Recursion

What is Recursion?

- The process in which a **function calls itself** directly or indirectly is called recursion and the corresponding function is called as **recursive function.**

```
int fact(int n)
{
            if (n < = 1) // base case
                        return 1;
            else
                        return n*fact(n-1);
 }
```

In the above example, base case for n < = 1 is defined and larger value of number can be solved by converting to smaller one till base case is reached.

A java program to illustrate recursion

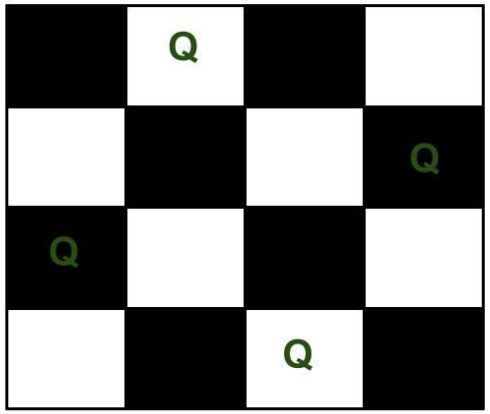
```
class GFG {
    static void printFun(int test)
    {
        if (test < 1)
            return;

        else {
            System.out.printf("%d ", test);

            // Statement 2
            printFun(test - 1);

            System.out.printf("%d ", test);
            return;
        }
    }

    public static void main(String[] args)
    {
        int test = 3;
        printFun(test);
    }
}
```

```
Output: 3 2 1 1 2 3
```

N Queen Problem

- Problem of placing N chess queens on an N×N chessboard so that no two queens attack each other. For example, following is a solution for 4 Queen problem.

The expected output is a binary matrix which has 1s for the blocks where queens are placed. For example, following is the output matrix for above 4 queen solution.




```
0 1 0 0
0 0 0 1
1 0 0 0
0 0 1 0
```

Backtracking algorithm

```
1) Start in the leftmost column
2) If all queens are placed
    return true
3) Try all rows in the current column.
   Do following for every tried row.
    a) If the queen can be placed safely in this row
       then mark this [row, column] as part of the
       solution and recursively check if placing
       queen here leads to a solution.
    b) If placing the queen in [row, column] leads to
       a solution then return true.
    c) If placing queen doesn't lead to a solution then
       unmark this [row, column] (Backtrack) and go to
       step (a) to try other rows.
3) If all rows have been tried and nothing worked,
   return false to trigger backtracking.
```

The Knight’s problem

```
If all squares are visited
    print the solution
Else
   a) Add one of the next moves to solution vector and recursively
   check if this move leads to a solution. (A Knight can make maximum
   eight moves. We choose one of the 8 moves in this step).
   b) If the move chosen in the above step doesn't lead to a solution
   then remove this move from the solution vector and try other
   alternative moves.
   c) If none of the alternatives work then return false (Returning false
   will remove the previously added item in recursion and if false is
   returned by the initial call of recursion then "no solution exists" )
```

Output:

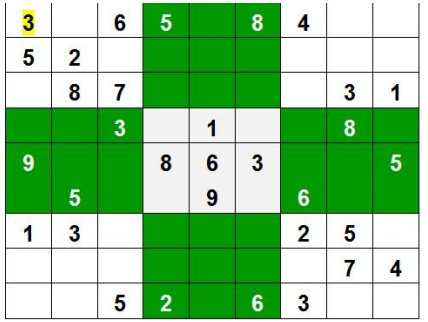
```
 0  59  38  33  30  17   8  63
37  34  31  60   9  62  29  16
58   1  36  39  32  27  18   7
35  48  41  26  61  10  15  28
42  57   2  49  40  23   6  19
47  50  45  54  25  20  11  14
56  43  52   3  22  13  24   5
51  46  55  44  53   4  21  12
```

Sudoku

3		6	5		8	4		
5	2							
	8	7					3	1
		3		1			8	
9			8	6	3			5
	5			9		6		
1	3					2	5	
							7	4
		5	2		6	3		

Sudoku

- we can solve Sudoku by one by one assigning numbers to empty cells.
- Before assigning a number, we check whether it is safe to assign.
- We basically check that the same number is not present in the current row, current column and current 3X3 subgrid.
- After checking for safety, we assign the number, and recursively check whether this assignment leads to a solution or not.
- If the assignment doesn't lead to a solution, then we try the next number for the current empty cell. And if none of the number (1 to 9) leads to a solution, we return false.



```
Find row, col of an unassigned cell
If there is none, return true
For digits from 1 to 9
  a) If there is no conflict for digit at row, col
      assign digit to row, col and recursively try fill in rest of grid
  b) If recursion successful, return true
  c) Else, remove digit and try another
If all digits have been tried and nothing worked, return false
```

Output:

```
3 1 6 5 7 8 4 9 2
5 2 9 1 3 4 7 6 8
4 8 7 6 2 9 5 3 1
2 6 3 4 1 5 9 8 7
9 7 4 8 6 3 1 2 5
8 5 1 7 9 2 6 4 3
1 3 8 9 4 7 2 5 6
6 9 2 3 5 1 8 7 4
7 4 5 2 8 6 3 1 9
```