

CS101 - Data Abstraction

DS Basics - Module2

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Ready for a programming challenge?



- Given the following arr, find the indices for the minimum value, maximum value, and calculate average for the entire array.

```
arr = [[7, 12, 4, -1], [-2, 3],  
       [8, 9, 0, 1], [-12, 3, 4], [2]]
```

An array of objects



- **An array of objects** is a set of objects, with each object is of heterogeneous type.
- So a homogeneous data store with heterogeneous cells?

A List of objects



- **Example:**

student.py, driver.py, and stub.py in code/student folder.

An alternative approach to Process Data



- **Recursion** is a technique that solves a problem by solving a smaller problem of the same type.
- Sometimes, the best way to solve a problem is by solving a smaller version of the exact same problem first.

Recursion Vs Iteration



- Iteration can be used in place of recursion.
 - An iterative algorithm uses a looping construct.
 - A recursive algorithm uses a branching structure.
- Recursive solutions are often less efficient, in terms of both time and space, than iterative solutions.
- Recursion can simplify the solution of a problem, often resulting in shorter, more easily understood source code.

How do I write a recursive function?

- Determine the size factor
- Determine the base case(s)
(the one for which you know the answer)
- Determine the general case(s)
(the one where the problem is expressed as a smaller version of itself)
- Verify the algorithm
use the ("Three-Question-Method")
- Draw a **Recursive Tree** to break down the problem step by step.

Three-Question Verification Method

1 The Base-Case Question:

Is there a nonrecursive way out of the function, and does the routine work correctly for this base case?

2 The Smaller-Caller Question:

Does each recursive call to the function involve a smaller case of the original problem, leading inescapably to the base case?

3 The General-Case Question:

Assuming that the recursive call(s) work correctly, does the whole function work correctly?

Example 1: Factorial Calculation



factoStack

- Question: What is "12!"?
 - $12! = 12 \cdot 11 \cdot 10 \cdot 9 \cdot 8 \cdot 7 \cdot 6 \cdot 5 \cdot 4 \cdot 3 \cdot 2 \cdot 1$
 - $12! = 479,001,600$
- Iterative calculation: Put it in a for-loop.
- Recursive calculation: Use $\text{fact}(n-1)$ to calculate $\text{fact}(n)$.
- Do each of these provide identical answers?
- Do each of these run at (roughly) the same speed?

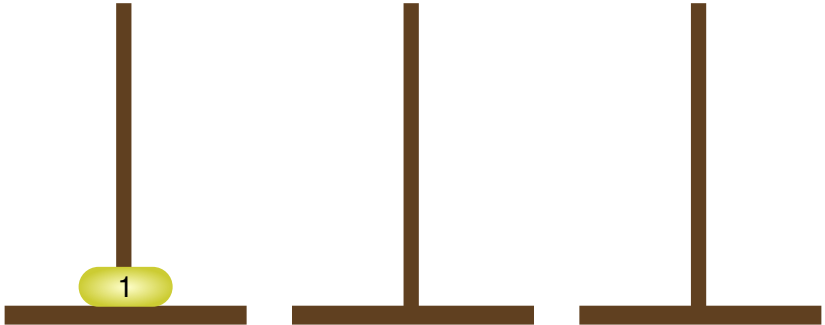
Example 2: Fibonacci Calculation



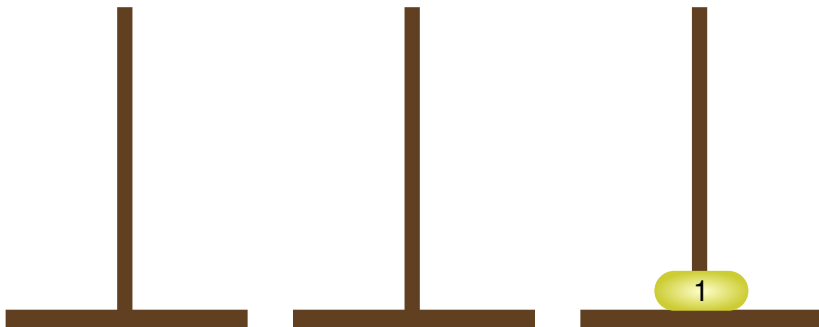
VectorStock

- Question: What are the Fibonacci numbers?
 - 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233
 - Each number is the sum of the two numbers preceding it.
- Iterative calculation: Put it in a for-loop.
- Recursive calculation: Use $\text{fib}(n-1)$ and $\text{fib}(n-2)$ to calculate $\text{fib}(n)$.
- Do each of these provide identical answers?
- Do each of these run at (roughly) the same speed?

Tower of Hanoi – 1 Disc



Tower of Hanoi – 1 Disc

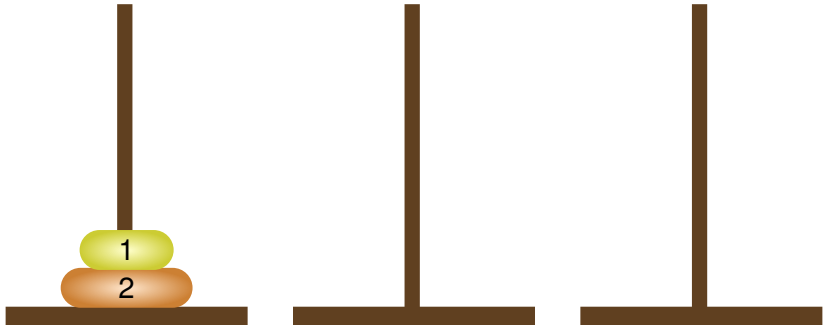


Moved disc from pole 1 to pole 3.

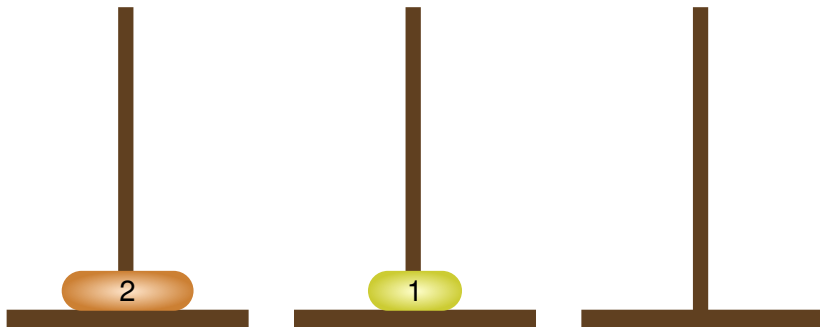
Tower of Hanoi – 1 Disc



Tower of Hanoi – 2 Discs

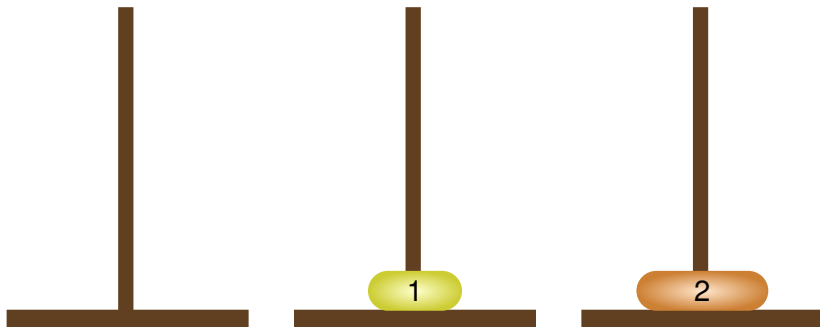


Tower of Hanoi – 2 Discs



Moved disc from pole 1 to pole 2.

Tower of Hanoi – 2 Discs



Moved disc from pole 1 to pole 3.

Tower of Hanoi – 2 Discs

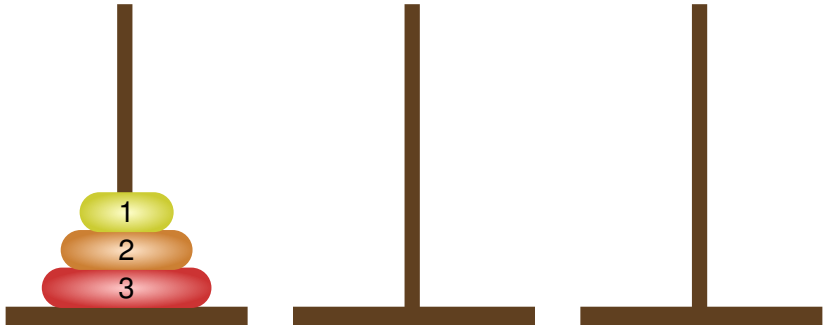


Moved disc from pole 2 to pole 3.

Tower of Hanoi – 2 Discs



Tower of Hanoi – 3 Discs

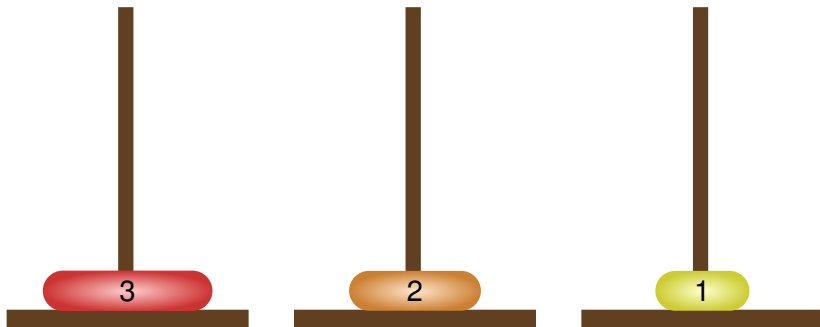


Tower of Hanoi – 3 Discs



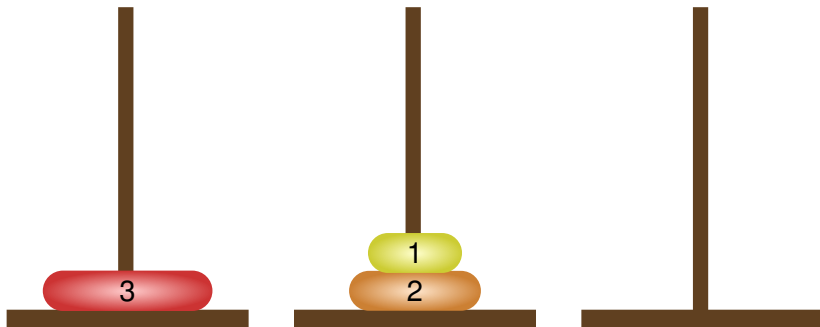
Moved disc from pole 1 to pole 3.

Tower of Hanoi – 3 Discs



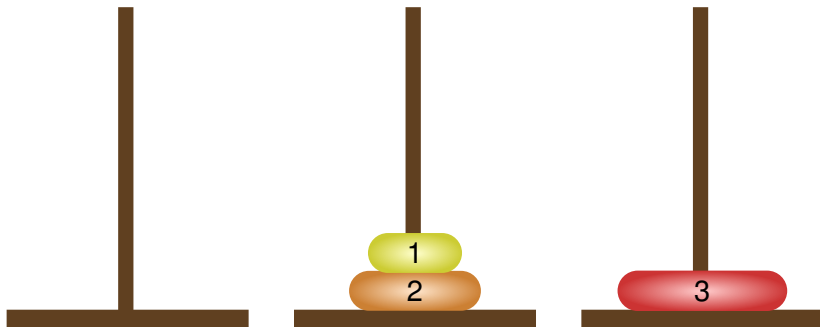
Moved disc from pole 1 to pole 2.

Tower of Hanoi – 3 Discs



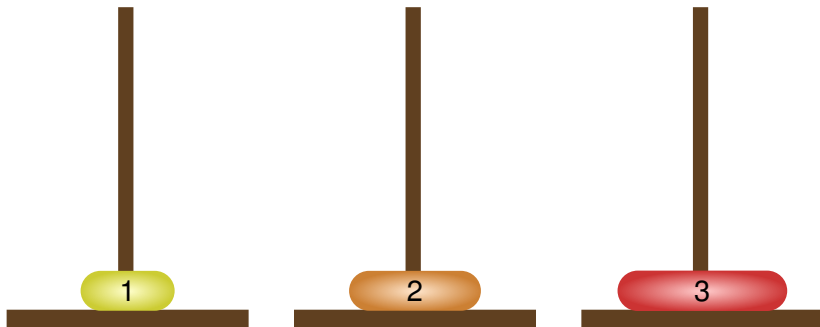
Moved disc from pole 3 to pole 2.

Tower of Hanoi – 3 Discs



Moved disc from pole 1 to pole 3.

Tower of Hanoi – 3 Discs



Moved disc from pole 2 to pole 1.

Tower of Hanoi – 3 Discs



Moved disc from pole 2 to pole 3.

Tower of Hanoi – 3 Discs

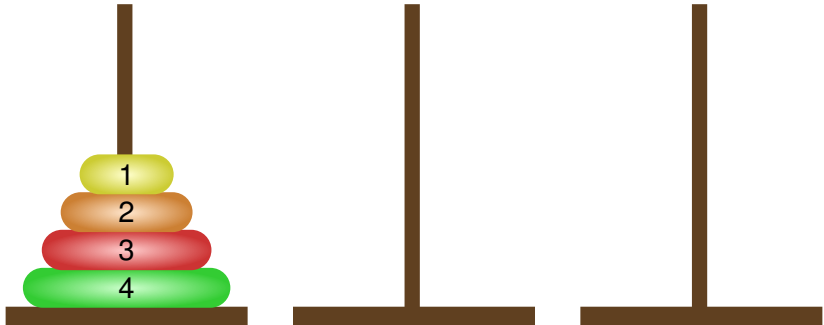


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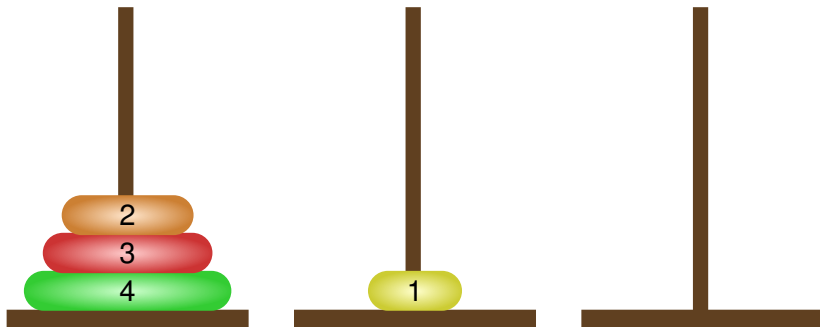
Tower of Hanoi – 3 Discs



Tower of Hanoi – 4 Discs

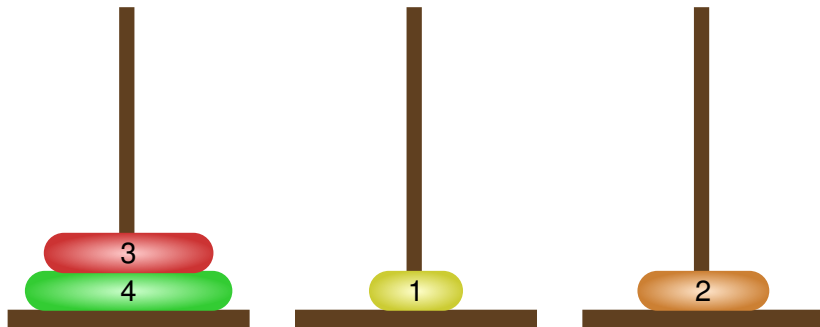


Tower of Hanoi – 4 Discs



Moved disc from pole 1 to pole 2.

Tower of Hanoi – 4 Discs



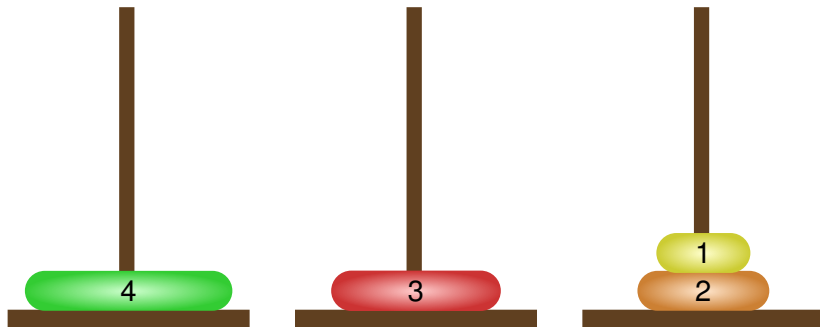
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Tower of Hanoi – 4 Discs



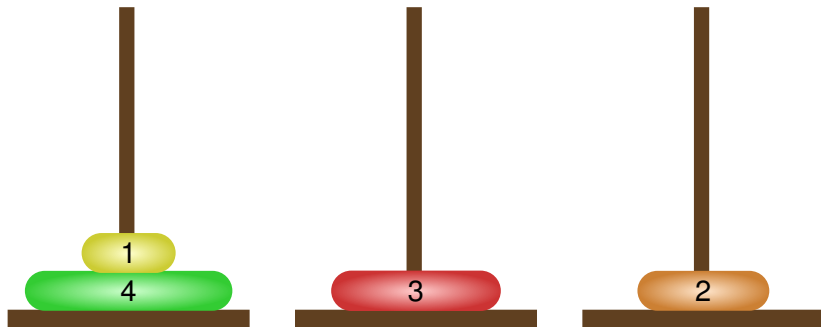
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Tower of Hanoi – 4 Discs



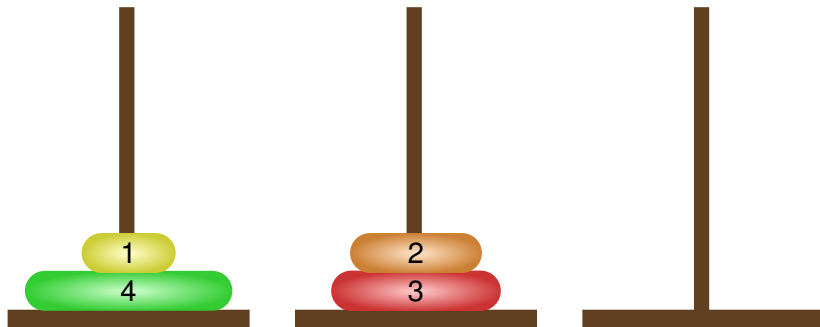
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Tower of Hanoi – 4 Discs



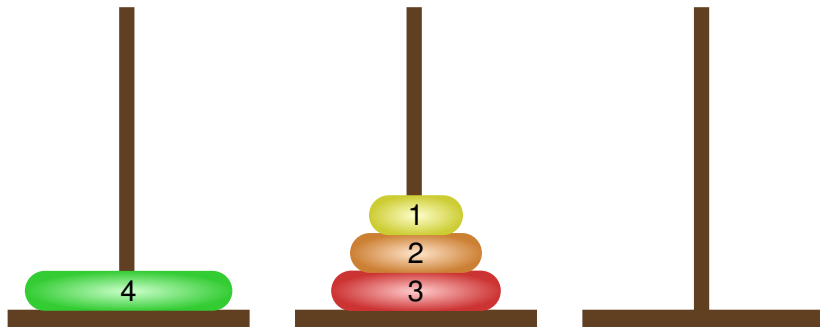
Moved disc from pole 3 to pole 1.

Tower of Hanoi – 4 Discs



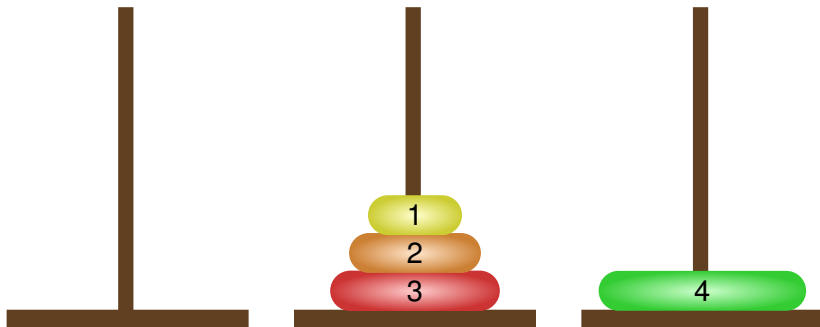
Moved disc from pole 3 to pole 2.

Tower of Hanoi – 4 Discs



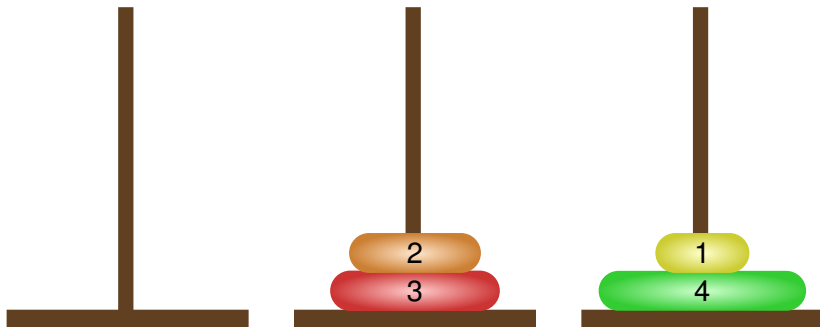
Moved disc from pole 1 to pole 2.

Tower of Hanoi – 4 Discs



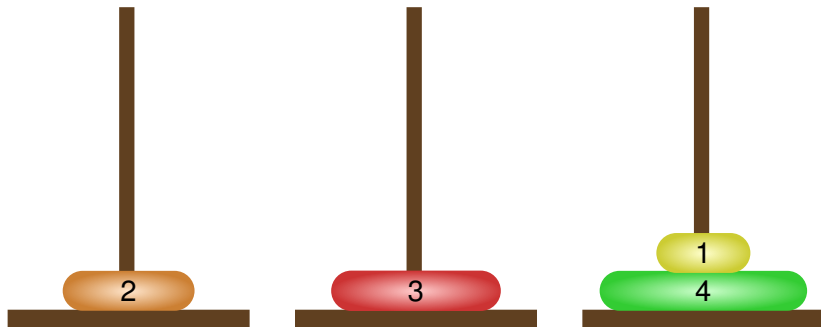
Moved disc from pole 1 to pole 3.

Tower of Hanoi – 4 Discs



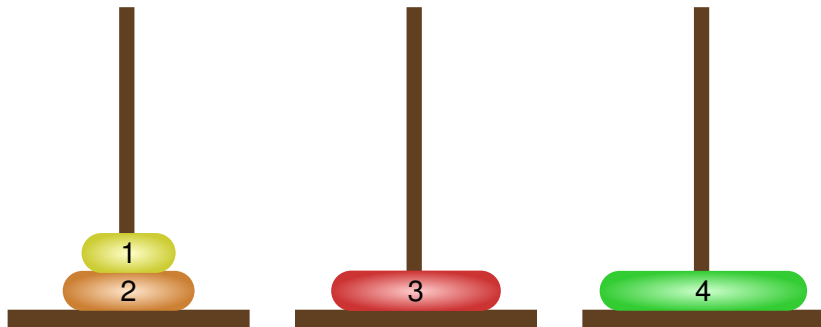
Moved disc from pole 2 to pole 3.

Tower of Hanoi – 4 Discs



Moved disc from pole 2 to pole 1.

Tower of Hanoi – 4 Discs



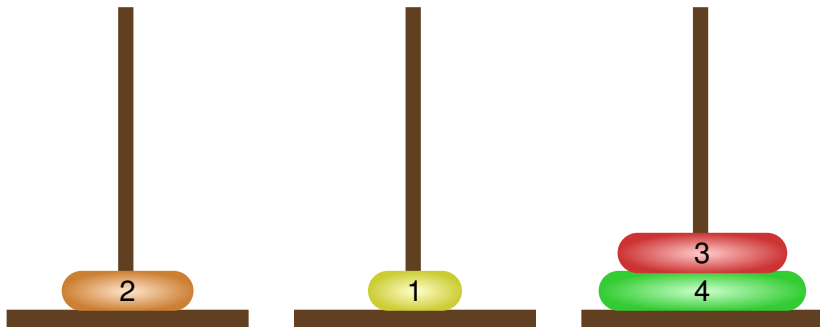
Moved disc from pole 3 to pole 1.

Tower of Hanoi – 4 Discs



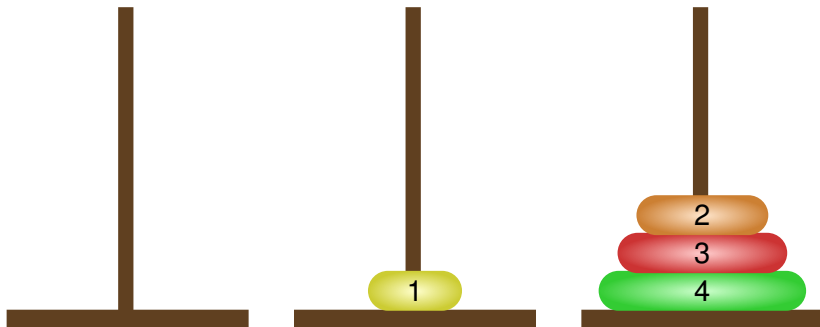
Moved disc from pole 2 to pole 3.

Tower of Hanoi – 4 Discs



Moved disc from pole 1 to pole 2.

Tower of Hanoi – 4 Discs



Moved disc from pole 1 to pole 3.

Tower of Hanoi – 4 Discs



Moved disc from pole 2 to pole 3.

Tower of Hanoi – 4 Discs



- **Linked List**

Reading Assignment

- **GT** Chapter 4 - 4.1, 4.2, 4.3
- **GT** Chapter 5 - 5.5, 5.6

Questions?

Please ask if there are any Questions!