Introduction to Programming

Week – *5*, Lecture – *1*

Iterative Operations on Arrays

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IIT KANPUR

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Usually, a loop is used to “iterate” through these variables, and use them appropriately

We will now have a look at two most common operations performed through loops on an array

- Sorting the values in an array
- Searching for a value in an array

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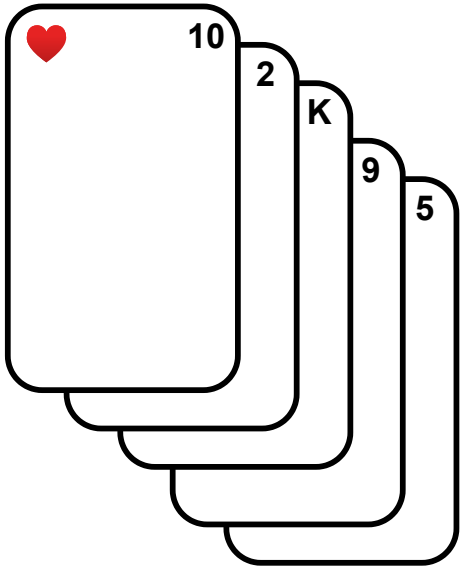

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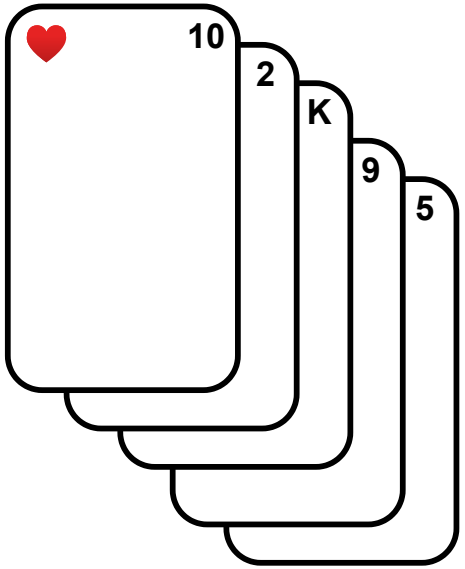

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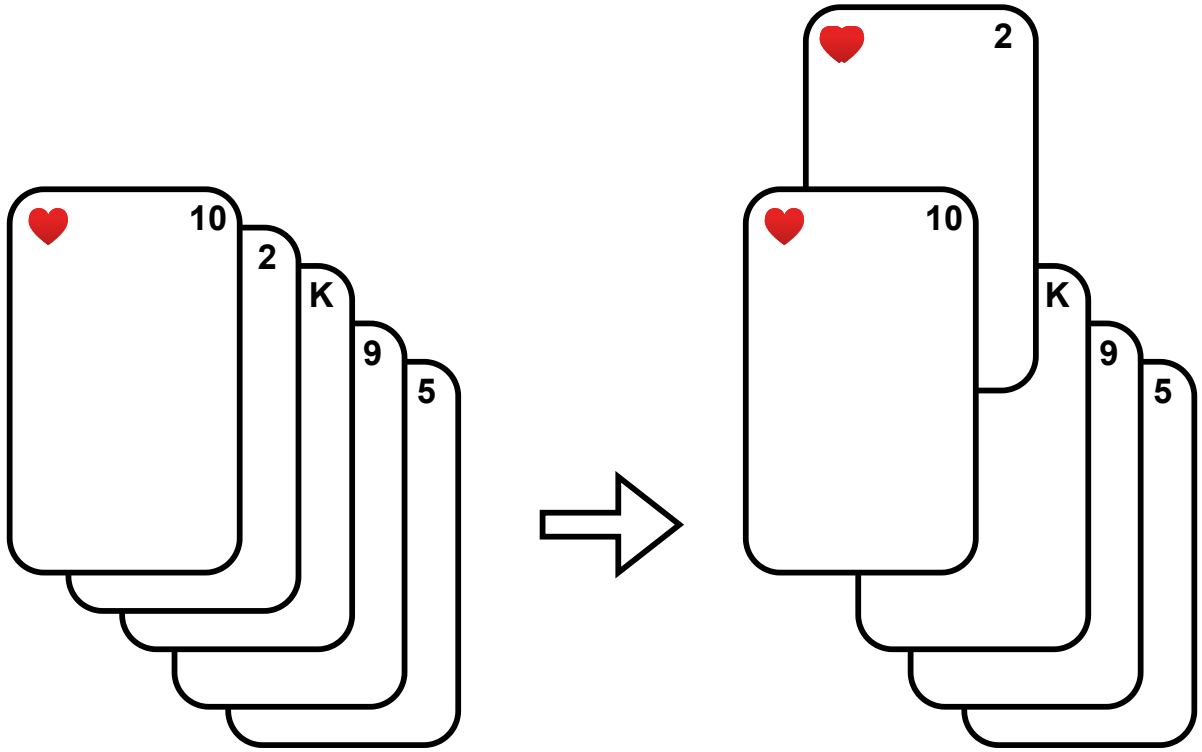
How do they usually do it?

“Sorting” the cards in hand

A common approach to get the cards in order (assuming the smallest card is on top) is this:

- Browse though the cards, and find the smallest card in the hand

“Sorting” the cards in hand



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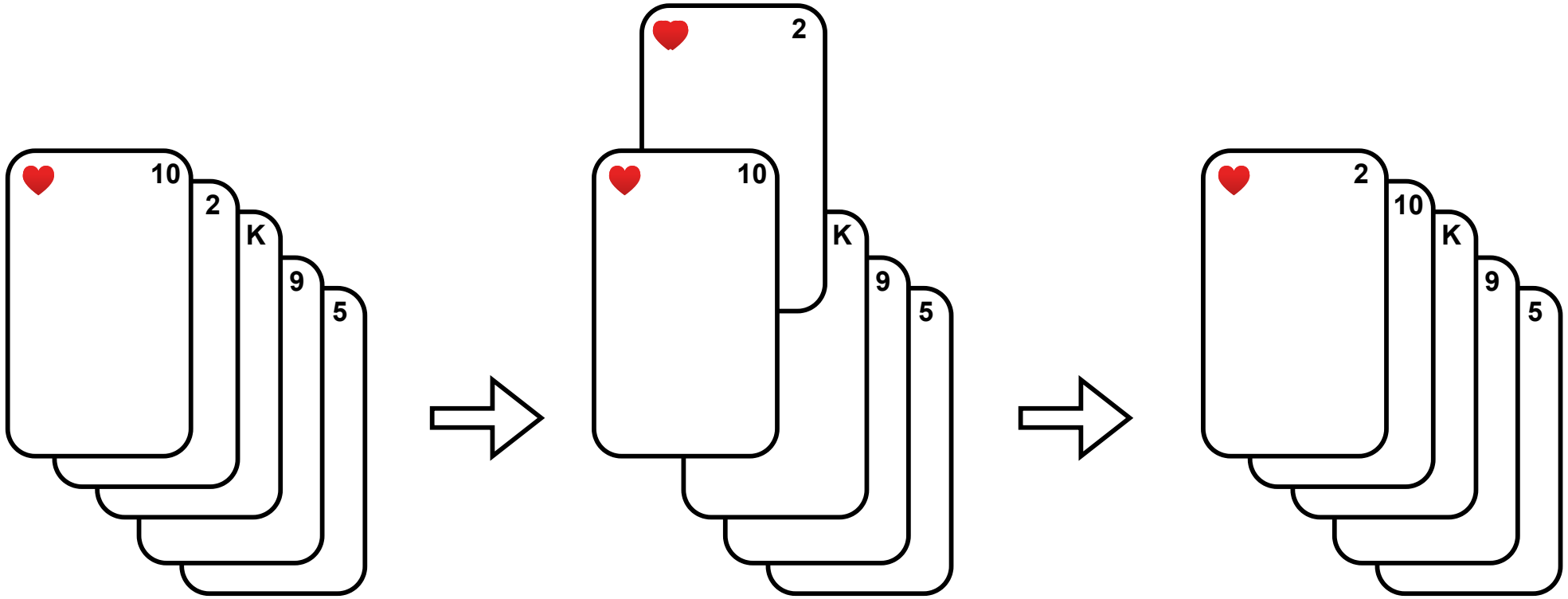

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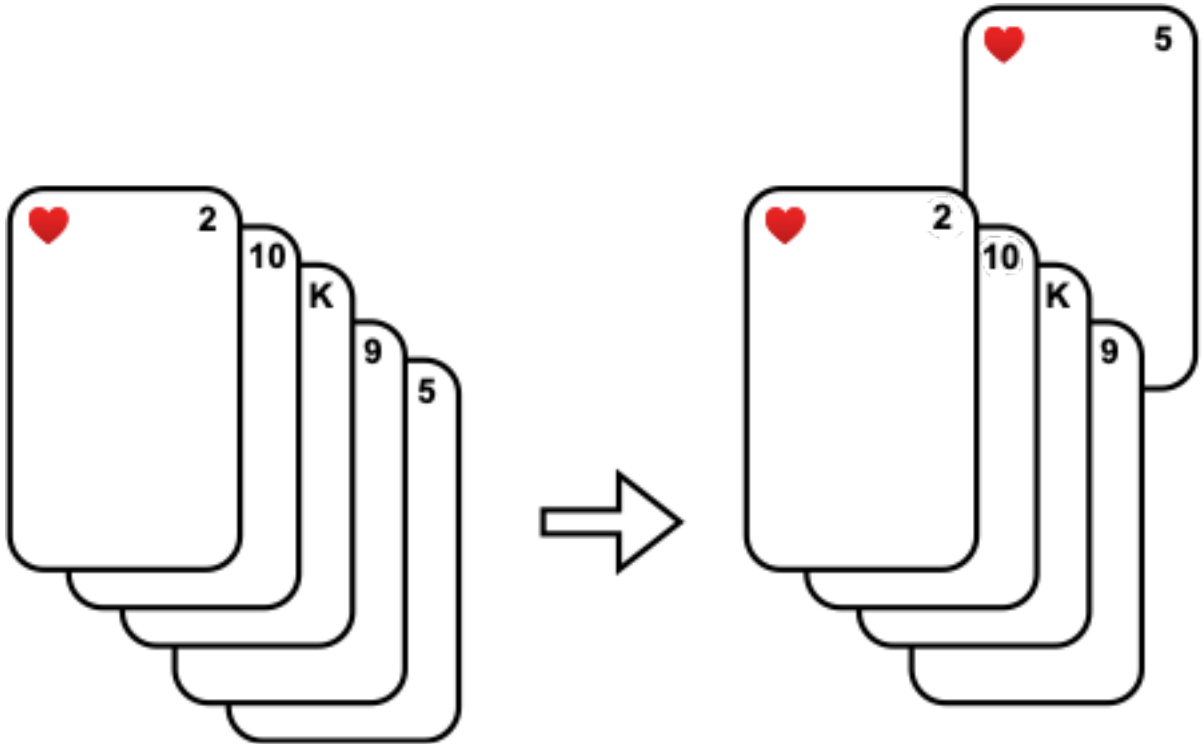

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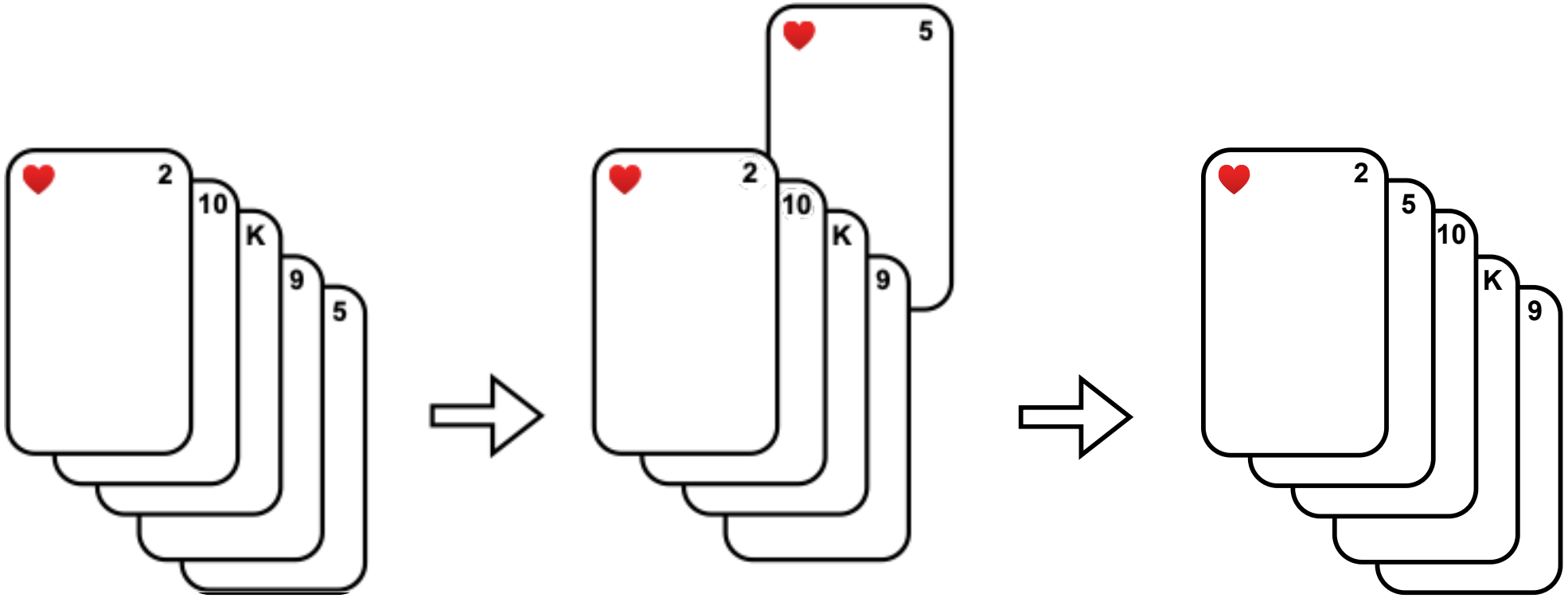

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What we just saw included examples of two common array operations

- *“inserting”* a value and *“deleting”* the value at a given index (in this case, it was the same value)

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Capacity: 5

10	13	9	5	X

Size	**Vacant Slots?**
4	Yes

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Assume that we have an array of capacity 5 and current size as 4

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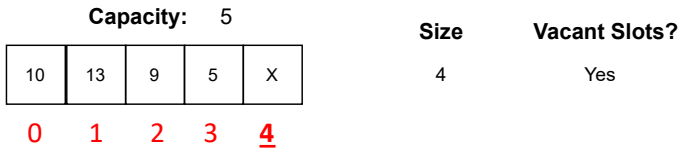

Size	Vacant Slots?
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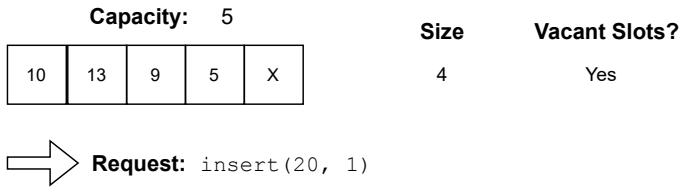
Assume that we have an array of capacity 5 and current size as 4

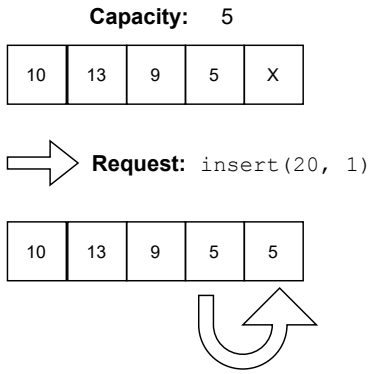
Here, there is no “recognized” value at index 4 (i.e., it could be some random value, that we don’t care)

Insertion in arrays



Assume that we now get a request to insert a new value, `20`, at index `1` of the array

Insertion in arrays



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We copy the value at last occupied index, i.e., index 3 to the next index, i.e., index 4

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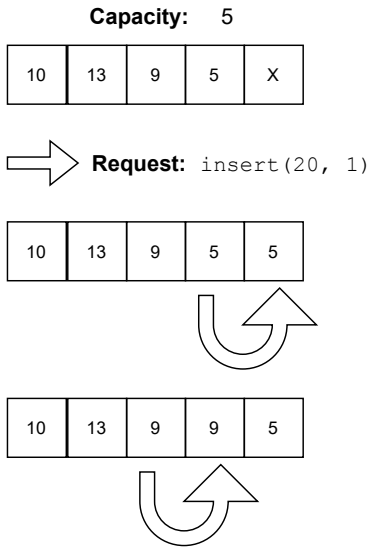

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We copy the value at last occupied index, i.e., index 3 to the next index, i.e., index 4

… then we copy the value at index 2 to index 3

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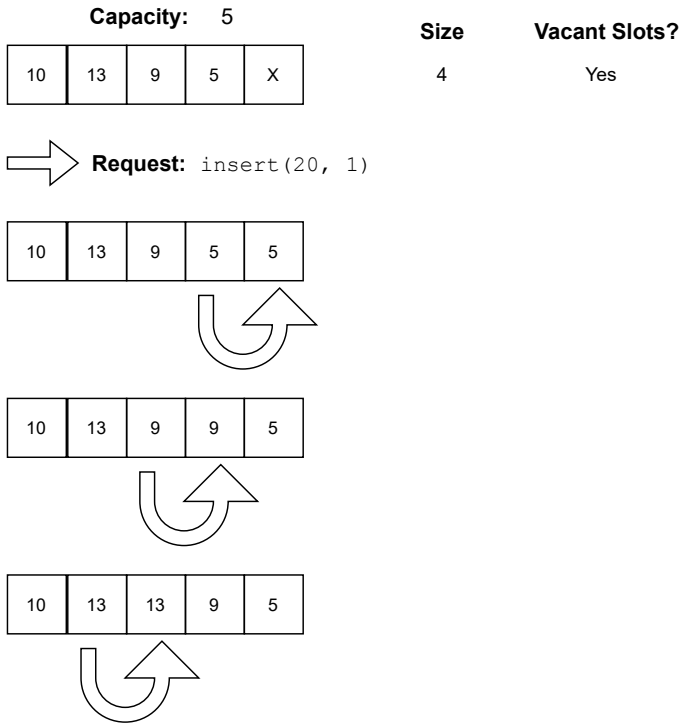
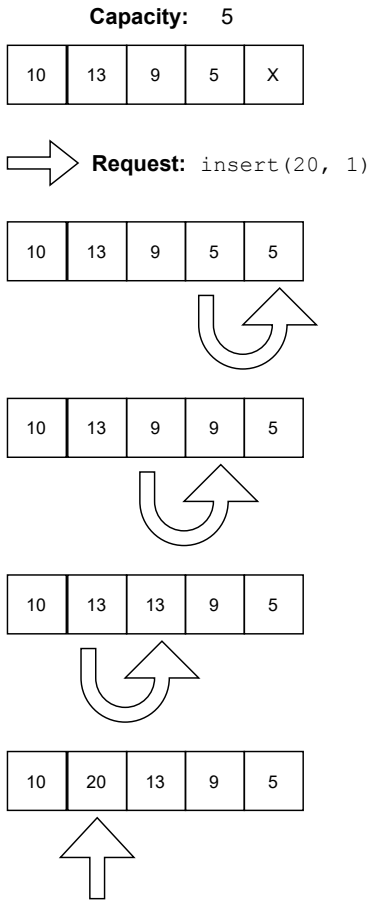


We copy the value at last occupied index, i.e., index 3 to the next index, i.e., index 4

… then we copy the value at index 2 to index 3

… and finally, we copy value at index 1 to index 2

Insertion in arrays



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Size	Vacant Slots?
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Finally, we can now insert new value at index 1

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- Checking if the array has any vacant slots; if there are, we can accommodate a new value
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Here, we are explicitly maintaining the size of an array

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It can range from 0 to the array capacity

- Array capacity is essentially its declared size

Insertion in arrays

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// Check for vacancy
if(size == CAPACITY)
{
        printf("The array is full; remove some elements first !\n");
        break;
}

printf("Enter the index where you would like to insert the value: ");
scanf("%d", &op1);

// Check if the index is valid
if(op1 < 0 || op1 >= CAPACITY)
{
        printf("Invalid insertion index\n");
        break;
}
else if(op1 > size)
{
        printf("WARNING: The element will be added at the end, i.e. index %d\n",size);
        op1 = size;
}

printf("Enter the value to insert: ");
scanf("%d", &op2);

// Shift elements to the right
for(i = size; i > op1; i--)
        arr[i] = arr[i-1];

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`op1` contains the index of insertion

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Focus on this part, and convince yourself that it performs the insertion

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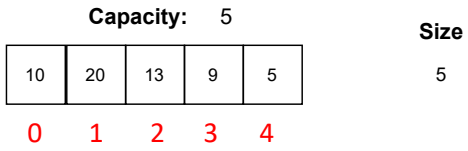

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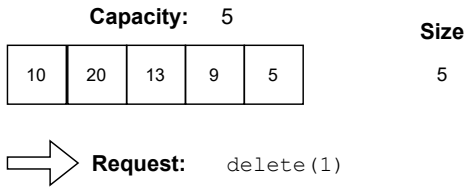
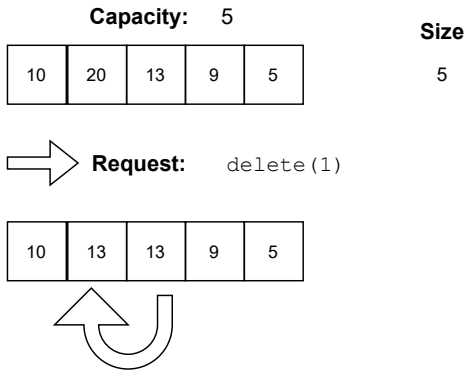
Let us go back to the array where we inserted the value

Deletion in arrays



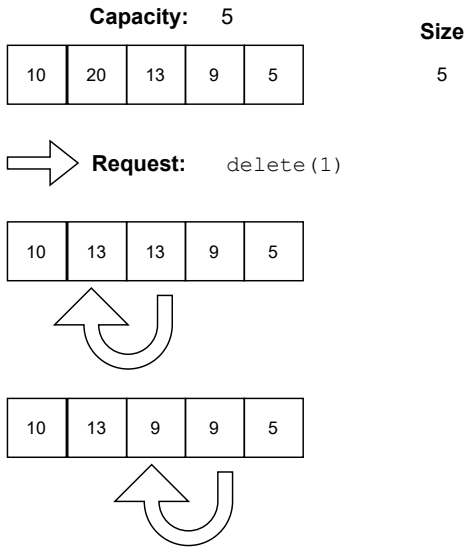
Assume that we now get a request to delete the value at index `1` of the array

Deletion in arrays



We copy the value at index `i+1` to `i`, i.e., index `2` to the previous index, i.e., index `1`

Deletion in arrays



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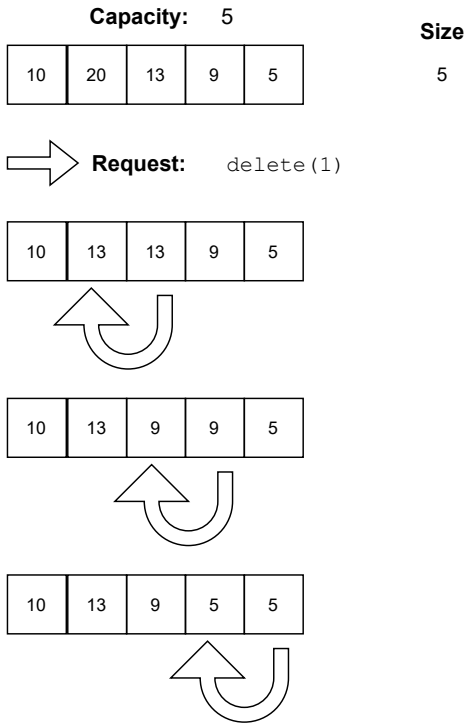

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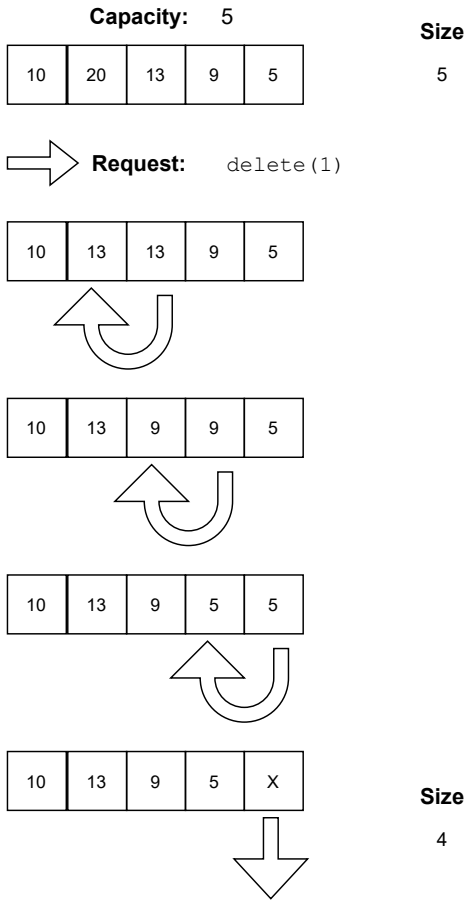
Deletion in arrays



We don’t really need to “delete” the value at last index…
we just reduce the size, and “ignore” the stored value

Deletion in arrays

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// Check if array has any elements
if(size == 0)
{
        printf("The array is empty; add some elements first !\n");
        break;
}

printf("Enter the index of the value you wish to delete: ");
scanf("%d", &op1);


// Check if the index is valid
if(op1 < 0 || op1 >= CAPACITY)
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}
else if(op1 >= size)
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// Shift elements to the left
for(i = op1; i < size - 1; i++)
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// Update the size
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The sorting method we saw with the cards, using insertions and deletions…

- … is actually a variant of a sorting protocol !!

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If we use insertions and deletions in a more systematic way, it is called the *Insertion Sort*

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- Then, we increase the size of the sorted part by 1 (thus, decreasing the size of unsorted part by 1)
- When the size of unsorted part becomes 0, the whole array has become sorted

The Insertion Sort

10	20	13	9	5

The Insertion Sort

Let us do insertion sort on our sample array !!

The Insertion Sort

At the start, the sorted part only contains the index `0`, while the unsorted part contains indices `1` to `4`

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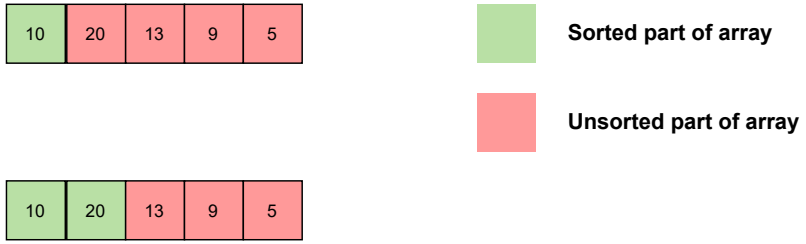
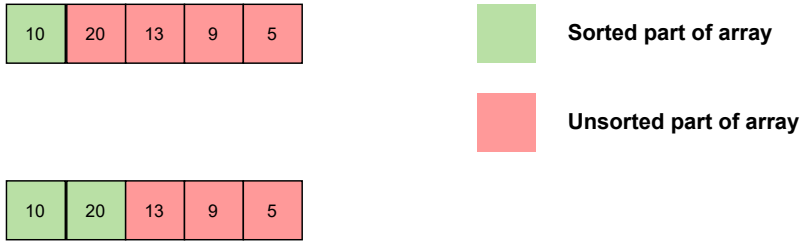
We delete the first element of the unsorted part, i.e., `20` at index `1`…

The Insertion Sort



… and insert it in the sorted part at its correct position, i.e., index 1 itself !!

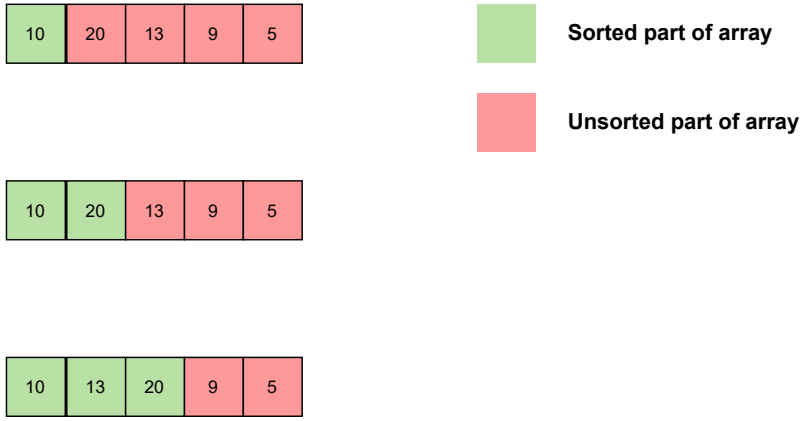
The Insertion Sort



… and insert it in the sorted part at its correct position, i.e., index 1 itself !!

Next, we delete 13 from index 2…

The Insertion Sort



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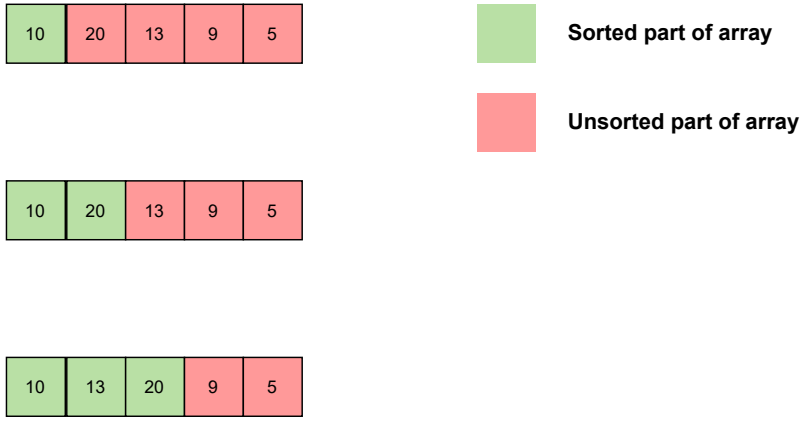
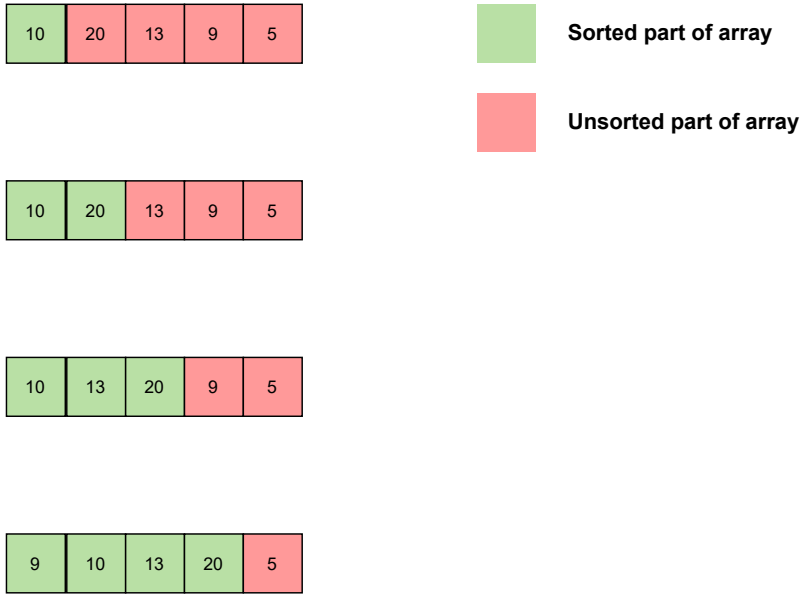
The Insertion Sort



… and insert it in the sorted part at its correct position, i.e., index 1 !!

The first element of the unsorted part, i.e., 9 at index 3 is now deleted…

The Insertion Sort



… which gets inserted at index 0 in the sorted part of the array !!

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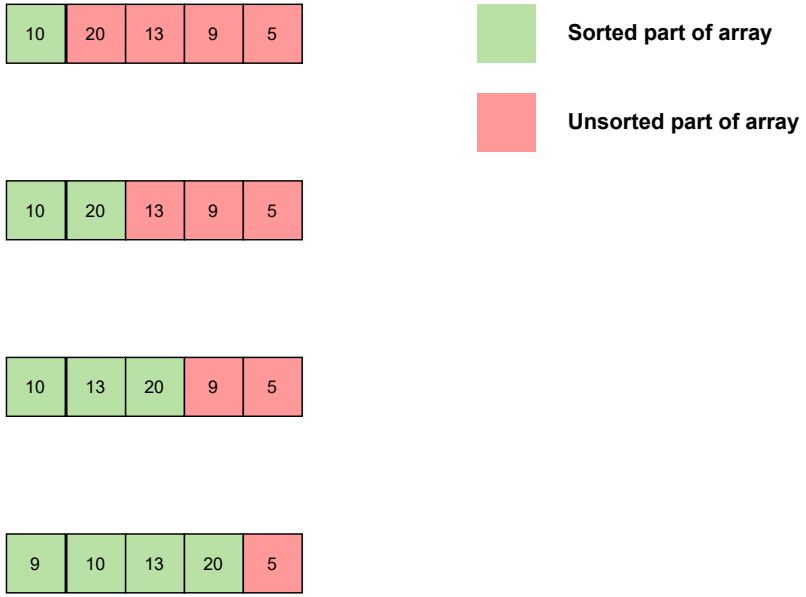
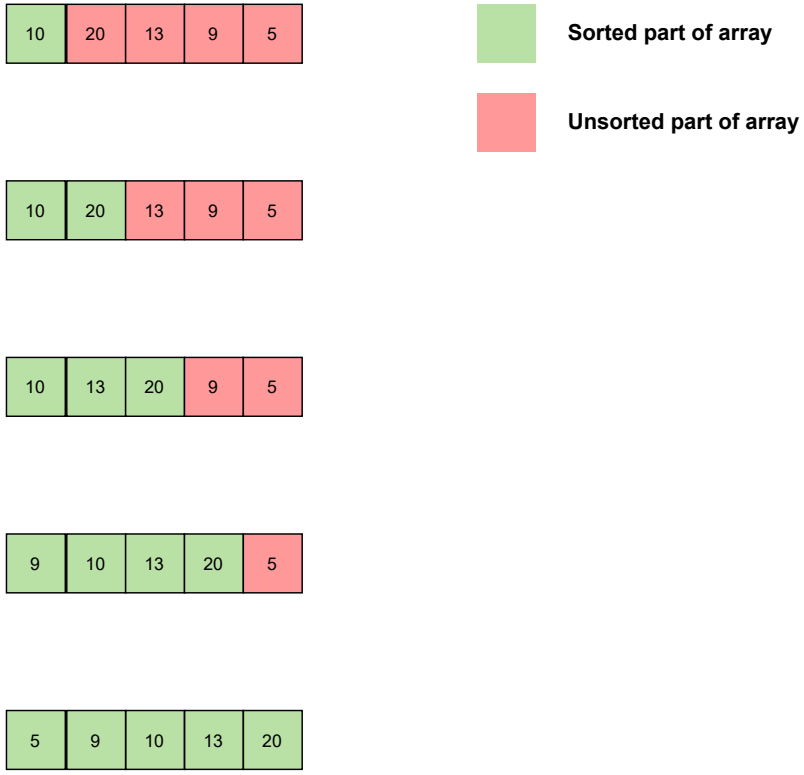


… which gets inserted at index 0 in the sorted part of the array !!

The last element of the unsorted part, i.e., 5 at index 4 is the last value to de deleted…

The Insertion Sort



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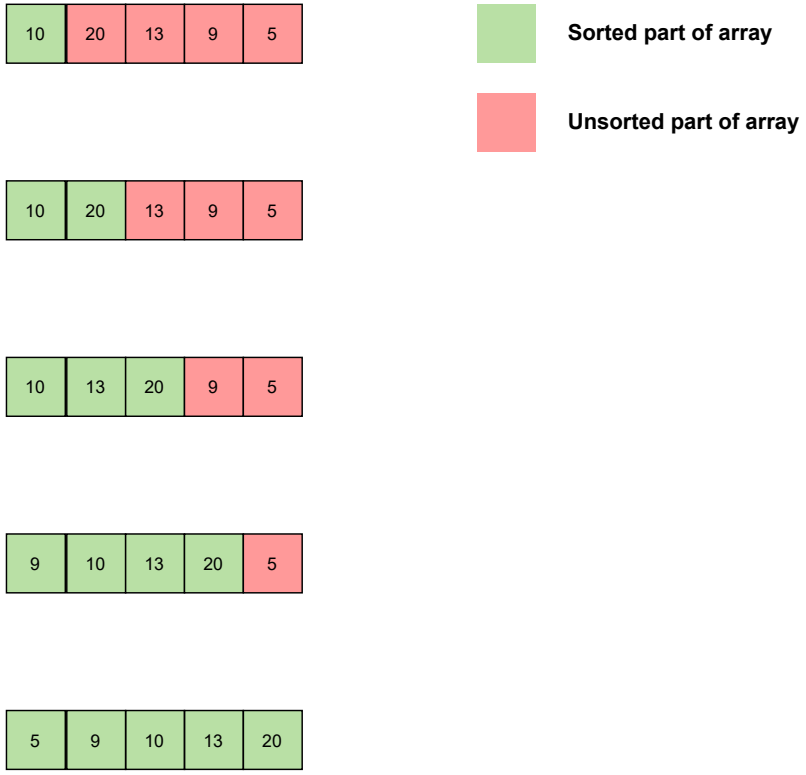

… which is inserted at the index `0`, its correct position in the sorted part

With this, the sorted part now contains the whole array… and we can feel proud that we have sorted the array :D

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- We don’t have much choice, but to check values at all the array indices, one by one

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- **If you always pick the mid-point of the array's part you are searching as `i`, it is called *Binary Search***

Searching in an array

5	9	10	13	20

Searching in an array

Going back to our array

Searching in an array

To search: 9

5	9	10	13	20

Assume that we have to search 9 in this sorted array

Searching in an array

In the beginning, we assume that 9 can be present anywhere in the array

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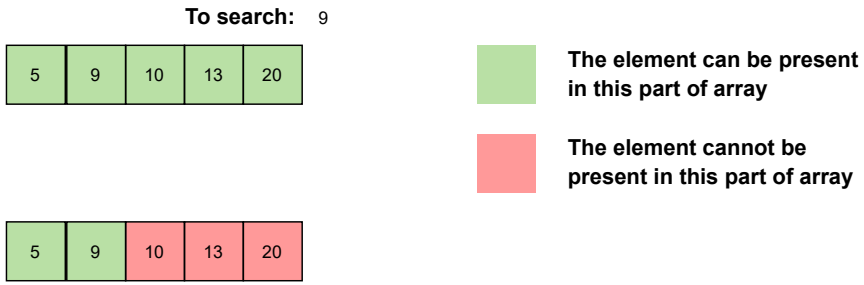
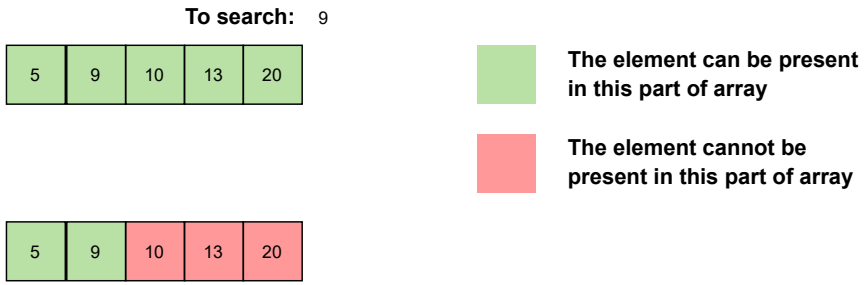
We compare it with the value at index 2, the mid-point of the part of the array where we must search (i.e., the whole array)

Searching in an array



Since 9 is smaller than 10, we can be sure that it cannot be present at indices 2 or higher, so only the left part of the array remains a candidate for further searching

Searching in an array



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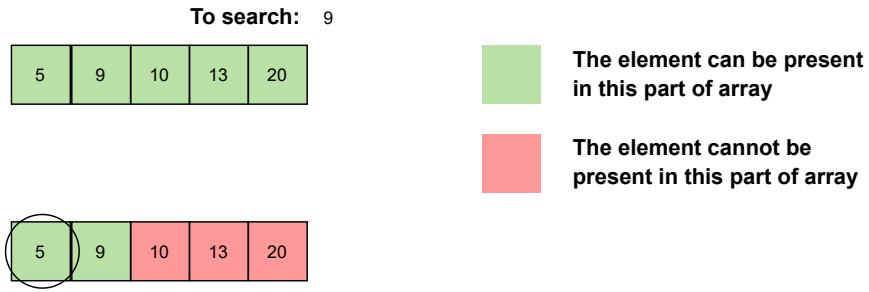

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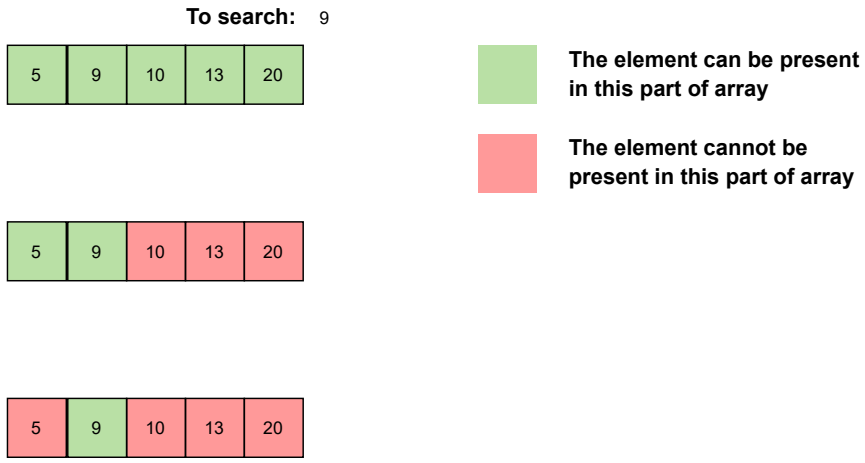
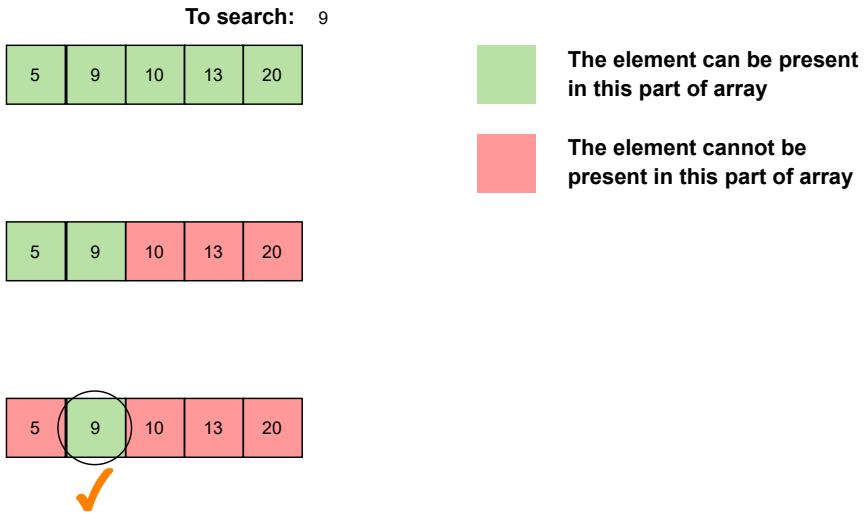
Let us pick index 0 for the next search

Searching in an array



Since 9 is larger than 5, it can only be present to the right of 5 in the array, leaving only index 1 to be searched

Searching in an array



… and this is where our element is !!

Homework !!

Go through the Example C file called `BasicArrayOperations.c`

- Create a new C file called `ArrayOperations.c`, containing two more operations…
- … “insertion sort array” operation, with operation code 3
- … and “binary search in array” operation, with operation code 4
- (assume that the user is “disciplined” enough to sort the array first, and then use binary search)

There are many other searching algorithms, you can easily comprehend at least two of them now

- Bubble Sort
- Selection Sort
- Try to write C code for them as well on your own