BORG AL ARAB TECHNOLOGICAL UNIVERSITY

CODE: ITS501

ADVANCED PROGRAMMING IN C

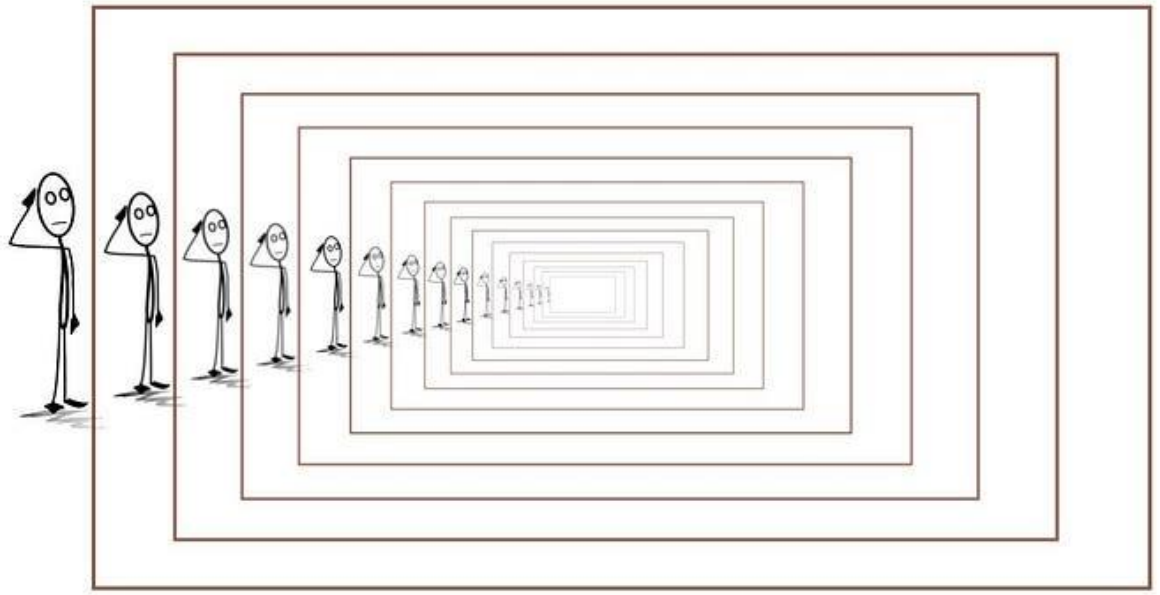
Third Year –Information Technology Program Fall 2026

LECTURE 3

UNDERSTANDING RECURSION IN C PROGRAMMING

WHAT IS RECURSION?

- **Definition:** Recursion is a programming technique where a function calls itself to solve a problem.
- **Key Concept:** A recursive function must have a base case to prevent infinite loops.



COMPONENTS OF A RECURSIVE FUNCTION

Base Case

- **Definition:** The condition under which the recursion stops.
- **Purpose:** Prevents infinite recursion and eventually returns a value.

```c
if (n == 0) return 1; // Base case for factorial
```

COMPONENTS OF A RECURSIVE FUNCTION

Recursive Case

- **Definition:** The part of the function where it calls itself.
- **Purpose:** Breaks down the problem into smaller sub-problems.

```
return n * factorial(n - 1); // Recursive case for factorial
```

GENERAL STRUCTURE OF A RECURSIVE FUNCTION

```
return_type function_name(parameters) {
    if (base_condition) {
        // Base case action
    } else {
        // Recursive case action
        return function_name(modified_parameters);
    }
}
```



FACTORIAL FUNCTION

The factorial of a non-negative integer n is the product of all positive integers less than or equal to n . It's defined as:

- $n! = n \times (n-1)!$ for $n > 0$
- $0! = 1$ (base case)

```
factorial(5)
    └─ 5 * factorial(4)
            └─ 4 * factorial(3)
                    └─ 3 * factorial(2)
                            └─ 2 * factorial(1)
                                    └─ 1 * factorial(0)
                                            └─ 1
```

- ***Explanation***: *5! = 5 × Fact(4) =5 × 4!=*
- *5× 4 × 3!=*
- *5× 4 × 3 × 2!=*
- *5× 4 × 3 × 2 × 1! =*
- *5× 4 × 3 × 2 × 1× 0! =*
- *5× 4 × 3 × 2 × 1× 1 = 120*

EXAMPLE

```c
#include <stdio.h>

// Recursive function to calculate factorial
int factorial(int n) {
    // Base case
    if (n == 0) {
        return 1;
    } else {
        // Recursive case
        return n * factorial(n - 1);
    }
}

int main() {
    int number = 5; // Example input
    printf("Factorial of %d is %d\n", number, factorial(number));
    return 0;
}
```

Explanation:

Base case: factorial(0) returns 1.

Recursive case: n * factorial(n - 1) reduces the problem size.

```
factorial(5)
  └─ factorial(4)
       └─ factorial(3)
            └─ factorial(2)
                 └─ factorial(1)
                      └─ factorial(0) -> returns 1
```

HOW THE CALLS HAPPEN

- **Call: factorial(5)**
  - n is 5, so it goes to the recursive case.
  - Calls factorial(4).
- **Call: factorial(4)**
  - n is 4, calls factorial(3).
- **Call: factorial(3)**
  - n is 3, calls factorial(2).
- **Call: factorial(2)**
  - n is 2, calls factorial(1).
- **Call: factorial(1)**
  - n is 1, calls factorial(0).
- **Call: factorial(0)**
  - Here, n is 0, which hits the base case.
  - Returns 1.

Now, we unwind the recursive calls:

7. **Return to factorial(1)**
   - Returns 1 * 1 = 1.
8. **Return to factorial(2)**
   - Returns 2 * 1 = 2.
9. **Return to factorial(3)**
   - Returns 3 * 2 = 6.
10. **Return to factorial(4)**
   - Returns 4 * 6 = 24.
11. **Return to factorial(5)**
   - Returns 5 * 24 = 120

The final output from factorial(5) is 120, as printed in the main function.

```c
#include <stdio.h>
// Function to calculate factorial recursively
unsigned long long factorial(int n) {
    // Debug: Print the current value of n
    printf("Calculating factorial of %d\n", n);

    // Base case: factorial of 0 or 1 is 1
    if (n == 0 || n == 1) {
        printf("Reached base case with n = %d\n", n);
        return 1;
    } else {
        // Recursive case: n * factorial(n - 1)
        unsigned long long result = n * factorial(n - 1);

        // Debug: Print the result of factorial(n)
        printf("Factorial of %d is %llu\n", n, result);
        return result;
    }
}

int main() {
    int number=5;
    // Prompt user for input
    printf("Enter a positive integer: ");
    //scanf("%d", &number);

    // Validate input
    if (number < 0) {
        printf("Factorial is not defined for negative numbers.\n");
        return 1;
    }
```

```
Enter a positive integer: Calculating factorial of 5
Calculating factorial of 4
Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
Reached base case with n = 1
Factorial of 2 is 2
Factorial of 3 is 6
Factorial of 4 is 24
Factorial of 5 is 120
Factorial of 5 is 120
```

C (C17 + GNU extensions)
known limitations

```
23 int main() {
24     int number;
25
26     // Prompt user for input
27     printf("Enter a positive integer: ");
28     //scanf("%d", &number);
29     number=3;
30     // Validate input
31     if (number < 0) {
32         printf("Factorial is not defined for negative numbers.\n");
33         return 1;
34     }
35
36     // Calculate factorial
37     unsigned long long result = factorial(number);
38
39     // Output the result
40     printf("Factorial of %d is %llu\n", number, result);
41
42     return 0;
43 }
```

Print output (drag lower right corner to resize)

Stack Heap

main

number	int ?
result	unsigned long long ?

Note: ? refers to an uninitialized value

C/C++ details: none [default view]

C (C17 + GNU extensions)
known limitations

```
23 int main() {
24     int number;
25
26     // Prompt user for input
27     printf("Enter a positive integer: ");
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42     return 0;
43 }
```

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Stack Heap

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42     return 0;
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```

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```
Enter a positive integer:
```

Stack Heap

main

number	int ?
result	unsigned long long ?

Note: ? refers to an uninitialized value

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known limitations

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int main() {
    int number;

    // Prompt user for input
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    //scanf("%d", &number);
    number=3;
    // Validate input
    if (number < 0) {
        printf("Factorial is not defined for negative numbers.\n");
        return 1;
    }

    // Calculate factorial
    unsigned long long result = factorial(number);

    // Output the result
    printf("Factorial of %d is %llu\n", number, result);

    return 0;
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer:
```

Stack Heap

main

number	int 3
result	unsigned long long ?

Note: ? refers to an uninitialized value

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23 int main() {
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Enter a positive integer:
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    if (n == 0 || n == 1) {
        printf("Reached base case with n = %d\n", n);
        return 1;
    } else {
        // Recursive case: n * factorial(n - 1)
        unsigned long long result = n * factorial(n - 1);

        // Debug: Print the result of factorial(n)
        printf("Factorial of %d is %llu\n", n, result);

        return result;
    }
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer:
```

Stack Heap

main

number	int	3
result	unsigned long long	?

factorial

n	int	?

Note: ? refers to an uninitialized value

C/C++ details: none [default view]

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        // Debug: Print the result of factorial(n)
        printf("Factorial of %d is %llu\n", n, result);

        return result;
    }
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer:
```

Stack Heap

main

number	int	3
result	unsigned long long	?

factorial

n	int	3

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        unsigned long long result = n * factorial(n - 1);

        // Debug: Print the result of factorial(n)
        printf("Factorial of %d is %llu\n", n, result);

        return result;
    }
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial
```

Stack Heap

main

number: int 3

result: unsigned long long ?

factorial

n: int 3

Note: ? refers to an uninitialized value

C/C++ details: none [default view]

C (C17 + GNU extensions)
known limitations

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        // Debug: Print the result of factorial(n)
        printf("Factorial of %d is %llu\n", n, result);

        return result;
    }
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial
```

Stack Heap

main

number	int 3
result	unsigned long long ?

factorial

n	int 3
result	unsigned long long ?

Note: ? refers to an uninitialized value

C/C++ details: none [default view]

C (C17 + GNU extensions)
known limitations

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    // Debug: Print the current value of n
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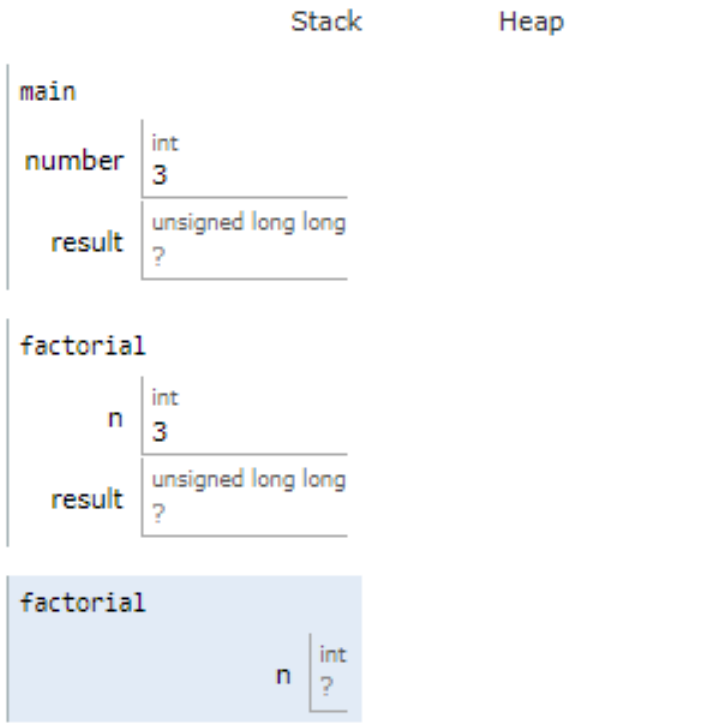
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        printf("Reached base case with n = %d\n", n);
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    } else {
        // Recursive case: n * factorial(n - 1)
        unsigned long long result = n * factorial(n - 1);

        // Debug: Print the result of factorial(n)
        printf("Factorial of %d is %llu\n", n, result);

        return result;
    }
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial
```



C (C17 + GNU extensions)
known limitations

```c
#include <stdio.h>

// Function to calculate factorial recursively
unsigned long long factorial(int n) {
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        return 1;
    } else {
        // Recursive case: n * factorial(n - 1)
        unsigned long long result = n * factorial(n - 1);

        // Debug: Print the result of factorial(n)
        printf("Factorial of %d is %llu\n", n, result);

        return result;
    }
}
```

Edit this code

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial
```

Stack Heap

main
- number: int 3
- result: unsigned long long ?

factorial
- n: int 3
- result: unsigned long long ?

factorial
- n: int 2

C (C17 + GNU extensions)
known limitations

```c
#include <stdio.h>

// Function to calculate factorial recursively
unsigned long long factorial(int n) {
    // Debug: Print the current value of n
    printf("Calculating factorial of %d\n", n);

    // Base case: factorial of 0 or 1 is 1
    if (n == 0 || n == 1) {
        printf("Reached base case with n = %d\n", n);
        return 1;
    } else {
        // Recursive case: n * factorial(n - 1)
        unsigned long long result = n * factorial(n - 1);

        // Debug: Print the result of factorial(n)
        printf("Factorial of %d is %llu\n", n, result);

        return result;
    }
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial
Calculating factorial of 2
```

Stack Heap

main
- number: int 3
- result: unsigned long long ?

factorial
- n: int 3
- result: unsigned long long ?

factorial
- n: int 2

C (C17 + GNU extensions)
known limitations

```c
#include <stdio.h>

// Function to calculate factorial recursively
unsigned long long factorial(int n) {
    // Debug: Print the current value of n
    printf("Calculating factorial of %d\n", n);

    // Base case: factorial of 0 or 1 is 1
    if (n == 0 || n == 1) {
        printf("Reached base case with n = %d\n", n);
        return 1;
    } else {
        // Recursive case: n * factorial(n - 1)
        unsigned long long result = n * factorial(n - 1);

        // Debug: Print the result of factorial(n)
        printf("Factorial of %d is %llu\n", n, result);

        return result;
    }
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial
Calculating factorial of 2
```

Stack Heap

main
- number: int 3
- result: unsigned long long ?

factorial
- n: int 3
- result: unsigned long long ?

factorial
- n: int 2
- result: unsigned long long ?

C (C17 + GNU extensions)
known limitations

```c
#include <stdio.h>

// Function to calculate factorial recursively
unsigned long long factorial(int n) {
    // Debug: Print the current value of n
    printf("Calculating factorial of %d\n", n);

    // Base case: factorial of 0 or 1 is 1
    if (n == 0 || n == 1) {
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        // Recursive case: n * factorial(n - 1)
        unsigned long long result = n * factorial(n - 1);

        // Debug: Print the result of factorial(n)
        printf("Factorial of %d is %llu\n", n, result);

        return result;
    }
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial
Calculating factorial of 2
```

Stack Heap

main
- number: int 3
- result: unsigned long long ?

factorial
- n: int 3
- result: unsigned long long ?

factorial
- n: int 2
- result: unsigned long long ?

factorial
- n: int ?

C (C17 + GNU extensions)
known limitations

```c
#include <stdio.h>

// Function to calculate factorial recursively
unsigned long long factorial(int n) {
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    } else {
        // Recursive case: n * factorial(n - 1)
        unsigned long long result = n * factorial(n - 1);

        // Debug: Print the result of factorial(n)
        printf("Factorial of %d is %llu\n", n, result);

        return result;
    }
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
```

Stack Heap

main
- number: int 3
- result: unsigned long long ?

factorial
- n: int 3
- result: unsigned long long ?

factorial
- n: int 2
- result: unsigned long long ?

factorial
- n: int 1

C (C17 + GNU extensions)
known limitations

```c
#include <stdio.h>

// Function to calculate factorial recursively
unsigned long long factorial(int n) {
    // Debug: Print the current value of n
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        // Recursive case: n * factorial(n - 1)
        unsigned long long result = n * factorial(n - 1);

        // Debug: Print the result of factorial(n)
        printf("Factorial of %d is %llu\n", n, result);

        return result;
    }
}
```

Edit this code

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
```

Stack Heap

main
- number: int 3
- result: unsigned long long ?

factorial
- n: int 3
- result: unsigned long long ?

factorial
- n: int 2
- result: unsigned long long ?

factorial
- n: int 1

C (C17 + GNU extensions)
known limitations

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// Function to calculate factorial recursively
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        return result;
    }
}
```

Edit this code

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
```

Stack Heap

main
- number: int 3
- result: unsigned long long ?

factorial
- n: int 3
- result: unsigned long long ?

factorial
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- result: unsigned long long ?

factorial
- n: int 1

C (C17 + GNU extensions)
known limitations

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        // Debug: Print the result of factorial(n)
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        return result;
    }
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
Reached base case with n = 1
```

Stack Heap

main
- number: int 3
- result: unsigned long long ?

factorial
- n: int 3
- result: unsigned long long ?

factorial
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- result: unsigned long long ?

factorial
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C (C17 + GNU extensions)
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```
11          return 1;
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16          // Debug: Print the result of factorial(n)
17          printf("Factorial of %d is %llu\n", n, result);
18
19          return result;
20      }
21  }
22
23  int main() {
24      int number;
25
26      // Prompt user for input
27      printf("Enter a positive integer: ");
28      //scanf("%d", &number);
29      number=3;
30      // Validate input
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
Reached base case with n = 1
```

Stack Heap

main
- number: int 3
- result: unsigned long long ?

factorial
- n: int 3
- result: unsigned long long ?

factorial
- n: int 2
- result: unsigned long long ?

factorial
- n: int 1

C (C17 + GNU extensions)
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11          return 1;
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```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
Reached base case with n = 1
```

Stack Heap

main
- number: int 3
- result: unsigned long long ?

factorial
- n: int 3
- result: unsigned long long ?

factorial
- n: int 2
- result: unsigned long long ?

factorial
- n: int 1

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25
26      // Prompt user for input
27      printf("Enter a positive integer: ");
28      //scanf("%d", &number);
29      number=3;
30      // Validate input
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
Reached base case with n = 1
```

Stack Heap

main

number	int	3
result	unsigned long long	?

factorial

n	int	3
result	unsigned long long	?

factorial

n	int	2
result	unsigned long long	2

C (C17 + GNU extensions)
known limitations

```
11          return 1;
12      } else {
13          // Recursive case: n * factorial(n - 1)
14          unsigned long long result = n * factorial(n - 1);
15
16          // Debug: Print the result of factorial(n)
17          printf("Factorial of %d is %llu\n", n, result);
18
19          return result;
20      }
21  }
22
23  int main() {
24      int number;
25
26      // Prompt user for input
27      printf("Enter a positive integer: ");
28      //scanf("%d", &number);
29      number=3;
30      // Validate input
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
Reached base case with n = 1
Factorial of 2 is 2
```

Stack Heap

main
- number: int 3
- result: unsigned long long ?

factorial
- n: int 3
- result: unsigned long long ?

factorial
- n: int 2
- result: unsigned long long 2

C (C17 + GNU extensions)
known limitations

```
11          return 1;
12      } else {
13          // Recursive case: n * factorial(n - 1)
14          unsigned long long result = n * factorial(n - 1);
15
16          // Debug: Print the result of factorial(n)
17          printf("Factorial of %d is %llu\n", n, result);
18
19          return result;
20      }
21  }
22
23  int main() {
24      int number;
25
26      // Prompt user for input
27      printf("Enter a positive integer: ");
28      //scanf("%d", &number);
29      number=3;
30      // Validate input
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
Reached base case with n = 1
Factorial of 2 is 2
```

Stack Heap

main

number	int	3
result	unsigned long long	?

factorial

n	int	3
result	unsigned long long	?

factorial

n	int	2
result	unsigned long long	2

C (C17 + GNU extensions)
known limitations

```
11          return 1;
12      } else {
13          // Recursive case: n * factorial(n - 1)
14          unsigned long long result = n * factorial(n - 1);
15
16          // Debug: Print the result of factorial(n)
17          printf("Factorial of %d is %llu\n", n, result);
18
19          return result;
20      }
21  }
22
23  int main() {
24      int number;
25
26      // Prompt user for input
27      printf("Enter a positive integer: ");
28      //scanf("%d", &number);
29      number=3;
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
Reached base case with n = 1
Factorial of 2 is 2
```

Stack Heap

main

number	int	3
result	unsigned long long	?

factorial

n	int	3
result	unsigned long long	?

factorial

n	int	2

C (C17 + GNU extensions)
known limitations

```
11          return 1;
12      } else {
13          // Recursive case: n * factorial(n - 1)
14          unsigned long long result = n * factorial(n - 1);
15
16          // Debug: Print the result of factorial(n)
17          printf("Factorial of %d is %llu\n", n, result);
18
19          return result;
20      }
21  }
22
23  int main() {
24      int number;
25
26      // Prompt user for input
27      printf("Enter a positive integer: ");
28      //scanf("%d", &number);
29      number=3;
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
Reached base case with n = 1
Factorial of 2 is 2
```

Stack Heap

main

number	int 3
result	unsigned long long ?

factorial

n	int 3
result	unsigned long long 6

C (C17 + GNU extensions)
known limitations

```
11          return 1;
12      } else {
13          // Recursive case: n * factorial(n - 1)
14          unsigned long long result = n * factorial(n - 1);
15
16          // Debug: Print the result of factorial(n)
17          printf("Factorial of %d is %llu\n", n, result);
18
19          return result;
20      }
21  }
22
23  int main() {
24      int number;
25
26      // Prompt user for input
27      printf("Enter a positive integer: ");
28      //scanf("%d", &number);
29      number=3;
30      // Validate input
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
Reached base case with n = 1
Factorial of 2 is 2
Factorial of 3 is 6
```

Stack Heap

main

number	int 3
result	unsigned long long ?

factorial

n	int 3
result	unsigned long long 6

C (C17 + GNU extensions)
known limitations

```
11          return 1;
12      } else {
13          // Recursive case: n * factorial(n - 1)
14          unsigned long long result = n * factorial(n - 1);
15
16          // Debug: Print the result of factorial(n)
17          printf("Factorial of %d is %llu\n", n, result);
18
19          return result;
20      }
21  }
22
23  int main() {
24      int number;
25
26      // Prompt user for input
27      printf("Enter a positive integer: ");
28      //scanf("%d", &number);
29      number=3;
30      // Validate input
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
Reached base case with n = 1
Factorial of 2 is 2
Factorial of 3 is 6
```

Stack Heap

main

number	int 3
result	unsigned long long ?

factorial

n	int 3
result	unsigned long long 6

C (C17 + GNU extensions)
known limitations

```
11          return 1;
12      } else {
13          // Recursive case: n * factorial(n - 1)
14          unsigned long long result = n * factorial(n - 1);
15
16          // Debug: Print the result of factorial(n)
17          printf("Factorial of %d is %llu\n", n, result);
18
19          return result;
20      }
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22
23  int main() {
24      int number;
25
26      // Prompt user for input
27      printf("Enter a positive integer: ");
28      //scanf("%d", &number);
29      number=3;
30      // Validate input
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
Reached base case with n = 1
Factorial of 2 is 2
Factorial of 3 is 6
```

Stack Heap

main

number	int	3
result	unsigned long long	?

factorial

n	int	3

C (C17 + GNU extensions)
known limitations

```
23 int main() {
24     int number;
25
26     // Prompt user for input
27     printf("Enter a positive integer: ");
28     //scanf("%d", &number);
29     number=3;
30     // Validate input
31     if (number < 0) {
32         printf("Factorial is not defined for negative numbers.\n");
33         return 1;
34     }
35
36     // Calculate factorial
37     unsigned long long result = factorial(number);
38
39     // Output the result
40     printf("Factorial of %d is %llu\n", number, result);
41
42     return 0;
43 }
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
Reached base case with n = 1
Factorial of 2 is 2
Factorial of 3 is 6
```

Stack Heap

main

number	int	3
result	unsigned long long	6

C/C++ details: none [default view]

C (C17 + GNU extensions)
known limitations

```c
int main() {
    int number;

    // Prompt user for input
    printf("Enter a positive integer: ");
    //scanf("%d", &number);
    number=3;
    // Validate input
    if (number < 0) {
        printf("Factorial is not defined for negative numbers.\n");
        return 1;
    }

    // Calculate factorial
    unsigned long long result = factorial(number);

    // Output the result
    printf("Factorial of %d is %llu\n", number, result);

    return 0;
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
Reached base case with n = 1
Factorial of 2 is 2
Factorial of 3 is 6
Factorial of 3 is 6
```

Stack Heap

main

number	int 3
result	unsigned long long 6

C/C++ details: none [default view]

C (C17 + GNU extensions)
known limitations

```c
int main() {
    int number;

    // Prompt user for input
    printf("Enter a positive integer: ");
    //scanf("%d", &number);
    number=3;
    // Validate input
    if (number < 0) {
        printf("Factorial is not defined for negative numbers.\n");
        return 1;
    }

    // Calculate factorial
    unsigned long long result = factorial(number);

    // Output the result
    printf("Factorial of %d is %llu\n", number, result);

    return 0;
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating factorial of 3
Calculating factorial of 2
Calculating factorial of 1
Reached base case with n = 1
Factorial of 2 is 2
Factorial of 3 is 6
Factorial of 3 is 6
```

Stack Heap

main

number	int	3
result	unsigned long long	6

C/C++ details: none [default view]

KEY POINTS

- **Base Case:** Prevents infinite recursion (stops the recursion).
- **Recursive Case:** Defines how to break the problem into smaller parts.
- **Call Stack:** Each function call waits for the result of the next until the base case is reached, and then results are returned in reverse order.

CALCULATING THE SUM OF FIRST N NATURAL NUMBERS USING RECURSION

- **Problem Statement:** How can we calculate the sum of the first n natural numbers?
- **Example:** For n=5, the sum is 1+2+3+4+5=15
  - Mathematical Formula:

$$\text{Sum}(n) = n + \text{Sum}(n-1)$$

  - Base Case:

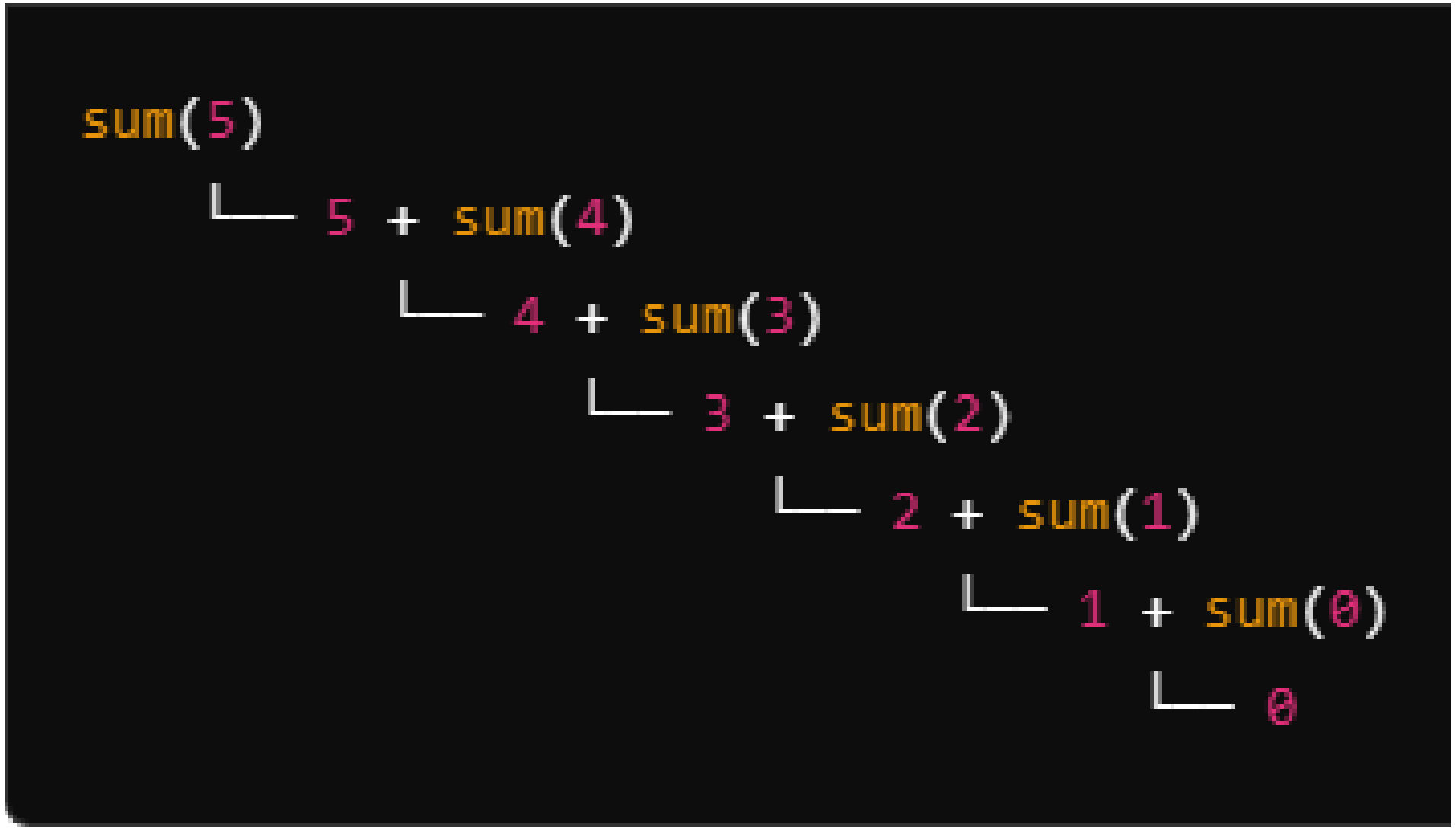
$$\text{Sum}(0) = 0$$

RECURSIVE SUM FUNCTION

```c
int sum(int n) {
    if (n == 0) return 0;  // Base case
    return n + sum(n - 1); // Recursive case
}
```

Explanation:
If n is 0, return 0.
Otherwise,
return n+sum(n−1).

VISUALIZING THE RECURSIVE CALLS



STEP-BY-STEP CALCULATION

- **Calculate:** sum(5)Calls sum(4)
- **Calculate:** sum(4)Calls sum(3)
- **Calculate:** sum(3)Calls sum(2)
- **Calculate:** sum(2)Calls sum(1)
- **Calculate:** sum(1)Calls sum(0)
- **Base Case:** sum(0) returns 0

- **Breakdown:**
- sum(1) returns 1+0=1
- sum(2) returns 2+1=3
- sum(3) returns 3+3=6
- sum(4) returns 4+6=10
- sum(5) returns 5+10=15

```c
#include <stdio.h>

// Function to calculate the sum of the first n natural numbers recursively
int sum_natural(int n) {
    // Debug: Print the current value of n
    printf("Calculating sum of first %d natural numbers\n", n);
    // Base case: sum of first 0 natural numbers is 0
    if (n == 0) {
        printf("Reached base case with n = %d\n", n);
        return 0;
    } else {
        // Recursive case: n + sum of first (n - 1) natural numbers
        int result = n + sum_natural(n - 1);

        // Debug: Print the current sum at this level of recursion
        printf("Sum of first %d natural numbers is %d\n", n, result);
        return result;
    }
}

int main() {
    int number=10;

    // Prompt user for input
    printf("Enter a positive integer: ");
    //scanf("%d", &number);

    // Validate input
    if (number < 0) {
        printf("Sum is not defined for negative numbers.\n");
        return 1;
    }
```

```
Enter a positive integer: Calculating sum of first 10 natural numbers
Calculating sum of first 9 natural numbers
Calculating sum of first 8 natural numbers
Calculating sum of first 7 natural numbers
Calculating sum of first 6 natural numbers
Calculating sum of first 5 natural numbers
Calculating sum of first 4 natural numbers
Calculating sum of first 3 natural numbers
Calculating sum of first 2 natural numbers
Calculating sum of first 1 natural numbers
Calculating sum of first 0 natural numbers
Reached base case with n = 0
Sum of first 1 natural numbers is 1
Sum of first 2 natural numbers is 3
Sum of first 3 natural numbers is 6
Sum of first 4 natural numbers is 10
Sum of first 5 natural numbers is 15
Sum of first 6 natural numbers is 21
Sum of first 7 natural numbers is 28
Sum of first 8 natural numbers is 36
Sum of first 9 natural numbers is 45
Sum of first 10 natural numbers is 55
Sum of first 10 natural numbers is 55
```

C (C17 + GNU extensions)
known limitations

```
23 int main() {
24     int number=3;
25
26     // Prompt user for input
27     printf("Enter a positive integer: ");
28     //scanf("%d", &number);
29
30     // Validate input
31     if (number < 0) {
32         printf("Sum is not defined for negative numbers.\n");
33         return 1;
34     }
35
36     // Calculate sum of first n natural numbers
37     int result = sum_natural(number);
38
39     // Output the result
40     printf("Sum of first %d natural numbers is %d\n", number, result);
41
42     return 0;
43 }
```

Print output (drag lower right corner to resize)

Stack Heap

main
number int ?
result int ?

Note: ? refers to an uninitialized value

C/C++ details: none [default view]

C (C17 + GNU extensions)
known limitations

```
23 int main() {
24     int number=3;
25
26     // Prompt user for input
27     printf("Enter a positive integer: ");
28     //scanf("%d", &number);
29
30     // Validate input
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37     int result = sum_natural(number);
38
39     // Output the result
40     printf("Sum of first %d natural numbers is %d\n", number, result);
41
42     return 0;
43 }
```

Print output (drag lower right corner to resize)

Stack Heap

main

number	int ?
result	int ?

Note: ? refers to an uninitialized value

C/C++ details: none [default view]

C (C17 + GNU extensions)
known limitations

```
23 int main() {
24     int number=3;
25
26     // Prompt user for input
27     printf("Enter a positive integer: ");
28     //scanf("%d", &number);
29
30     // Validate input
31     if (number < 0) {
32         printf("Sum is not defined for negative numbers.\n");
33         return 1;
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35
36     // Calculate sum of first n natural numbers
37     int result = sum_natural(number);
38
39     // Output the result
40     printf("Sum of first %d natural numbers is %d\n", number, result);
41
42     return 0;
43 }
```

Print output (drag lower right corner to resize)

Stack Heap

main

number	int 3
result	int ?

Note: ? refers to an uninitialized value

C/C++ details: none [default view]

C (C17 + GNU extensions)
known limitations

```c
int main() {
    int number=3;

    // Prompt user for input
    printf("Enter a positive integer: ");
    //scanf("%d", &number);

    // Validate input
    if (number < 0) {
        printf("Sum is not defined for negative numbers.\n");
        return 1;
    }

    // Calculate sum of first n natural numbers
    int result = sum_natural(number);

    // Output the result
    printf("Sum of first %d natural numbers is %d\n", number, result);

    return 0;
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer:
```

Stack Heap

main

number	int 3
result	int ?

Note: ? refers to an uninitialized value

C/C++ details: none [default view]

C (C17 + GNU extensions)
known limitations

```c
int main() {
    int number=3;

    // Prompt user for input
    printf("Enter a positive integer: ");
    //scanf("%d", &number);

    // Validate input
    if (number < 0) {
        printf("Sum is not defined for negative numbers.\n");
        return 1;
    }

    // Calculate sum of first n natural numbers
    int result = sum_natural(number);

    // Output the result
    printf("Sum of first %d natural numbers is %d\n", number, result);

    return 0;
}
```

Edit this code

Print output (drag lower right corner to resize)

```
Enter a positive integer:
```

Stack Heap

main

number	int	3
result	int	?

Note: ? refers to an uninitialized value

C/C++ details: none [default view]

C (C17 + GNU extensions)
known limitations

```c
#include <stdio.h>

// Function to calculate the sum of the first n natural numbers recursively
int sum_natural(int n) {
    // Debug: Print the current value of n
    printf("Calculating sum of first %d natural numbers\n", n);

    // Base case: sum of first 0 natural numbers is 0
    if (n == 0) {
        printf("Reached base case with n = %d\n", n);
        return 0;
    } else {
        // Recursive case: n + sum of first (n - 1) natural numbers
        int result = n + sum_natural(n - 1);

        // Debug: Print the current sum at this level of recursion
        printf("Sum of first %d natural numbers is %d\n", n, result);

        return result;
    }
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer:
```

Stack Heap

main

number	int	3
result	int	?

sum_natural

n	int	?

Note: ? refers to an uninitialized value

C/C++ details: none [default view]

C (C17 + GNU extensions)
known limitations

```c
#include <stdio.h>

// Function to calculate the sum of the first n natural numbers recursively
int sum_natural(int n) {
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    } else {
        // Recursive case: n + sum of first (n - 1) natural numbers
        int result = n + sum_natural(n - 1);

        // Debug: Print the current sum at this level of recursion
        printf("Sum of first %d natural numbers is %d\n", n, result);

        return result;
    }
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer:
```

Stack Heap

main

number	int 3
result	int ?

sum_natural

n	int 3

Note: ? refers to an uninitialized value

C/C++ details: none [default view]

C (C17 + GNU extensions)
known limitations

```c
#include <stdio.h>

// Function to calculate the sum of the first n natural numbers recursively
int sum_natural(int n) {
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        // Recursive case: n + sum of first (n - 1) natural numbers
        int result = n + sum_natural(n - 1);

        // Debug: Print the current sum at this level of recursion
        printf("Sum of first %d natural numbers is %d\n", n, result);

        return result;
    }
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating sum of fir
```

Stack Heap

main

number	int	3
result	int	?

sum_natural

n	int	3

Note: ? refers to an uninitialized value

C/C++ details: none [default view]

C (C17 + GNU extensions)
known limitations

```c
#include <stdio.h>

// Function to calculate the sum of the first n natural numbers recursively
int sum_natural(int n) {
    // Debug: Print the current value of n
    printf("Calculating sum of first %d natural numbers\n", n);

    // Base case: sum of first 0 natural numbers is 0
    if (n == 0) {
        printf("Reached base case with n = %d\n", n);
        return 0;
    } else {
        // Recursive case: n + sum of first (n - 1) natural numbers
        int result = n + sum_natural(n - 1);

        // Debug: Print the current sum at this level of recursion
        printf("Sum of first %d natural numbers is %d\n", n, result);

        return result;
    }
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating sum of fir
```

Stack Heap

main

number	int 3
result	int ?

sum_natural

n	int 3
result	int ?

Note: ? refers to an uninitialized value

C/C++ details: none [default view]

C (C17 + GNU extensions)
known limitations

```c
#include <stdio.h>

// Function to calculate the sum of the first n natural numbers recursively
int sum_natural(int n) {
    // Debug: Print the current value of n
    printf("Calculating sum of first %d natural numbers\n", n);

    // Base case: sum of first 0 natural numbers is 0
    if (n == 0) {
        printf("Reached base case with n = %d\n", n);
        return 0;
    } else {
        // Recursive case: n + sum of first (n - 1) natural numbers
        int result = n + sum_natural(n - 1);

        // Debug: Print the current sum at this level of recursion
        printf("Sum of first %d natural numbers is %d\n", n, result);

        return result;
    }
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating sum of first 3 natura
```

Stack Heap

main
- number: int 3
- result: int ?

sum_natural
- n: int 3
- result: int ?

sum_natural
- n: int ?

C (C17 + GNU extensions)
known limitations

```c
#include <stdio.h>

// Function to calculate the sum of the first n natural numbers recursively
int sum_natural(int n) {
    // Debug: Print the current value of n
    printf("Calculating sum of first %d natural numbers\n", n);

    // Base case: sum of first 0 natural numbers is 0
    if (n == 0) {
        printf("Reached base case with n = %d\n", n);
        return 0;
    } else {
        // Recursive case: n + sum of first (n - 1) natural numbers
        int result = n + sum_natural(n - 1);

        // Debug: Print the current sum at this level of recursion
        printf("Sum of first %d natural numbers is %d\n", n, result);

        return result;
    }
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating sum of first 3 natura
```

Stack Heap

main
- number: int 3
- result: int ?

sum_natural
- n: int 3
- result: int ?

sum_natural
- n: int 2

C (C17 + GNU extensions)
known limitations

```c
#include <stdio.h>

// Function to calculate the sum of the first n natural numbers recursively
int sum_natural(int n) {
    // Debug: Print the current value of n
    printf("Calculating sum of first %d natural numbers\n", n);

    // Base case: sum of first 0 natural numbers is 0
    if (n == 0) {
        printf("Reached base case with n = %d\n", n);
        return 0;
    } else {
        // Recursive case: n + sum of first (n - 1) natural numbers
        int result = n + sum_natural(n - 1);

        // Debug: Print the current sum at this level of recursion
        printf("Sum of first %d natural numbers is %d\n", n, result);

        return result;
    }
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating sum of first 3 natura
Calculating sum of first 2 natural numbers
```

Stack Heap

main
- number: int 3
- result: int ?

sum_natural
- n: int 3
- result: int ?

sum_natural
- n: int 2
- result: int ?

C (C17 + GNU extensions)
known limitations

```c
#include <stdio.h>

// Function to calculate the sum of the first n natural numbers recursively
int sum_natural(int n) {
    // Debug: Print the current value of n
    printf("Calculating sum of first %d natural numbers\n", n);

    // Base case: sum of first 0 natural numbers is 0
    if (n == 0) {
        printf("Reached base case with n = %d\n", n);
        return 0;
    } else {
        // Recursive case: n + sum of first (n - 1) natural numbers
        int result = n + sum_natural(n - 1);

        // Debug: Print the current sum at this level of recursion
        printf("Sum of first %d natural numbers is %d\n", n, result);

        return result;
    }
}
```

Print output (drag lower right corner to resize)

```
Enter a positive integer: Calculating sum of first 3 natura
Calculating sum of first 2 natural numbers
```

Stack Heap

main
- number: int 3
- result: int ?

sum_natural
- n: int 3
- result: int ?

sum_natural
- n: int 2
- result: int ?

sum_natural
- n: int 1

C (C17 + GNU extensions)
known limitations

```c
#include <stdio.h>

// Function to calculate the sum of the first n natural numbers recursively
int sum_natural(int n) {
    // Debug: Print the current value of n
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        return 0;
    } else {
        // Recursive case: n + sum of first (n - 1) natural numbers
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}
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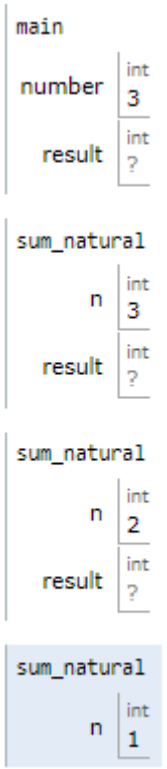
Stack Heap

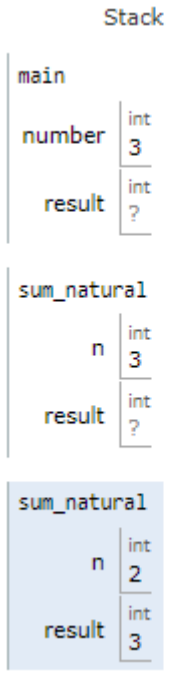
main
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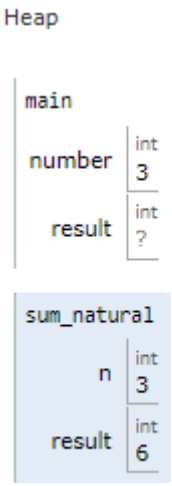
sum_natural
- n: int 3
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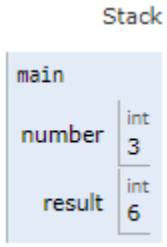
sum_natural
- n: int 2

AFTER SOME STEPS .....



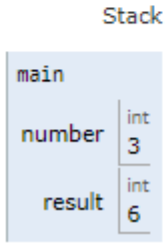






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```
Enter a positive integer: Calculating sum of first 3 natural numbers
Calculating sum of first 2 natural numbers
Calculating sum of first 1 natural numbers
Calculating sum of first 0 natural numbers
Reached base case with n = 0
Sum of first 1 natural numbers is 1
Sum of first 2 natural numbers is 3
Sum of first 3 natural numbers is 6
Sum of first 3 natural numbers is 6
```



ADVANTAGES OF USING RECURSION

- **Simplicity:**
  - Easier to read and maintain than iterative solutions.
- **Natural Fit:**
  - Suitable for problems that can be defined in terms of smaller sub-problems.
- **Reduced Code Size:**
  - Recursive solutions can require fewer lines of code, making them easier to maintain and debug.
- **Easier to Conceptualize:**
  - Recursion closely mirrors the mathematical definition of problems, which can make the implementation more intuitive.

DISADVANTAGES OF RECURSION

- **Memory Usage:** Each recursive call consumes stack space.
- **Performance:** Can be slower than iterative approaches due to overhead.
- **Limited by Stack Size:** This makes it unsuitable for very large problems.
- **Difficult to Debug:** Debugging recursive functions can be more challenging due to multiple function calls and the complexity of the call stack.