Recursion In C

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Course Title :- Structured Programming Language Sessional

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Level Term: 1-II-A(G1) & 1-II-B(G3,G4)

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Outlines:

- ❑ Introduction to Recursion in C
- ❑ Fundamental Components of C Recursion
- ❑ Need of Recursive Function
- ❑ Types of C Recursion
- ❑ Approaches of Recursion
- ❑ Difference between Recursion and Iteration
- ❑ How Recursion Actually Works in C?
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  2) Print N to 1
- ❑ Important Programs Using Recursion
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- ❑ Examples to Find the output of this pattern
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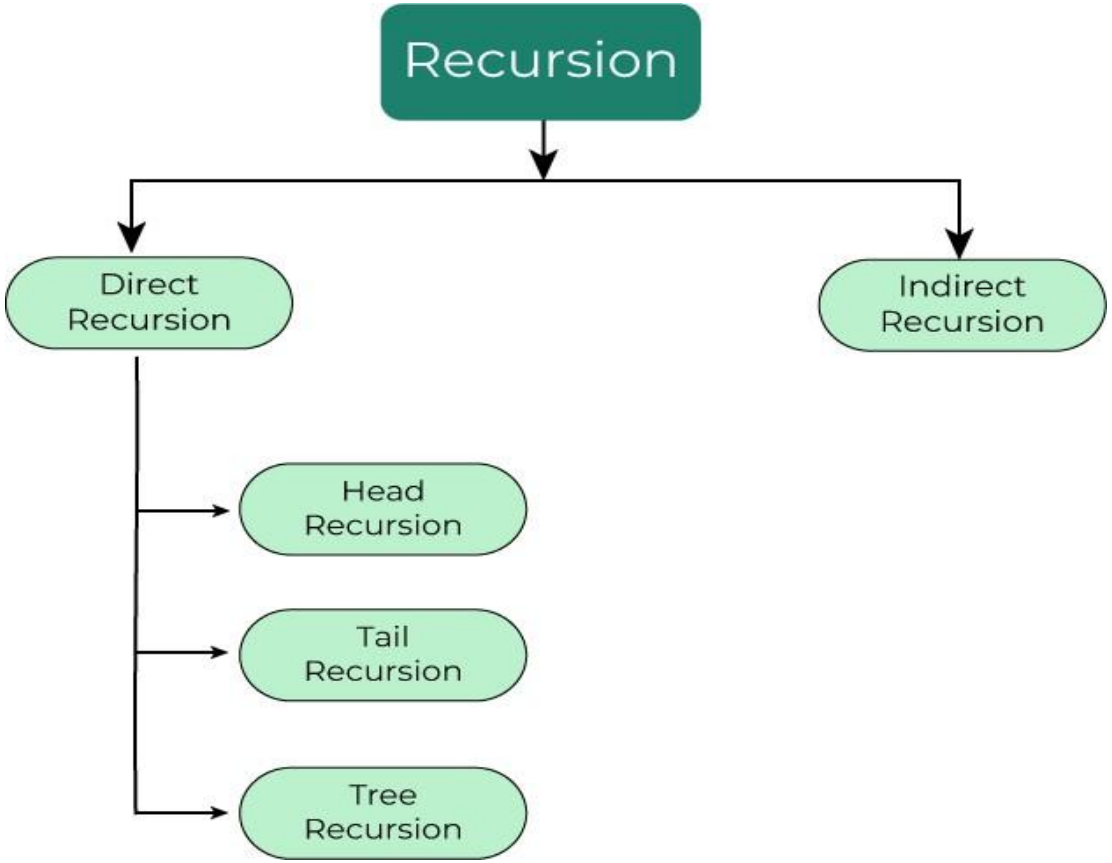
- ❑ Printing Pyramid Patterns using Recursion

✓ A Recursive function can be defined as a function that calls itself directly or indirectly.

❑ Fundamental Components of C Recursion

1.Recursion Case
2.Base Condition

❑ Types of Recursion in C:




```
int nSum(int n)
{
    if (n==0) {
    return 0;
    }
int res = n+ nsum(n-1);
    return res;
}
```

Base condition

Recursive case

❑ Indirect Recursion:-

```
void functionA(int n){
 if (n < 1) { return; }
 printf("%d ", n);
 n = n - 1;
 functionB(n);
}
void functionB(int n){
 if (n < 2) { return; }
 printf("%d ", n);
 n = n / 2;
 functionA(n);
}
```

1.What is Head Recursion

The **head recursion** is a linear recursion where the position of its only recursive call is at the start of the function. It is generally the first statement in the function.

```
int sum(int k)
{
    if (k > 0) {
        return k + sum(k - 1);
    }
    else {
        return 0;
    }
}
```

2.What is Tail Recursion

Tail recursion is defined as a recursive function in which the recursive call is the last statement that is executed by the function. So basically, nothing is left to execute after the recursion call.

```
void print(int n)
{
    if (n < 0)
    return;
    printf("%d ", n);
    print(n - 1);
}
```

3.What is Tree Recursion

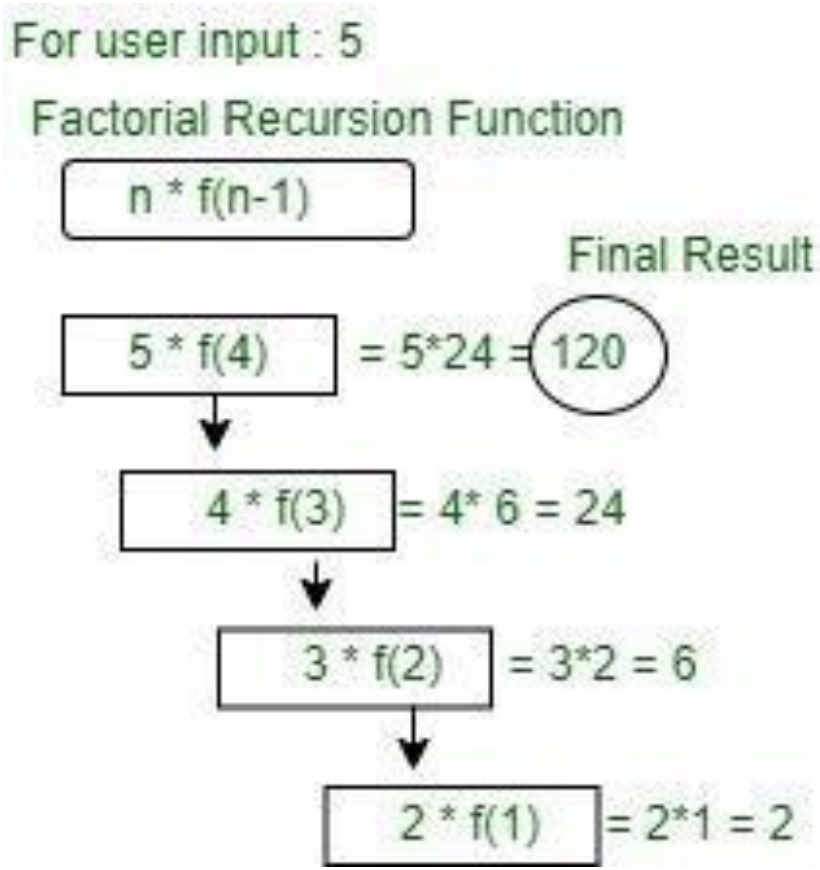
In **tree recursion**, there are multiple recursive calls present in the body of the function. Due to this, while tracing the program flow, it makes a tree-like structure, hence the name Tree Recursion.

```
int fib(int n)
{
    if (n ≤ 1)
        return 1;
    else
        return fib(n - 1) + fib(n - 2);
}
```

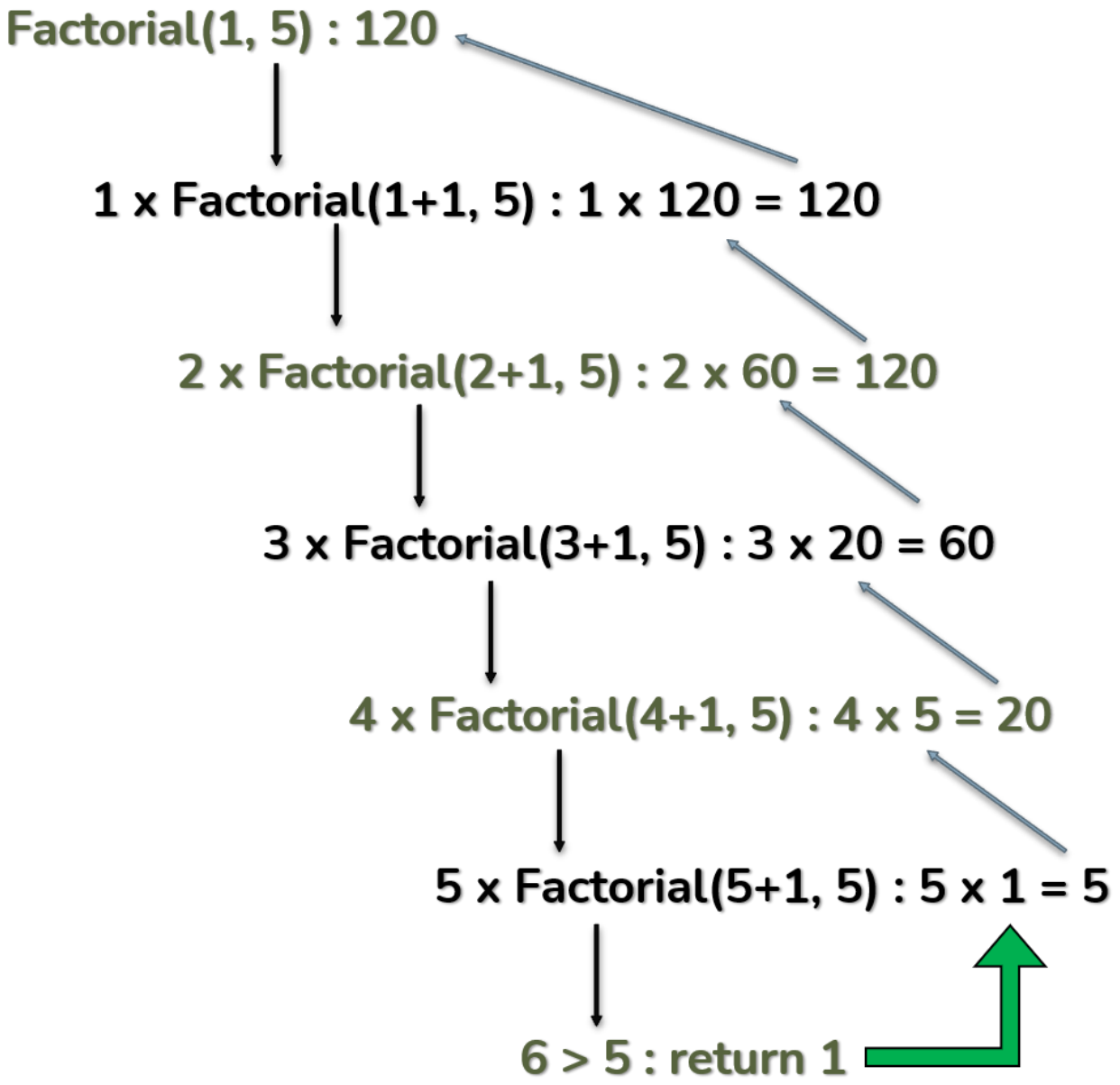
❑ Approaches of Recursion

There are two approaches for a recursive function.

a. Top down approach



b. Bottom up approach



❑How Recursion works in C?

1. Print 1 to N using recursion
    a. manual
    b. function
    c. recursion top-down
    d. recursion bottom-up

Print 1 to n without using loops

You are given an integer N. Print numbers from 1 to N without the help of loops.
Input: N = 5
Output: 1 2 3 4 5

a. Manually

```
#include <stdio.h>
int main(){
     int N=10;
     for(int i = 1; i≤ N; i++)
     {
        printf("%d ", i);
     }
}
```

b. Using Normal Function

```
#include <stdio.h>
int printFunction(int N){
    for(int i = 1; i≤ N; i++)
    {
        printf("%d ", i);
    }
}
int main(){
    int N=10;
    printFunction(N);
}
```

c. Using Recursive Function [Bottom-Up]

```
int printRecursion(1, 3){
   if(1 <= 3){
      print → 1
      printRecursion(1+1, 3);
   }
   else return 0;
}
```

```
int printRecursion(2, 3){
   if(2 <= 3){
      print → 2
      printRecursion(2+1, 3);
   }
   else return 0;
}
```

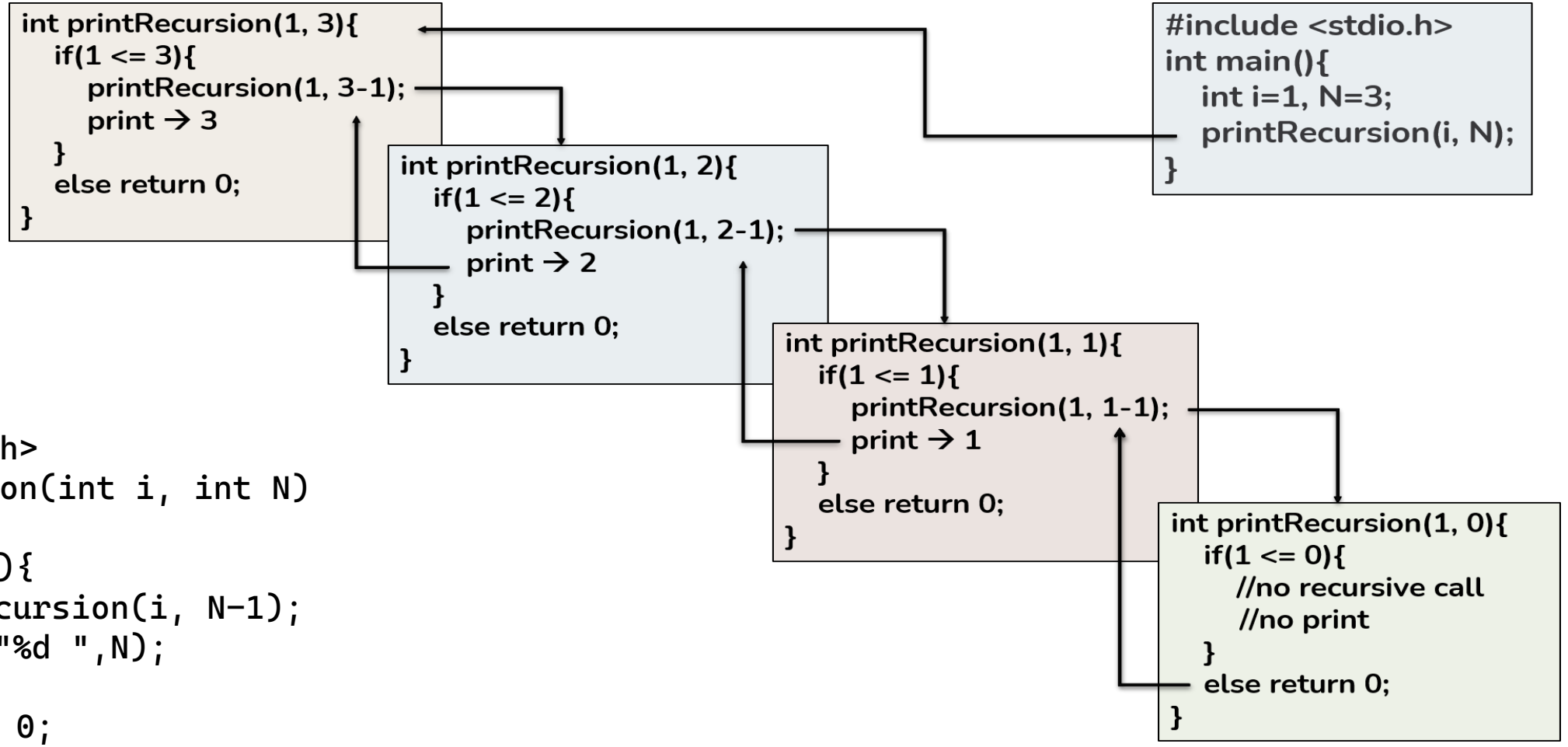
```
int printRecursion(3, 3){
   if(3 <= 3){
      print → 3
      printRecursion(3+1, 3);
   }
   else return 0;
}
```

```
int printRecursion(4, 3){
   if(4 <= 3){
      //no recursive call
      //no print
   }
   else return 0;
}
```

```
#include <stdio.h>
int main(){
   int i=1, N=3;
   printRecursion(i, N);
}
```

```
#include <stdio.h>
int printRecursion(int i, int N)
{
     if(i ≤ N){
         printf("%d ",i);
         printRecursion(i+1, N);
     }
     else return 0;
}
int main(){
    int i=1, N=5;
    printRecursion(i, N);
}
```

d. Using Recursive Function [Top-Down]




```c
#include <stdio.h>
int printRecursion(int i, int N)
{
     if( i ≤ N ){
         printRecursion(i, N-1);
         printf("%d ",N);
     }
     else return 0;
}
int main(){
     int i=1, N=5;
     printRecursion(i, N);
}
```

H.W. Recursive C Programs:-

1.Print odd numbers 1 to n using recursion.
Numbers : 1, 3, 5, 7, 9,…….n
2.Print even numbers 2 to n using recursion.
Numbers : 2, 4, 6, 8, 10,……..n

2. Print N to 1 using recursion
    a. manual
    b. function
    c. recursion top-down
    d. recursion bottom-up

Print n to 1 without using loops

You are given an integer N. Print numbers from 1 to N without the help of loops.

Input: N = 5

Output: 5 4 3 2 1

a. Manually

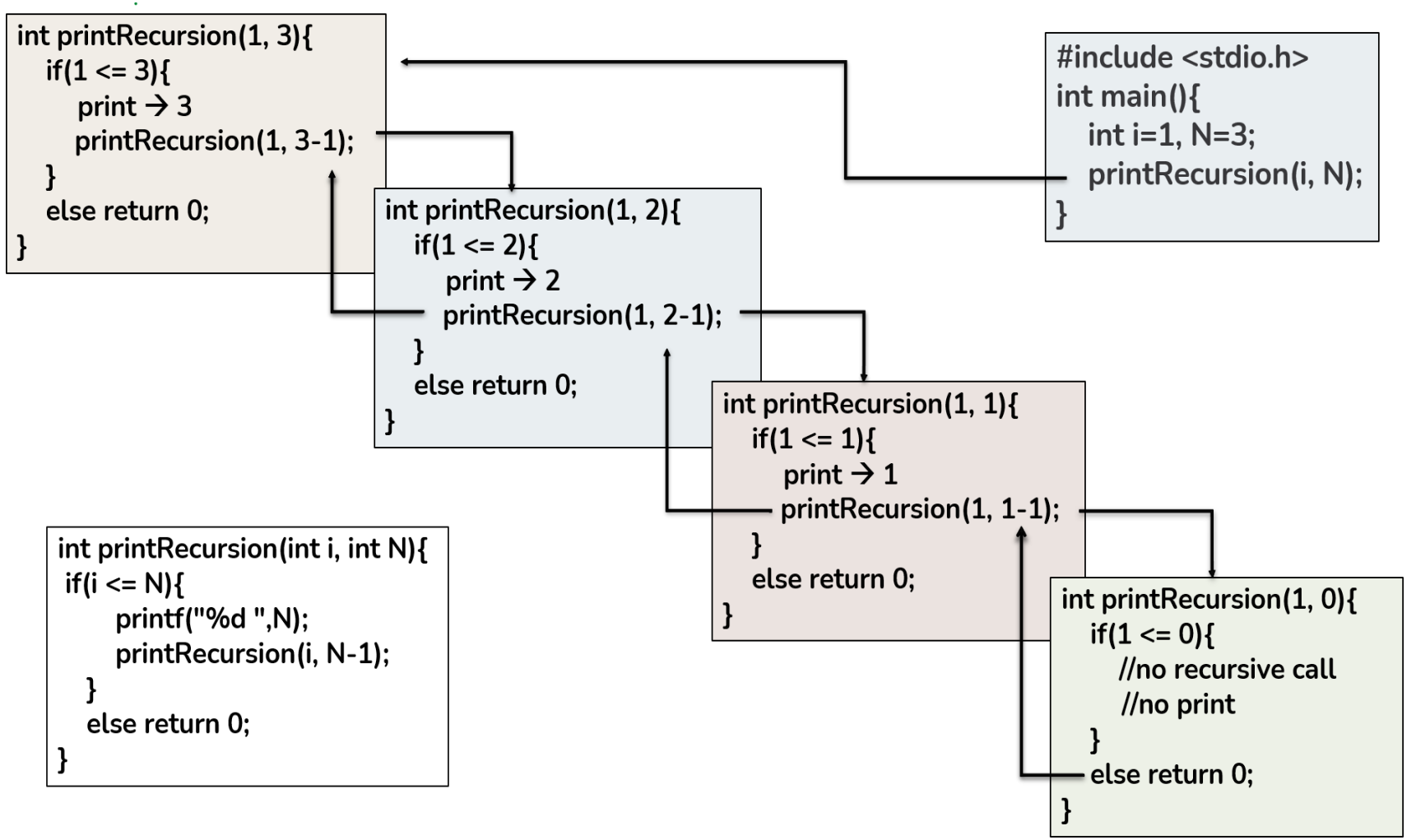
```
#include <stdio.h>
int main(){
 int N=10;
 for(int i = N; i ≥ 1; i--) {
    printf("%d ", i);
 }
}
```

b. Using Normal Function

```
#include <stdio.h>
int printFunction(int N){
     for(int i = N; i ≥ 1; i--) {
         printf("%d ", i);
     }
}
int main(){
     int N=10;
     printFunction(N);
}
```

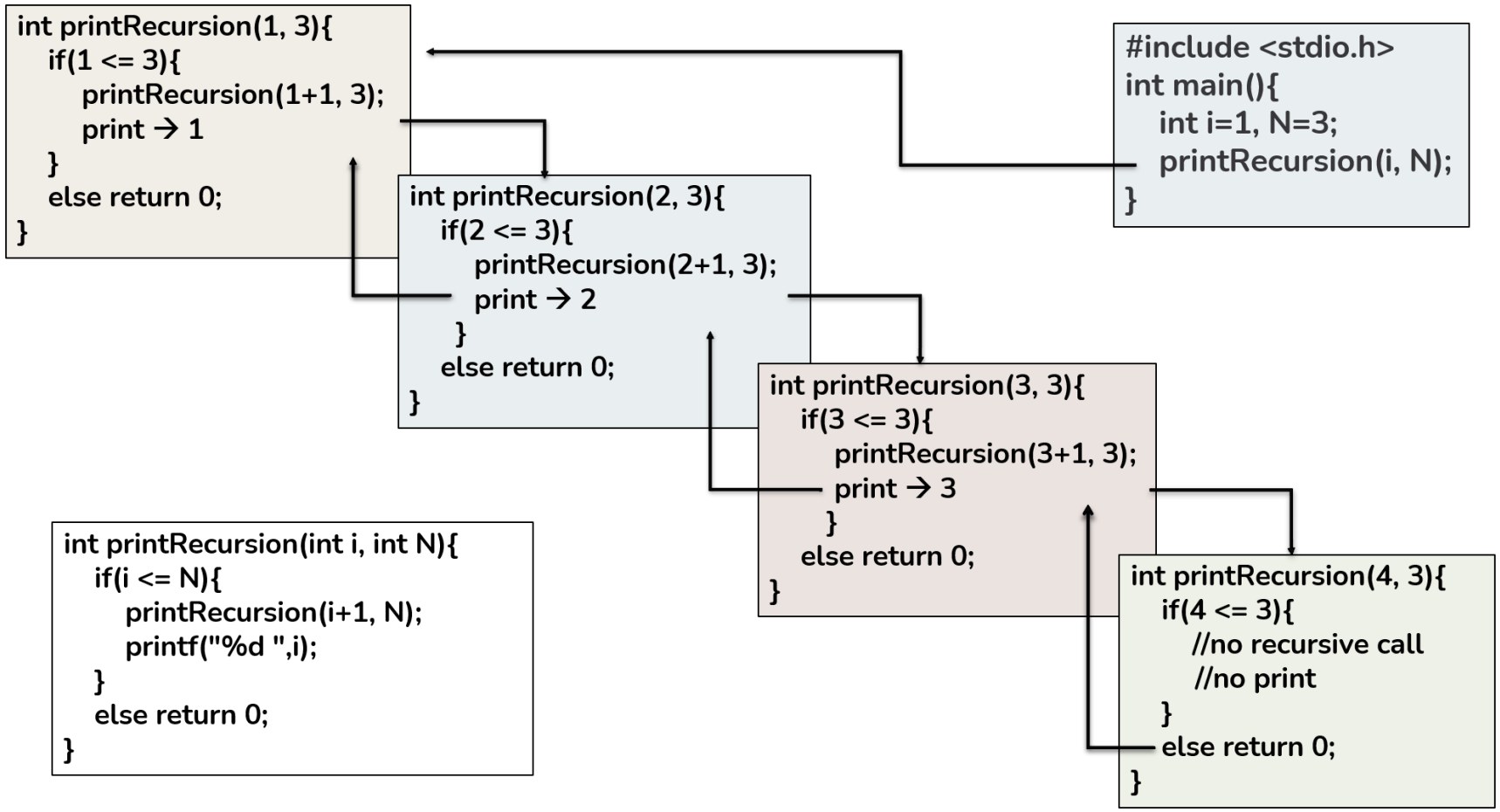
c. Using Recursive Function [Bottom-Up]

```c
#include <stdio.h>
int printRecursion(int i, int N){
    if(i ≤ N){
        printf("%d ",N);
        printRecursion(i, N-1);
    }
    else return 0;
}
int main(){
    int i=1, N=5;
    printRecursion(i, N);
}
```



d. Using Recursive Function [Top-Down]

```c
#include <stdio.h>
int printRecursion(int i, int N){
      if(i ≤ N){
           printRecursion(i+1, N);
           printf("%d ",i);
      }
      else return 0;
}
int main(){
      int i=1, N=5;
      printRecursion(i, N);
}
```



H.W. Recursive C Programs:-

1. Print even number from N to 2 using recursion [top down & bottom up]
2. Print odd number from N to 1 using recursion [top down & bottom up]

❑Important Programs Using Recursion

1) C program to calculate Factorials of N
    1. Basic
    2. Using function
    3. Using recursive function[bottom – up]
    4. Using recursive function[top – down]

C program to calculate Factorials of N. You are given a number N. Find the factorial of N.
Input N = 5
Output : 120
Explanation: 5 x 4 x 3 x 2 x 1 = 120

1. Manually

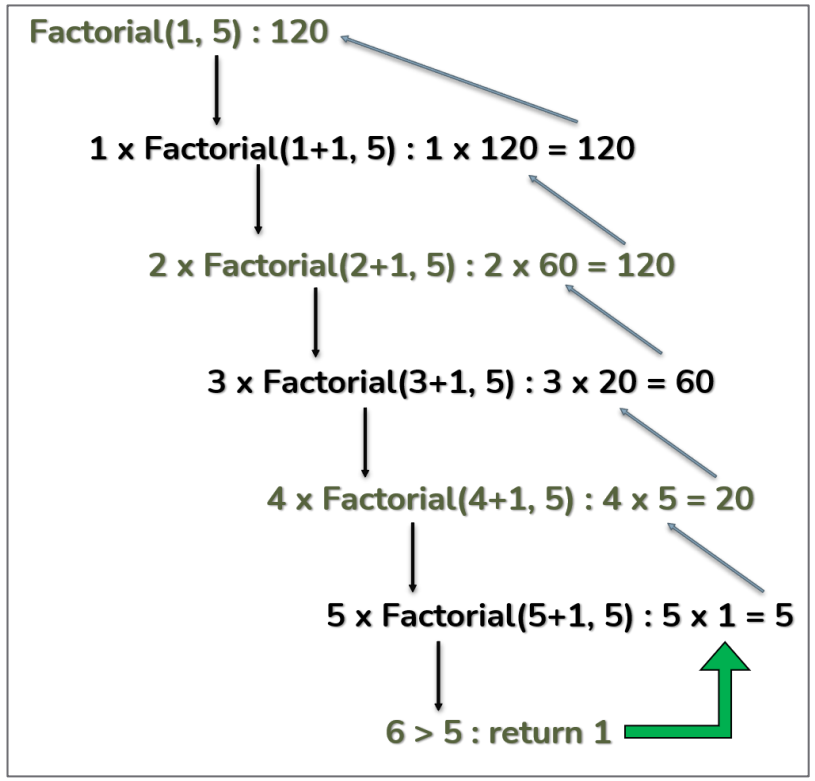
```
#include <stdio.h>
int main(){
     int fact = 1;
     int N=5;
     for(int i=1; i≤N; i++)
     {
         fact = fact * i;
     }
     printf("%d", fact);
}
```

2. Using Function

```
#include <stdio.h>
int Factorial(int fact, int N){
     for(int i=1; i≤N; i++)
     {
        fact = fact * i;
     }
     return fact;
}
int main(){
     int fact = 1, N=5;
     printf("%d", Factorial(1, 5));
}
```

3. Using recursive function [Bottom – up]

```
#include <stdio.h>
int Factorial(int fact, int N){
      if(fact ≤ N){
         return fact * Factorial(fact+1, N);
      }
      return 1;
}
int main(){
      int fact = 1, N=5;
      printf("%d", Factorial(1, 5));
}
```




```
int Factorial(1, 5){
   if(1 <= 5){
      return 1 * Factorial(1+1, 5);
   }
   return 1;
}
```

```
int Factorial(2, 5){
   if(2 <= 5){
      return 2 * Factorial(2+1, 5);
   }
   return 1;
}
```

```
int Factorial(3, 5){
   if(3 <= 5){
      return 3 * Factorial(3+1, 5);
   }
   return 1;
}
```

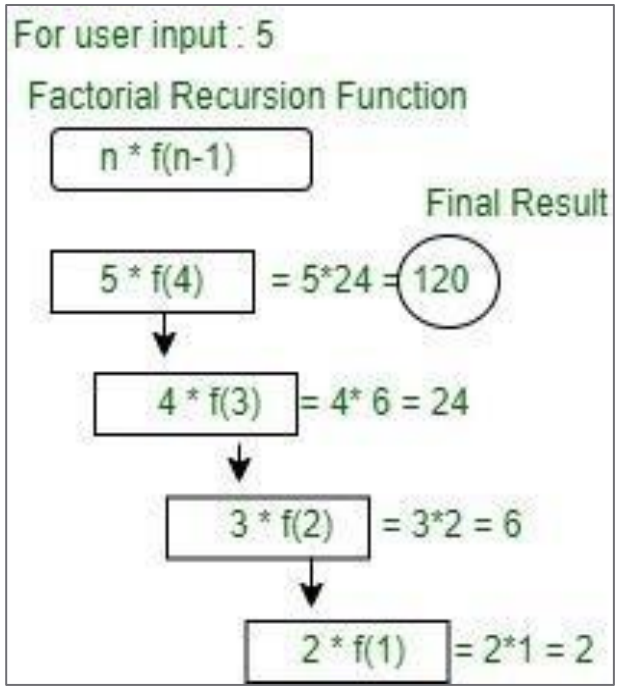
```
int Factorial(4, 5){
   if(4 <= 5){
      return 4 * Factorial(4+1, 5);
   }
   return 1;
}
```

```
int main(){
   int fact = 1, N=5;
   printf("%d", Factorial(1, 5));
}
```

```
int Factorial(int fact, int N){
   if(fact <= N){
      return fact * Factorial(fact+1, N);
   }
   return 1;
}
```

4. Using recursive function [Top – down]

```
#include <stdio.h>
int fact(int N){
    if (N ≤ 1)
        return 1;
    return N * fact(N – 1);
}
int main(){
     int N=5;
     printf("%d", fact(N));
}
```




```
int Fact(int N){
      if (N <= 1)
            return 1;
      return N * Fact(N - 1);
}
```

```
int Fact(5){
   if(5 <= 1)  return 1 ;
   else  return 5 * Fact(5-1);
   }
```

```
int Fact(4){
   if(4 <= 1)  return 1 ;
   else  return 4 * Fact(4-1);
   }
```

```
int Fact(3){
   if(3 <= 1)  return 1 ;
   else  return 3 * Fact(3-1);
   }
```

```
int Fact(2){
   if(2 <= 1)  return 1 ;
   else  return 2 * Fact(2-1);
   }
```

```
int Fact(1){
   if(1 <= 1)  return 1 ;
   else  return 1 * Fact(1-1);
   }
```

```
int main(){
   int N=5;
   printf("%d", Fact(N));
}
```

2) C program to calculate nth Fibonacci numbers

a) Using Array[bottom – up]
b) Using recursive function[top – down]

Given a number n, print n-th Fibonacci Number. The Fibonacci numbers are the numbers in the following integer sequence: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, ……

a) Using Array [bottom – up]:

```
#include <stdio.h>
int fib(int n){
     int f[n];
     f[0] = 0;
     f[1] = 1;
     for(int i = 2; i ≤ n; i++)
     {
        f[i] = f[i – 1] + f[i – 2];
     }

     return f[n];
}
int main(){
    printf("%d", fib(8));
}
```

❑ How Fibonacci sequence works?

N^{th} Fibonacci is summation of previous 2 Fibonacci number.

Fibonacci [n] = Fibonacci [n – 1] + Fibonacci [n – 2]

0^{th} Fibonacci = 0

1^{th} Fibonacci = 1

2^{nd} Fibonacci = 0^{th} Fibonacci + 1^{th} Fibonacci = 0 + 1 = 1

3^{rd} Fibonacci = 1^{th} Fibonacci + 2^{nd} Fibonacci = 1 + 1 = 2

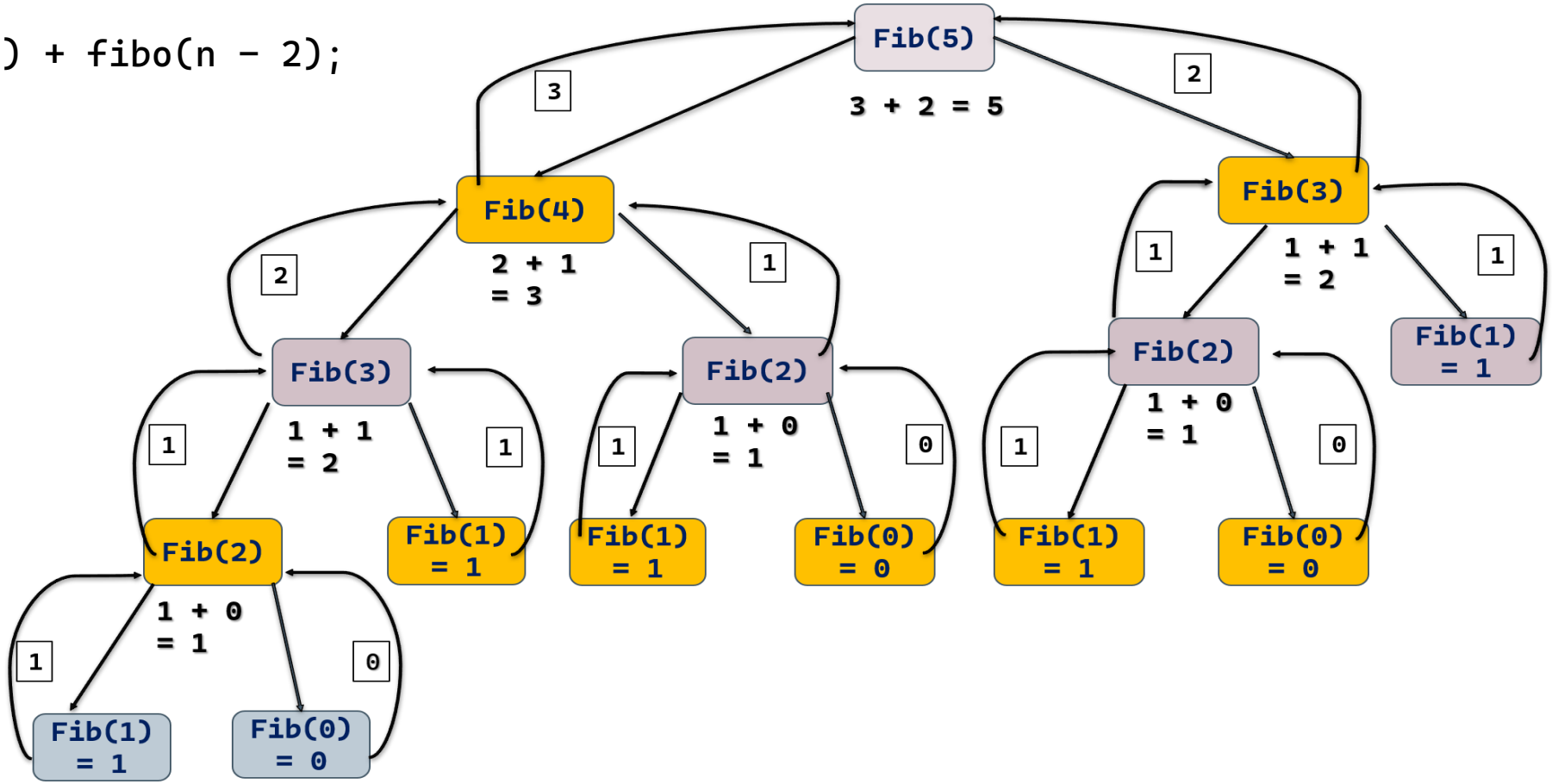
4^{th} Fibonacci = 2^{nd} Fibonacci + 3^{rd} Fibonacci = 1 + 2 = 3

5^{th} Fibonacci = 3^{rd} Fibonacci + 4^{th} Fibonacci = 2 + 3 = 5

And so on……

b) Using Recursion[Top – Down]:

```
#include <stdio.h>
int fibo(int n){
     if (n ≤ 1) {
        return n;
     }
     else {
        return fibo(n – 1) + fibo(n – 2);
     }
}
int main(){
     int n = fibo(5);
     printf("%d", n);
}
```

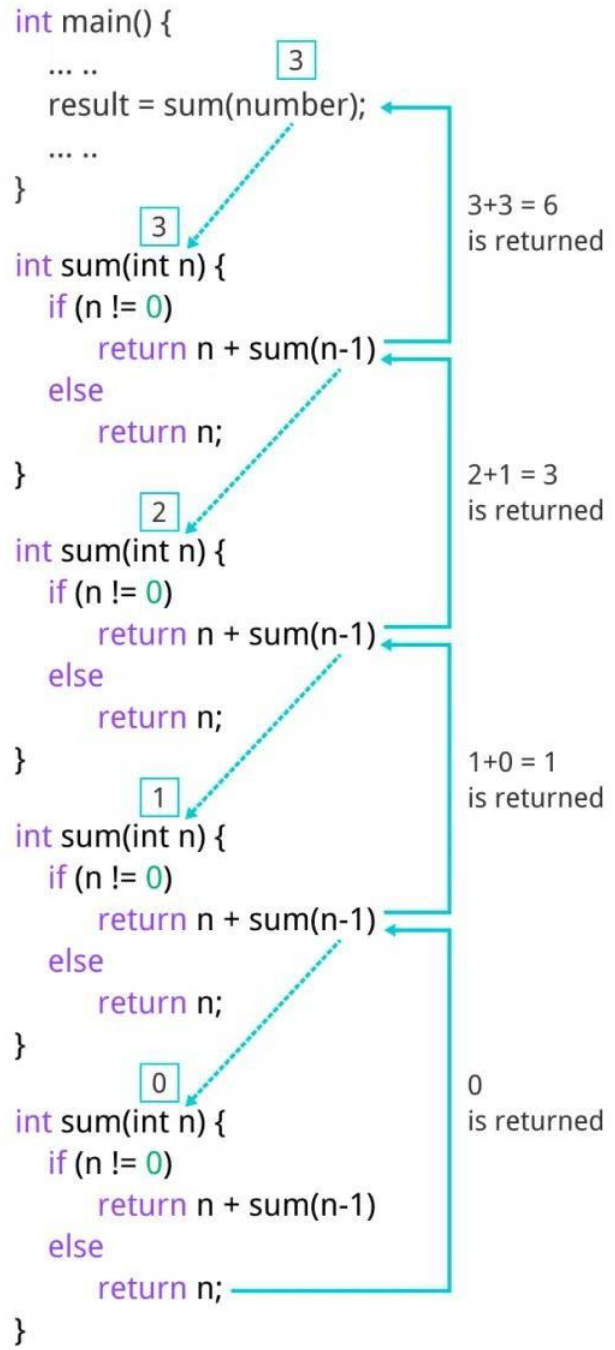


3) C program to calculate sum of natural numbers from 1 to N
[top – down]

C program to Calculate Sum of all-Natural Number
Input n = 5
Output: 15

N.B. The sum of numbers from 1 to 5 : 1 + 2 + 3 + 4 + 5 = 15

```
#include <stdio.h>
int sum(int n){
     if( n ≥ 1)
     {
        return n + sum(n-1);
     }
     else
        return 0;
}
int main()
{
    int n = 10;
    printf("Sum = %d", sum(n));
}
```



❖ Find the output of a pattern without using any loop

Example-1 : Given a number n, print the following pattern without using any loop.

Sequence: n, n-5, n-10, …, 0, 5, 10, …, n-5, n

Examples :

Input: n = 16

Output: 16, 11, 6, 1, -4, 1, 6, 11, 16

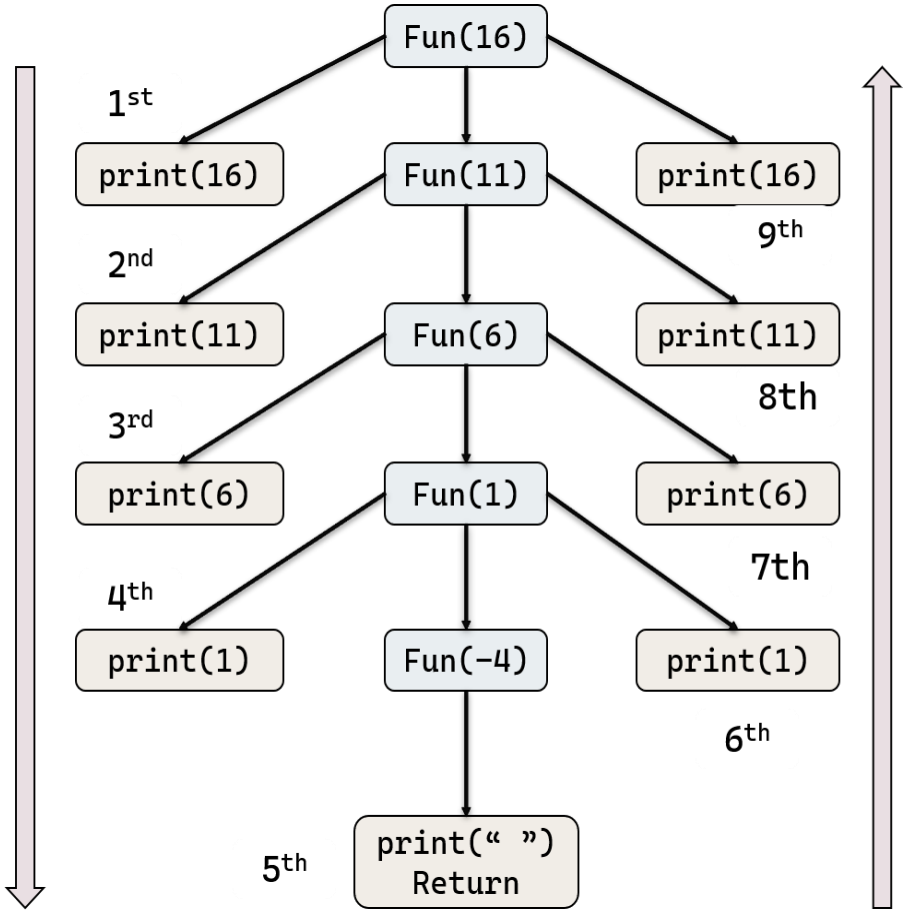
Input: n = 10

Output: 10, 5, 0, 5, 10

```
#include <stdio.h>
void printPattern(int n){
    if (n ≤ 0){
        printf(" ");
        return;
    }
    printf("%d ", n);
    printPattern(n - 5);
    printf("%d ", n);
}
int main(){
    int n = 16;
    printPattern(n);
}
```

Output

16 11 6 1 1 6 11 16



Example-2:-

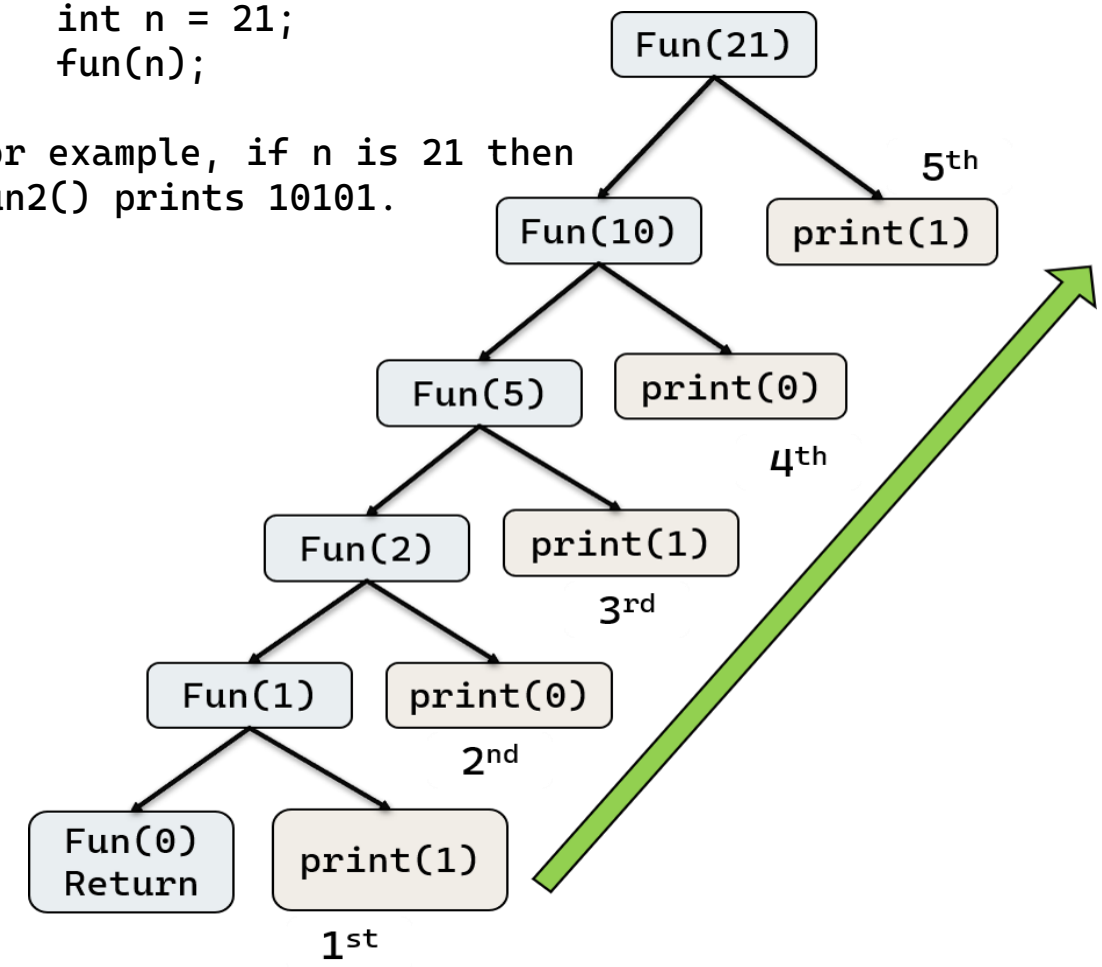
Assignment!! Find the Recursion Tree for this program:-

```
#include <stdio.h>
void printFun(int test){
    if (test < 1)
        return;
    else {
        printf("%d ", test);
        printFun(test - 1);
        printf("%d ", test);
    }
}
int main(){
    int test = 3;
    printFun(test);
}
```

Example – 3: Predict the output pattern

```
#include <stdio.h>
void fun(int n){
     if(n == 0)
        return;
     fun(n/2);
     printf("%d", n%2);
}
int main(){
    int n = 21;
    fun(n);
}
```

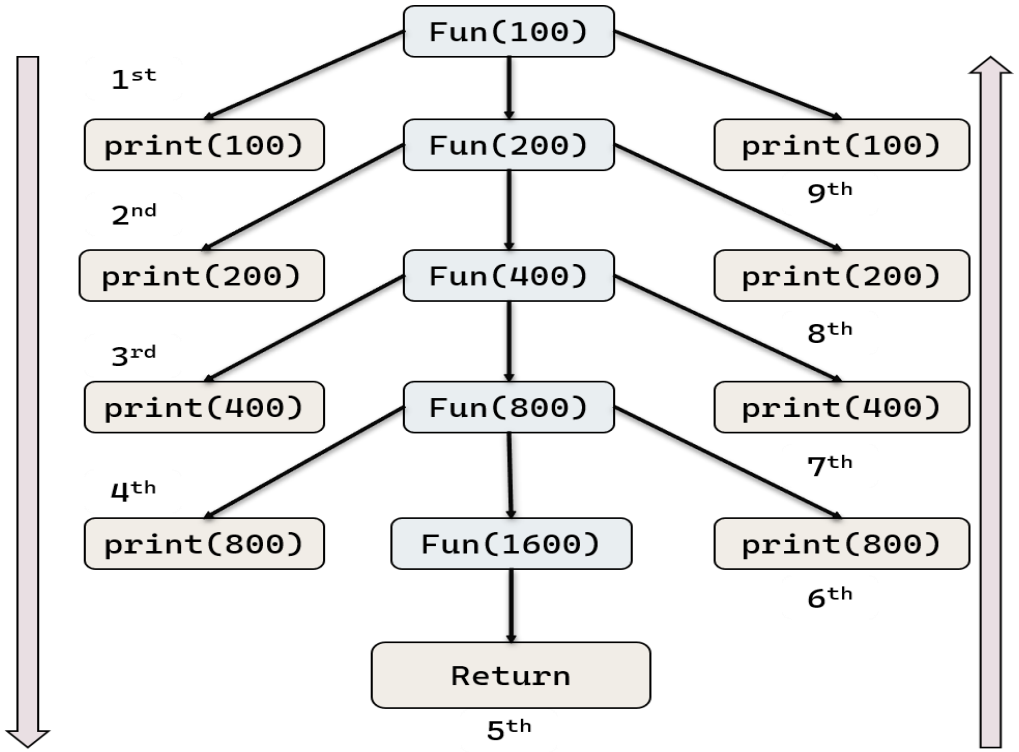
For example, if n is 21 then fun2() prints 10101.



Example – 4: Predict the output pattern

```
#define LIMIT 1000
void fun(int n){
     if (n > LIMIT |= n ≤ 0) return;
     printf("%d ", n);
     fun(2*n);
     printf("%d ", n);
}
int main(){
    int n = 100;
    fun(n);
}
```

For example fun2(100) prints :-
100, 200, 400, 800, 800, 400, 200, 100

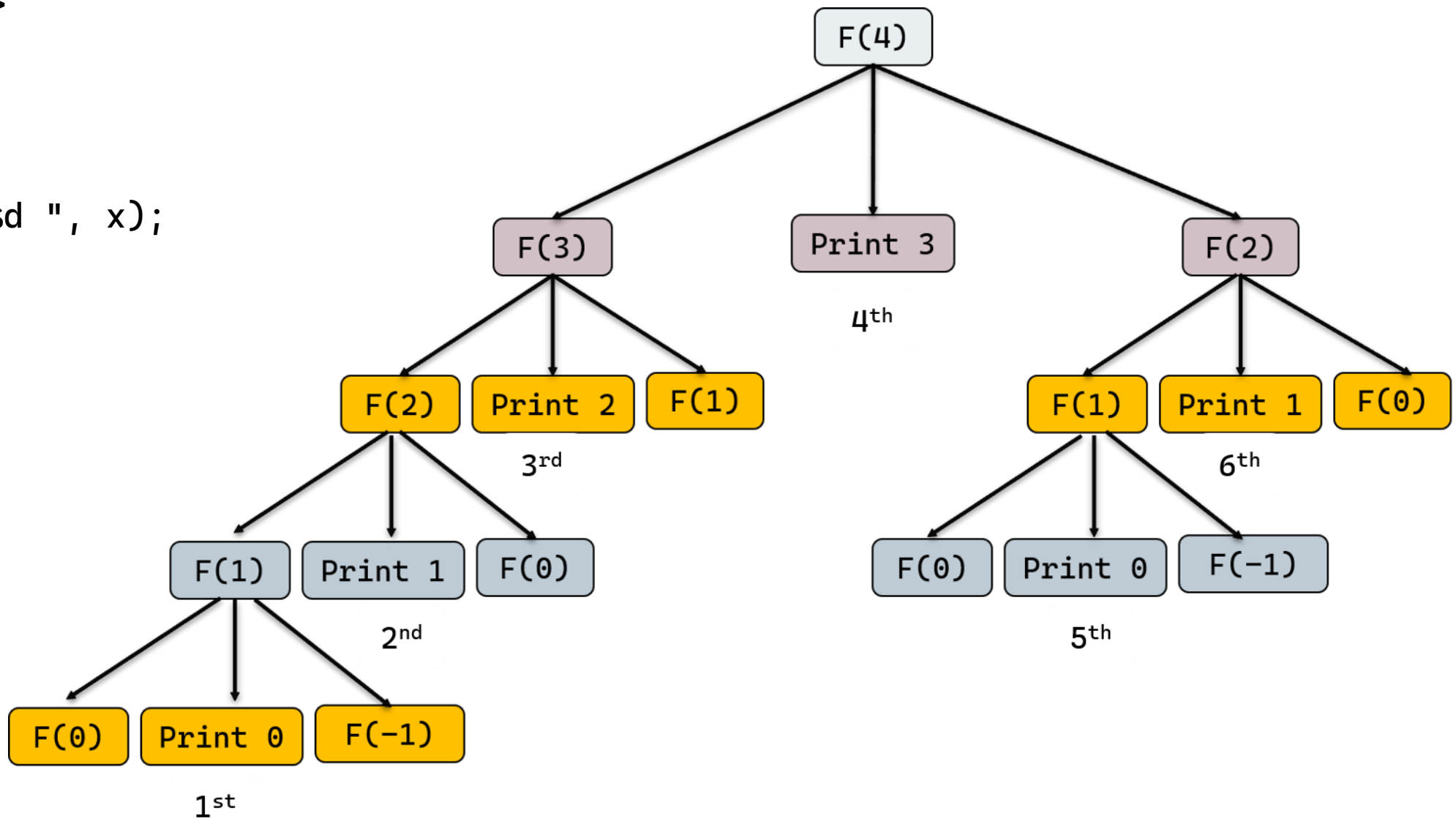


Example – 5: Predict the output pattern

```
#include<stdio.h>
void fun(int x)
{
    if(x > 0){
        fun(--x);
        printf("%d ", x);
        fun(--x);
    }
    else return;
}
int main()
{
    int a = 4;
    fun(a);
}
```

Output:

0 1 2 0 3 0 1

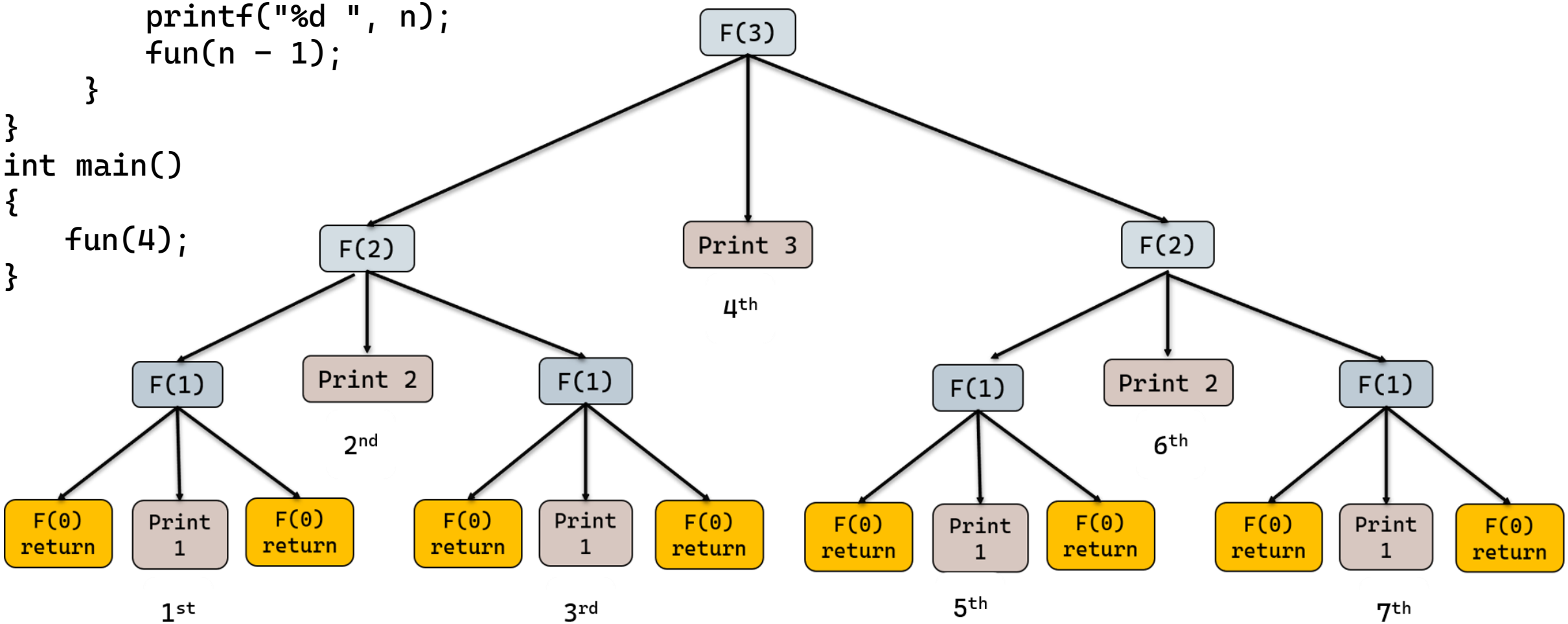


Example – 6: Predict the output pattern

```
#include <stdio.h>
void fun(int n)
{
    if (n > 0) {
        fun(n - 1);
        printf("%d ", n);
        fun(n - 1);
    }
}
int main()
{
   fun(4);
}
```

Output

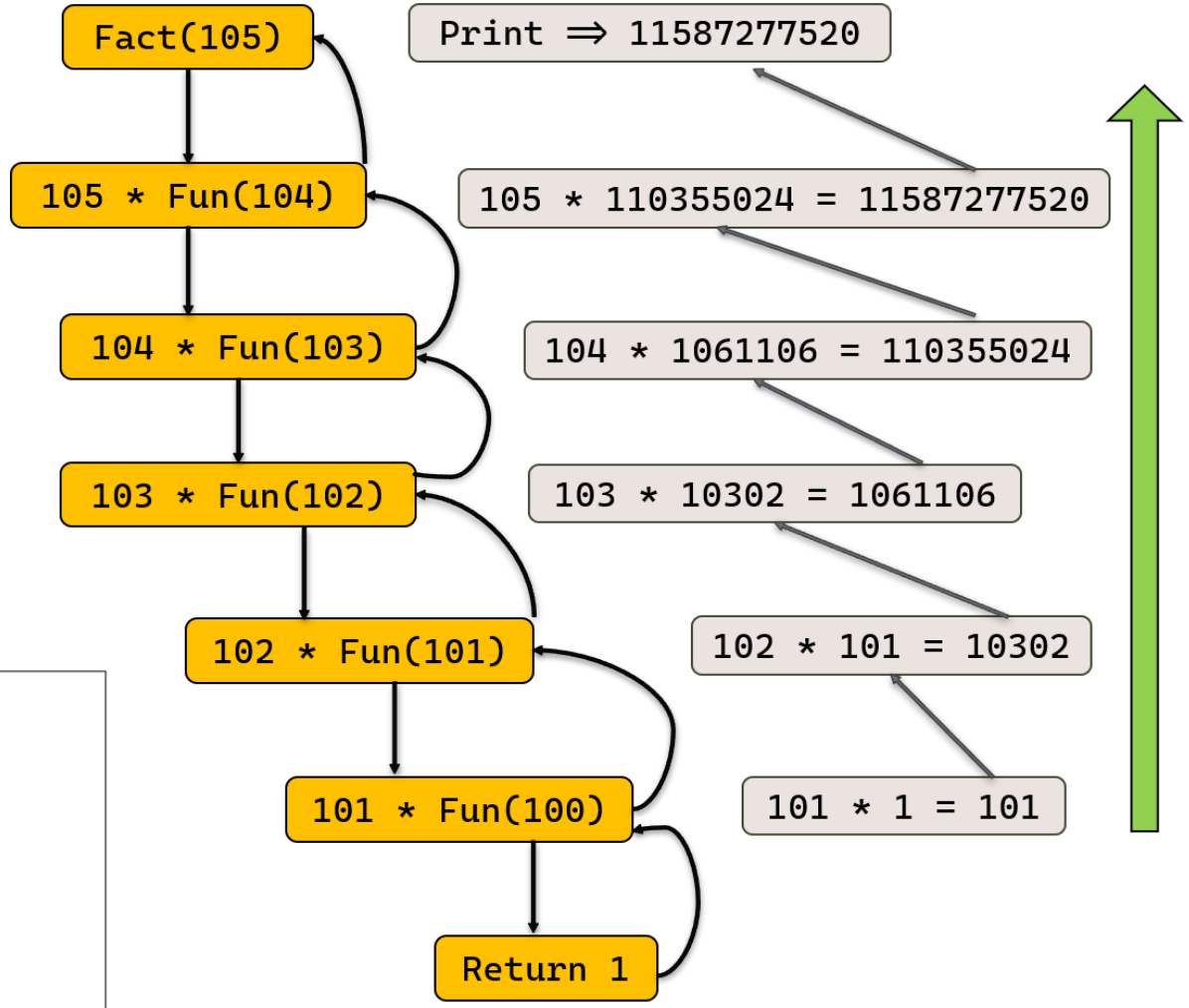
1 2 1 3 1 2 1 4 1 2 1 3 1 2 1



❑Practice problems for recursion

Example – 1: Calculate the output

```
int fact(int n)
{
     if (n == 100)
        return 1;
     else
        return n*fact(n-1);
}
int main(){
     printf("%d", fact(105));
}
```



Example – 2: Assignment!!

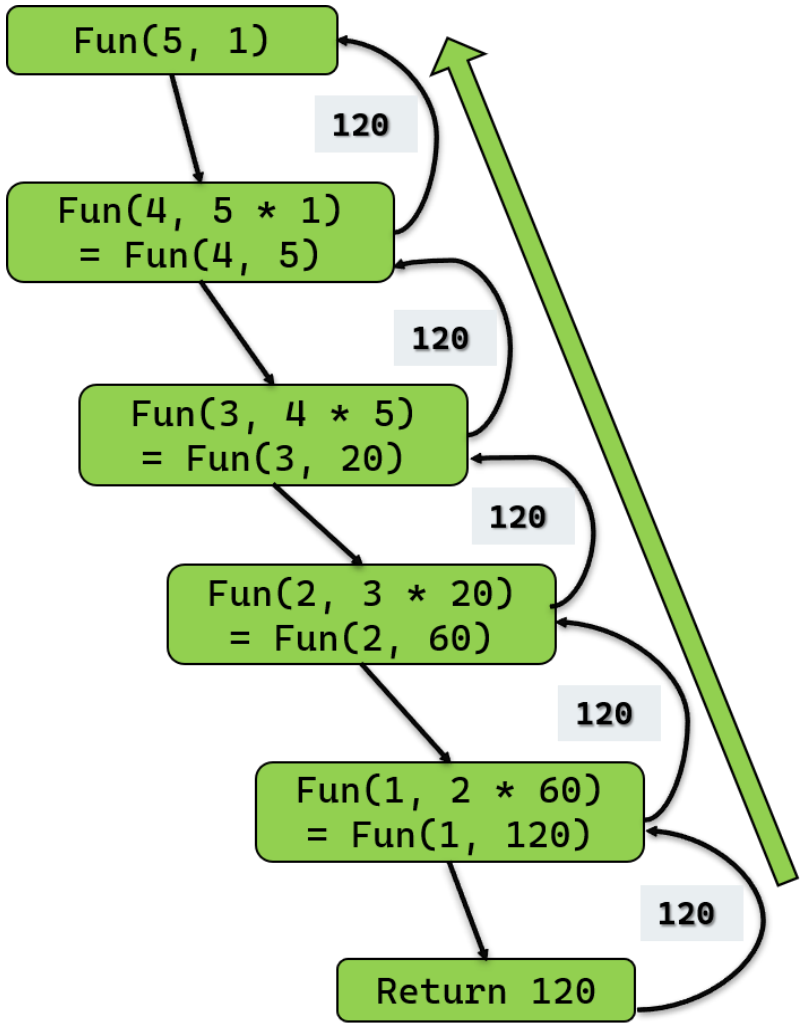
Find the Recursion Tree and Calculate the output

```
int fun1(int n)
{
    if (n == 1)
        return 0;
    else
        return 1 + fun1(n / 2);
}
```

For example, if n is between 8 and 15 then fun1() returns 3.
If n is between 16 to 31 then fun1() returns 4.

Example – 3: Calculate the output

```
#include <stdio.h>
int factTR(int n, int a){
    if (n ≤ 1)
        return a;
    return factTR(n – 1, n * a);
}
int fact(int n)
{
    return factTR(n, 1);
}
int main(){
    printf(“%d”, fact(5));
}
```



Example – 4: Assignment!!

Find the Recursion Tree and Calculate the output

```
int fun1(int x, int y)
{
     if (x == 0)
        return y;
     else
        return fun1(x – 1, x + y);
}
```

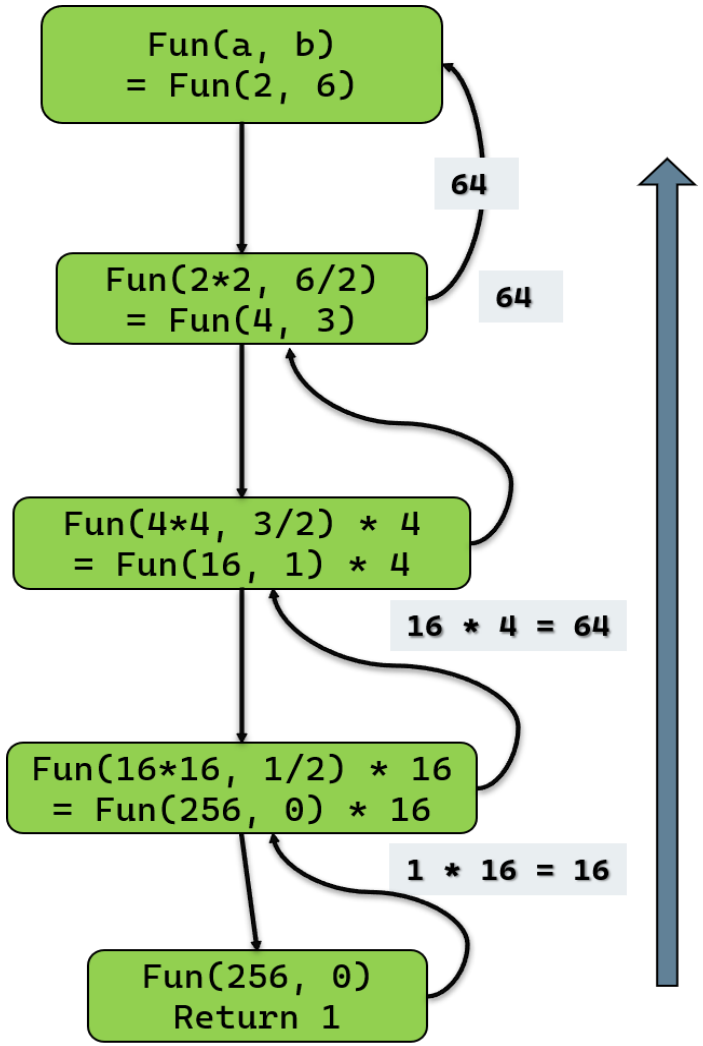
For example, if x is 5 and y is 2, then fun should return 15 + 2 = 17.

Example – 5: Calculate the output

```
#include<stdio.h>
int fun(int a, int b){
     if (b == 0)
        return 1;
     if (b % 2 == 0)
         return fun(a*a, b/2);
         return fun(a*a, b/2)*a;
}
int main(){
 printf("%d", fun(2, 6));
}
```

Output:

64



Example – 6: Assignment!!
Find the Recursion Tree and
Calculate the output

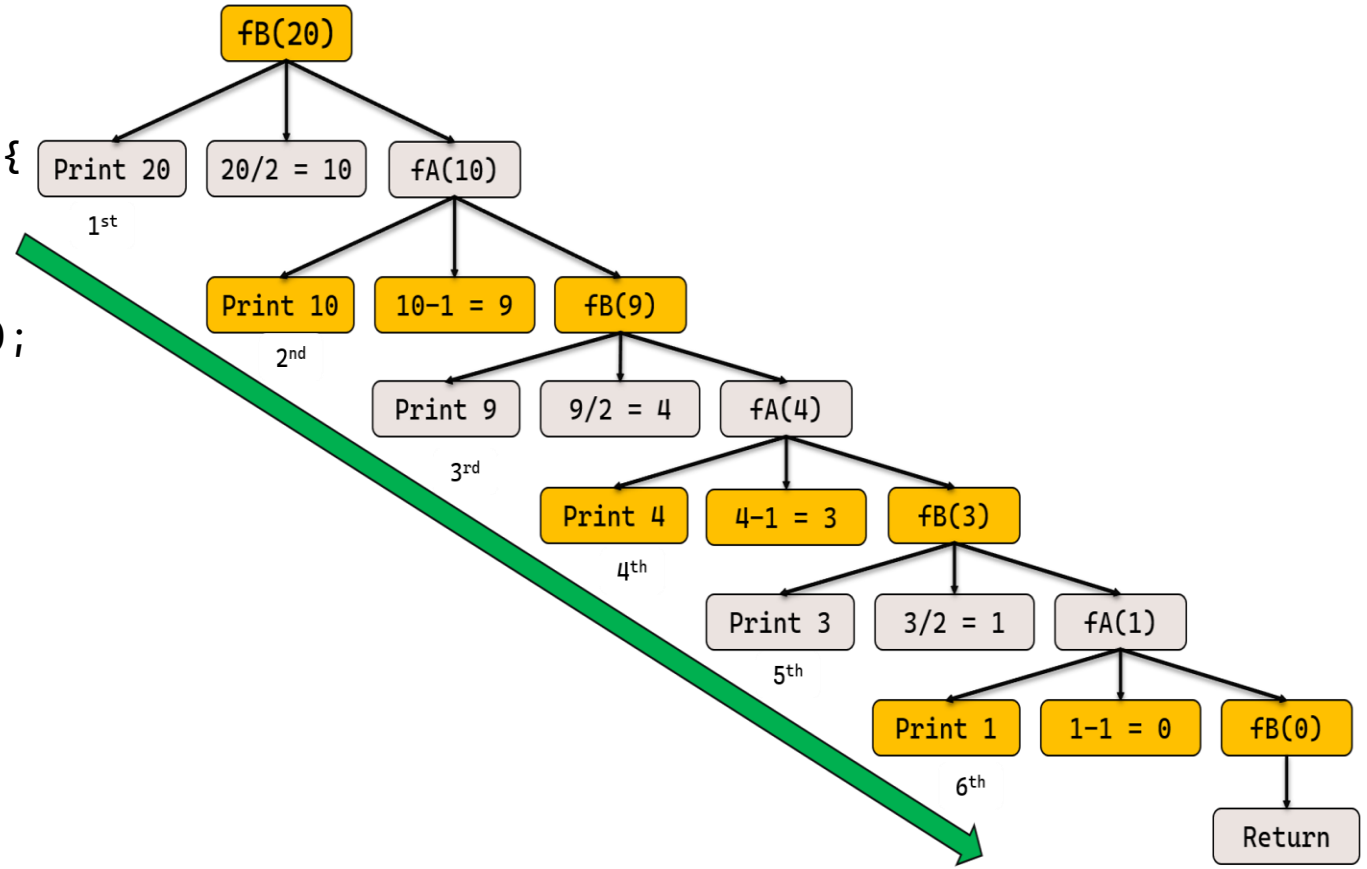
```
#include<stdio.h>
int fun(int a, int b) {
     if (b == 0)
        return 0;
     if (b % 2 == 0)
         return fun(a+a, b/2);
         return fun(a+a, b/2) + a;
}
int main(){
     printf("%d", fun(4, 3));
}
```

Output:

12

Example – 7: Calculate the output

```
void functionB(int n);
void functionA(int n){
      if (n < 1) {
         return;
      }
      printf("%d ", n);
      n = n – 1;
      functionB(n);
}
void functionB(int n){
      if (n < 2) {
         return;
      }
      printf("%d ", n);
      n = n / 2;
      functionA(n);
}
int main(){
     functionB(20);
}
```



Example – 8: Assignment!!
Find the Recursion Tree and Calculate the output

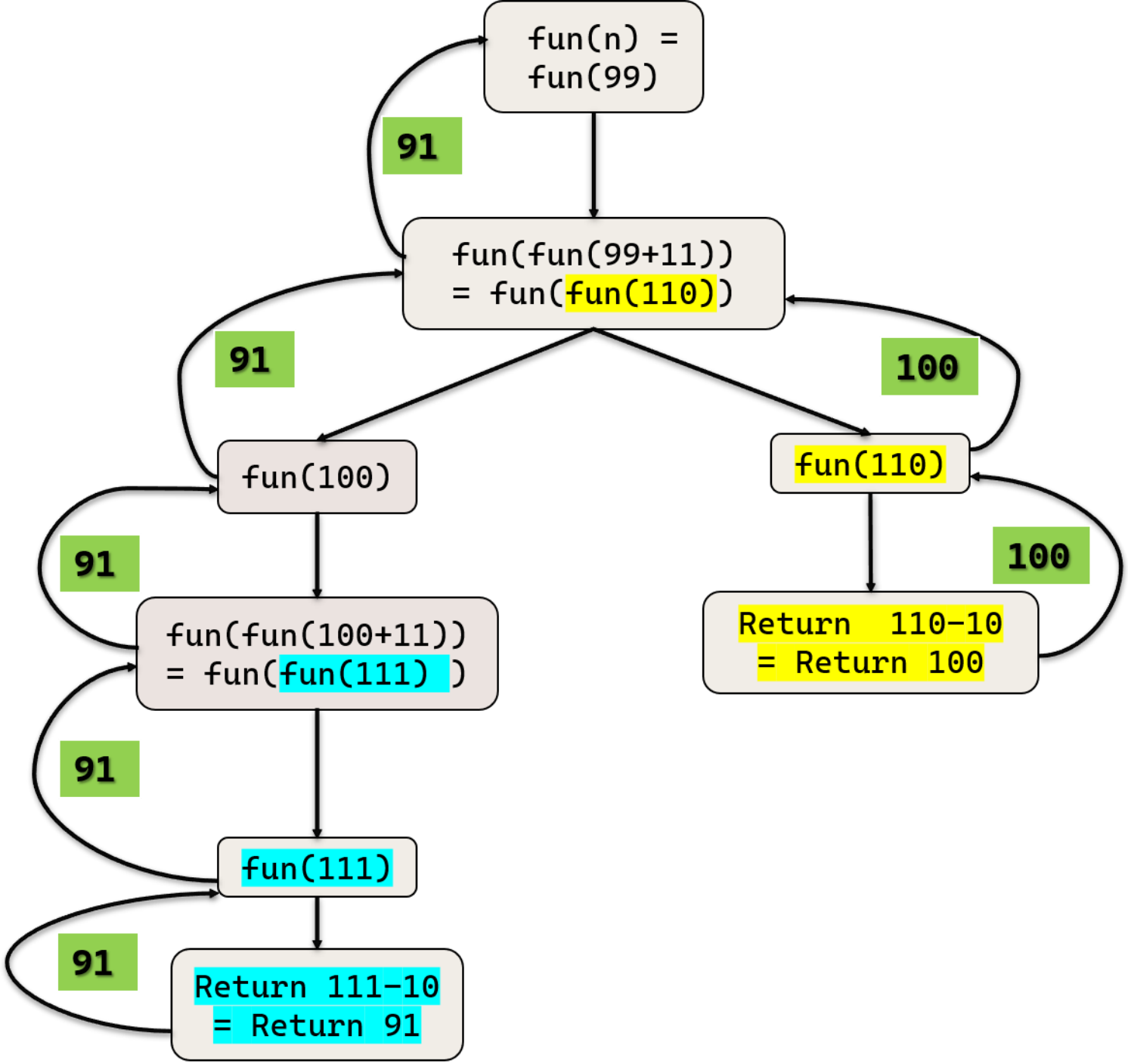
```
void functionB(int n);
void functionA(int n)
{
      if (n < 1) {
         return;
      }
      printf("%d ", n);
      n = n – 1;
      functionB(n);
}
void functionB(int n)
{
      if (n < 2) {
         return;
      }
      printf("%d ", n);
      n = n / 2;
      functionA(n);
}
int main(){
     functionA(20);
}
```

Example – 9: Calculate the output

```
#include<stdio.h>
int fun(int n)
{
     if (n > 100)
     return n – 10;
     return fun(fun(n+11));
}
int main()
{
     printf(" %d ", fun(99));
}
```

Output:

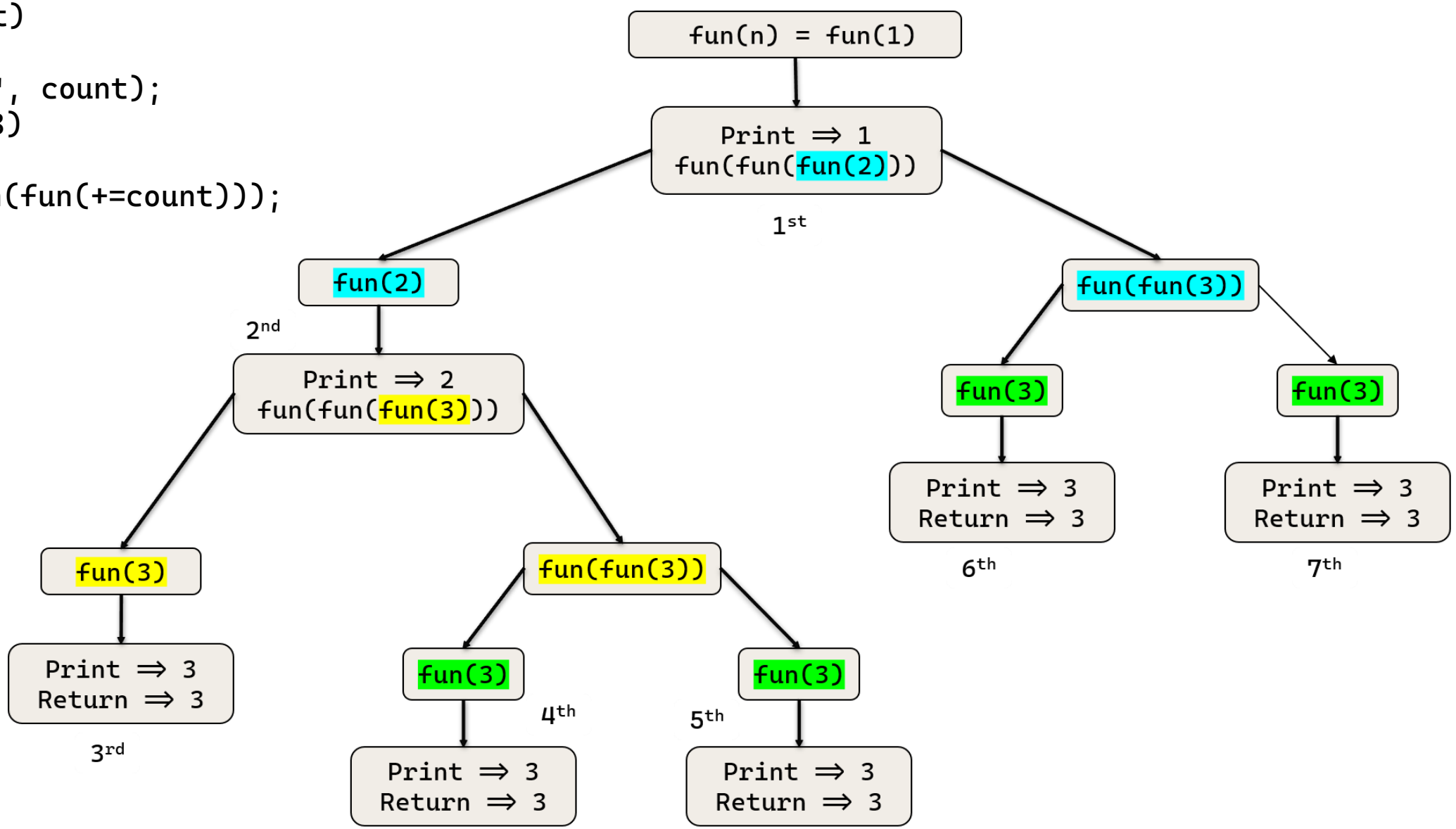
91



Example – 10: Guess the output of the following code.

```
#include<stdio.h>
int fun(int count)
{
     printf("%d ", count);
     if(count < 3)
     {
          fun(fun(fun(+=count)));
     }
     return
          count;
}
int main()
{
    fun(1);
}
```

Output:
1 2 3 3 3 3 3



❖Printing Pyramid Patterns using Recursion

Example-1: Write a recursion code for this pattern

```
*
* *
* * *
* * * *
* * * * *
```

```
#include <stdio.h>
void printn(int num) {
    if (num == 0)
        return;
    printf("* ");
    printn(num - 1);
}
void pattern(int n, int i) {
    if (n == 0)
        return;
    printn(i);
    printf("\n");
    pattern(n - 1, i + 1);
}
int main() {
    int n = 5;
    pattern(n, 1);
    return 0;
}
```

Example-2: Write a recursion code for this pattern

```
* * * * *
* * * *
* * *
* *
*
```

```
#include <stdio.h>
void printn(int num) {
    if (num == 0)
        return;
    printf("* ");
    printn(num - 1);
}
void pattern(int n) {
    if (n == 0)
        return;
    printn(n);
    printf("\n");
    pattern(n - 1);
}
int main() {
    int n = 5;
    pattern(n);
    return 0;
}
```