CECS 329 MW, LO Assessment 3, Fall 2026, Dr. Ebert

IMPORTANT: For each problem (LO5,LO6,GK,Advanced, All LO Makeups) write your solution using a **SINGLE** and **SEPARATE SHEET OF PAPER (FRONT AND BACK IF NECESSARY)**. Write your **FULL NAME** and **PROBLEM CODE** on each sheet.

25 Points Each

LO5 Do the following.

a. Given the CFG whose set of rules are

$$S \to S0S0S1S \mid S1S0S0S \mid S0S1S0S \mid \varepsilon$$

use these rules to provide a leftmost derivation of the word 010100. (10 pts)

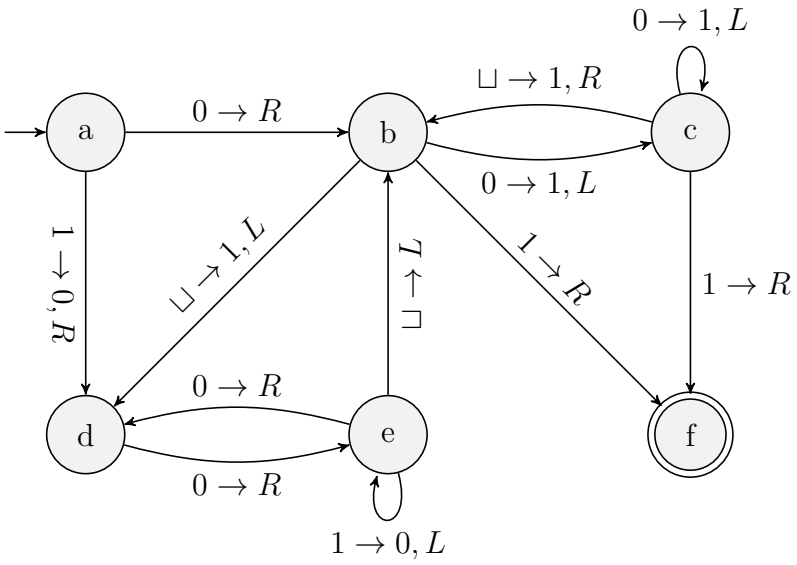
b. Provide a context-free grammar that describes the language of all words of the form

$$(a_1\#b_1)(a_2\#b_2)\cdots(a_n\#b_n),$$

where $n \geq 1$, and each a_i and b_i are nonempty binary words for each $i = 1, \ldots, n$. (15 pts)

LO6 Do the following.

a. For the TM M whose state diagram is shown below, suppose M is performing a computation and the current configuration has memory word 01010, is in state a and the head is reading the leading 0. Draw this configuration and show the next five configurations of the compuation. (10 pts)



b. Provide the state diagram for a Turing machine that counts down from the binary input word w when viewed as a nonnegative integer. For example, if $w = 101$, then the three tape cells that store w will together successively store 100, 011, 010, 001, and 000, in that order. (15 pts)

GK Which of the following statements are true? (3 pts each)

a. There are context-free languages that are not regular.

b. When formally defining a context-free grammar, the R represents the set of relations that relate the variables (V) to the terminals (Σ).

c. For the CFG that uses rule set $S \to aSb \mid S \mid \varepsilon$, $S \stackrel{*}{\Rightarrow}$ aababbab is a true statement.

d. The CFG with rule set $S \to aSb \mid S \mid \varepsilon$ is ambiguous.

e. For a language L to be **Turing decidable** it is necessary for there to be a Turing machhine M that halts on all inputs, but only accepts words in L.

f. If a language is Turing decidable, then it is also Turing recognizable.

g. A Turing machine configuration is completely determined by the memory word and the head location.

h. When formally defining a Turing machine there are seven different components that must be defined.

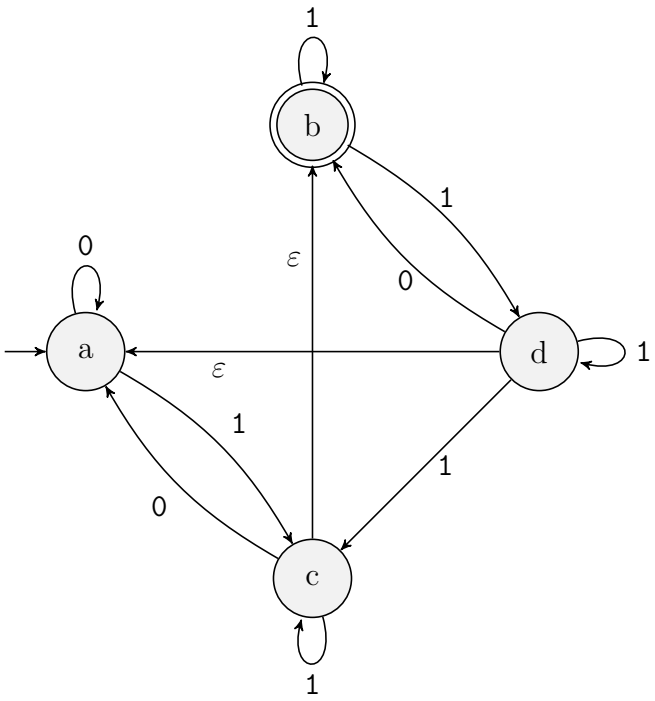
ADV Provide the state diagram of a Turing machine M that, on binary input w, writes the mirror reflection of w immediately to the left of w, and then accepts. For. example, if the input word is $w = 00111$, then the final word on the tape should be 1110000111. Of course, if $w = \varepsilon$, then the final word should be ε. It does not matter where the head is located when your machine accepts. (17 pts). Use your TM to provide a complete computation of M on input 110. (8 pts).

Makeup LO's (Pass/No Pass)

LO1. Provide a DFA M that describes the language of all words over the alphabet {a,b} and for which every b that appears in the words has a's to its immediate left and right. Show the computation of M on input ababaaba. For example, aababaaaabaa is in the language but not abba.

LO2. Do the following.

(a) For the NFA N whose state diagram is shown below, provide a table that represents N's δ transition function.



(b) Use the table from part a to convert N to an equivalent DFA M using the method of subset states. Draw M's state diagram. Show the computation of M on input 111000.

LO3. Do the following.

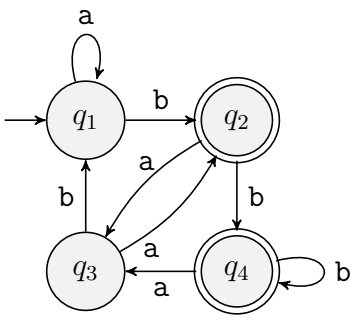
(a) Let A denote the language of binary words that begin with a 1 and represent a prime number (i.e. 2,3,5,7, etc.), while B is the language of all binary words that begin with 11 and have an odd number of 0's. Provide three different words that are members of $A \oplus B$, and three different words that are members of $A \cap B$.

(b) For the languages A and B described in part a, is 11000101101001100 a member of AB? Justify your answer.

(c) Provide a regular expression that describes the language consisting of all words over the alphabet {a,b} that have at least two a's, at most one b, but excludes the word aba.

LO4. Do the following.

(a) Consider the DFA M_1 below which accepts language A and the DFA M_2 shown in part b which accepts language B. Use these DFA's to provide the state diagram of an NFA that accepts the language $A \cup B$.



(b) The DFA M_2 shown below accepts some regular language L. Demonstrate each of the following steps of the GNFA-to-Regular-Expression algorithm to compute a regular expression that describes L: i) create a new accepting state and label it q_5, ii) remove state q_2, iii) remove state q_3, iv) remove state q_4. Redraw the GNFA after each step. Therefore, you must draw four different NFA's.

