Introduction to Recursion

Any function which calls itself is called recursion. **A recursive method solves a problem by calling a copy of itself to work on a smaller problem.** Each time a function calls itself with a slightly simpler version of the original problem. This sequence of smaller problems must eventually converge on a base case.

Working of recursion

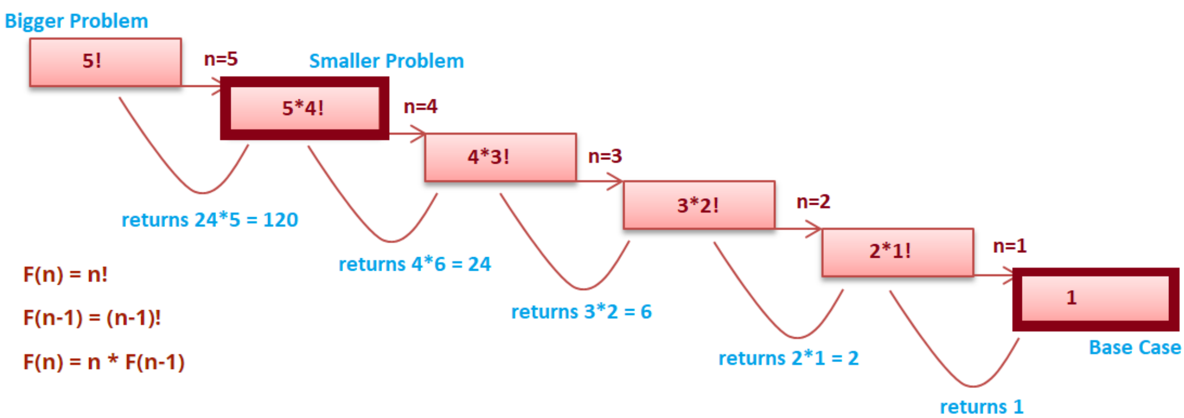
We can define the steps of the recursive approach by summarizing the above three steps:

- **Base case:** A recursive function must have a terminating condition at which the process will stop calling itself. Such a case is known as the base case. In the absence of a base case, it will keep calling itself and get stuck in an infinite loop. Soon, the **recursion depth*** will be exceeded and it will throw an error.
- **Recursive call (Smaller problem):** The recursive function will invoke itself on a **smaller version** of the main problem. We need to be careful while writing this step as it is crucial to correctly figure out what your smaller problem is.
- **Self-work:** Generally, we perform a calculation step in each recursive call. We can achieve this calculation step before or after the recursive call depending upon the nature of the problem.

Note*: Recursion uses an in-built stack that stores recursive calls. Hence, the number of recursive calls must be as small as possible to avoid memory overflow. If the number of recursion calls exceeded the maximum permissible amount, the **recursion depth*** will be exceeded. This condition is called **stack overflow**.
Now, let us see how to solve a few common problems using Recursion.

Problem Statement - Find Factorial of a number n.

Factorial of any number n is defined as n! = n * (n-1) * (n-2) * ... *1. Ex: 5! = 5 * 4 * 3 * 2 * 1 = 120;
Let n = 5 ;



In recursion, the idea is that we represent a problem in terms of smaller problems. We know that 5! = 5 * 4!. Let's assume that recursion will give us an answer of 4!. Now to get the solution to our problem will become 4 * (the answer of the recursive call).

Similarly, when we give a recursive call for 4!; recursion will give us an answer of 3!. Since the same work is done in all these steps we write only one function and give it a call recursively. Now, what if there is no base case? Let's say 1! Will give a call to 0!; 0! will give a call to -1! (doesn't exist) and so on. Soon the function call stack will be full of method calls and give an error **Stack Overflow.** To avoid this we need a base case. So in the base case, we put our own solution to one of the smaller problems.

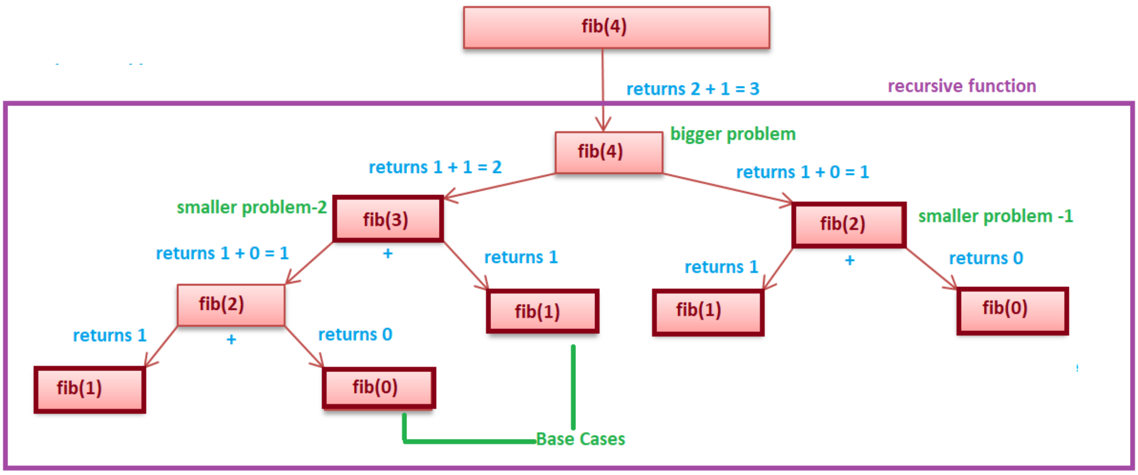
```
function factorial(n)
        //   base case
        if n equals 0
                return 1

        //   getting answer of the smaller problem
        recursionResult = factorial(n-1)

        // self work
        ans = n * recursionResult
        return ans
```

Problem Statement - Find nth fibonacci.

We know that Fibonacci numbers are defined as follows

fibo(n) = n	for n <= 1
fibo(n) = fibo (n - 1) + fibo (n - 2)	otherwise

Let n = 4



F(n) = F(n-1) + F(n-2)

As you can see from the above fig and recursive equation that the bigger problem is dependent on 2 smaller problems.

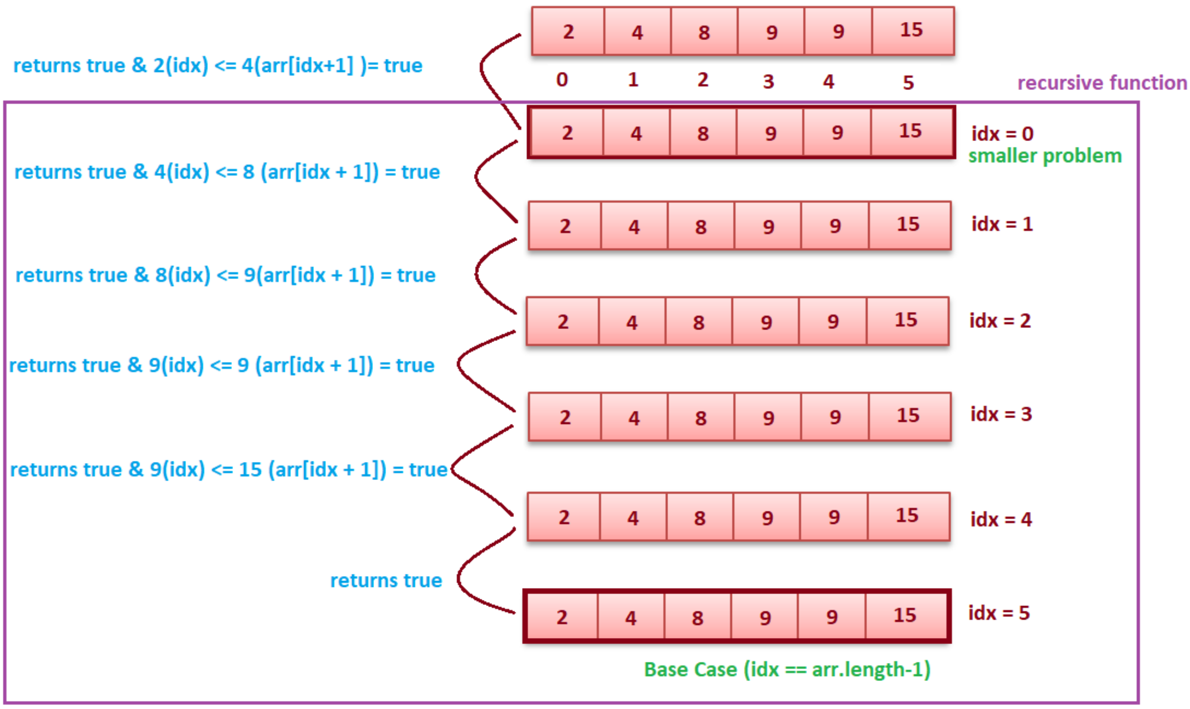
Depending upon the question, the bigger problem can depend on N number of smaller problems.

```
function fibonacci(n)

      //  base case
      if n equals 1 OR 0
             return n

       //  getting answer of the smaller problem
       recursionResult1 = fibonacci(n - 1)
       recursionResult2 = fibonacci(n - 2)

       // self work
       ans = recursionResult1 + recursionResult2
       return ans
```

Problem Statement - Check if an array is sorted

For example:

- If the array is {2, 4, 8, 9, 9, 15}, then the output should be **true.**
- If the array is {5, 8, 2, 9, 3}, then the output should be **false.**




```
function isArraySorted(arr, idx)    //   0 is passed in idx
```

```
//   base case
if idx equals arr.length - 1
        return true

//   getting answer of the smaller problem
recursionResult = isArraySorted(arr, idx+1)


//   self work
ans = recursionResult & arr[idx] <= arr[idx+1]
return ans
```