Logic and Maths for Computing Laboratory Task 2

In this laboratory you will explore combinatorics. This lab will be marked, so you need to produce a report and hand it in on Learn. You should describe in the report what you did, analyse and discuss your results and provide a copy of your code (which should be properly documented!).

1) Code up this set of nested loops

```
for i = 1 to 5
        for j = 1 to i
                for k = 1 to j
                        print "maths is fun"
                next k
        next j
next i
```

The general formula for analysis of these kinds of nested structures is:

$$\frac{(n+p-1)!}{n!(p-1)!}$$

Where p is the size of the outermost loop and n is the number of loops.

Experimentally verify that this general formula for the number of print statements executed is correct. To do this for larger n and p I suggest you use a counter variable instead of actually counting the number of print statements. Vary both n and p.

2) Investigate how many of the four digit numbers between 0001 and 9999 have four digits which are increasing (i.e. 1358). Do a combinatoric analysis which verifies the experimental result.

3) Suppose you toss a coin 6 times and you are interested in the maximum number of heads you get in a row. For example HTTHHH scores three. HHTHHT scores two and HHHHHT scores 5.

Write a program which works out the probability of each possible score. Start by using this simple method:

You program should run through all possible combinations of heads and tails. Let the total number of combinations be N. If n of these combinations have a maximum run of 4, then the probability of getting 4 in a row is n/N

Explore what the probabilities are for the same problem but with N = 5,4,3,2 coins. This should enable you to derive a general result for any number of coins N and maximum run length n. Now predict what the answer should be for 7 coins and maximum run length 7,6,5,4….) with your formula and check the answer. (If you are extra enthusiastic you can try to formally prove that your formula is correct!)