Linear Search and Binary Search

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1. Linear Search - Logic

Linear search scans each element one by one until it finds the target element or reaches the end.

Key Idea

For an array of size n, linear search checks each index from 0 to $n-1$ for the key.

2. Linear Search - Pseudocode

```
function linearSearch(arr, key):
    for i from 0 to length(arr) - 1:
        if arr[i] == key:
            return i
    return -1
```

3. Binary Search - Logic

Binary search divides the search space in half repeatedly, working only on sorted arrays.

Key Idea

Start with low and high pointers. At each step, check the middle. If the middle is the key, return it. Else reduce the search space by half.

4. Binary Search - Pseudocode

```
function binarySearch(arr, key):
    low = 0
    high = length(arr) - 1
    while low <= high:
        mid = (low + high) // 2
        if arr[mid] == key:
            return mid
        else if arr[mid] < key:
            low = mid + 1
        else:
            high = mid - 1
    return -1
```

5. Binary Search - Python Code

```
def binary_search(arr, key):
    low = 0
    high = len(arr) - 1

    while low <= high:
        mid = (low + high) // 2

        if arr[mid] == key:
            return mid
        elif arr[mid] < key:
            low = mid + 1
        else:
            high = mid - 1

    return -1
```

6. Binary Search - Example Walkthrough

Given: `arr = [2, 4, 6, 8, 10, 12, 14]`
Target: `10`

Initial Setup

- low = 0
- high = 6

Step 1

- mid = (0 + 6) // 2 = 3
- arr[3] = 8
- 8 ¡ 10 → Search right half
- New low = 4, high = 6

Step 2

- mid = (4 + 6) // 2 = 5
- arr[5] = 12
- 12 ¿ 10 → Search left half
- New low = 4, high = 4

Step 3

- mid = (4 + 4) // 2 = 4
- arr[4] = 10
- Match found at index 4

Final Result

The element `10` is found at index **4**.

7. Time and Space Complexity Comparison

Aspect	**Linear Search**	**Binary Search**
Best Case	$O(1)$	$O(1)$
Average Case	$O(n)$	$O(\log n)$
Worst Case	$O(n)$	$O(\log n)$
Space	$O(1)$	$O(1)$
Requires Sorted?	No	Yes