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10CS56

Fifth Semester B.E. Degree Examination, Dec.2014/Jan.2015
Formal Languages and Automata Theory

Time: 3 hrs.

Max. Marks:100

Note: Answer any FIVE full questions, selecting at least TWO questions from each part.

PART - A

- 1 a. Define the following with proper examples:
 - i) Alphabet ii) Powers of an alphabet. (03 Marks)
- b. Design the DFA's for the following languages:
 - i) Set of all strings with at least one 'a' and exactly two 'b's on $\Sigma = \{a, b\}$.
 - ii) Set of all strings such that number of 1's is even and the number of 0's is a multiple of 3 on $\Sigma = \{0, 1\}$. (08 Marks)
- c. Design an NFA with no more than 5 states for the following language:

$$L = \{abab^n \mid n \geq 0\} \cup \{aba^n \mid n \geq 0\}$$
 (03 Marks)
- d. Prove that if $D = (Q_D, \Sigma, \delta_D, \{q_0\}, F_D)$ is the DFA constructed from NFA $N = (Q_N, \Sigma, \delta_N, q_0, F_N)$ by the subset construction, then $L(D) = L(N)$. (06 Marks)

- 2 a. Convert the following ϵ - NFA into an equivalent DFA: (05 Marks)

δ	ϵ	a	b	c
$\rightarrow p$	$\{q, r\}$	ϕ	$\{q\}$	$\{r\}$
$*q$	ϕ	$\{p\}$	$\{r\}$	$\{p, q\}$
r	ϕ	ϕ	ϕ	ϕ

- b. Define regular expression and also write the regular expressions for the following languages:
 - i) $L = \{w \in \{a, b\}^* \mid w \text{ has exactly one pair of consecutive a's}\}$.
 - ii) Set of all strings not ending in substring 'ab' over $\Sigma = \{a, b\}$. (06 Marks)
- c. Prove that if $L = L(A)$ for some DFA A, then there is a regular expression R such that $L = L(R)$. (06 Marks)
- d. Obtain the regular expression for the following DFA using state elimination technique: (03 Marks)

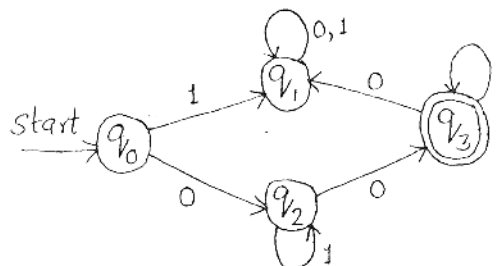


Fig.Q.2(d)

- 3 a. State and prove pumping lemma for regular languages. (07 Marks)
- b. Let $\Sigma = \{a, b\}$. Show that the language $L = \{w \in \Sigma^* \mid n_a(w) < n_b(w)\}$ is not regular. (05 Marks)

c. Consider the DFA given by the transition table:

δ	a	b
$\rightarrow q_0$	q_1	q_2
q_1	q_1	q_3
q_2	q_1	q_2
q_3	q_1	q_4
$*q_4$	q_1	q_2

- i) Draw the table of distinguishabilities for this automaton.
- ii) Construct the minimum state equivalent DFA.
- iii) Write the language accepted by the DFA. (08 Marks)

4 a. Define a Context-Free Grammar (CFG) and also obtain the CFG's for the following languages:

- i) $L_1 = \{a^n ww^R b^n \mid w \in \{0,1\}^* \text{ and } n \geq 2\}$
- ii) $L_2 = \{a^k b^m c^n \mid m + n = k \text{ and } m, n \geq 1\}$
- iii) $L_3 = \{w \in \{a\}^* \mid |w| \bmod 3 \neq |w| \bmod 2\}$. (10 Marks)

b. Consider the CFG with productions

$$E \rightarrow E * T \mid T$$

$$T \rightarrow F - T \mid F$$

$$F \rightarrow (E) \mid 0 \mid 1$$

Write the leftmost derivation, rightmost derivation and parse tree for the string $'0 - ((1 * 0) - 0)'$. (06 Marks)

c. Show that the following grammar is ambiguous:

$$S \rightarrow SbS$$

$$S \rightarrow a.$$

(04 Marks)

PART - B

5 a. Design a PDA for the following language : $L = \{ww^R \mid w \in \{a,b\}^+\}$. Also, draw the transition diagram for the constructed PDA. Write the instantaneous description (ID) for the string 'abbbba'. (08 Marks)

b. Convert the following CFG to a PDA that accepts the same language by empty stack:

$$E \rightarrow E + E \mid E * E \mid (E) \mid 1$$

$$1 \rightarrow 1a \mid 1b \mid 10 \mid 11 \mid a \mid b$$

(05 Marks)

c. Define a deterministic PDA (DPDA). Also, design a DPDA along with transition diagram for the following language: $L = \{a^n b^{2n} \mid n \geq 0\}$. (07 Marks)

6 a. Begin with the grammar

$$S \rightarrow aAa \mid bBb \mid \epsilon$$

$$A \rightarrow C \mid a$$

$$B \rightarrow C \mid b$$

$$C \rightarrow CDE \mid \epsilon$$

$$D \rightarrow A \mid B \mid ab$$

- i) Eliminate ϵ -productions.
ii) Eliminate any unit productions in the resulting grammar.
iii) Eliminate any useless symbols in the resulting grammar. (08 Marks)
- b. Define Chomsky Normal Form (CNF). Also, convert the following CFG to CNF:
 $S \rightarrow AB|a$
 $A \rightarrow aab$
 $B \rightarrow Ac$. (06 Marks)
- c. Show that the language $L = \{x \in \{0, 1\}^* \mid |x| \text{ is a perfect square} \}$ is not context-free. (06 Marks)
- 7 a. Define a Turing machine. Also, design a Turing machine to accept the set of all palindromes over $\{0, 1\}^*$. Write the transition diagram for the constructed Turing machine and write the sequence of ID's for the input string '1001'. (12 Marks)
b. Explain multitape Turing machine and non-deterministic Turing machines with neat block diagrams. (08 Marks)
- 8 Write short notes on the following topics:
a. Applications of finite automata in text search.
b. Inherent ambiguity of context-free languages.
c. Post's correspondence problem.
d. Recursive language and its relationship with RE and non-RE languages. (20 Marks)

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