What is an Algorithm

“An algorithm is the step by step set of meaningful and clear instructions to solve a particular problem”

In the above definition of algorithm, I have mentioned the words “meaningful and clear”, which means the instructions should not be ambiguous(double meaning, no clear meaning).

To understand the concept of algorithm, **lets take an example**: Lets write an algorithm to “make a tea”

```
1. Get the frying pan
2. Pour the water in the frying pan and let it boil for some time
3. Add sugar, tea leaves and milk.
    a. Do we have sugar?
       i. if yes, put it in the pan
       ii. If no, get the sugar from market and then put it
    b. Do we have tea leaves?
       i. if yes, put it in the pan
       ii. If no, get the tea leaves from market and then put it
    c. Do we have milk?
       i. if yes, put it in the pan
       ii. If no, get the milk from market and then put it
4. Once done, switch off the stove and serve it.
```

Now that we know what is an algorithm, lets talk about the analysis of algorithm

What is Analysis of Algorithms

The analysis of algorithm is to compare the various algorithms to solve a same problem. This is done to analyse which algorithm takes less resources such as time, effort and memory to solve a particular problem.

Types of analysis of algorithm

To analyze a particular algorithm, we need to understand for which input the algorithm takes less time and for which input it takes more time. Based on this, we divide the inputs in three cases:

1. **Best case** where we assume the input, for which algorithm takes less time.
2. **Worst case** where we assume the input, for which algorithm takes long time.
3. **Average case** where the input lies in between best and worst case.

Now that we know the cases and types of analysis we perform on a algorithm. Lets move forward and understand how can we represent the best, worst and average cases of an algorithm with the help of expressions (**notations**).

Asymptotic Notations are the expressions that are used to represent the complexity of an algorithm.

As we discussed above, there are three **types of analysis** that we perform on a particular algorithm.
Best Case: In which we analyse the performance of an algorithm for the input, for which the algorithm takes less time or space.

Worst Case: In which we analyse the performance of an algorithm for the input, for which the algorithm takes long time or space.

Average Case: In which we analyse the performance of an algorithm for the input, for which the algorithm takes time or space that lies between best and worst case.

Types of Data Structure Asymptotic Notation

1. Big-O Notation (O) – Big O notation specifically describes worst case scenario.
2. Omega Notation (Ω) – Omega(Ω) notation specifically describes best case scenario.
3. Theta Notation (θ) – This notation represents the average complexity of an algorithm.

Big-O Notation (O)

Big O notation specifically describes worst case scenario. It represents the upper bound running time complexity of an algorithm. Lets take few examples to understand how we represent the time and space complexity using **Big O notation**.

O(1)

Big O notation O(1) represents the complexity of an algorithm that always execute in same time or space regardless of the input data.

O(1) example
The following step will always execute in same time(or space) regardless of the size of input data.

```
Accessing array index(int num = arr[5])
```

O(n)

Big O notation O(N) represents the complexity of an algorithm, whose performance will grow linearly (in direct proportion) to the size of the input data.

O(n) example
The execution time will depend on the size of array. When the size of the array increases, the execution time will also increase in the same proportion (linearly)

```
Traversing an array
```

O(n^2)

Big O notation O(n^2) represents the complexity of an algorithm, whose performance is directly proportional to the square of the size of the input data.

O(n^2) example

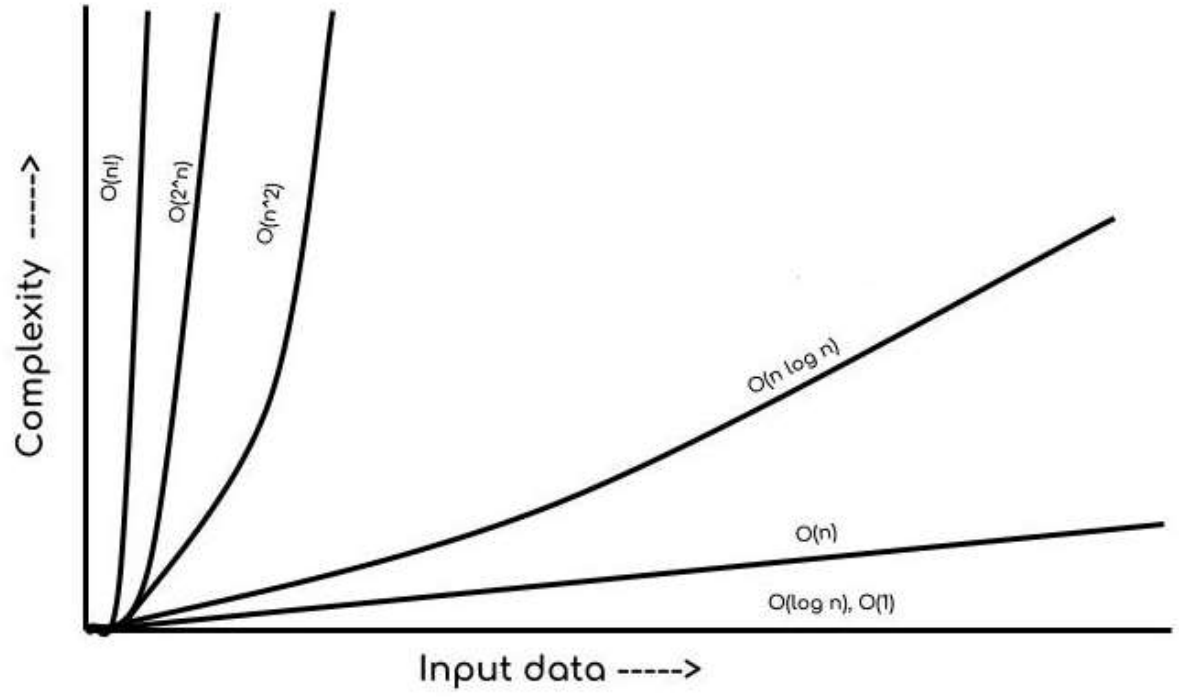
```
Traversing a 2D array
```

Other examples: Bubble sort, insertion sort and selection sort algorithms

Similarly there are other Big O notations such as:
logarithmic growth O(log n), log-linear growth O(n log n), exponential growth O(2^n) and factorial growth O(n!).

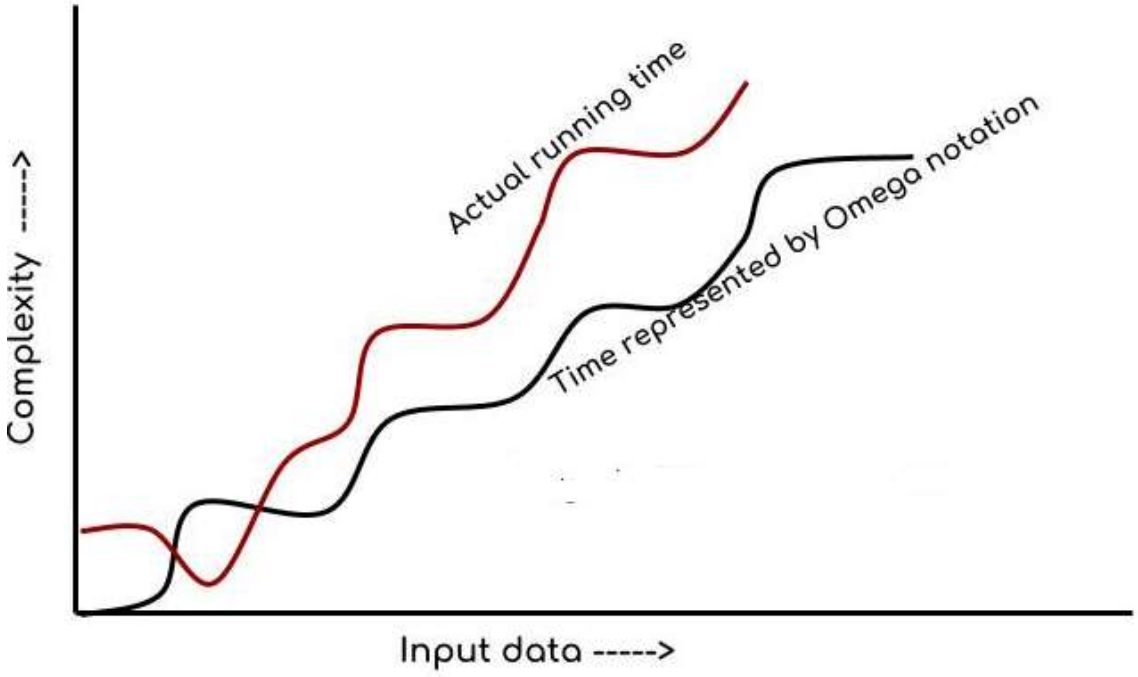
If we have to draw a diagram to compare the performance of algorithms denoted by these notations, then we would draw it like this:

```
O(1) < O(log n) < O (n) < O(n log n) < O(n^2) < O (n^3)< O(2^n) < O(n!)
```



Omega Notation (Ω)

Omega notation specifically describes best case scenario. It represents the lower bound running time complexity of an algorithm. So if we represent a complexity of an algorithm in Omega notation, it means that the **algorithm cannot be completed in less time than this**, it would at-least take the time represented by Omega notation or it can take more (when not in best case scenario).



Theta Notation (θ)

This notation describes both upper bound and lower bound of an algorithm so we can say that it defines exact asymptotic behaviour. In the real case scenario the algorithm not always run on best and worst cases, the average running time lies between best and worst and can be represented by the theta notation.