Sliding Window Technique

This technique shows how a nested for loop in some problems can be converted to a single for loop to reduce the time complexity.

Example :-

Given an array of integers of size **'n'**.

Calculate the maximum sum of **'k'** consecutive elements in the array.

Input : arr[] = {100, 200, 300, 400}
k = 2
output = 700

Input : arr[] = {1, 4, 2, 10, 23, 3, 1, 0, 20}
k = 4
output = 39

We get maximum sum by adding subarray {4, 2, 10, 23} of size 4.

Input : arr[] = {2, 3}
k = 3
output = Invalid

There is no subarray of size 3 as size of whole array is 2.

So, let's analyze the problem with **Brute Force Approach**.

We start with first index and sum till **k-th** element.
We do it for all possible consecutive blocks or groups of k elements.
This method requires nested for loop, the outer for loop starts with the starting element of the block of k elements and the inner or the nested loop will add up till the k-th element.

Consider the below implementation :

```
class Test {
   // Returns maximum sum in  a subarray of size k.
   static int maxSum(int arr[], int n, int k)
   {
      // Initialize result
      int max_sum = Integer.MIN_VALUE;
```

```
        // Consider all blocks starting with i.
        for (int i = 0; i < n - k + 1; i++) {
            int current_sum = 0;
            for (int j = 0; j < k; j++)
                current_sum = current_sum + arr[i + j];

            // Update result if required.
            max_sum = Math.max(current_sum, max_sum);
        }

        return max_sum;
    }

    public static void main(String[] args)
    {
        int arr[] = { 1, 4, 2, 10, 2, 3, 1, 0, 20 };
        int k = 4;
        int n = arr.length;
        System.out.println(maxSum(arr, n, k));
    }
}
```

Sliding Window Technique

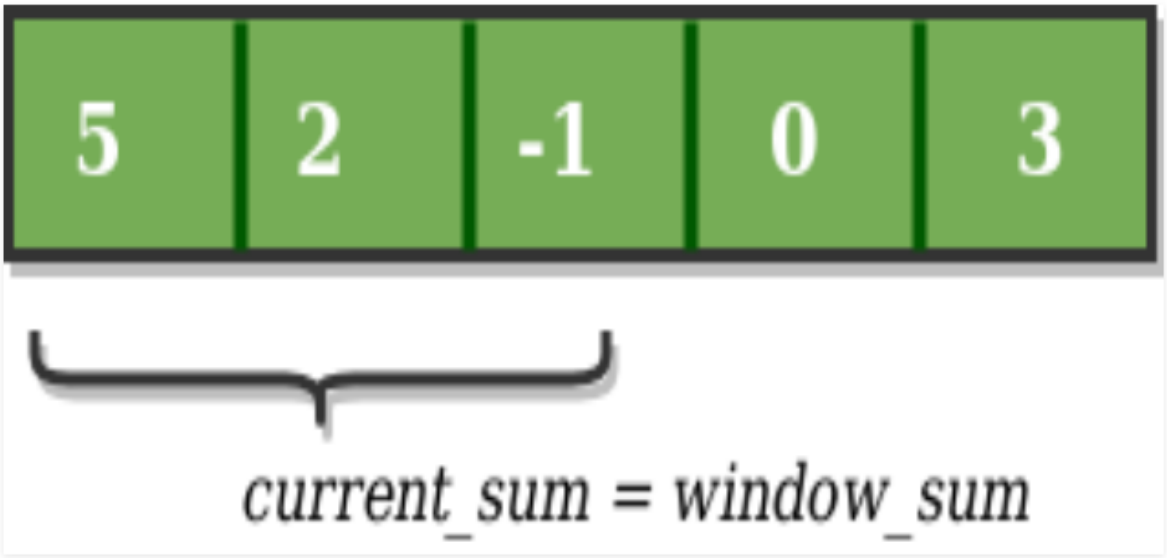
The technique can be best understood with the window pane in bus, consider a window of length **n** and the pane which is fixed in it of length **k**.
Consider, initially the pane is at extreme left i.e., at 0 units from the left.
Now, co-relate the window with array arr[] of size n and pane with current_sum of size k elements.
Now, if we apply force on the window such that it moves a unit distance ahead.
The pane will cover next **k** consecutive elements.

Consider an array **arr[]** = {5, 2, -1, 0, 3} and value of **k** = 3 and **n** = 5

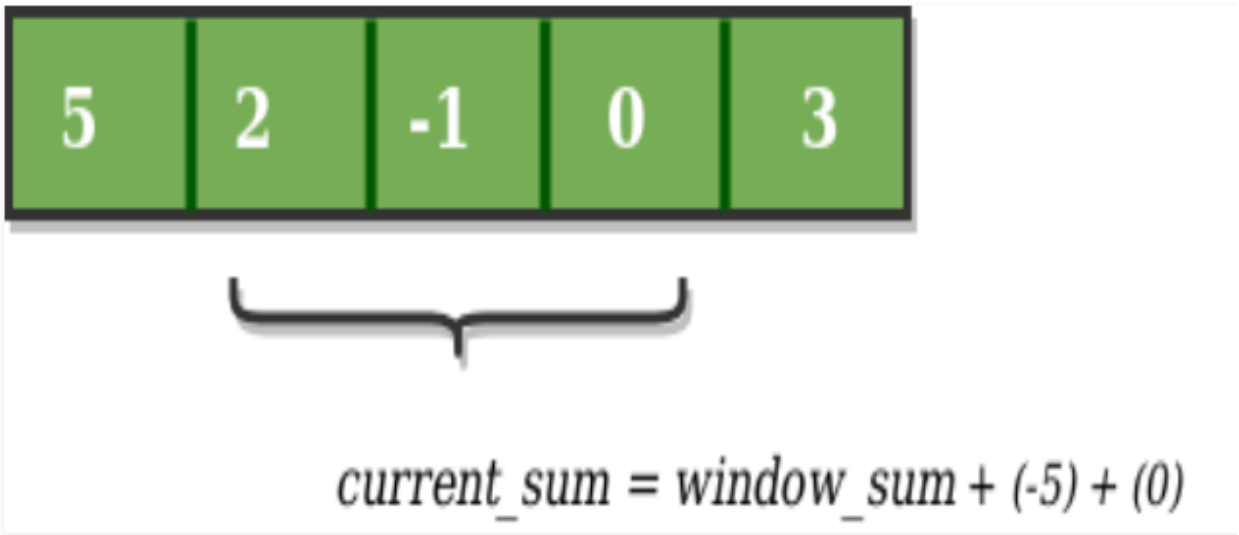
Applying sliding window technique :

1. We compute the sum of first k elements out of n terms using a linear loop and store the sum in variable window_sum.
2. Then we will graze linearly over the array till it reaches the end and simultaneously keep track of maximum sum.
3. To get the current sum of block of k elements just subtract the first element from the previous block and add the last element of the current block .

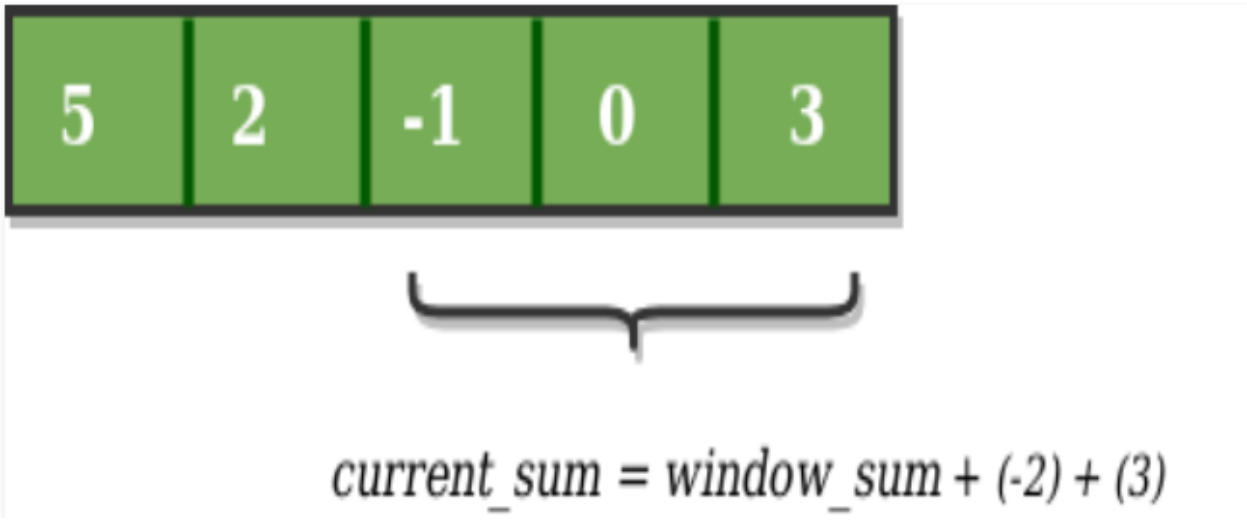
The below representation will make it clear how the window slides over the array.
This is the initial phase where we have calculated the initial window sum starting from index 0 .
At this stage the window sum is 6. Now, we set the maximum_sum as current_window i.e 6.



Now, we slide our window by a unit index. Therefore, now it discards 5 from the window and adds 0 to the window.
Hence, we will get our new window sum by subtracting 5 and then adding 0 to it.
So, our window sum now becomes 1.
Now, we will compare this window sum with the maximum_sum.
As it is smaller we wont the change the maximum_sum.



Similarly, now once again we slide our window by a unit index and obtain the new window sum to be 2.
Again we check if this current window sum is greater than the maximum_sum till now.
Once, again it is smaller so we don't change the maximum_sum.
Therefore, for the above array our maximum_sum is 6.




```
// Java code for O(n) solution for finding  maximum sum of a subarray of size k

class Test {

	// Returns maximum sum in  a subarray of size k.
	static int maxSum(int arr[], int n, int k)
	{
		// n must be greater
		if (n < k) {
			System.out.println("Invalid");
			return -1;
		    }

		// Compute sum of first window of size k
		int max_sum = 0;
		for (int i = 0; i < k; i++)
			max_sum += arr[i];

		// Compute sums of remaining windows by
		// removing first element of previous
		// window and adding last element of
		// current window.
		int window_sum = max_sum;
		for (int i = k; i < n; i++) {
			window_sum += arr[i] - arr[i - k];
			max_sum = Math.max(max_sum, window_sum);
		}

		return max_sum;
	}

	public static void main(String[] args)
```

```
	{
		int arr[] = { 1, 4, 2, 10, 2, 3, 1, 0, 20 };
		int k = 4;
		int n = arr.length;
		System.out.println(maxSum(arr, n, k));
	}
}
```