Sub Array Problem 🚀

> A **subarray** is a contiguous part of an array—meaning its elements are adjacent in the original array. Unlike a subsequence (which can skip elements), a subarray maintains both order and proximity.

Examples:

- Original array: `[1, 2, 3, 4]`
  - Valid subarrays: `[1]`, `[2, 3]`, `[1, 2, 3]`, `[4]`
  - Invalid: `[1, 3]` (skips `2`)

Real-life analogy:

Imagine a row of books on a shelf. A subarray is like picking a contiguous line of books (you can't skip any in between!).

📋 Generating Subarrays in Java

To find or iterate through all subarrays, we use **nested loops**. The outer loop sets the starting index, and the inner loop sets the ending index.

Java Code Example:

```
public class SubarrayExample {
    public static void printAllSubarrays(int[] arr) {
        int n = arr.length;
        for (int i = 0; i < n; i++) { // Starting index
            for (int j = i; j < n; j++) { // Ending index
                System.out.print("Subarray from index " + i + " to " + j + ": ");
                for (int k = i; k <= j; k++) {
                    System.out.print(arr[k] + " ");
                }
                System.out.println();
            }
        }
    }
    public static void main(String[] args) {
        int[] arr = {1, 2, 3};
        printAllSubarrays(arr);
    }
}
```

Output:

```
Subarray from index 0 to 0: 1
Subarray from index 0 to 1: 1 2
Subarray from index 0 to 2: 1 2 3
Subarray from index 1 to 1: 2
Subarray from index 1 to 2: 2 3
Subarray from index 2 to 2: 3
```

Key Points:

- Time complexity: **$O(n^3)$** (due to printing elements).
- Optimize by avoiding printing if needed (e.g., store subarrays in a list).

Self-check questions:

1. Why do we use nested loops to generate subarrays?

2. How many subarrays does an array of length `n` have?

🧠 Common Subarray Problems

Subarrays are core to solving problems like:

- **Maximum subarray sum** (Kadane's algorithm)
- **Sliding window for variable-length subarrays**
- **Product of subarray**
- **Subarray with sum divisible by k**

🚀 Quick Recap 🌈

- A subarray is a **contiguous** segment of an array.
- Generate subarrays using nested loops ($O(n^3)$ time).
- Solve problems like max sum with Kadane's algorithm ($O(n)$).
- Subarrays are used in real-world apps like finance, IoT, and image processing.

Practice Tip: Start with small arrays to debug subarray logic!