Programming for Data Science 18/11/2024

Upload the solutions to the programming exercises to the following link:
https://evo.di.unipi.it/student/courses/16/exams/051aL50

Exercise 1. (Math, on paper)

A. Determine how many strings of length 7, built with characters from C={A,B,C,D,E},
   a. either start with AE or end with A
   b. include the substring AB
B. Consider the sequence Q_n defined recursively as: $Q_1=1$, and $Q_n=Q_{n-1}+n$ for $n\geq 2$
   a. Write the first six terms of the sequence.
   b. Prove by induction that $Q_n= n(n+1)/2$ for all $n\geq 1$
C. Let the domain of discourse be all humans. Let the following predicates be defined:
   - P(x): "x is a parent."
   - C(x,y): "x is a child of y."

Write the following statements in **first-order logic**:

1. Every parent has at least one child.
2. There is at least one human who is not a parent.
3. If x is a child of y, then y is a parent.
4. Some humans are both parents and children.

Exercise 2. (Python) In cryptography, a Caesar cipher is one of the simplest and most widely known encryption techniques. It is a type of substitution cipher in which each letter in the plaintext is replaced by a letter some fixed number of positions down the alphabet (consider the ASCII code as your alphabet). For example, with a left shift of 3, D would be replaced by A, E would become B, and so on. All shift operations are modulo the size of the alphabet.

Design a Python class Caesar that implements a Caesar cipher. The class has to specify the shift type (left or right) and the shift amount (at most 10 characters). Also, it has to expose a method encrypt() that takes as input the name of a .txt file, encrypts its content, and writes the result into a file named encrypted.txt

Exercise 3. (C) Write a program in C implementing exercise 1.A with a recursive function generating all the strings with the given alphabet and counting how many of them satisfy the conditions 1.A.a and how many the conditions 1.A.b.

TIP: exploit that each string is of length exactly 7, and that you don't need to list all of them but only to count the ones satisfying the given condition!