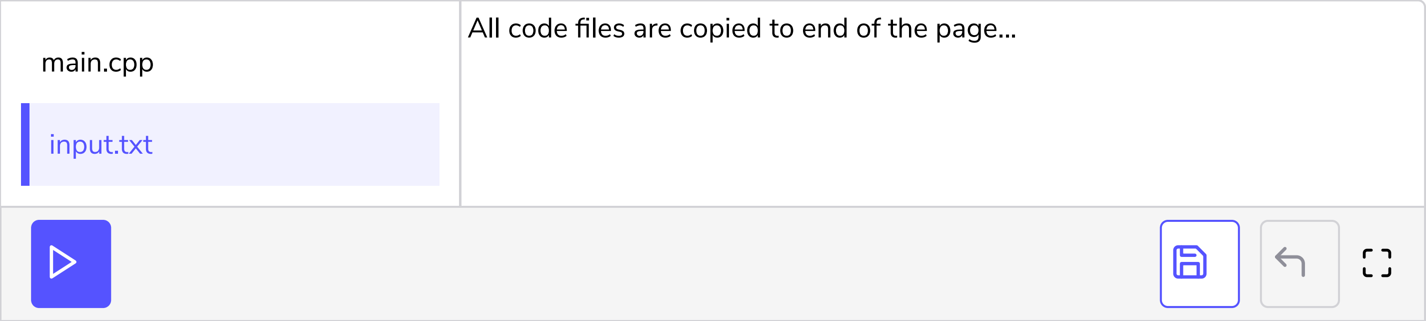
$= sum[j] - sum[i-1]$

From preprocessing to computing the $sum[]$ array takes $O(N)$ time. Each query is just $O(1)$.

So the total time complexity is $O(N + Q)$.

See the below illustration for a better understanding.





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In the next chapter, we'll start with Sieve of Eratosthenes, an efficient algorithm to generate primes.

Code Files Content !!!

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```
-------------------------------------------------------------------------
|  main.cpp [1]
-------------------------------------------------------------------------



#include
#include
#include
using namespace std;

int main() {
  ifstream cin("input.txt");

  int N, Q;
  cin >> N >> Q;
  vector A(N);
  for (int i = 0; i < N; i++) cin>>A[i];
  for (int i = 0; i < N; i++) cin>>A[i];

  vector sum(N);
  sum[0] = A[0];
  for(int i = 1; i < N; i++)
    sum[i] = sum[i - 1] + A[i];

  for(int i = 0; i < Q; i++) {
    int l, r;
    cin >> l >> r;
    l--; r--; // Convert to 0-based indexing
    int ans = sum[r];
    if (l > 0)
      ans -= sum[l - 1];

    cout << ans << " ";
  }

  return 0;
}


-------------------------------------------------------------------------
|  input.txt [1]
-------------------------------------------------------------------------



5 3
1 2 4 8 16
1 5
2 3
3 5





**********************************************************************************
```