

3.2 Second Largest Element

EASY

■ What You Will Learn

- ✓ How to track two variables simultaneously
- ✓ Why naive two-pass approach works, and how to do it in one pass
- ✓ Handling edge cases: duplicates and small arrays

■ Intuition First

You're watching a race and want to know the runner-up. You track first and second place simultaneously. If someone beats first place, the old first becomes second. If someone beats only second place, update second. Simple, right?

■ Track Two Variables

- large = largest seen so far
- second = second largest seen so far
- If $\text{arr}[i] > \text{large}$: $\text{second} = \text{large}$, $\text{large} = \text{arr}[i]$
- Else if $\text{arr}[i] > \text{second}$ AND $\text{arr}[i] \neq \text{large}$: $\text{second} = \text{arr}[i]$

■ Visual Trace

Input

12	35	1	10	34	1
----	----	---	----	----	---

```
Start: large=12, second=-INF
35>12 → second=12, large=35
1 < 12 → skip (not > second)
10 < 12 → skip
34 > 12 but 34 < 35 → second=34
1 < 34 → skip
Result: second = 34 ✓
```

■ Java Code

```
public static int secondLargest(int[] arr) {
    int large = Integer.MIN_VALUE;
    int second = Integer.MIN_VALUE;
    for (int x : arr) {
```

```
if (x > large) {  
    second = large; // Old largest becomes second  
    large = x;  
} else if (x > second && x != large) {  
    second = x; // New second largest  
}  
  
return second; // Returns MIN_VALUE if no second exists  
}
```

■ Complexity

Case	Time	Space	What happens?
All Cases	$O(n)$	$O(1)$	Single pass, two variables

■ Common Mistakes

- Forgetting $x \neq \text{large}$ — without this, $[3,3,1]$ gives $\text{second}=3$ (wrong)
- Initializing with $\text{arr}[0]$ and $\text{arr}[1]$ without comparing them first

■ Edge Cases to Test

- All same elements: $[5,5,5] \rightarrow$ no second largest
- Two elements: $[1,2] \rightarrow \text{second} = 1$
- Negatives: $[-1,-2,-3] \rightarrow \text{second} = -2$

■ Practice Problems

[Easy] Find second largest in $[1,2,3,4,5]$

[Med] Find kth largest element (generalize this pattern)

[Med] Find second largest without modifying the array

■ Quick Revision

- Track large and second simultaneously
- If $x > \text{large}$: $\text{second}=\text{large}$, $\text{large}=x$
- Else if $x > \text{second}$ AND $x \neq \text{large}$: $\text{second}=x$

- $O(n)$ time, $O(1)$ space
- Handle duplicates with the $x \neq \text{large}$ check