

# The Longest Collatz Sequence

## Question 02

### Story

The Collatz Conjecture, also known as the " $3n + 1$ " problem, is a famous unsolved problem in mathematics. The conjecture involves a sequence of numbers generated from a starting point following these rules:

1. If the number is even, divide it by 2.
2. If the number is odd, multiply it by 3 and add 1.

This process repeats until the number becomes 1. The Collatz Conjecture suggests that this process will always reach 1, regardless of the starting number. As a mathematician, you have been tasked with exploring the Collatz sequences to find the starting number under a given limit that produces the longest sequence.

### Problem Statement

Given a limit  $N$ , your task is to find the starting number under  $N$  that produces the longest Collatz sequence. You must determine the length of each Collatz sequence and identify the starting number with the longest length. Write a C program that calculates the length of Collatz sequences for all starting numbers under  $N$  and returns the number with the longest sequence.

### Input

- A single integer  $N > 1$ , representing the upper limit for the starting numbers.

### Output

- The starting number under  $N$  that produces the longest Collatz sequence.
- The length of the longest Collatz sequence.

### Hints

- Consider implementing a function that calculates the Collatz sequence length for a given starting number.
- Keep track of the lengths to identify the longest sequence.
- Use a loop to iterate through all starting numbers under  $N$ .

### Example Scenario

Given a limit of 10, the longest Collatz sequence is produced by the starting number 9, with a length of 20.

## Tasks

1. **Collatz Sequence Function:** Write a function that calculates the Collatz sequence length for a given starting number.
2. **Longest Collatz Sequence:** Implement a function that finds the starting number under  $N$  with the longest Collatz sequence.
3. **Main Program:** Create a program that takes an upper limit  $N$  and outputs the starting number with the longest Collatz sequence and its length.

## Deliverables

- The source code of your program, with comments explaining the logic and key sections.
- A brief explanation of the approach taken to solve the problem.