19-6-25:- DATA STRUCTURES AND ALGORITHS:- 10:00 AM.

Analysis of Algorithm:-

→ Algorithm :- A step-by-step procedure to solve a problem

→ Analysis of Algorithm :- Determining the time/space requirements to solve a problem

→ why Data structures & Algorithms :-

* Efficient data structure + optimal algorithm = high performance application.

* Helps to solve complex complex problems faster & manage data efficiently.

→ Types of DS:-

* Linear : Array, stack, queue, Linked list
* Non linear : Tree, graph
* Static : Array (Fixed size)
* Dynamic : Linked list (Flexible size).

→ Notation :-

→ T(n) → Time taken by an algorithm to solve an problem

→ S(n) → Space taken.

→ Framework for describing & analyzing algorithm:-

→ Input size identification

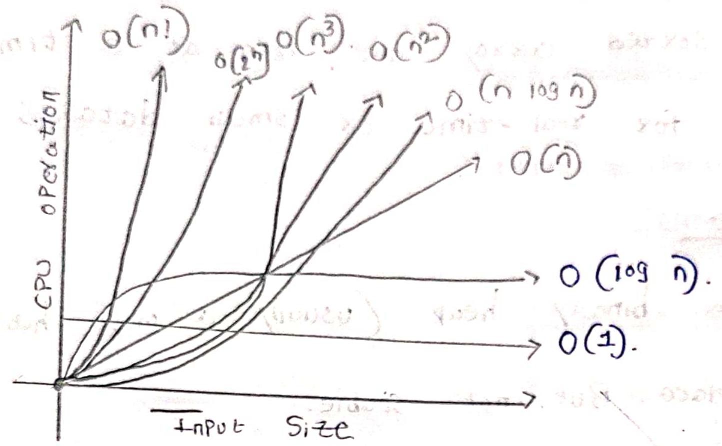
→ Basic operation selection.

→ worst case, Average case.

→ Use reccurence relations for recurssive algorithms.

→ Asympototic Notations:-

* Used to express time Complexity without constant factors.
* Big O (O) :- Upper bound - worst case
* Omega (Ω) :- Lower bound - Best case
* Theta (Θ) :- Tight bound - Average case.



Ex:

```
for (i=0; i<n; i++)
        ↓
      O(n).
```

```
for (i=0; i<n; i++)
    for (j=0; j<n; j++)
              ↓
           O(n^2)
```

```
int fact(int n)
{
  if (n==0)
      return 1.
  return n* Fact(n-1).
}
        ↓
      O(2^n)
```

SORTINGS:-

→ A sorting algorithm is used to rearrange a give array or list of elements in a order (Either in ascending/Descending)

Algorithms	Best case	Average case	Worst case	space compl
Bubble sort	$O(n)$	$O(n^2)$	$O(n^2)$	$O(1)$
Insertion Sort	$O(n)$	$O(n^2)$	$O(n^2)$	$O(1)$
Heap Sort	$O(n \log n)$	$O(n \log n)$	$O(n \log n)$	$O(1)$
Quick Sort	$O(n \log n)$	$O(n \log n)$	$O(n^2)$	$O(\log n)$
Merge sort.	$O(n \log n)$	$O(n \log n)$	$O(n \log n)$	$O(n)$.

→ Bubble sort :-

* Repeatedly swaps adjacent elements if they are in wrong order
* Optimized version can stop early if no swaps are made in a pass.

→ Insertion sort :-

* Builds sorted array one item at a time
* Good for real-time or small datasets.

→ Heap sort :-

* Use a binary heap (usually a max heap).
* In-place. But not stable.

→ Quick sort :-

* Use divide & conquer by choosing a pivot.
* Worst case can be avoided by using random or median pivot.

→ Merge sort :-

* Recursively splits array, then merges sorted subarrays.
* Requires extra space for merging.

Array Traversal & representation :-

* Array representation in memory

→ Arrays are stored in contiguous memory blocks.

→ For an array arr [i] :

Address of arr [i] = Base Address + i * size of element

Ex: For int (size = 4 bytes).

Base Address = 100 then arr [3] = 100 + 3 × 4 = 112

* Measuring Time Complexity of Traversal.

```
for (int i =0; i<n; i++)
        Systemm.out.println (arr [i]);
```

TC: O(n)

SC: O(1).

SEARCHING:

Linear Search

* checks each element one by 1
* Time Complexity :-

→ BC :- O(1)

→ AC :- O(n/2) ≅ O(n)

→ WC :- O(n)

* Space Complexity :- O(1).

```
int search (int arr[], int n, int key)
{
  for (int i=0; i<n; i++)
      if (arr[i] == key)
            return i;
   return -1;
}
```

Binary search :

* Divide & conquer by comparing middle element
* Time Complexity

* BC : O(1)
* AC : O(log n)
* WC : O(log n)

* Space :- O(1).

```
int  BS (int arr[], int low, int high, int k)
{
   while (low <= high)
   {
       int mid = (low+high)/2.
       if (arr [mid] == k)
              return mid.
       else if (arr[mid] < key)
              low =mid +1;
       else
              high = mid -1.
   }
   return -1.
}
```

LINKED LIST :-

Types of Linked List :-

Type	Description
Singly Linked list (SLL)	Each node Points to next node on
Circular singly Linked List (CSLL)	Last node Points Back to head
Doubly Linked list (DLL)	Each node has both next & pre Pt
Circular Doubly Linked list (CDLL)	Last node Connects to head & vice versa

Common Operations & Time Complexities.

Operation	SLL	CSLL	DLL	CDLL
Traverse	O(n)	O(n)	O(n)	O(n)
Search	O(n)	O(n)	O(n)	O(n)
Insert at beginning	O(1)	O(1)	O(1)	O(1)
Insert at end	O(n)	O(n)	O(n)	O(n)
Delete from beginning	O(1)	O(1)	O(1)	O(1)
Delete from End	O(n).	O(n)	O(n)	O(n)