Exame de Época Normal / First Exam (2016/01/14)

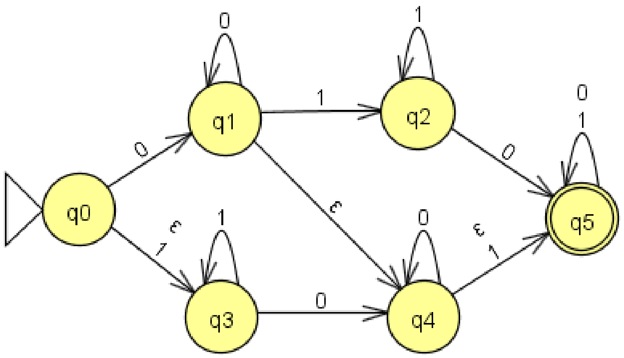
Name: ____ **Number:** ______________

Duration: 2h30 **Version E**
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 participants.

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

Grupo I: [4.5 Val] Finite Automata and Regular Expressions

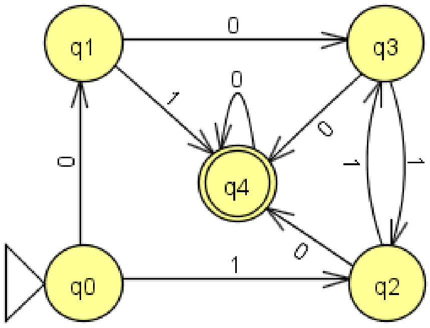
Consider the ε-NFA to the right.



a) Determine the ε-closure for each of the states of the ε-NFA.

b) Obtain the equivalent DFA to the ε-NFA on the right. Present both the transition table and the diagram of the DFA.

Consider the DFA below.



c) Minimize the DFA on the left. Present the distinguishable state table, and the transition diagram for the minimized DFA.

d) Obtain a regular expression for the language defined by the DFA on the left using the state elimination method, considering the elimination order 1-2-3 (eliminate state q1 first, then q2 and then q3). Show all intermediate steps.

e) Present the values for the terms $R_{01}^{(0)}$, $R_{02}^{(0)}$, $R_{23}^{(0)}$, $R_{12}^{(0)}$, $R_{23}^{(1)}$, $R_{12}^{(1)}$ e $R_{14}^{(1)}$ obtained by the path construction method to convert the DFA into a regular expression.

f) Present a regular expression to recognize strings that contain the code, telephone code and name of a country in the format presented in the examples below. The code of a country is composed by two capital letters, and the telephone code by one to four digits (the first digit not being 0). Consider the symbol **D** as representing any digit (0 to 9), **M** as a capital letter, **m** as a lower-case letter, **E** as a space, **T** as a dash, **A** as '(' and **F** as ')'. Examples of strings: 'PT (351) – Portugal', 'US (1) – United States of America', 'ES (34) – Spain', 'TV (688) – Tuvalu', 'AG (1268) – Antigua and Barbuda'.

Grupo II: [2 Val] Properties of Regular Languages

Prove, for each of the following languages, whether it is regular or not. In case it is, present an automaton to recognize it. In case it's not, prove it using the pumping lemma for regular languages.

a) Strings over the alphabet {a, b} where the number of a's in the string is odd and the number of b's in the string is double the number of a's in the string.

b) Strings over the alphabet {a, b} where there are at least two b's separating each pair of a's.

Grupo III: [4.5 Val] Context-Free Grammars (CFG) and Push-Down Automata (PDA)

$A \rightarrow A + A \mid B$
$B \rightarrow B \times B \mid C$
$C \rightarrow (A) \mid D$
$D \rightarrow 0 \mid 1$

Consider the CFG to the left, where A is the start variable.

a) Present a parse tree and a leftmost derivation for the string 0+1x(1+0)+1.

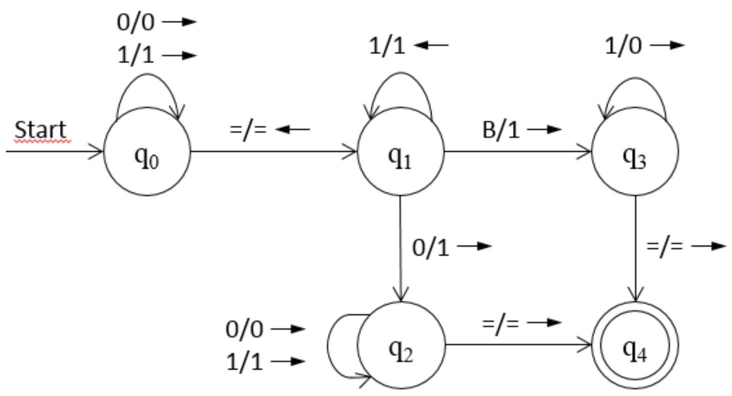
b) Is the presented grammar ambiguous? Justify.

c) Convert the CFG to a PDA with acceptance by final state, presenting the diagram for the resulting PDA.

d) Is the PDA obtained in the previous point deterministic? Justify.

e) Present, using the PDA, the sequence of instantaneous descriptions that accepts the string 0+1x(1+0)+1.

Grupo IV: [4 Val] Turing Machine



a) Consider the Turing machine presented on the left. Describe what it does, and exemplify, presenting the computation sequence when the tape contains **101=**.

b) It's intended to use the TM on the left as part of the implementation of a TM that compares the contents of two operands in binary (the two operands are guaranteed to be of the same size), and provides a count of the number of different bits between the two operands. E.g.: =0110v1001 should result in 100=0110v1001; =00110101v00110110 should result in 10=00110101v00110110. Note that the count of the number of different bits is also made in binary, to the left of the operands, and that the operands keep their initial value at the end of the execution.

Grupo V: [5 Val] Statements about Languages (Wrong answer = 50% negative quote)

Indicate, justifying succinctly, whether each of the following statements is True or False.

a) Not all languages expressed by DFAs can be expressed by regular expressions.

b) A regular language can only be expressed by a DFA, NFA, ε-NFA or by a regular expression.

c) Let B be an ambiguous Context-Free Grammar (CFG). There is always a non-ambiguous CFG A that defines the same language as B.

d) Let L be a Context-Free Language (CFL) expressed in Chomsky Normal Form (CNF). The parse tree for any string w belonging to L will always be a binary tree.

e) Let L1, L2 and L3 be CFLs. The language L=(L1 L2) $\cap$ (L1 L3) is also a CFL.

f) Not all PDAs can be transformed into DFAs.

g) The language $L = \{xyz \mid x,y,z \in \{0,1\}^* \wedge |x| = |z| \wedge$ the number of zeros in x equals the number of zeros in y$\}$ is a regular language.

h) Not all PDAs can be transformed into CFGs.

i) One can prove that $L=\{a^n b^m c^r d^s e^t \mid n+m-r=s+t\}$ is not a regular language knowing that $\{a^n b^n \mid n \geq 0\}$ is not a regular language.