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.**

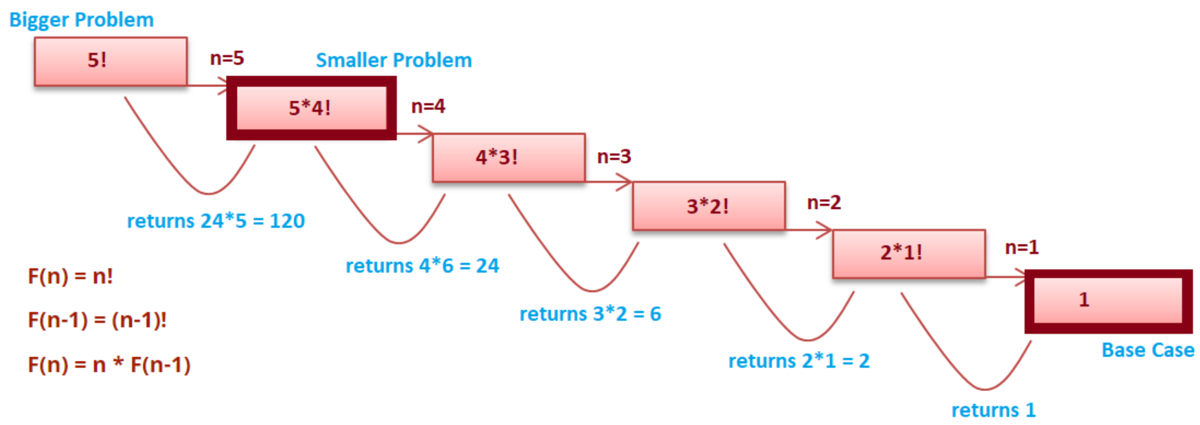
Note*: Recursion uses an in-built stack that stores recursive calls. Hence, the number of recursive calls must be as small as possible to avoid memory-overflow. If the number of recursion calls exceeded the maximum permissible amount, the **recursion depth*** will be exceeded. This condition is called **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 5 * (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

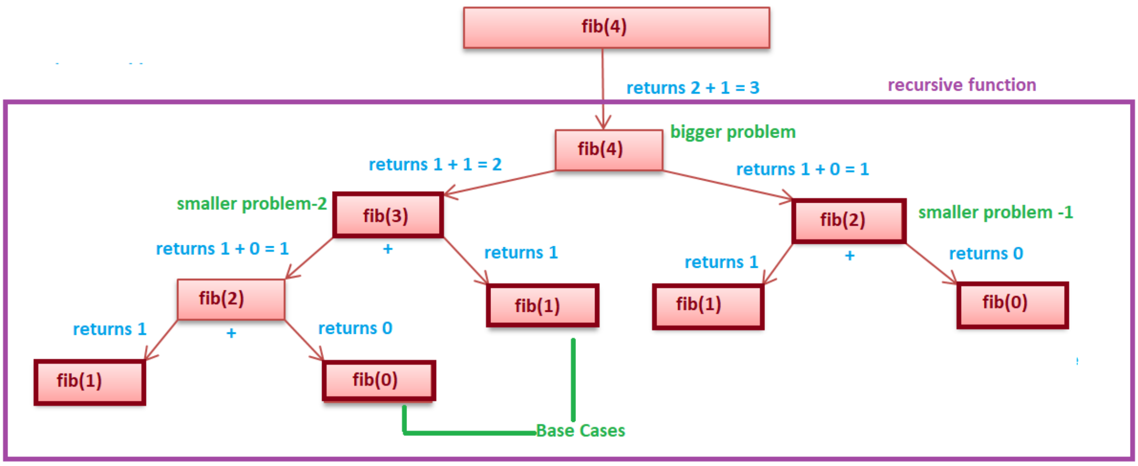
Problem Statement - Find nth fibonacci.

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.

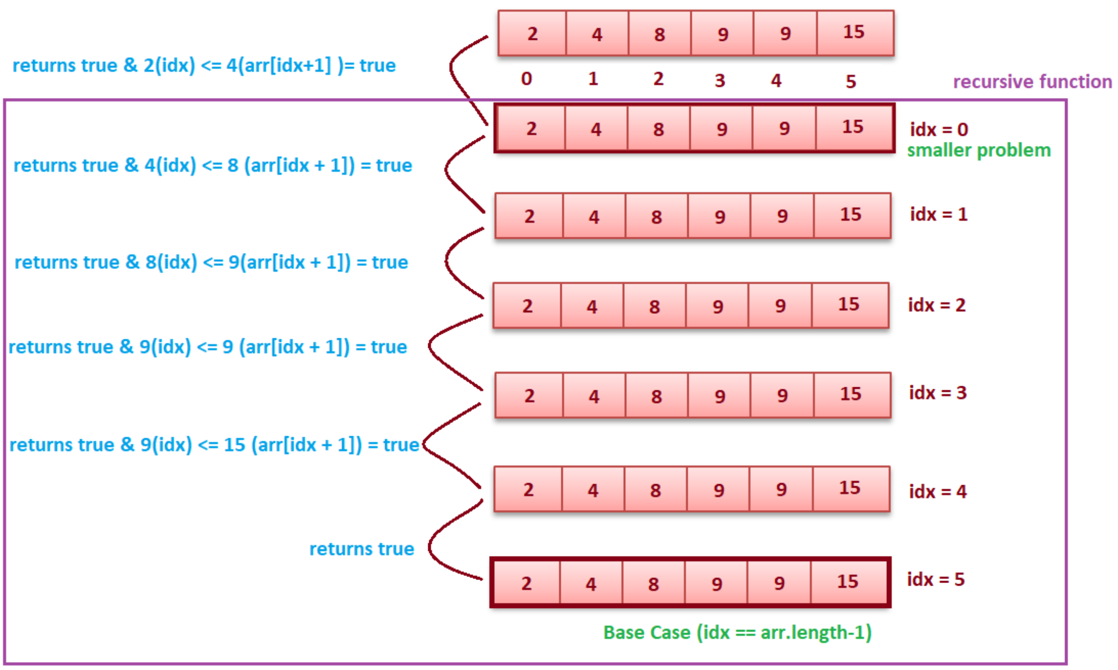
Depending upon the question, the bigger problem can depend on N number of smaller problems.

```
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
```