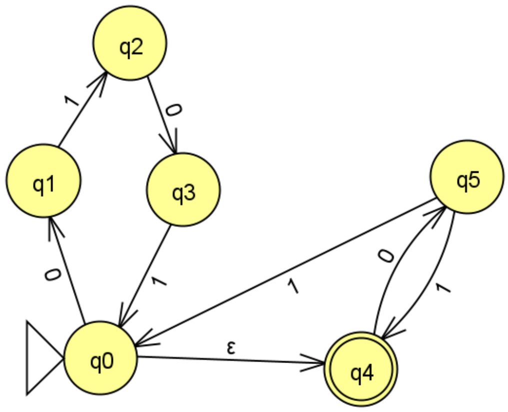
Exame de Época Normal / First Exam Period (2022/07/01)

Duration: 2 hours **Version A**
No consultation is allowed, other than the supplied document.
No electronic means are allowed (computer, cellphone, …).
Fraud attempts lead to the annulment of the exam for all students involved.

Answer each group in separate sheets!
Write your full name and exam version in all sheets!

Group I: Construct [5 Pts] Finite Automata, Regular Expressions, and Regular Languages (RLs)

Consider the following ε-NFA N1:



a) Show a regular expression that represents L(N1) and obtained by using state elimination with the ordering of elimination: q1→q2→q3→q5. [note: show all the steps needed]

b) Using the subset construction technique convert N1 to a DFA and present the transition table and the state diagram of the resultant DFA. [note: while applying the technique consider only the states reached from the start state of the DFA]

c) Minimize the previous DFA and show the state diagram of the minimized DFA.

d) Can you conclude that the regular expression obtained in a) is equivalent to (01)*? Justify your answer.

e) Prove by induction that all the strings represented by the regular expression 0101(01)* belong to L(N1).

Group II: [5 Pts] Context-Free Languages (CFLs), Context-Free Grammars (CFGs), and Push-Down Automata (PDAs)

Consider the following context-free grammar G:

$S \rightarrow aSc \mid B$
$B \rightarrow bBc \mid \varepsilon$

a) Formally define the set of strings of the language of G.

b) Is G ambiguous? Justify your answer.

c) Using the technique presented in the lectures, draw a PDA that accepts the language of G.

d) If the PDA you just presented accepts by empty stack, transform it into one that accepts by final state. If the PDA accepts by final state, then transform it to accept by empty stack. Use the conversion presented in classes for this transformation.

Group III: [5 Pts] Turing Machine

We want to implement a Turing Machine (TM) able to accept the language $L=\{0^{2n}10^n \mid n \geq 0\}$. For example: 0010 and 1 are accepted; 00010 is rejected.

a) Draw a possible TM for L.
b) Indicate the first 10 steps of the computing trace when the input to the TM is: 0010.
c) Reusing the TM in a) with as few as possible modifications, draw a possible TM to accept the language $L'=\{0^{3n}10^n \mid n \geq 0\}$.

Group IV: [5 Pts] Statements about Languages (T/F: 20%, justification: 80%; wrong answer = -10%)

Indicate, justifying succinctly (with a couple of sentences or a counter example), whether each of the following statements is True (T) or False (F).

a) The language obtained by a subtraction of a regular language (RL) by a non-regular language (NRL) that includes strings belonging to the RL is always an NRL.
b) The language $L = \{w^{2n+3m} \mid w \in \{0,1\}^* \wedge n, m \geq 0\}$ is an RL.
c) Given a context-free grammar G, if it is possible to define two different derivations for the same word, we can say G is ambiguous.
d) Any non-deterministic push-down automaton (PDA) obtained from a context-free grammar, using the conversion presented in the lectures, can be transformed to a deterministic PDA.
e) If $L_1 \cap L_2$ is decidable (recursive) then L_1 and L_2 are both decidable.