■ Binary Search Master Templates & Patterns

By Shivam Chauhan

Binary Search is not just for sorted arrays — it's a framework for reasoning about monotonic behavior. This guide compiles all major templates, reasoning patterns, and top problem types to help you master it for interviews and beyond.

■ Template 1 — Classic Binary Search (Exact Match)

Find the exact target value in a sorted array.

```
def binary_search(nums, target):
    left, right = 0, len(nums) - 1
    while left <= right:
        mid = (left + right) // 2
        if nums[mid] == target:
            return mid
        elif nums[mid] < target:
            left = mid + 1
        else:
            right = mid - 1
    return -1
```

Examples:

704. Binary Search

374. Guess Number Higher or Lower

■ Template 2 — Lower Bound (First Element ≥ target)

Find smallest index where nums[i] ≥ target.

```
def lower_bound(nums, target):
    left, right = 0, len(nums)
    while left < right:
        mid = (left + right) // 2
        if nums[mid] < target:
            left = mid + 1
        else:
            right = mid
    return left
```

Examples:

35. Search Insert Position

■ Template 3 — Upper Bound (First Element > target)

Find smallest index where nums[i] > target.

```
def upper_bound(nums, target):
    left, right = 0, len(nums)
    while left < right:
        mid = (left + right) // 2
        if nums[mid] <= target:
            left = mid + 1
        else:
            right = mid
```

```
    return left
```

Examples:

34. Find First and Last Position of Element in Sorted Array

■ Template 4 — Search in Answer Space

Used when searching over possible answers instead of direct array indices.

```
def check(x):
    # returns True if condition satisfied for value x
    ...

def search_space(lo, hi):
    while lo < hi:
        mid = (lo + hi) // 2
        if check(mid):
            hi = mid
        else:
            lo = mid + 1
    return lo
```

Examples:

875. Koko Eating Bananas
1011. Ship Packages Within D Days
1482. Minimum Days to Make m Bouquets
410. Split Array Largest Sum

■ Template 5 — Search for Last True / First False

Used for monotonic functions like True→False sequences.

```
def binary_search_bool(lo, hi):
    while lo < hi:
        mid = (lo + hi + 1) // 2
        if condition(mid):
            lo = mid
        else:
            hi = mid - 1
    return lo
```

Examples:

1552. Magnetic Force Between Two Balls
1802. Maximum Value at a Given Index in a Bounded Array

■ Practice Playlist

Difficulty	Problems
Easy	704. Binary Search 35. Search Insert Position 69. Sqrt(x)
Medium	34. Find First and Last Position 33. Search in Rotated Array 162. Find Peak Element 153. Find Min in Rotated Array 240. Search 2D Matrix

Hard	410. Split Array Largest Sum 875. Koko Eating Bananas 1011. Ship Packages 1482. Make Bouquets 1552. Magnetic Force Between Two Balls

■ Debugging Tips:

• Define invariants clearly (inclusive/exclusive bounds).
• Prefer `while lo < hi` for searching answer space.
• Use `(lo + hi + 1)//2` for last-True search patterns.
• Move bounds carefully to avoid infinite loops.
• Keep your function monotonic — always moving toward a decision.

This Binary Search Master Template was curated by Shivam Chauhan — designed for clarity, confidence, and clean problem-solving under pressure.