NPTEL MOOC,JAN-FEB 2015
Week 2, Module 7

DESIGN AND ANALYSIS OF ALGORITHMS

Quicksort

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Merge Sort: Shortcomings

- Merging A and B creates a new array C
  - No obvious way to efficiently merge in place
- Extra storage can be costly
- Inherently recursive
  - Recursive call and return are expensive

Alternative approach

- Extra space is required to merge
- Merging happens because elements in left half must move right and vice versa
- Can we divide so that everything to the left is smaller than everything to the right?
  - No need to merge!

Divide and conquer without merging

- Suppose the median value in A is m
- Move all values ≤ m to left half of A
  - Right half has values > m
  - This shifting can be done in place, in time O(n)
- Recursively sort left and right halves
- A is now sorted! No need to merge
  - $t(n) = 2t(n/2) + n = O(n \log n)$

Divide and conquer without merging

- How do we find the median?
  - Sort and pick up middle element
  - But our aim is to sort!
- Instead, pick up some value in A — pivot
  - Split A with respect to this pivot element

Quicksort

- Choose a pivot element
  - Typically the first value in the array
- Partition A into lower and upper parts with respect to pivot
- Move pivot between lower and upper partition
- Recursively sort the two partitions

Quicksort

- High level view

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43	32	22	78	63	57	91	13

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Quicksort: Partitioning

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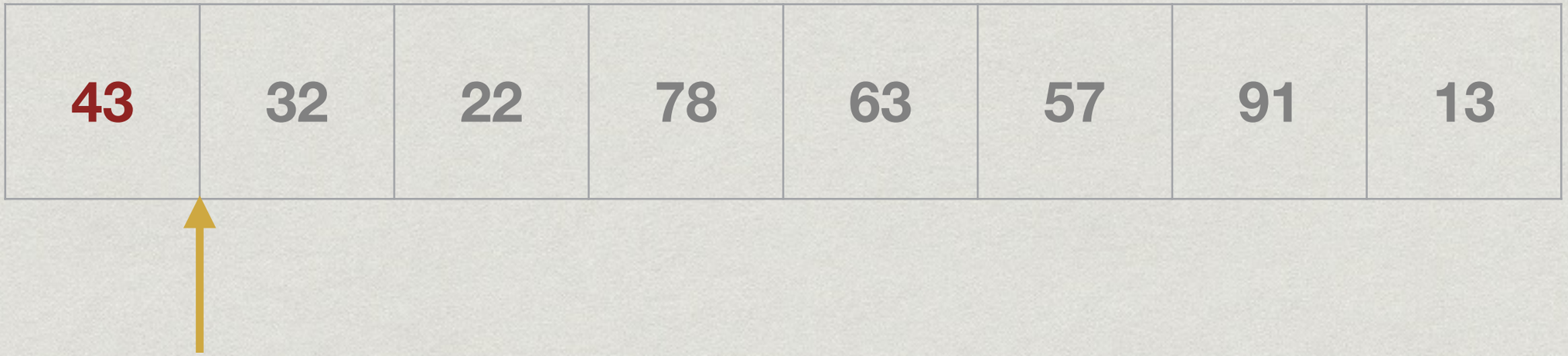
Quicksort: Partitioning



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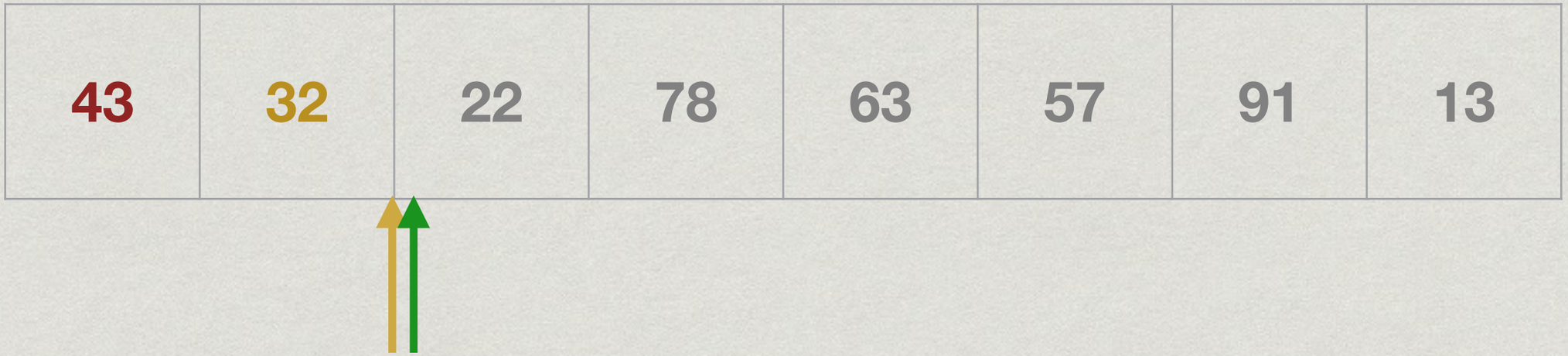

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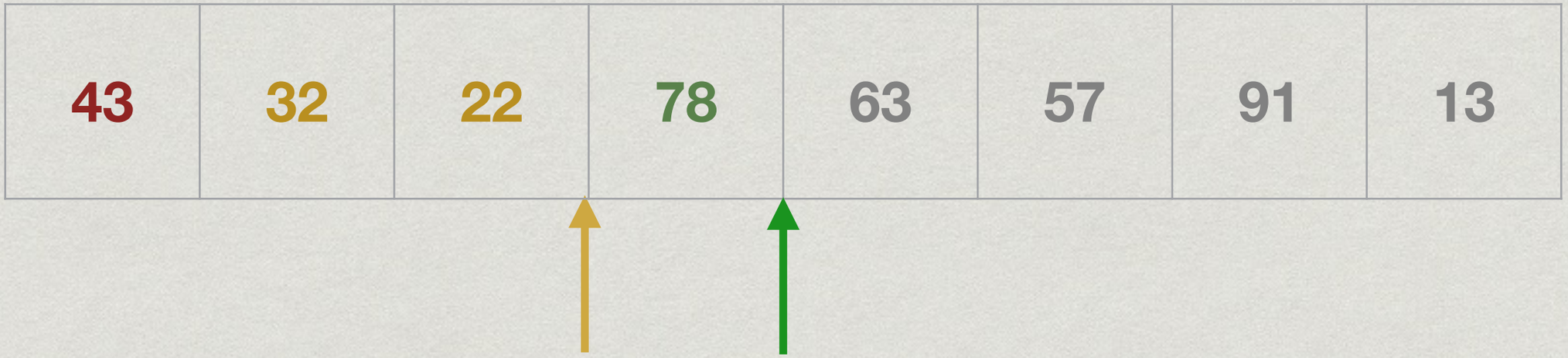

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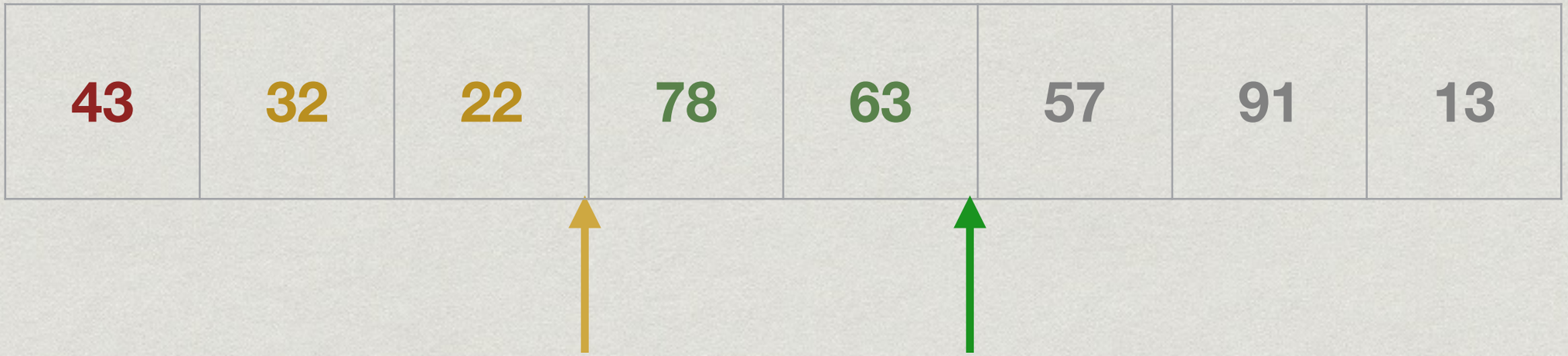

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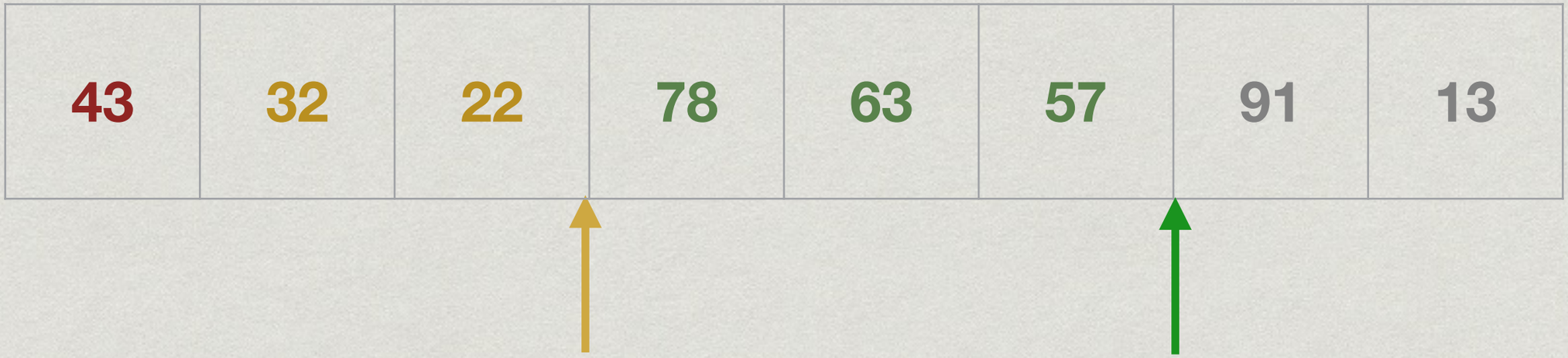

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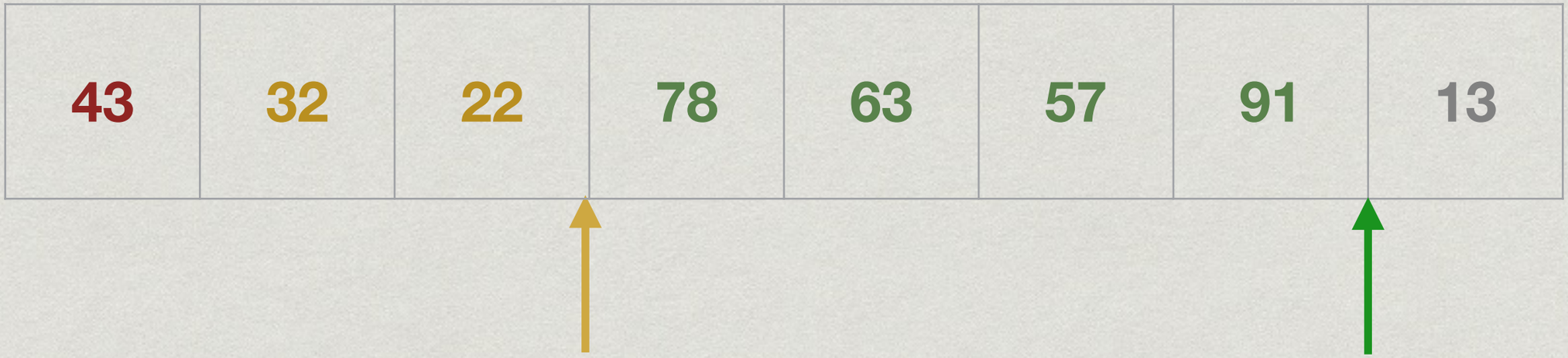

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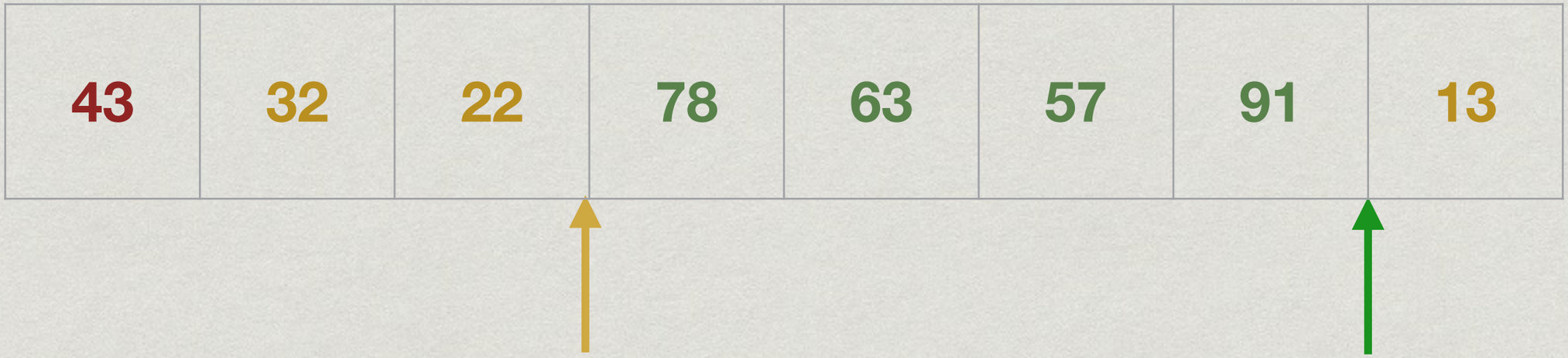

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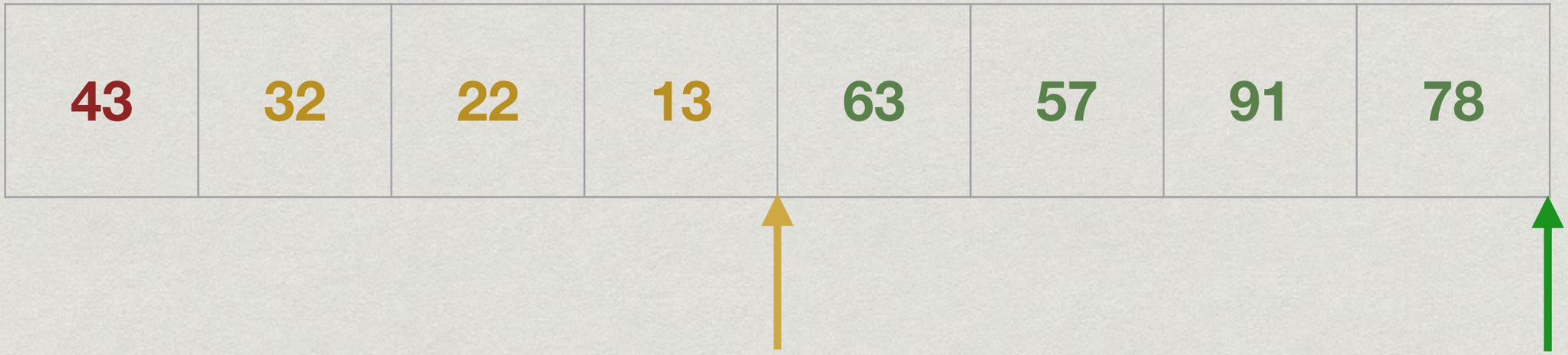

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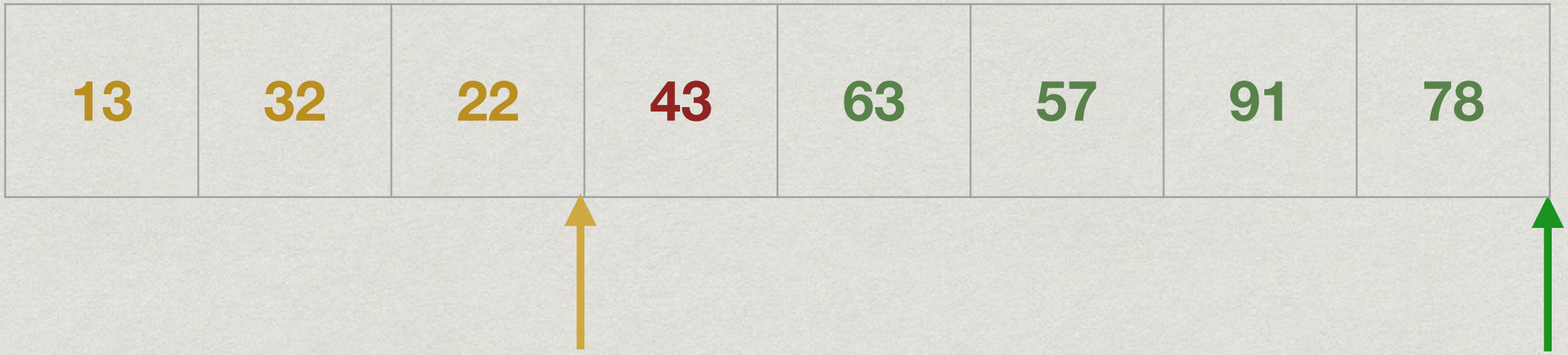

Quicksort: Implementation

```
Quicksort(A,l,r) // Sort A[l..r-1]

   if (r - l <= 1)) return; // Base case

   // Partition with respect to pivot, a[l]
   yellow = l+1;
   for (green = l+1; green < r; green++)
      if (A[green] <= A[l])
         swap(A,yellow,green);
         yellow++;

   swap(A,l,yellow-1); // Move pivot into place

   Quicksort(A,l,yellow);  // Recursive calls
   Quicksort(A,yellow+1,r);
```

Quicksort:
Another Partitioning Strategy

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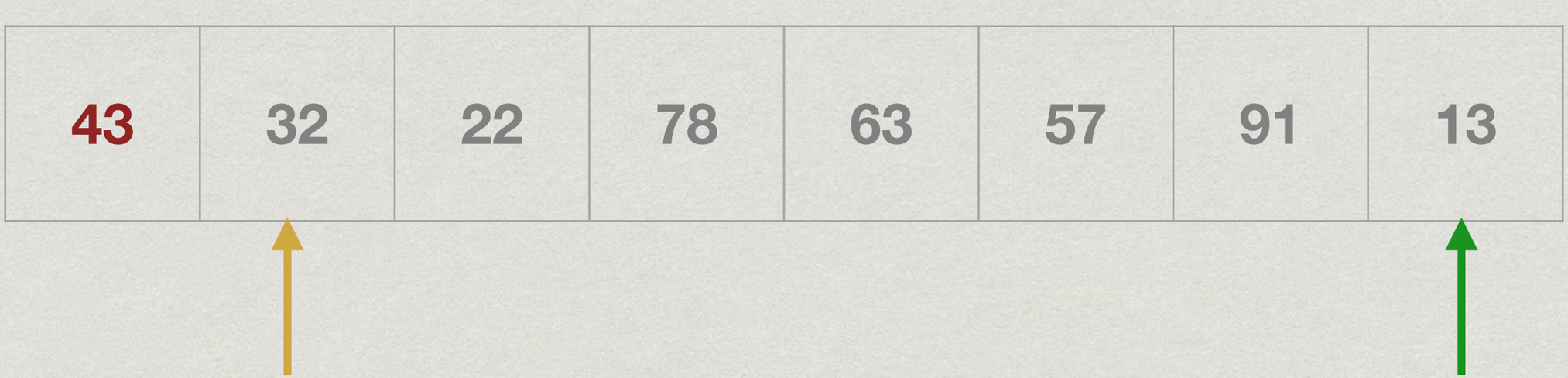

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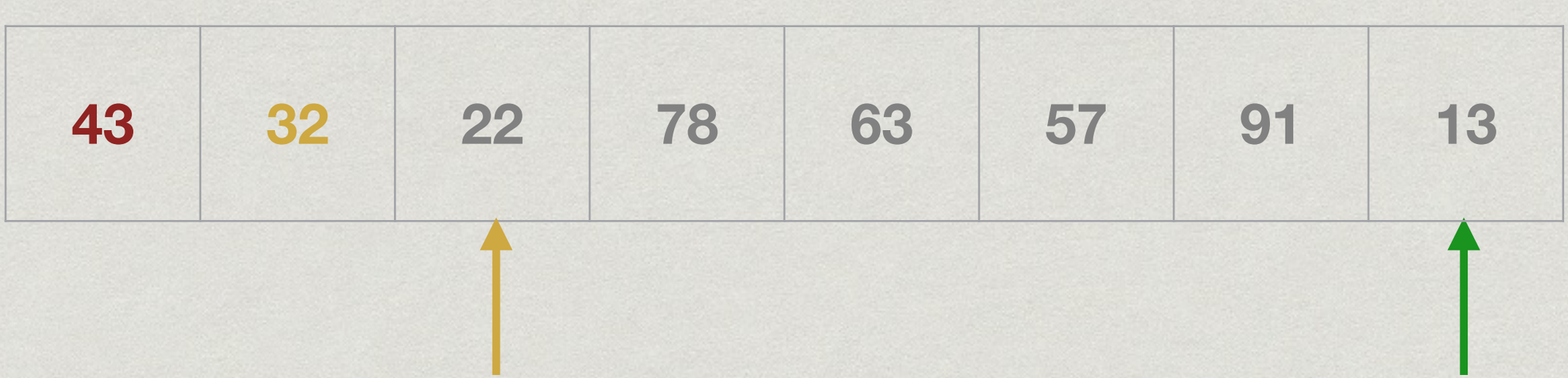

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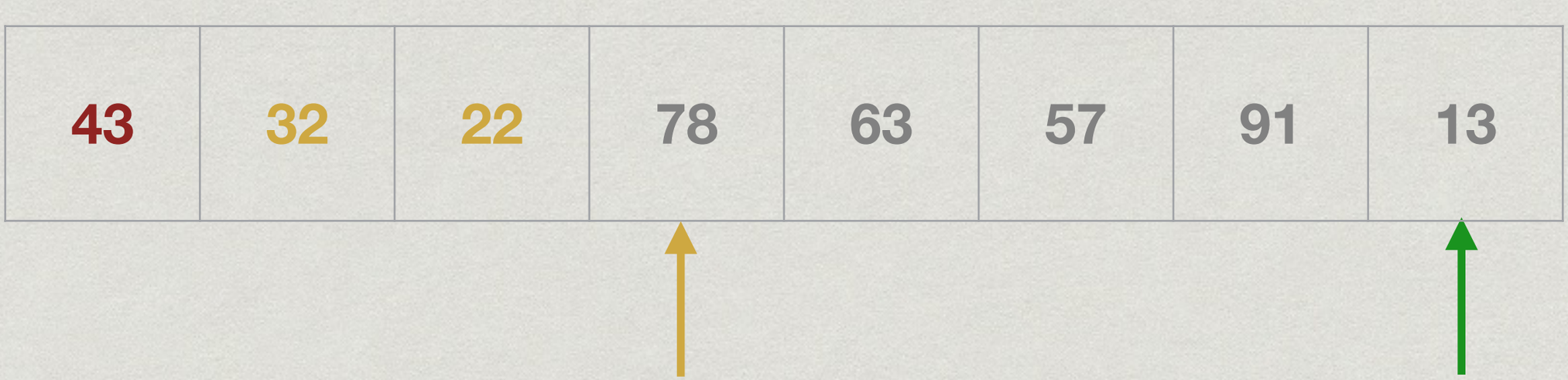

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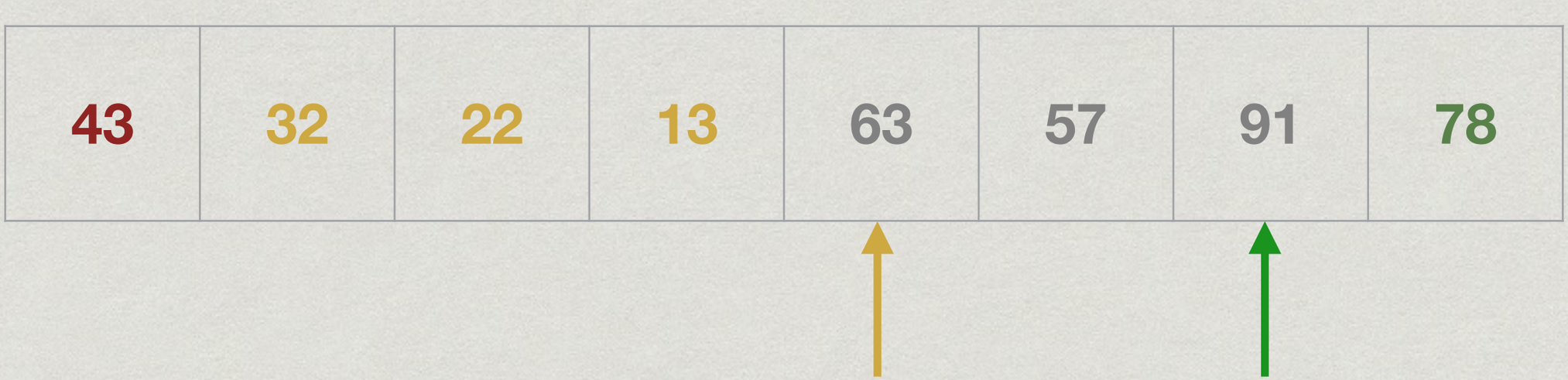

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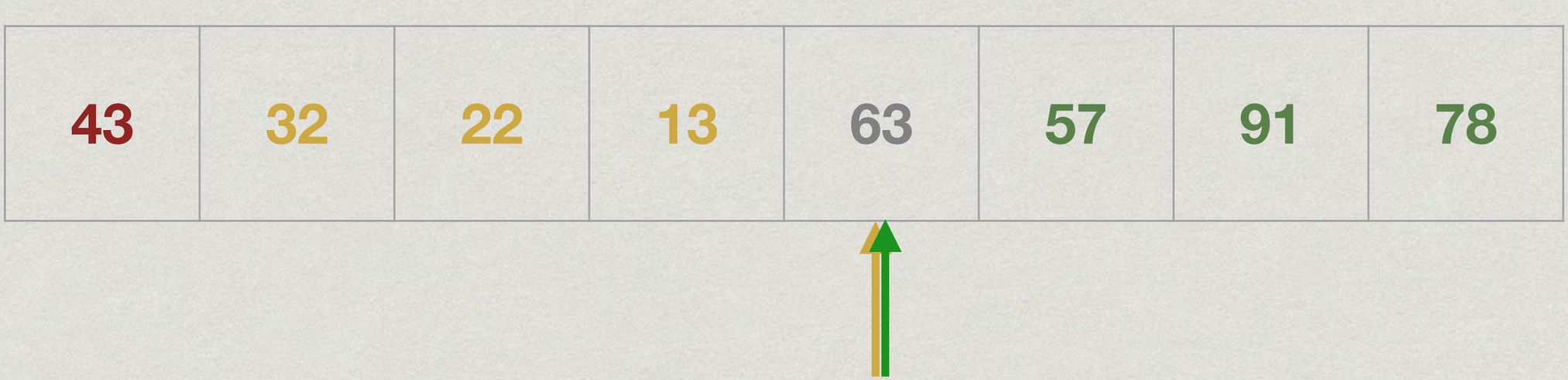

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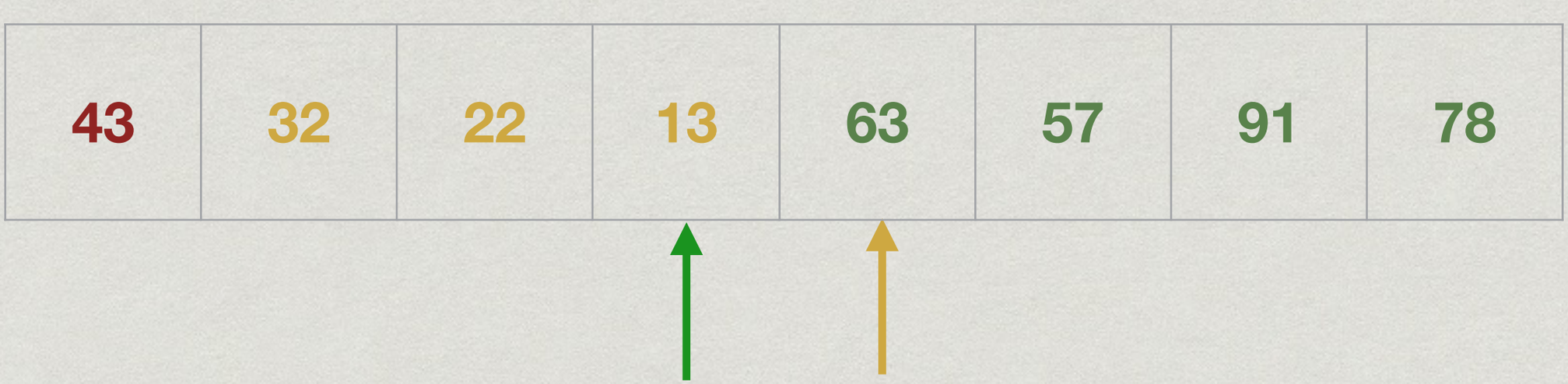

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