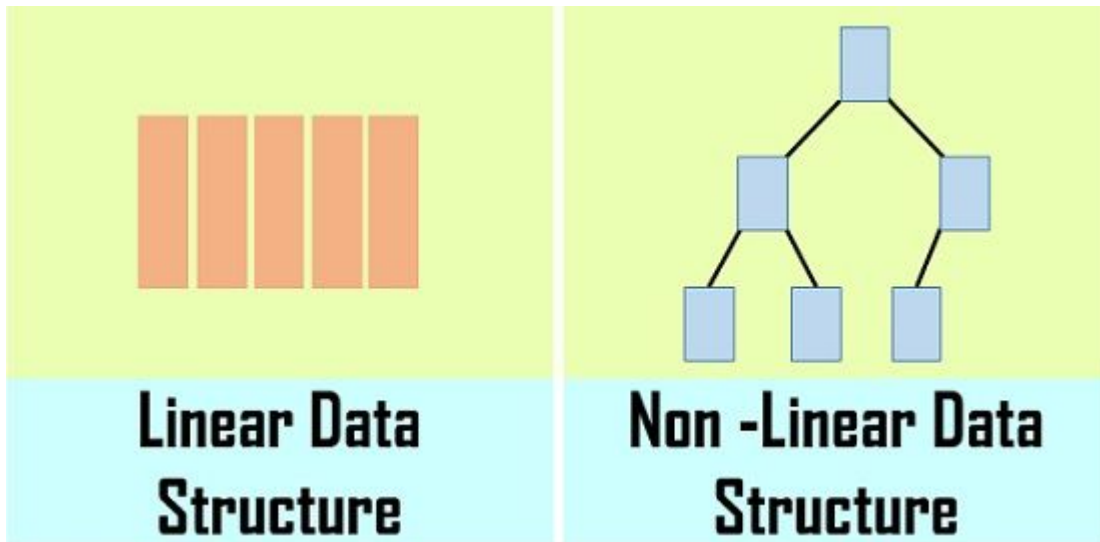


# **Data Structures & Algorithms**

- It is a way to organize data.
- After organizing data it becomes easy to process it.

## **Data Structures Types:**

- **Linear:**
  - They have data elements arranged in a sequential manner.
  - Each member is connected to its previous and next element.
  - Because they are connected sequentially it becomes easy to traverse them.
  - Array, Linked List, Stack, Queue are linear data structures.
  - They are single level.
- **Non-Linear:**
  - Data elements inside these data structures are not in sequence.
  - They are basically connected to one another through different paths.
  - They are basically stored in multi-level so in order to traverse each and every element in that non-linear data structure takes some amount of time.
  - Tree and Graph are non-linear data structures.



## Algorithms:

- An algorithm is a set of instructions to perform a task or solve a given problem.

## Analysis of Algorithms:

- There are several different algorithms to solve a given problem.
- Analysis of algorithm deals in finding the best algorithm which runs fast and takes in less memory.
- We should check time complexity and space complexity to find the best algorithm.

## **Time Complexity:**

- Its amount of time taken by algorithm to run.
- The input processed by an algorithm helps in determining the time complexity.

## **Space Complexity:**

- Its amount of memory or space taken by an algorithm to run.
- The memory required to process the input by an algorithm helps in determining the space complexity.

## **Asymptotic Analysis of an Algorithm:**

- Asymptotic analysis helps in evaluating performance of an algorithm in terms of input size and its increase.
- Using asymptotic analysis we don't measure actual running time of the algorithm.
- It helps in determining how time and space taken by an algorithm increases with input size.

## **Asymptotic Notations:**

- Asymptotic Notations are the mathematical tools used to describe the running time of an algorithm in terms of input size.

## **Types of Asymptotic Notations:**

- There are three notations for performing runtime analysis of an algorithm.

1. Omega ( $\Omega$ ) Notation
2. Big O (O) Notation
3. Theta ( $\theta$ ) Notation

## Omega ( $\Omega$ ) Notation:

- It is a formal way to express the lower bound of an algorithm's running time.
- Lower bound means for any given input this notation determines the best amount of time an algorithm can take to complete.

## Big O (O) Notation:

- It is the formal way to express the upper bound of an algorithm's running time.
- Upper bound means for any given input this notation determines the longest amount of time an algorithm can take to complete.

### Rules:

- It's a Single Processor
- It performs Sequential Execution of statements
- Assignment operation takes 1 unit of time
- Return statement takes in 1 unit of time
- Arithmetical operation takes 1 unit of time
- Logical operation takes 1 unit of time
- Other small/single operations takes 1 unit of time
- Drop lower order terms  $\rightarrow T = n^2 + 3n + 1 \rightarrow O(n^2)$
- Drop constant multipliers  $\rightarrow T = 3n^2 + 6n + 1 \rightarrow O(n^2)$

## Theta ( $\theta$ ) Notation:

- It is the formal way to express both the upper and lower bound of an algorithm's running time.

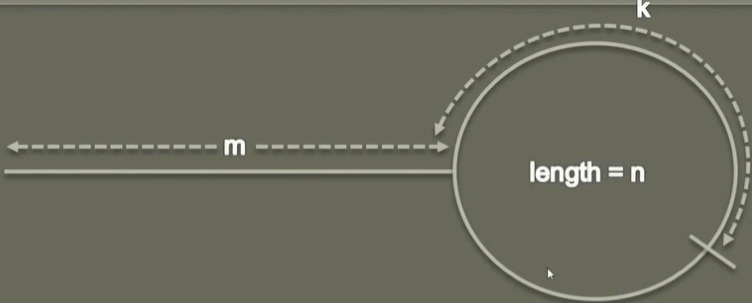
- By Lower and Upper bound means for any given input this notation determines the average amount of time an algorithm can take to complete.
- 

## **Array Data Structure:**

- Array is the collection(box) of data elements of specified type.
- All members holding partitions are adjacent or contiguous.
- Each partition has two neighbors except the first and last one.
- Size of the array is fixed and cannot be modified.
- Being adjacent each partition is indexed and can be determined by its position.
- All data holding the partitions have contiguous memory locations.
- Index starts at 0 and for (one dimensional array) ends at length - 1

# Linked List:

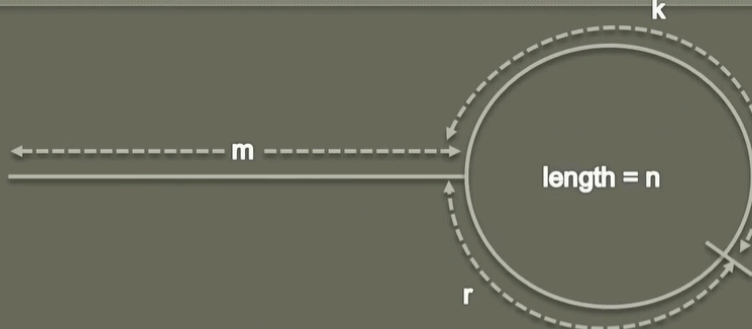
## Floyd's Cycle Detection Algorithm:



Distance travelled by fast pointer  $D_f = m + n \times c_f + k$

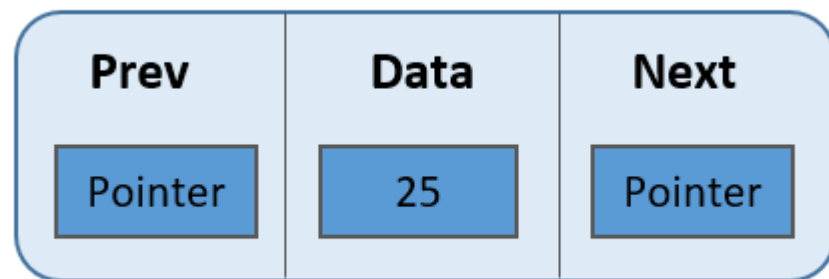
Distance travelled by slow pointer  $D_s = m + n \times c_s + k$

Distance travelled by fast pointer will be twice the distance travelled by slow pointer.  
Let distance travelled by slow pointer is X.  $X = m + n \times c_s + k$   
So, distance travelled by fast pointer will be  $2X$ .  $2X = m + n \times c_f + k$   
Subtract X from  $2X \Rightarrow (2X - X)$

$$X = n \times (c_f - c_s)$$

$$\begin{aligned} n(c_f - 2c_s) &= m + k \\ n(c_f - 2c_s) - k &= m \\ n(c_f - 2c_s) - (n - r) &= m \\ n(c_f - 2c_s) - n + r &= m \\ n(c_f - 2c_s - 1) + r &= m \end{aligned}$$

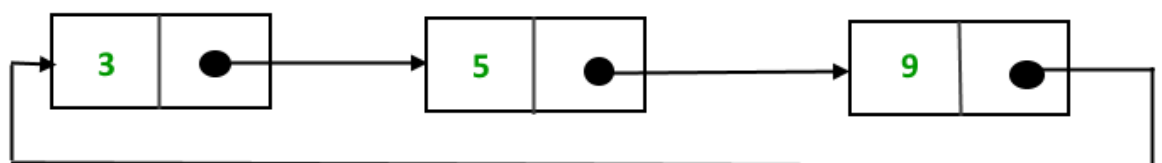
# Doubly Linked List:

- It is called a two way linked list.
- Given a node, we can navigate lists in both forward and backward direction, which is not possible in a Singly Linked List.
- A node in a Singly Linked List can only be deleted if we have a pointer to its previous node. But in the Doubly Linked List we can delete the node even if we don't have a pointer to its previous node.



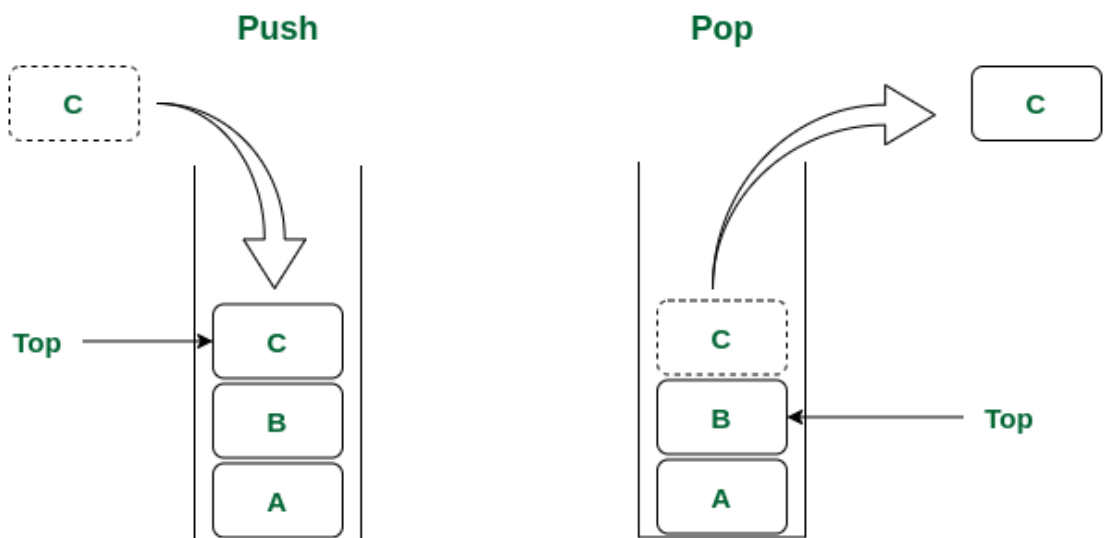
# Circular Singly Linked List:

- It's similar to Singly Linked List, with a difference that in Circular Linked List the last node points to the first node and not null.
- Instead of head, we keep track of the last node in the Circular Singly List.



# Stack:

- It is a linear data structure used for storing the data.
- It's an ordered list in which insertion and deletion are done at one end, called the top.
- The last element inserted is the first one to be deleted.  
Hence, it is called the Last In First Out (LIFO) list.



**Stack Data Structure**



# Queue:

- It is a linear data structure used for storing the data.
- It's an ordered list in which insertions are done at one end, called as rear and deletion are done at other end called as front.
- The first element inserted is the first one to be deleted. Hence, it is called the First In First Out (FIFO) list.



**Queue Data Structure**