# Asymptotic Notation

Asymptotic notation is a mathematical framework used to describe the time complexity and space complexity of algorithms.

It helps compare algorithms and predict their performance as input size (n) approaches infinity.

**Time Complexity** : How runtime grows with input size of the algorithm.

**Space Complexity** : How memory usage grows with respect to each algorithm.

# Types of Asymptotic Notations

There are three primary notations:

**1. Big-O Notation (O) - Upper Bound (Worst Case)**

* Describes the **maximum** time/space an algorithm can take.

**2. Omega Notation (Ω) - Lower Bound (Best Case)**

* Describes the **minimum** time/space required.

**3. Theta Notation (Θ) - Tight Bound (Average Case)**

* Describes **both upper and lower bounds** (exact growth rate).

# Big-O Notation (O)

**Big-O** is a way to express the upper boundof an algorithm’s time or space complexity.

* Describes the asymptotic behaviour of a function.
* It provides anupper limit on the time taken by an algorithm in terms of the size of the input.
* It’s denoted asO(f(n)), where f(n) is a function that represents the number of operations (steps) that an algorithm performs to solve a problem of size **n**.

# Search Operation Scenarios

* **Best case**: The target is found immediately (O(1) for both linear and binary search)
* **Average case**: The target is found after examining a typical number of elements
  + Linear search: O(n)
  + Binary search: O(log n)
* **Worst case**: The target isn't present or is the last element checked
  + Linear search: O(n)
  + Binary search: O(log n)

# Time Complexity Comparison

| **Algorithm** | **Best Case** | **Average Case** | **Worst Case** | **Space Complexity** |
| --- | --- | --- | --- | --- |
| Linear Search | O(1) | O(n) | O(n) | O(1) |
| Binary Search | O(1) | O(log n) | O(log n) | O(1) |

# Analysis

Linear Search is used when:

* If the products are not sorted then linear search is used.
* Works very well for small shops where the search is limited.
* Used in small environments for flexibility.

Binary Search is used

* If the products are already sorted then binary search is used.
* For big stores with thousands of items.
* It is best for exact matches.