

Q1. Write linear search Pseudocode to search an element in a sorted array with minimum Comparisons.

Ans

```
for (i=0 to n)
{
    if (arr[i] == value)
        // element found
}
```

Q2. Write Pseudo Code for iterative & recursive insertion sort. Insertion sort is called Online sorting. Why? What about other sorting algorithms that has been discussed?

Ans. Iterative

```
void insertion_sort (int arr[], int n)
{
    for (int i=1; i<n; i++)
    {
        j = i-1;
        x = arr[i];
        while (j>0 && arr[j] > x)
        {
            arr[j+1] = arr[j];
            j--;
        }
        arr[j+1] = x;
    }
}
```

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## Recursive

```
void insertion_sort (int arr[], int n)
{
    if (n <= 1)
        return;
    insertion_sort (arr, n-1);
    int last = arr[n-1];
    int j = n-2;
    while (j >= 0 & arr[j] > last)
    {
        arr[j+1] = arr[j];
        j--;
    }
    arr[j+1] = last;
}
```

Insertion sort is called 'Online Sort' because it does not need to know anything about what values it will sort and information is requested while algorithm is running.

## Other Sorting Algorithms :-

- 1) Bubble Sort
- 2) Quick Sort
- 3) Merge Sort
- 4) Selection Sort
- 5) Heap Sort

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3. Complexity of all sorting algorithm that has been discussed in lectures.

Ans.

Sorting Algorithm	Best	Worst	Average
Selection Sort	$O(n^2)$	$O(n^2)$	$O(n^2)$
Bubble Sort	$O(n)$	$O(n^2)$	$O(n^2)$
Insertion Sort	$O(n)$	$O(n^2)$	$O(n^2)$
Heap Sort	$O(n \log n)$	$O(n \log n)$	$O(n \log n)$
Quick Sort	$O(n \log n)$	$O(n^2)$	$O(n \log n)$
Merge Sort	$O(n \log n)$	$O(n \log n)$	$O(n \log n)$

Q4. Divide all sorting algorithms into inplace / stable / Online sorting.

Ans.

<u>INPLACE SORTING</u>	<u>STABLE SORTING</u>	<u>ONLINE SORTING</u>
Bubble Sort Selection Sort Insertion Sort Quick Sort Heap Sort	Merge Sort Bubble Sort Insertion Sort Count Sort	Insertion Sort

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Q5. Write recursive/iterative pseudocode for binary search. What is the Time & Space Complexity of Linear & Binary Search.

Ans. Iterative  $\Rightarrow$

```
int b_search (int arr[], int l, int r, int key)
{
    while (l <= r) {
        int m = ((l+r)/2);
        if (arr[m] == key)
            return m;
        else if (key < arr[m])
            r = m-1;
        else
            l = m+1;
    }
    return -1;
}
```

Recursive  $\Rightarrow$

```
int b_search (int arr[], int l, int r, int key)
{
    while (l <= r) {
        int m = ((l+r)/2);
        if (key == arr[m])
            return m;
        else if (key < arr[m])
            return b_search(arr, l, mid-1, key);
        else
            return b_search(arr, mid+1, r, key);
    }
    return -1;
}
```

Time Complexity :-

- o) Linear Search -  $O(n)$
- o) Binary Search -  $O(\log n)$

*for*

Q6. Write recurrence relation for binary recursive search. (5)

$$T(n) = T(n/2) + 1 \quad \text{--- (1)}$$

$$T(n/2) = T(n/4) + 1 \quad \text{--- (2)}$$

$$T(n/4) = T(n/8) + 1 \quad \text{--- (3)}$$

$$\begin{aligned} T(n) &= T(n/2) + 1 \\ &= T(n/4) + 1 + 1 \\ &= T(n/8) + 1 + 1 + 1 \\ &\vdots \end{aligned}$$

$$T(n/2^k) + 1 \text{ (k Times)}$$

$$\text{Let } 2^k = n$$

$$k = \log n.$$

$$T(n) = T(n/n) + \log n$$

$$T(n) = T(1) + \log n$$

$$T(n) = O(\log n) \rightarrow \text{Answer.}$$

Q7. Find two indexes such that  $A[i] + A[j] = k$  in minimum time complexity.

```
→ for (i=0; i<n; i++)  
    {  
        for (int j=0; j<n; j++)  
            if (a[i] + a[j] == k)  
                printf("%d %d", i, j);  
    }
```

Q8. Which sorting is best for practical uses? Explain.

→ Quick sort is fastest general-purpose sort. In most practical situations quicksort is the method of choice as stability is important and space is available, mergesort might be best.

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Q9. What do you mean by inversions in an array? Count the number of inversions in Array arr [ ] = { 7, 21, 31, 5, 10, 1, 20, 6, 4, 5 } using merge sort.

Ans. A Pair  $(A[i], A[j])$  is said to be inversion if

- $A[i] > A[j]$
- $i < j$

• Total no. of inversions in given array are 31 using merge sort.

Q10. In which cases Quick Sort will give best & worst case time complexity.

Ans. Worst Case  $O(n^2)$  → The worst case occurs when the pivot element is ~~an~~ extreme (smallest / largest) element. This happens when input array is sorted or reverse sorted and either first or last element is selected as pivot.

Best Case  $O(n \log n)$  → The best case occurs when we will select pivot element as a mean element.

Q11. Write Recurrence Relation of Merge / Quick Sort in best & worst case. What are the similarities & differences between complexities of two algorithm & why?

Ans. Merge Sort →

Best Case →  $T(n) = 2T(n/2) + O(n)$       $\left\{ \begin{array}{l} O(n \log n) \\ O(n^2) \end{array} \right.$

Worst Case →  $T(n) = 2T(n/2) + O(n)$

Quick Sort →

Best Case →  $T(n) = 2T(n/2) + O(n) \rightarrow O(n \log n)$

Worst Case →  $T(n) = T(n-1) + O(n) \rightarrow O(n^2)$

In quick sort, array of element is divided into 2 parts repeatedly until it is not possible to divide it further.

In merge sort the elements are split into 2 subarray  $(n/2)$  again & again until only one element is left.

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2. Selection sort is not stable by default but can you write a version of stable selection sort? (7)

Ans.

```
for (int i = 0; i < n - 1; i++)  
{  
    int min = i;  
    for (int j = i + 1; j < n; j++)  
    {  
        if (a[min] > a[j])  
            min = j;  
    }  
    int key = a[min];  
    while (min > i)  
    {  
        a[min] = a[min - 1];  
        min --;  
    }  
    a[i] = key;  
}
```

Q13. Bubble sort scans array even when array is sorted. Can you modify the bubble sort so that it does not scan the whole array once it is sorted.

Ans.

A better version of bubble sort, known as an improved bubble sort, includes a flag that is set if an exchange is made after an entire ~~time~~ pass over. If no exchange is made then it should be called the array is already sorted because no two elements need to be switched.

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```

void bubbleSort(int arr[], int n)
{
    for (int i = 0; i < n; i++)
    {
        int swaps = 0;
        for (int j = 0; j < n - i - 1; j++)
        {
            if (arr[j] > arr[j + 1])
            {
                int t = arr[j];
                arr[j] = arr[j + 1];
                arr[j + 1] = t;
                swaps++;
            }
        }
        if (swaps == 0)
            break;
    }
}

```

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