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)

Solution. $S \Rightarrow S0S1S0S \Rightarrow 0S1S0S \Rightarrow 01S0S \Rightarrow 010S \Rightarrow 010S10S0S \Rightarrow \cdots \Rightarrow 010100$

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

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

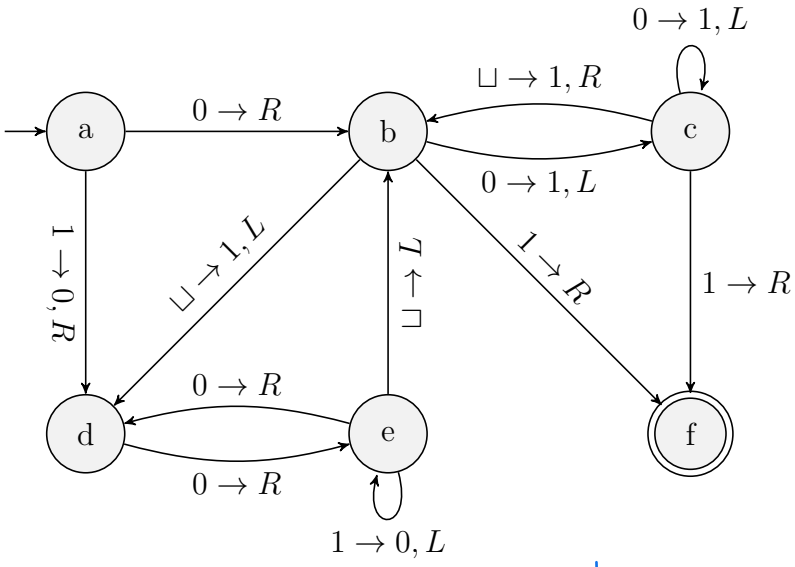
where $n \geq 1$, and each a_i and b_i are nonempty binary words for each $i = 1, \ldots, n$. (15 pts)

Solution. $S \to (W\#W)S \mid \varepsilon$

$W \to 0W \mid 1W \mid 0 \mid 1$

LO6 Do the following.

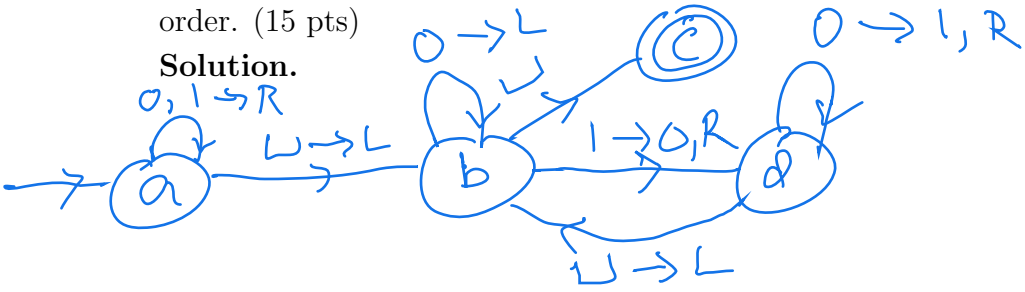
a. For the TM M whose state diagram is shown below, suppose M is performing a computation and the current configuration has memory word 01010, is in state a and the head is reading the leading 0. Draw this configuration and show the next five configurations of the compuation. (10 pts)



Solution. a 01010, b 01010, f 01010 (accept)

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)

Solution.



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 $S \to aSb \mid SS \mid \varepsilon$, $S \stackrel{*}{\Rightarrow}$ aababbab is a true statement.

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

Solution.

a. True. $\{0^n 1^n \mid n \geq 0\}$ is one such languaage.

b. True and False: depends on how one interprets the definition of "relation".

c. True. The word represents a valid parenthesization.

d. False. Every word in the corresponding CFL has a unique leftmost derivation.

e. True

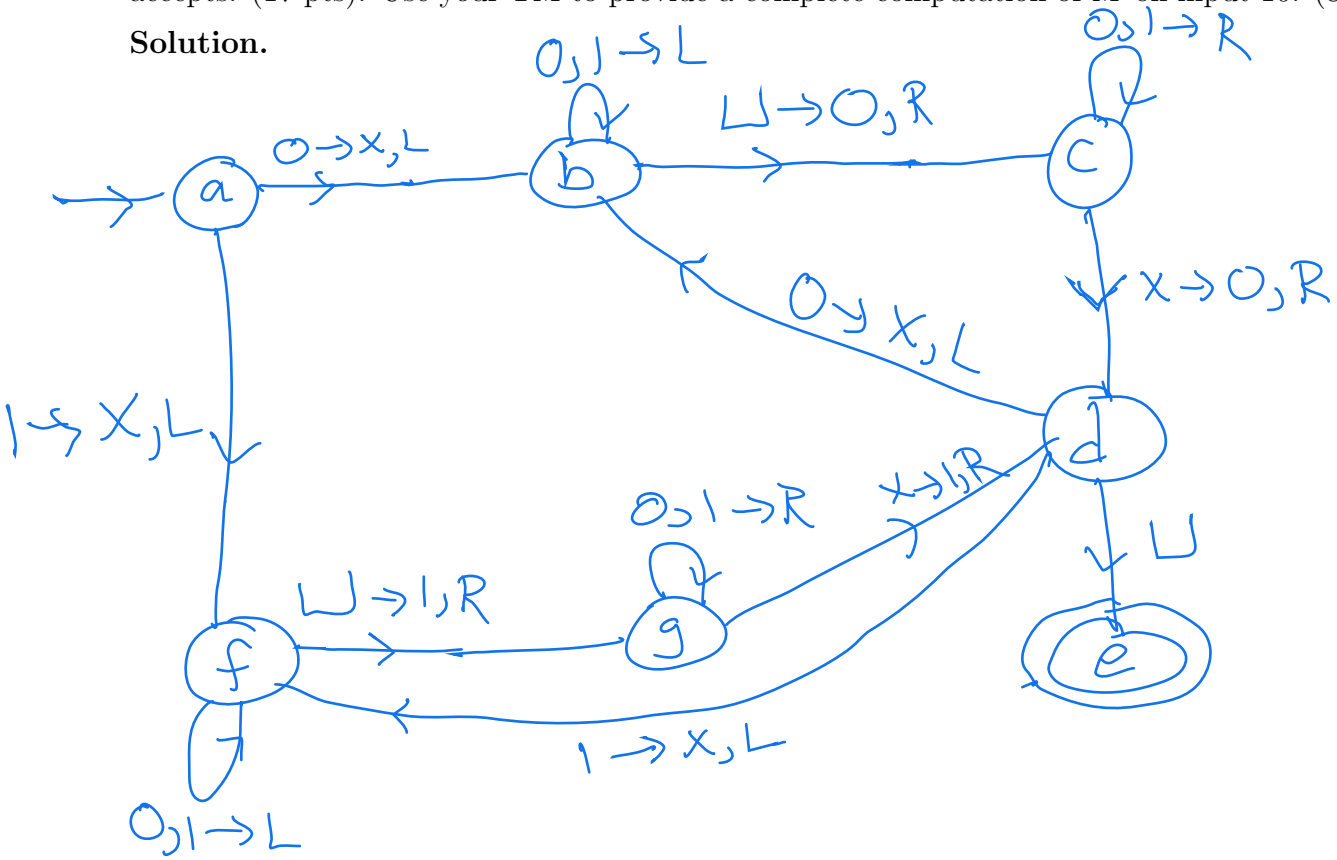
f. True. Turing Decidable is a stronger property than Turing Recognizable.

g. False. A Turing machine configuration must also include the current state.

h. True.

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 10. (8 pts).

Solution.

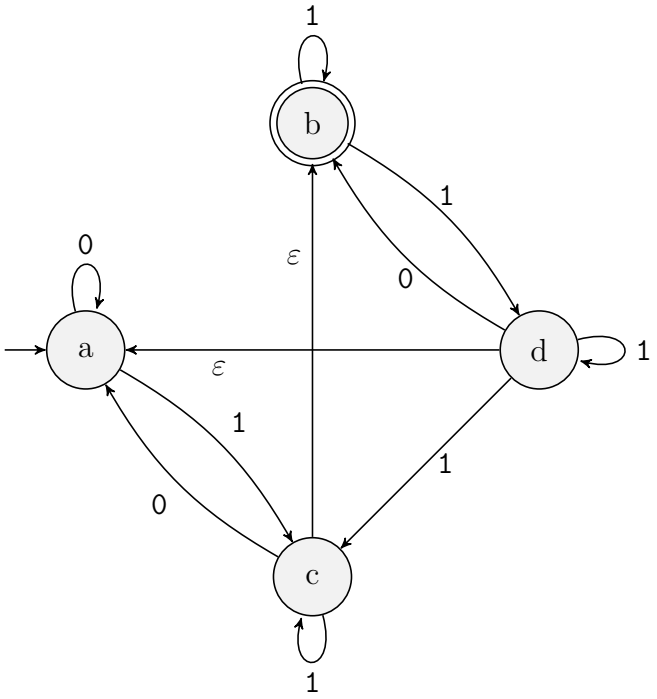


Makeup LO's (Pass/No Pass)

LO1. Provide a DFA M that describes the language of all words over the alphabet {a,b} that have an even number of a's or (inclusive) and odd number of b's. Show the computation of M on input abababaaba.

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.

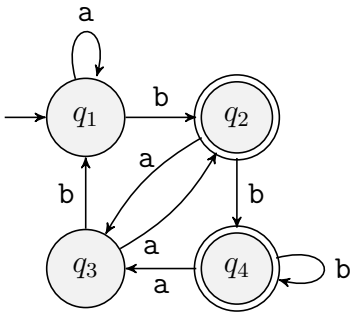
(a) Let A denote the language of binary words that begin with a 1 and represent a prime number (i.e. 2,3,5,7, etc.), while B is the language of all binary words that begin with 11 and have an odd number of 0's. Provide three different words that are members of $A \oplus B$, and three different words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



(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.

