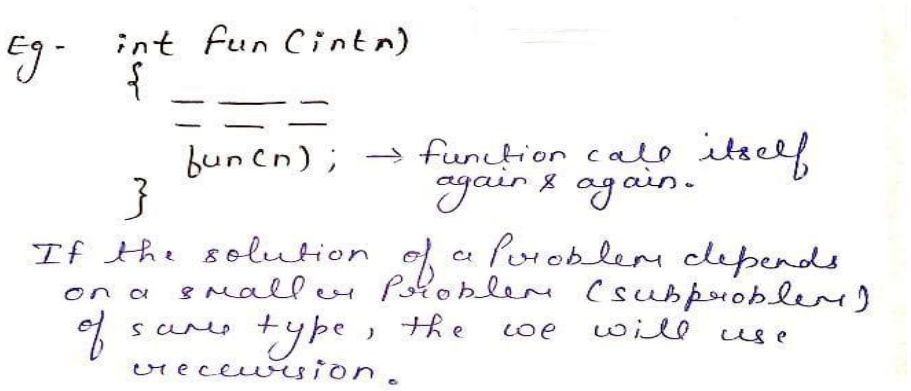
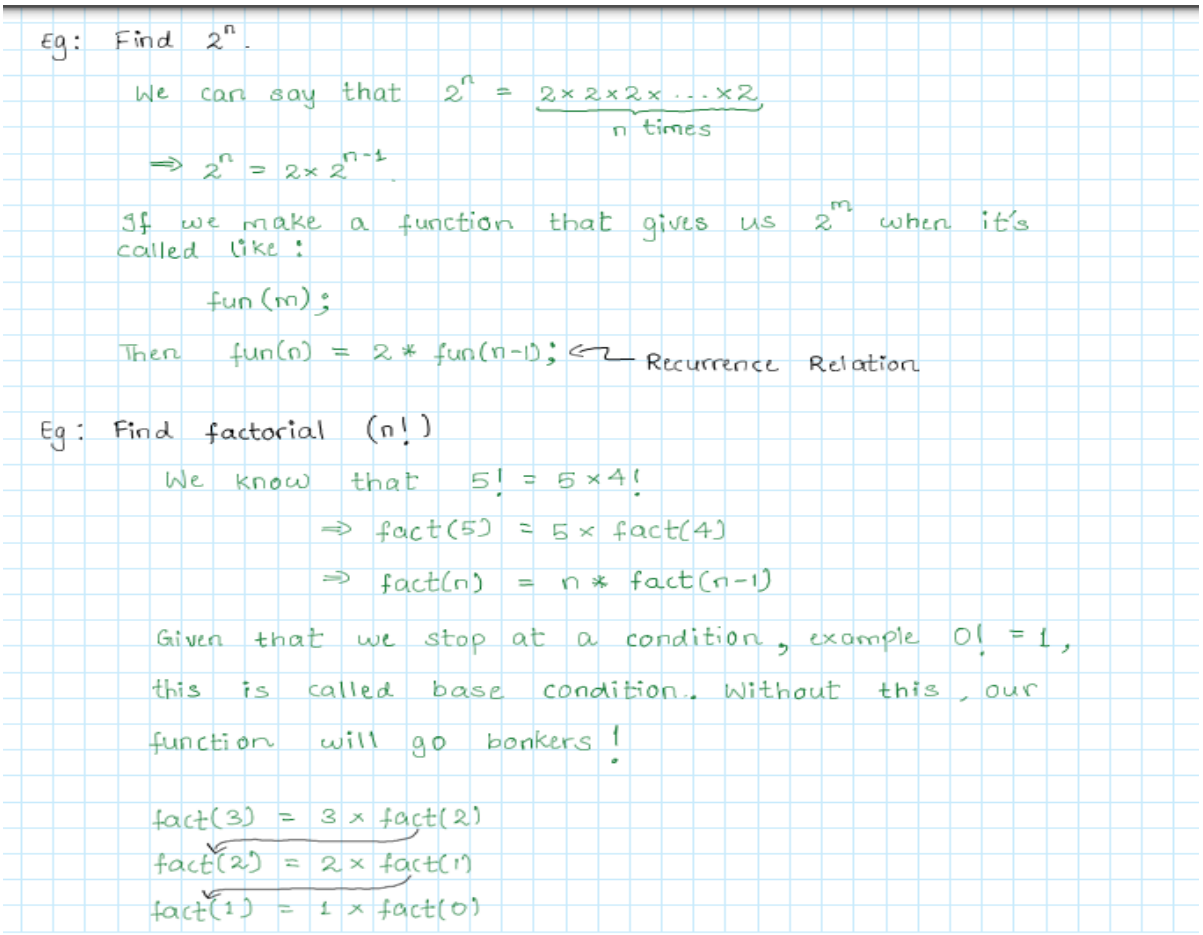
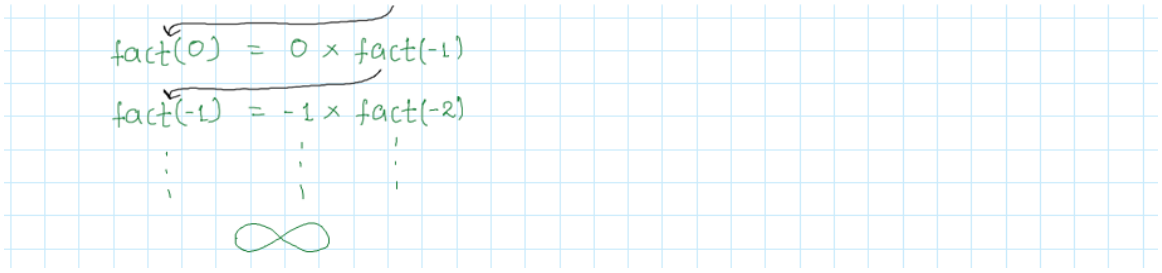
Recursion - The process in which a function calls itself directly or indirectly is called recursion and **the corresponding function is called a recursive function** . And This Process is Call **Reccursive Call .**



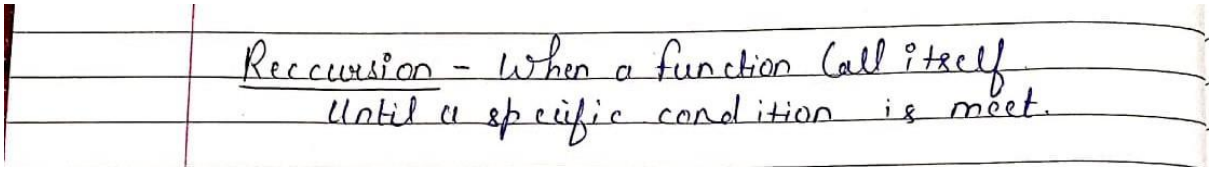
Using a recursive algorithm, certain problems can be solved quite easily. Examples of such problems are **Towers of Hanoi (TOH)**, **Inorder / Preorder / Postorder Tree Traversals, DFS of Graph,** etc

A recursive function solves a particular problem by calling a copy of itself and **solving smaller subproblems of the original problems**.



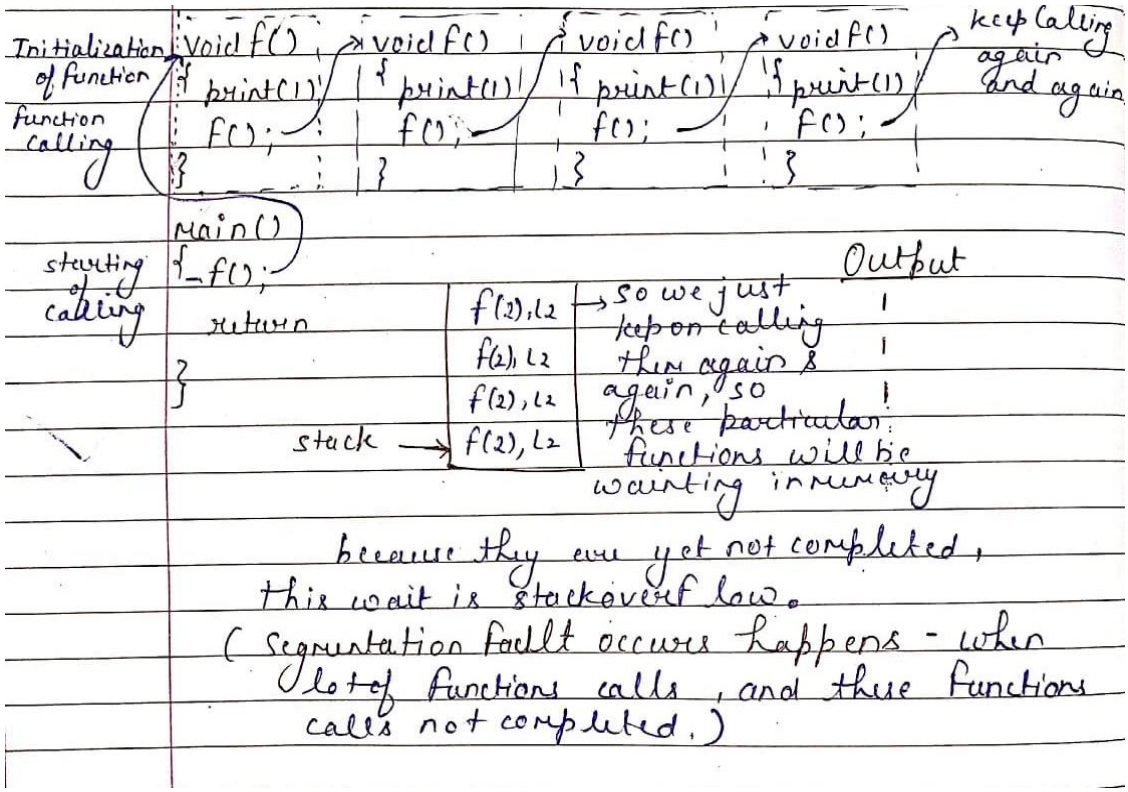


Need of Recursion - Recursion is an amazing technique with the help of which we can reduce the length of our code and make it easier to read and write.



This is Reccursion Code without Given Base Case , This will Print 1 again and again infinity

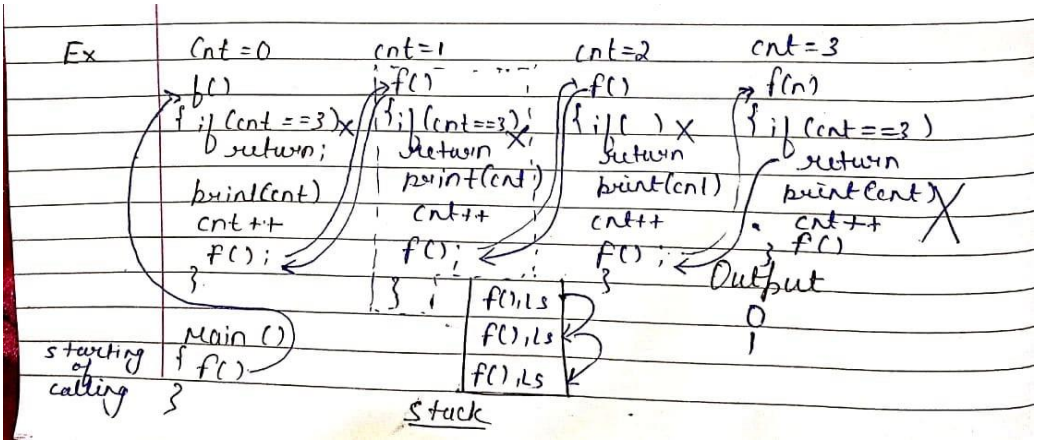
Example –



```cpp
#include <bits/stdc++.h>
using namespace std;
void print()
{
    cout<<'1'<<endl;
    print();
}
int main()
{
    print();
    return 0;
}
```

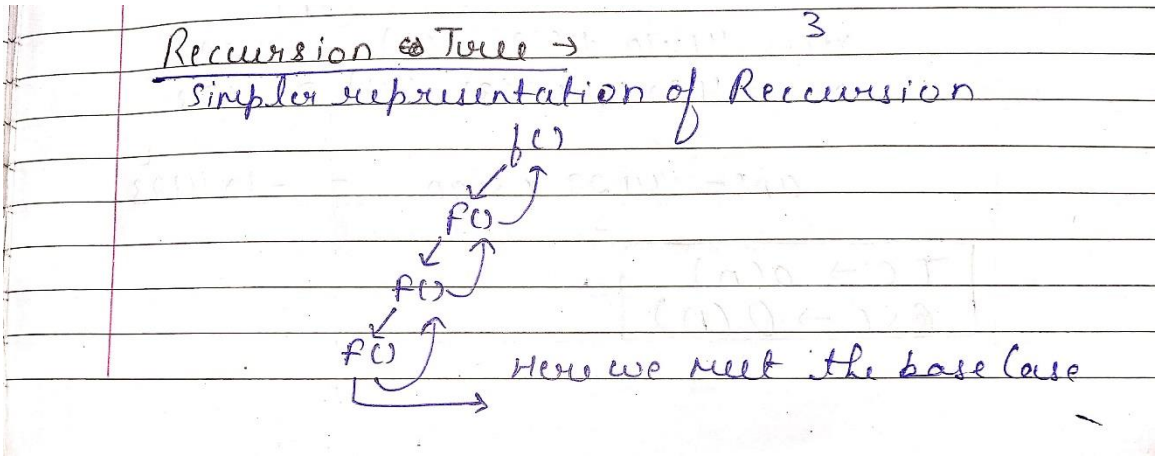
This is Reccursion Code with Given Base Case , This will Print finite no of 1

Example –



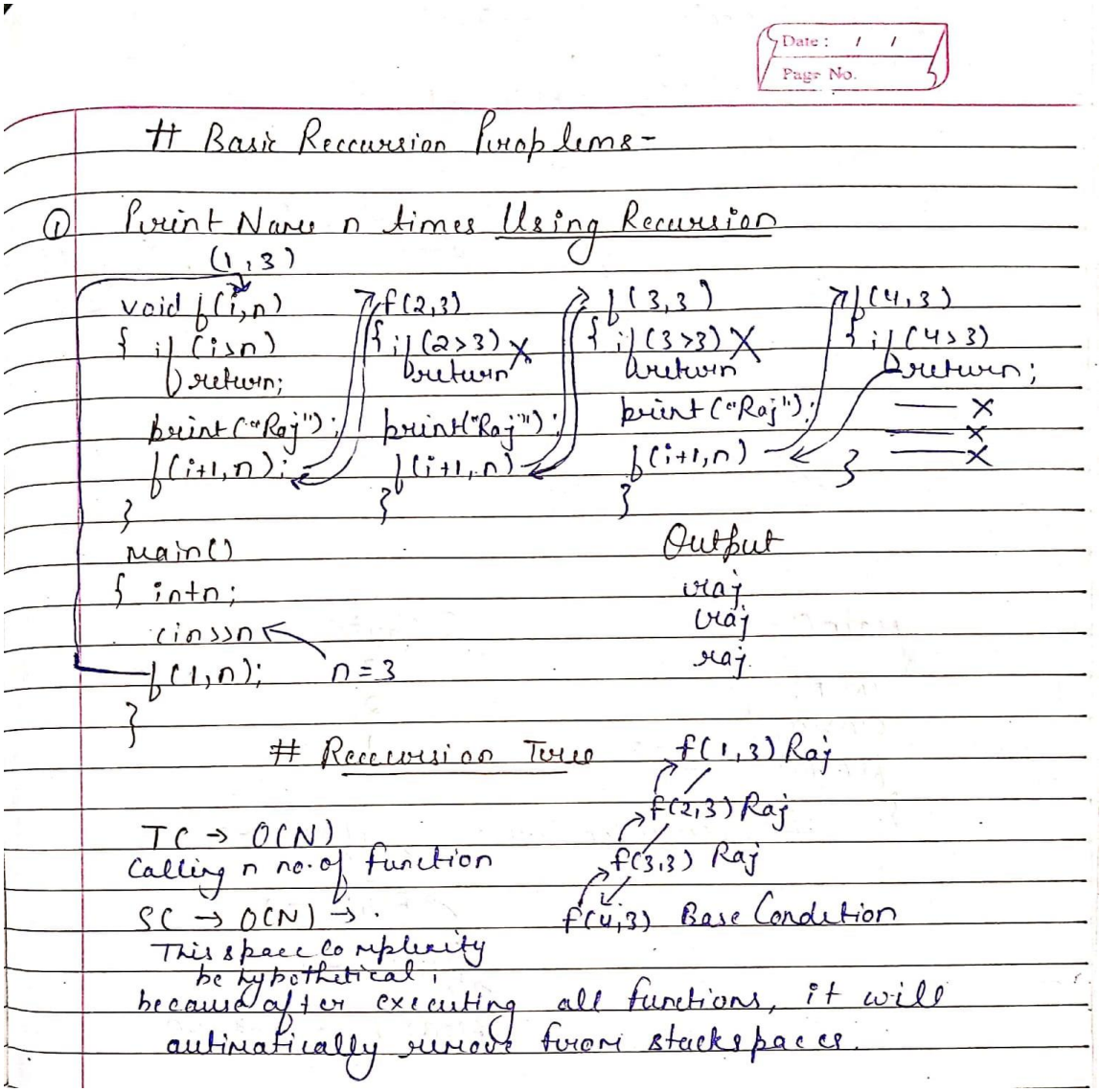

```cpp
#include <bits/stdc++.h>
using namespace std;

int cnt = 0;  // Define Globally
void print()
{
    if(cnt==4)  // Base Condition
    return ;
    cout<<cnt<<endl;
    cnt++;
    print();   // Function Calling untill Reach The Base Condition
}
int main()
{
    print();
    return 0;
}
```

OutPut - 0 1 2 3

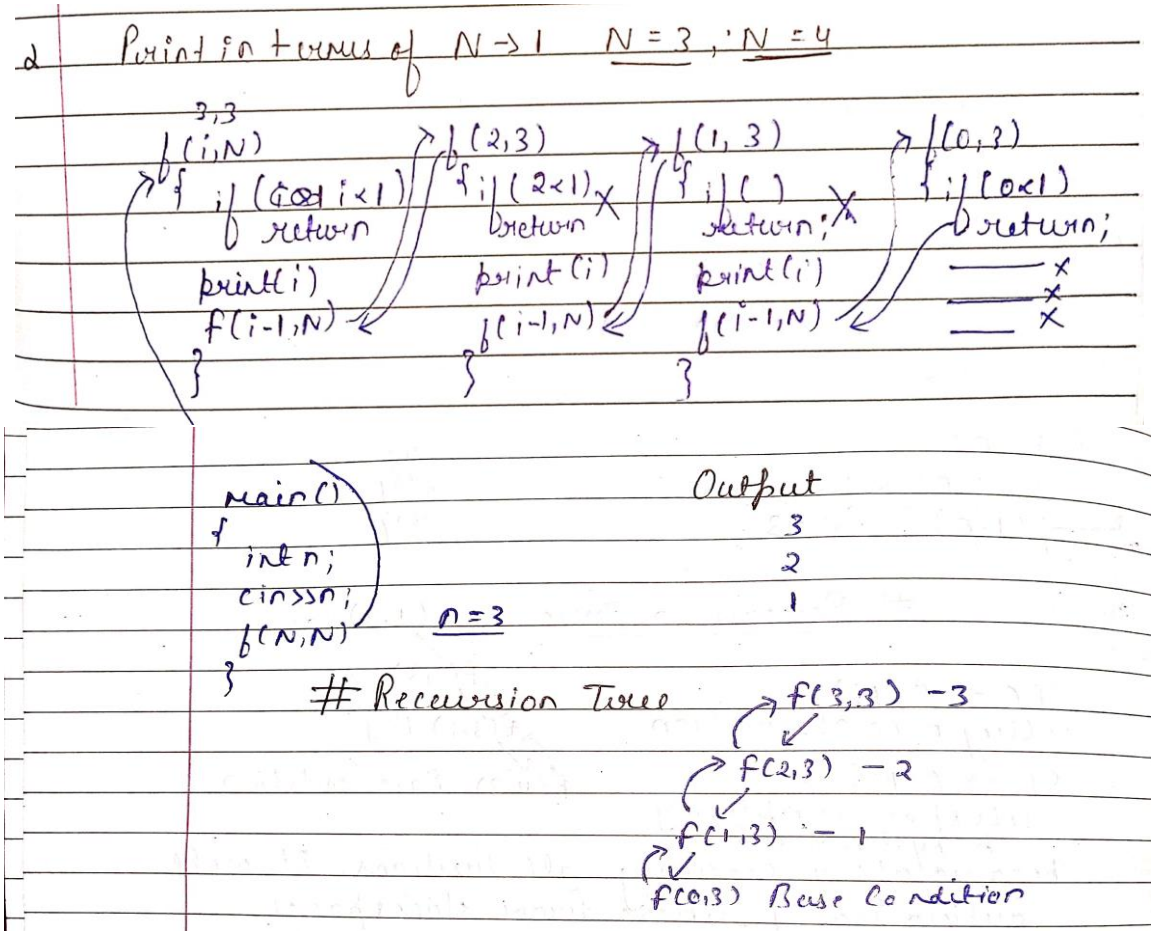


Reccursion
Base Case
Stack OverFlow / Stack Space
Reccursion Tree

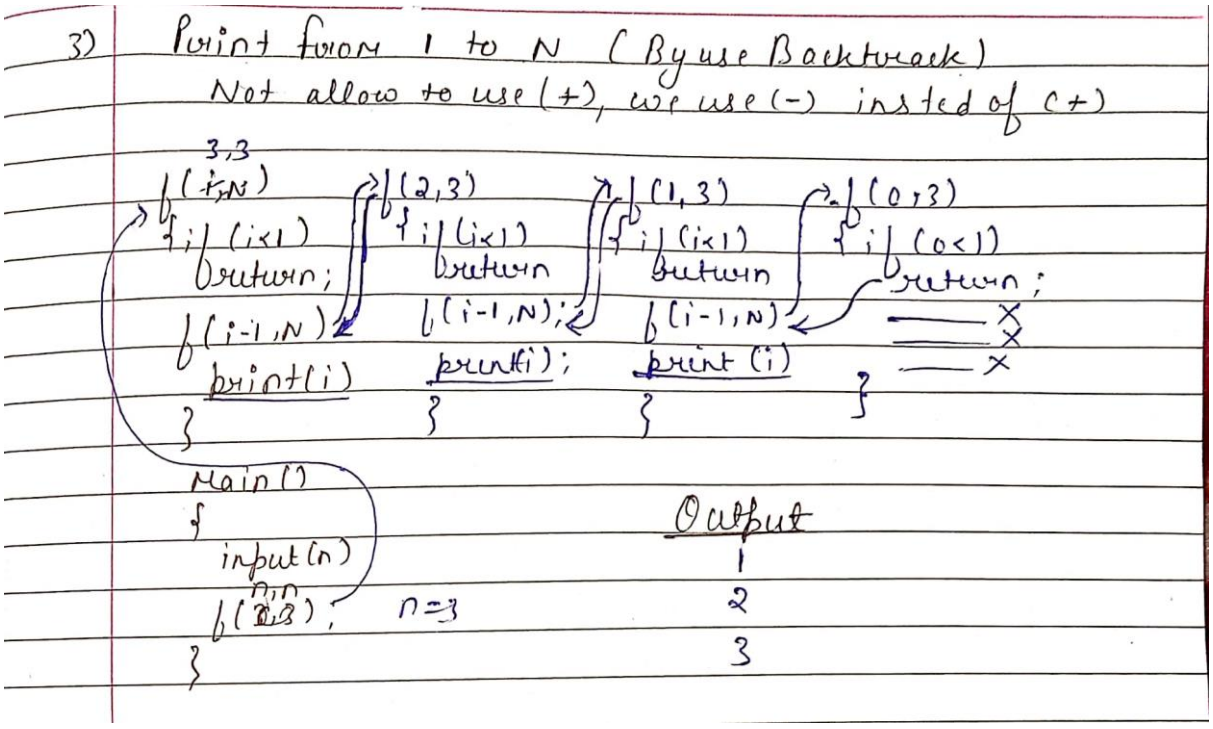
Question - 1



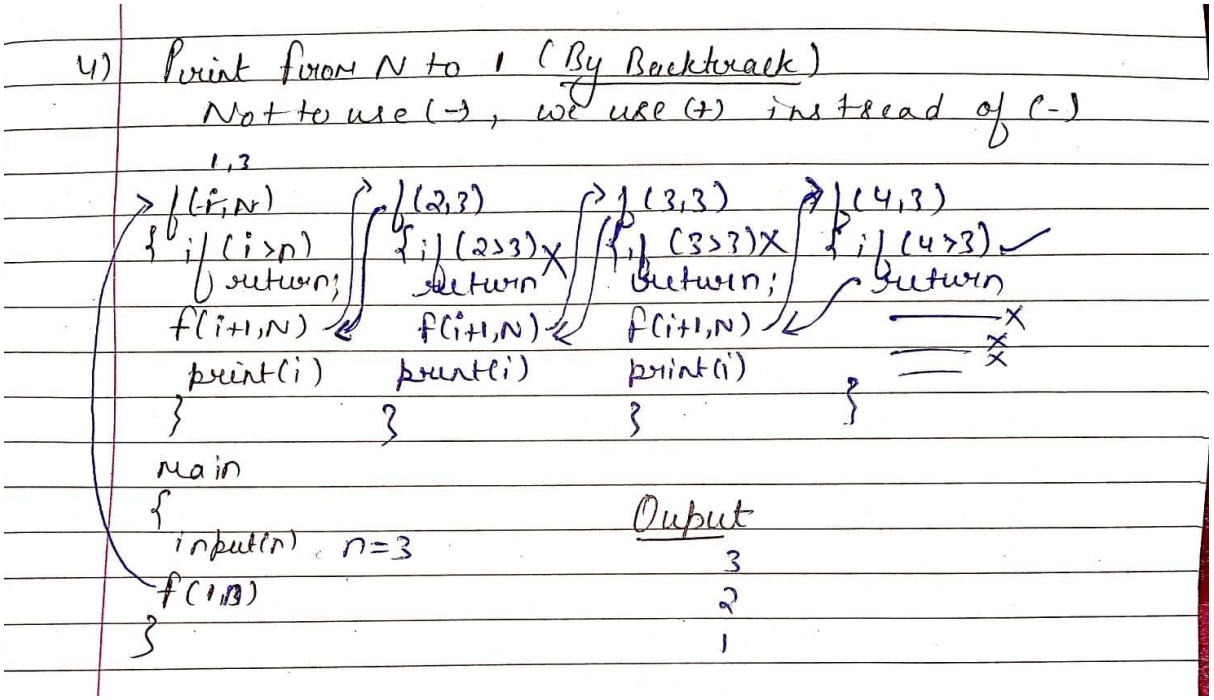
Question – 2

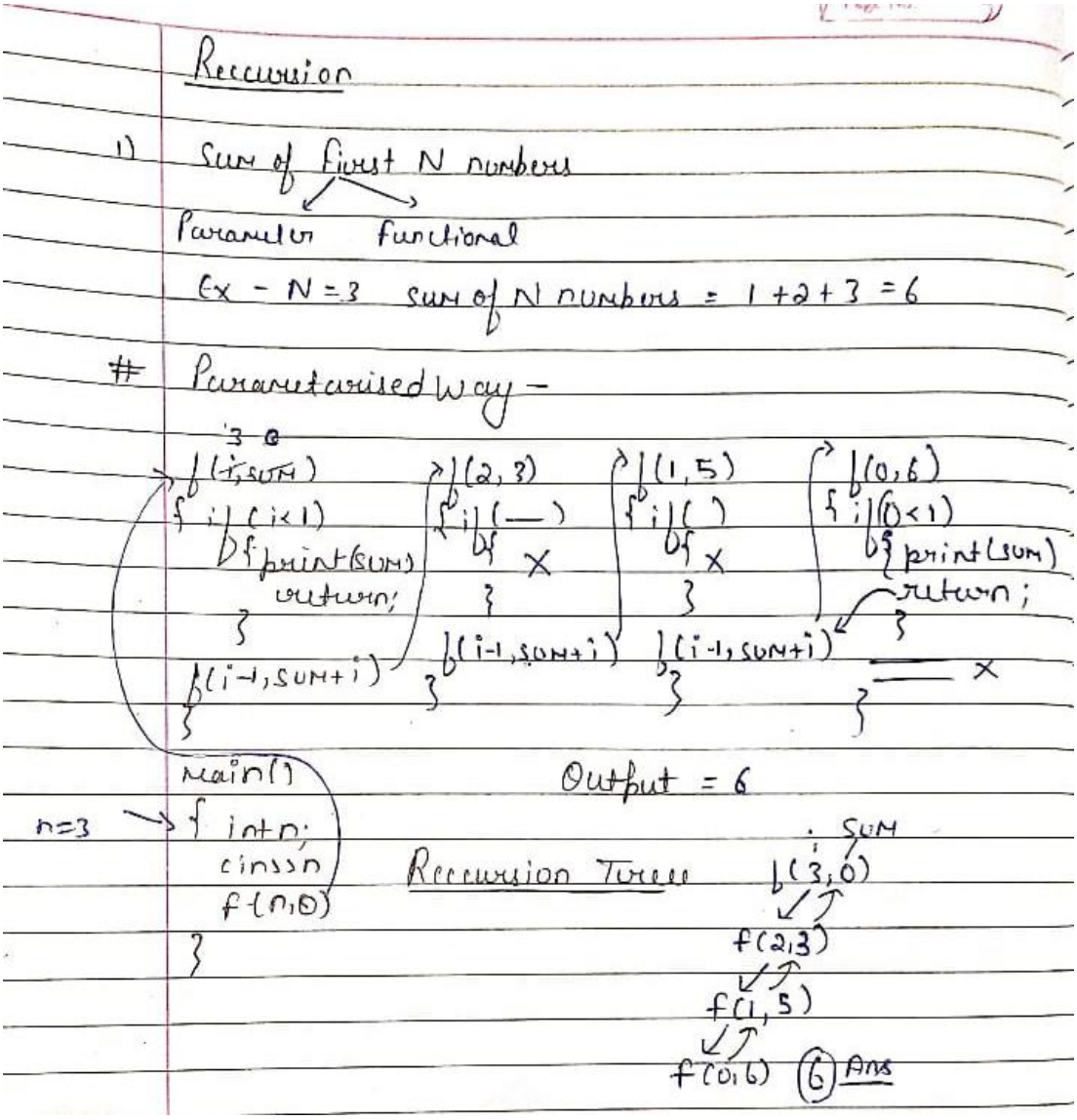


Question – 3



Question – 4

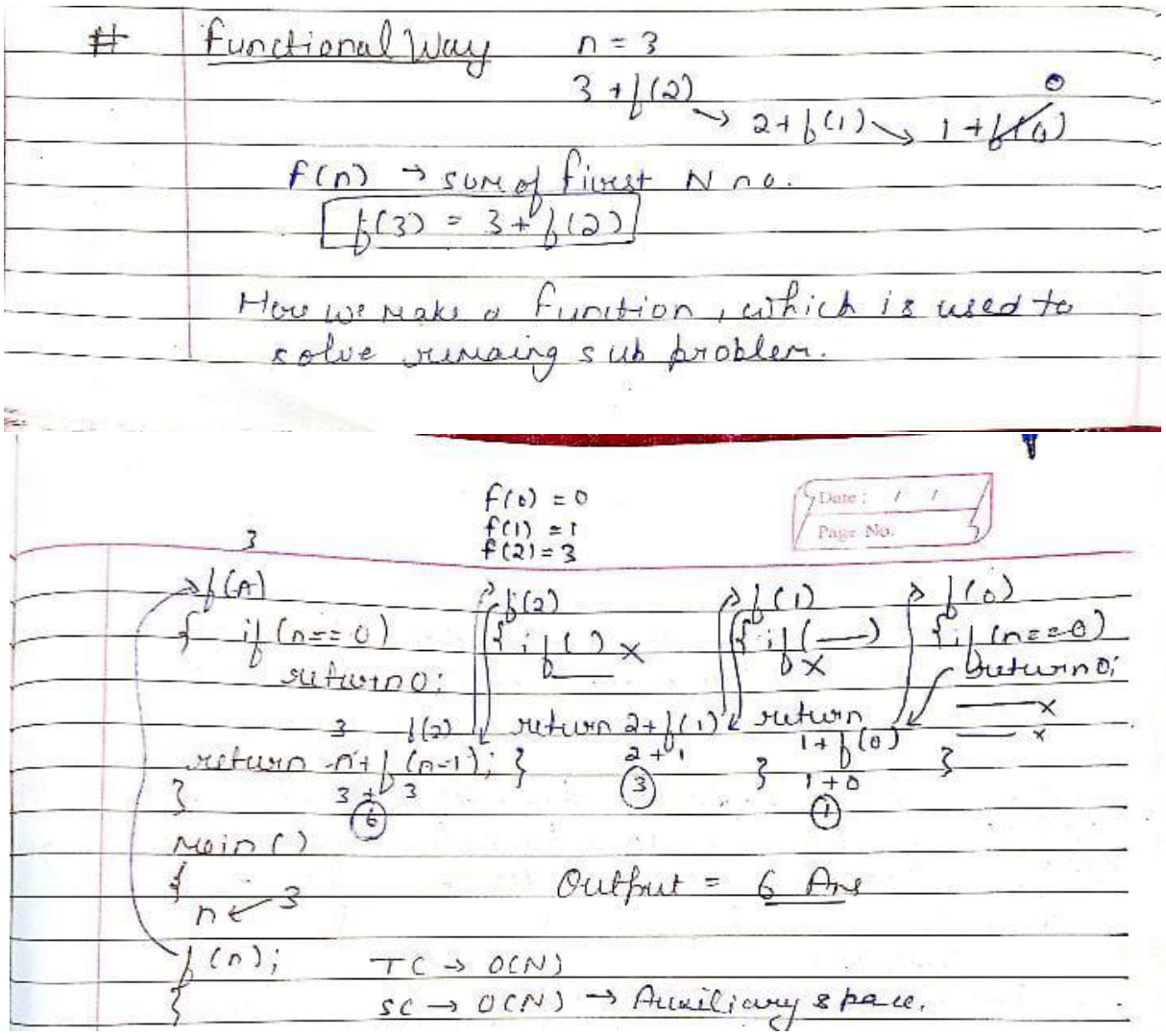

4) Print from N to 1 (By Backtrack)
Not to use (-), we use (+) instead of (-)
1,3
f(i,N)
{ if (i>n)
return;
f(i+1,N)
print(i)
}
(2,3)
(2>3)X
(3,3)
(3>3)X
(4,3)
(4>3)
main
{
input(n) n=3
f(1,3)
}
Ouput
3
2
1



Sum **TC – O(N)**

```cpp
#include<bits/stdc++.h>
using namespace std;
int sum(int N)
{
    if(N==0)return 0;
    return N+sum(N-1);
}
int main() {
    // Write C++ code here
    int n;
    cout<<"Enter the no : "<<endl;
    cin>>n;
    cout<<sum(n)<<endl;
    return 0;
}
```

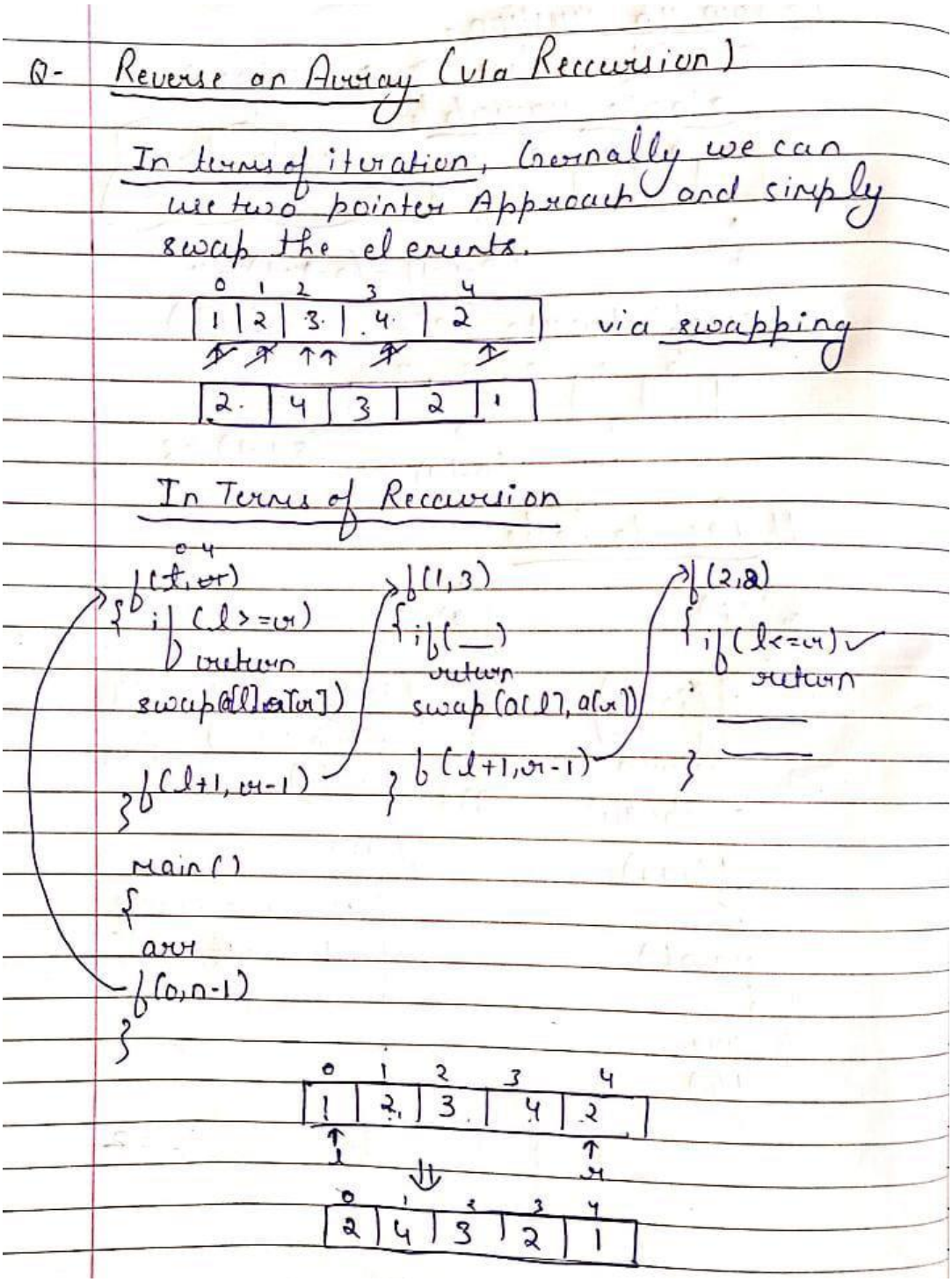
Factorial **TC – O(N)**

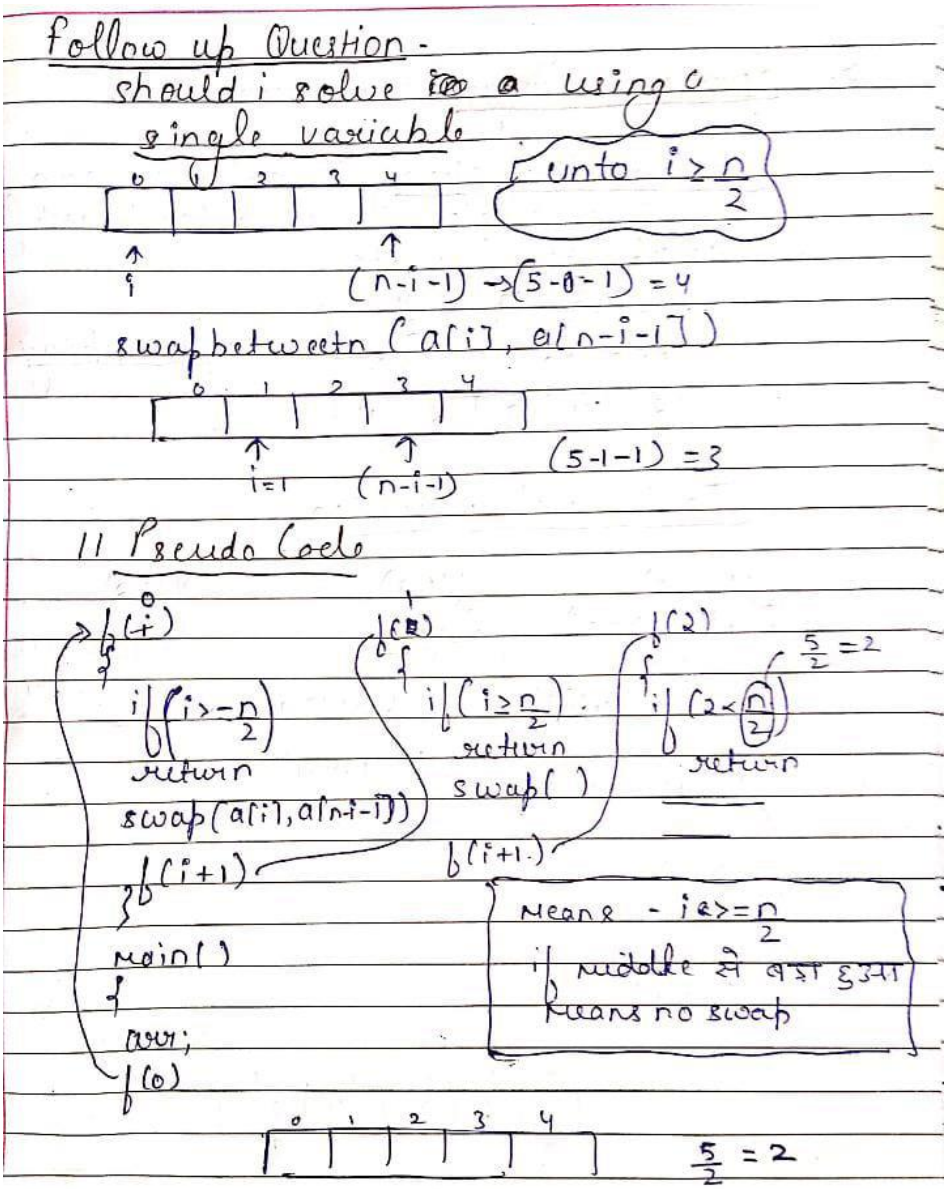



```cpp
#include<bits/stdc++.h>
using namespace std;
int sum(int N)
{
    if(N==0)return 1;
    return N*sum(N-1);
}
int main() {
    int n;
    cout<<"Enter the no : "<<endl;
    cin>>n;
    cout<<sum(n)<<endl;
    return 0;
}
```

Important Question –

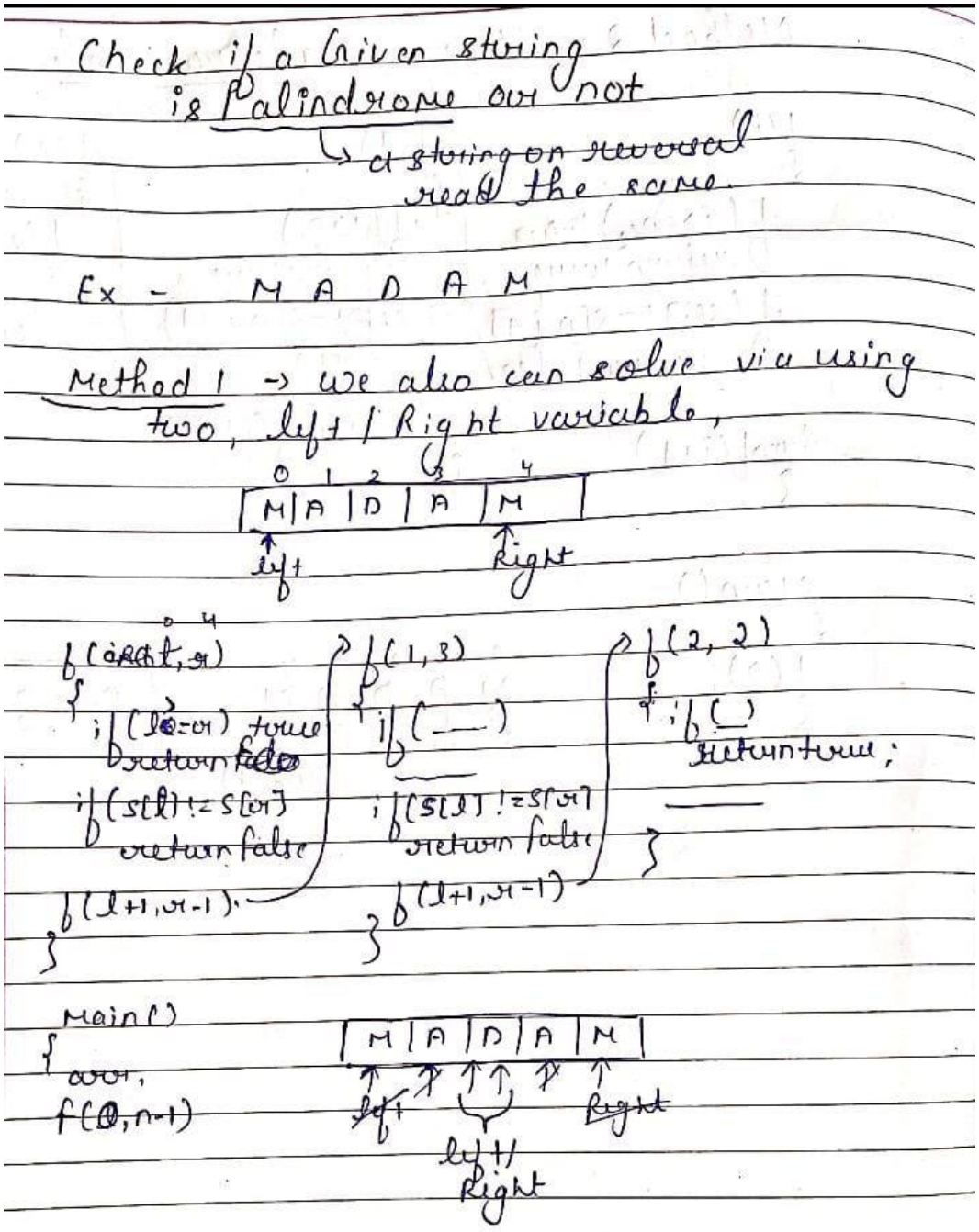
Q1 – Reverse An Array

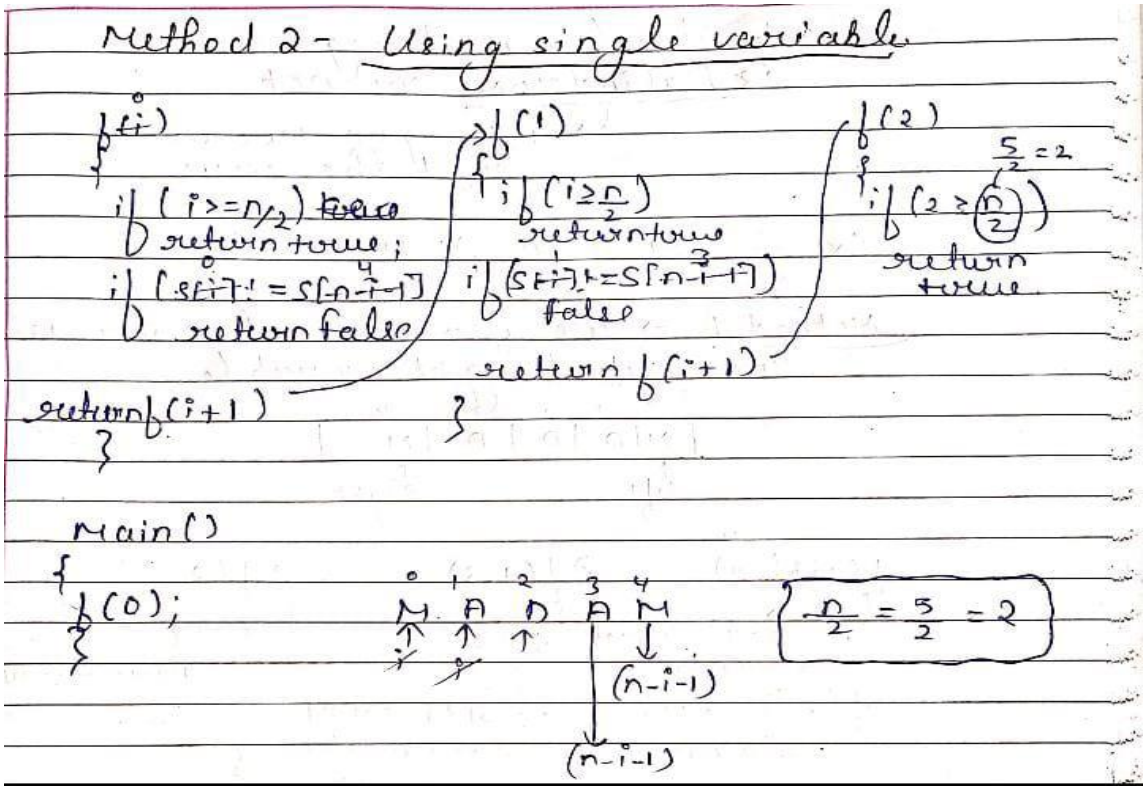





```cpp
#include <bits/stdc++.h>
using namespace std;

void f(int i,int arr[],int n)
{
    if(i>=n/2)return ;
    swap(arr[i],arr[n-i-1]);
    f(i+1,arr,n);
}
int main()
{
    int arr[5];
    for(int i=0;i<5;i++) cin>>arr[i];
    f(0,arr,5);
    for(int i=0;i<5;i++)
    cout<<arr[i]<<" ";
    return 0;
}
```

Q2 – Check If A Given String I s Palindome or Not

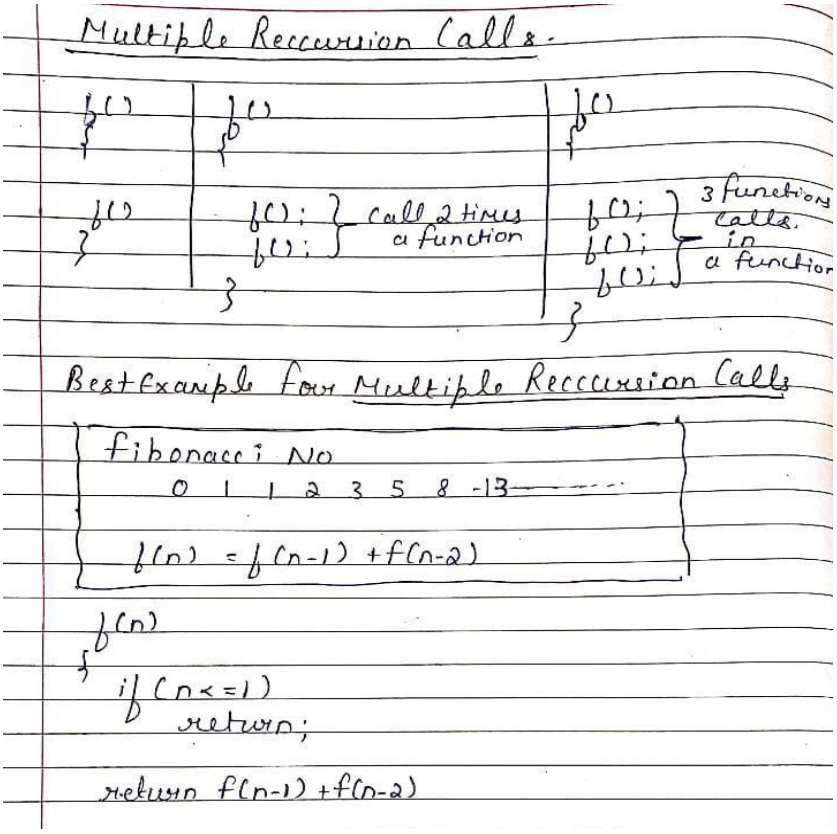


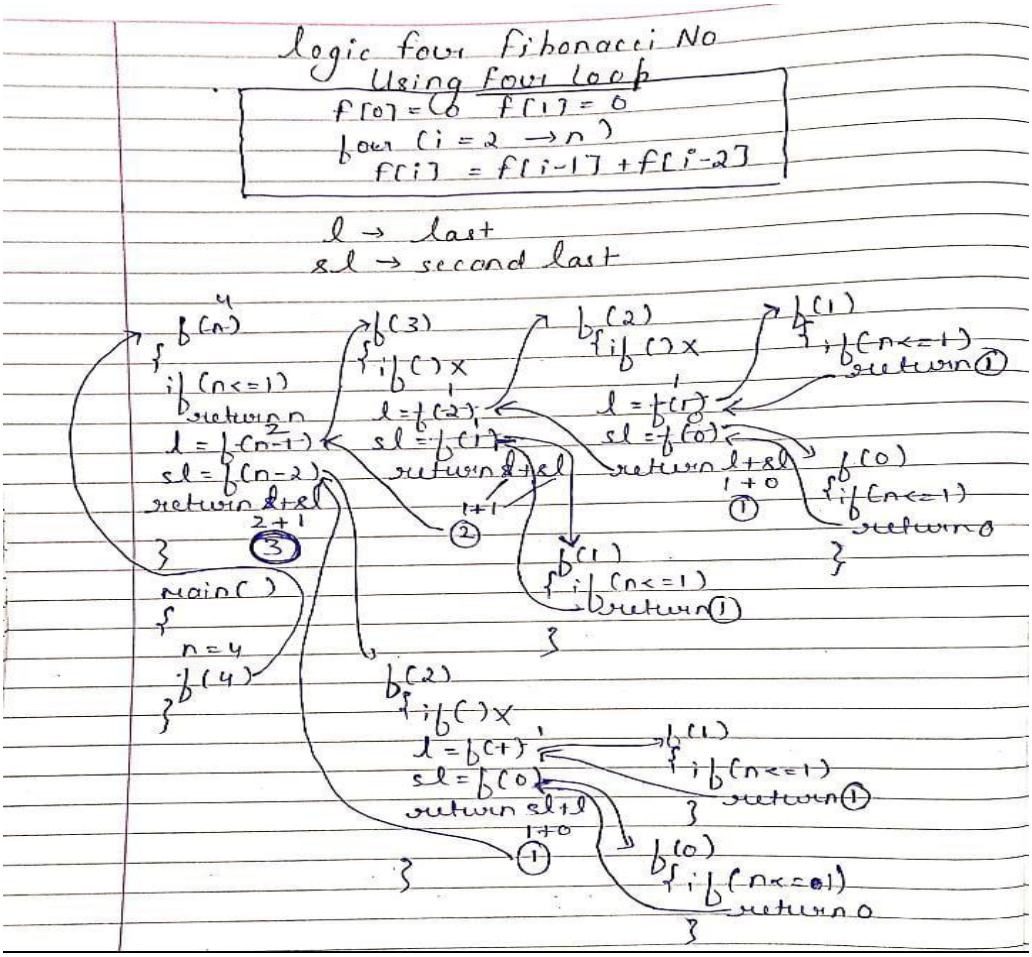


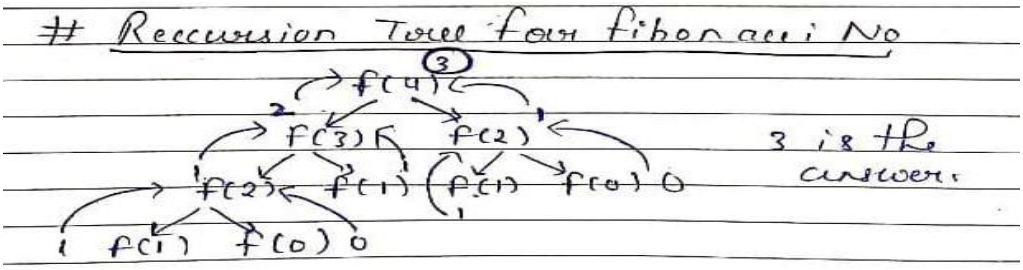
Source Code

```cpp
#include<bits/stdc++.h>
using namespace std;
bool f(int i,string &s)
{
    if(i>=s.size()/2)return true;
    if(s[i]!=s[s.size()-i-1])
    return false;

    return f(i+1,s);
}
int main()
{
    string s = "MADAM";
    cout<<f(0,s);
    return 0;
}
```

Multiple Reccursion Calls





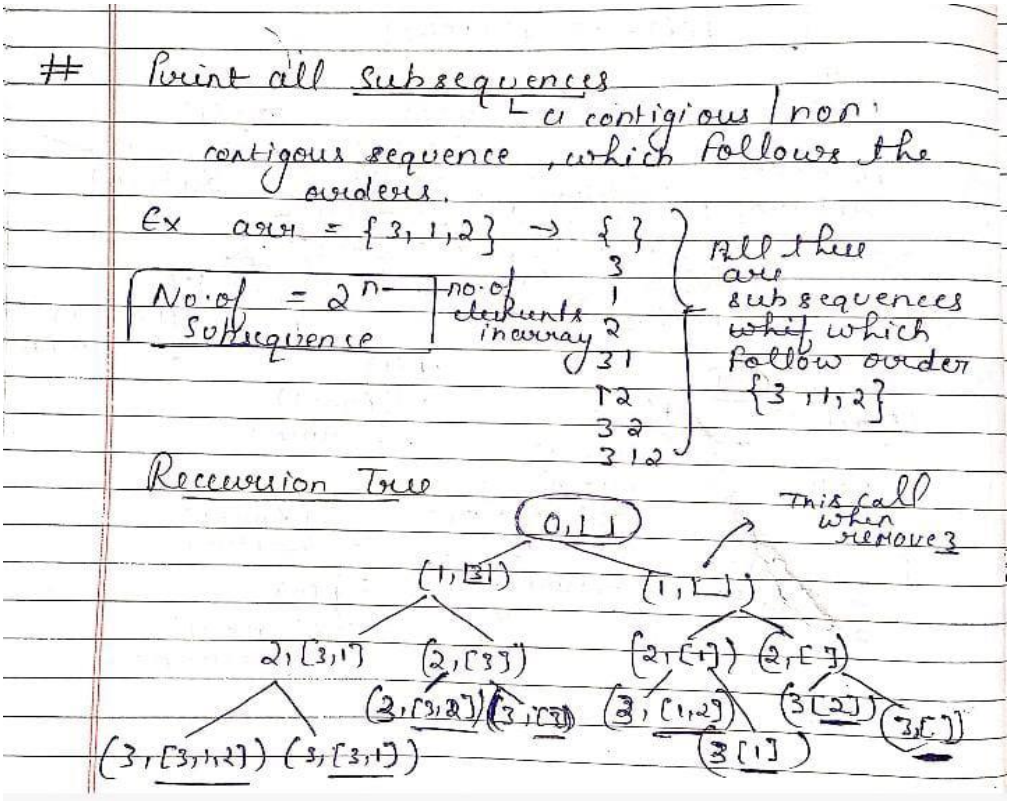


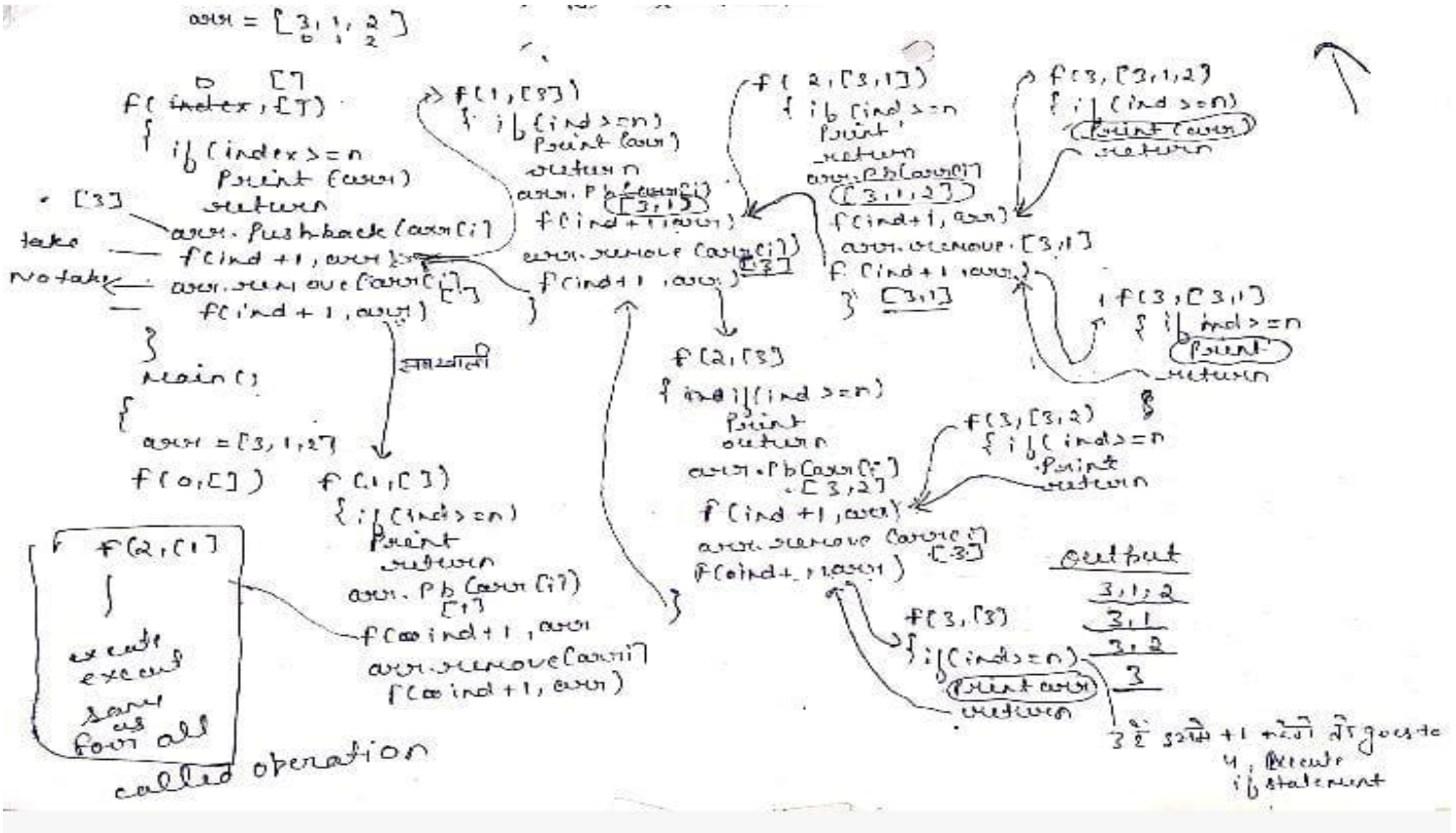
Here Every N Calls two recursion Which is (N-1) ,(N-2)

That's Why it take O(2^N) Time Complexity

```cpp
#include <bits/stdc++.h>
using namespace std;
int factorial(int n)
{
    if(n<=1)return n;
    int last = factorial(n-1);
    int secondlast = factorial(n-2);
    int fib = last+secondlast;
    return fib;
}
int main(){
    int n;
    cout <<"ENTER VALUE"<<endl;
    cin>>n;
    int fibo = factorial(n);
    cout<<"Your result is "<<fibo<<endl;
    return 0;
}
```

Print All Subsequences





```cpp
#include <bits/stdc++.h>
using namespace std;
void printSubsequences(int index,vector<int> &ds,int arr[],int n)
{
    if(index==n)
    {

        for(auto it:ds)
        {
            cout <<it;
        }
        if(ds.size()==0)cout<<"{}";
        cout<<endl;
        return ;    }
    ds.push_back(arr[index]);
    printSubsequences(index+1,ds,arr,n);
    ds.pop_back();
    printSubsequences(index+1,ds,arr,n);
}
int main()
{
    int arr[] = {3,2,1};
    int n = 3;
    vector<int> ds;
    printSubsequences(0,ds,arr,n);
    return 0;
}
```

TC - Every Index Having Couple Of Options O(2^N *N)

SC – O(N)

OutPut

321
32
31
3
21
2
1
{}

*** Print All Subsets (Another Methdod) - In Case Of Array

```
class Solution {
public:

    void solve(vector<int>& nums ,vector<int>ans,int index, vector<vector<int>>
&result)
    {
        // Agr index hamara traverse krte krte array size se bahar so return

        if(index>=nums.size())
        {
            // but return krne se phle saare , jo bhi ans me daale hai unko print
krna pdega
            result.push_back(ans);
            return ;
        }
        // excluding the element
        solve(nums,ans,index+1,result);

        // including the Element
        int element = nums[index];
        ans.push_back(element);

        solve(nums,ans,index+1,result);

    }
    vector<vector<int>> subsets(vector<int>& nums)
    {
        vector<vector<int>>result;
        vector<int>ans;
        int index = 0;  // indicates elements of nums array
        solve(nums,ans,index,result);
        return result ;
    }
};
```

Input: nums = [1,2,3]
Output:([],[1],[1,2],[3],[1,3],[2,3],[1,2,3]]

*** Print All Subsets (Another Methdod) - In Case Of String

```cpp
#include <bits/stdc++.h>
// During Function Calling yaha hume original wo wala vector bhejna pdega jisme fi
nal answer store hoga
void solve(string str ,string ans , int index,vector<string>& result)

{
    // Agr index hamara traverse krte krte array size se bahar so return
    if(index>=str.length())
    {
        // means is Question me empty size ka sub array output me nhi dena hai
        if(ans.length()>0)
        {
            result.push_back(ans);
        }
        return;
    }

    // excluding the element
    solve(str,ans,index+1,result);

    // including the Element
    // string ke case me char lekr kaam krna hai
    char element = str[index];
    ans.push_back(element);

    solve(str,ans,index+1,result);

}
vector<string> subsequences(string str)
{
    vector<string>result;
    // string ke case me empty string lena hai , or array ke case me ek vector len
a hai
    string ans = "";
    int index = 0;

    solve(str,ans,index,result);
    return result ;

}
```

*** Print Sub Array Via USING BIT MANIPULATION

```
 // Using Bit Manipulation

       vector<vector<int>>result;
       vector<vector<int>> subsets(vector<int>& nums)
    {

        int n = nums.size();  // ex  - n = 3 -> 2^3  = 8

        // here we can also use 1<<n instead Of pow funtion , Because 1<<n it
generally means
        /*
        1 << n = 1 << 3 = ( multiply 3 times two )  2 * 2 * 2
        */
        for(int i=0;i<pow(2,n);i++)
        {
            // i = 0
            // i = 1
            // i = 2
            /* i = 3    suppose 3 - 011  -  means take elemets at first and
second index
                        011 in this index starting from right to left
                        But [1,2,3] in this case index starts from left to
right
                        means Take
                        So For 3 ( 011 -> [1,2] )
            */
            // ..... till i = 7
            vector<int>ans;
            for(int j = 0;j<n;j++)
            {
                 // j loop iterate over its bits
            /*
            i = 5 -> 1 0 1
                     2 1 0 - index

                                  j
            j = 1 0 1 - then 1 0 1
                        And  1 0 1  - [1,3]
                        First check for j = 0 , so first bit is set so push
[1] at vector
                        then j left shift

                                  j
            j = 1 0 1 - then 0 1 0      <<<
                        And  1 0 1  - [1,3]
```

```
                        First check for j = 1 , so 2nd bit is not set so not
push [2] at vector
                        then j left shift

                             j
            j = 1 0 1 - then 1 0 0
                        And  1 0 1  - [1,3]
                        First check for j = 2 , so 3rd is bit is set so push
[3] at vector

            */
            // i = 5 -> 101  -> [1,3] -- Her we Goona Find which bit is set or
whis is not set , because those bit is set we take it

                if((1<<j)&i)
                  ans.push_back(nums[j]);
            }
            result.push_back(ans);
        }
        return result;
    }
```