Practical 3: Recursion

What am I doing today?
Today's practical focuses on 3 things:

1. Quick questions about Recursion
2. Comparing an iterative fibonacci algorithm to a recursive one
3. Help the monks solve the Towers of Hanoi

Instructions
Try all the questions. Ask for help from the demonstrators if you get stuck.
Solutions will be posted afterward.

*****Grading: Remember** if you complete the practical, add the code to your GitHub repo which needs to be submitted at the end of the course **for an extra 5%**

Warm-up questions

1. What are the two principal characteristics of a recursive algorithm?

The two characteristics is the base case and the recursive case. The base case deals with the smallest or simplest case. The base case returns a value with ends the recursion.
The recursive case calls a smaller instance of itself of the same problem which will eventually each the base case.

2. Recursion is..

Answer	
	theoretically interesting but rarely used in actual programs
	theoretically uninteresting and rarely used in programs
X	theoretically powerful and often used in algorithms that could benefit from recursive methods

3. True or false: All recursive functions can be implemented iteratively
   True

4. True or false: if a recursive algorithm does NOT have a base case, the compiler will detect this and throw a compile error?
   False

5. True or false: a recursive function must have a void return type.
   False

6. True or False: Recursive calls are usually contained within a loop.
   True

7. True or False: Infinite recursion can occur when a recursive algorithm does not contain a base case.
   True

8. **Which of these statements is true about the following code?**

```
int mystery(int n)
{
        if (n>0) return n + mystery(n-1);
        return 0;
}
```

Your answer	The base case for this recursive function is an argument with the value zero.
	The base case for this recursive method is an argument with any value which is greater than zero.
X	The base case for this recursive function is an argument with the value zero.
	There is no base case.

9. **List common bugs associated with recursion?**

1	Missing a base case: function will repeatedly call itself & never return
2	No guarantee of convergence: the sub-problem is not smaller than the original problem
3	Excessive memory requirements: excessive self-calls before returning, memory Java needs to keep track may be too much
4	Excessive Re-computation: sometimes a seemingly simple recursive program can require exponential time although this can be fixed

10. **What method can be used to address recursive algorithms that excessively recompute?**

Memoisation: A technique to speed up algorithms by keeping track of expensive operations and returning the cached result if the same computation is required again.

Fibonacci

The Fibonacci numbers are a sequence of integers in which the first two elements are 0 and 1, and each following element is the sum of the two preceding elements:

0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, and so on…

The Nth Fibonacci number is output with the following function:

$$fib(n) = fib(n-1) + fib(n-2) \rightarrow \text{for } n > 1$$

$$fib(n) = 1 \rightarrow \text{for } n = 0, 1$$

The first two terms of the series are 0, 1.

For example: fib(0) = 0, fib(1) = 1, fib(2) = 1

Exercises

1. Below is an iterative algorithm that computes Fibonacci numbers. Write a recursive function to do the same.
2. Test both algorithms with various sizes of Ns. What do you find? Recursion takes much longer to compute when dealing with larger sizes of N.
3. What is the time complexity of both functions? Iterative: O(n), Recursive: O(2^n)

Iterative Fibonacci

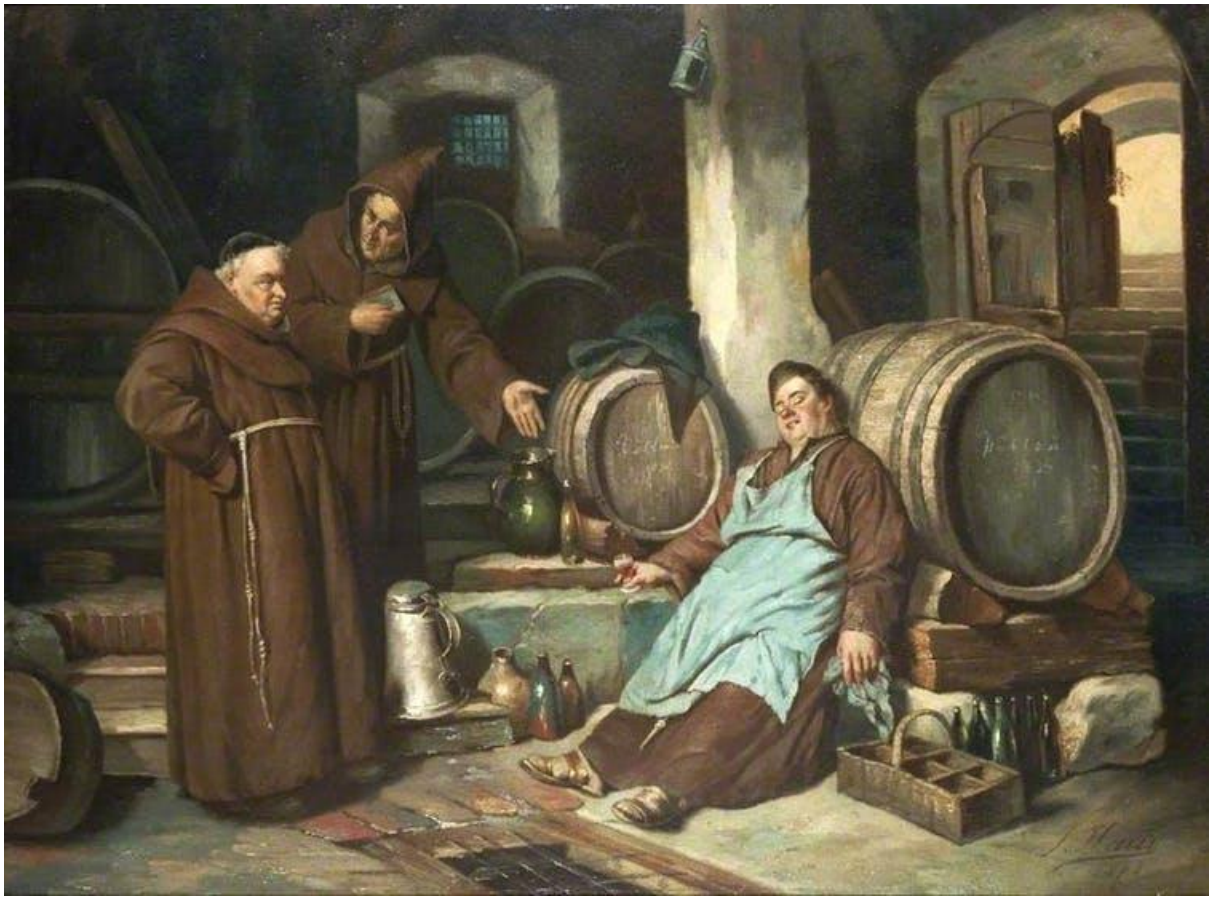
```
static int fibonacciIterative(int n){
  if (n<=1)
      return 1;

  int fib = 1;
  int prevFib =  1;

  for (int i = 2; i < n; i++) {
   int temp = fib;
   fib = fib + prevFib;
   prevFib = temp;
  }
  return fib;
 }

 public static void main (String args[])
    {
    int n = 9;
    System.out.println(fibonacciIterative(n));
    }
```

Hanoi - The Monks need your help!



Convert the pseudo-code into java and add your own output instructions so junior monks can learn how to perform the legal moves in the Tower of Hanoi so they can end the world.

There are two rules:

- Move only one disc at a time.
- Never place a larger disc on a smaller one.

Tasks:

1. Implement Hanoi in java
2. Test with various size disks
3. Output the moves for the monks as step-by-step instructions so the monks can end the world

Pseudocode for Hanoi

```
towersOfHanoi(disk, source, dest, auxiliary):
IF n == 0, THEN:
    move disk from source to dest
ELSE:
   towersOfHanoi(disk - 1, source, auxiliary, dest)
   towersOfHanoir(disk - 1, auxiliary, dest, source)
```

END IF