

9 [This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 1042

C

Unique Paper Code : 32341502

Name of the Paper : Theory of Computation

Name of the Course : B.Sc. (Hons.) Computer Science

Semester : V (Admissions 2019-2021)

Duration : 3 Hours

Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question No. 1 (Section A) is compulsory.
3. Attempt any four Questions from Nos. 2 to 7 (Section B).
4. Parts of a question must be answered together.
5. Consider $\Sigma = \{a, b\}$ for all the questions unless specified otherwise.

SECTION A

1. (a) Let $s = \{aa, bb\}$ and $T = \{aa, bb, bbaa\}$. Show that $S^* = T^*$. Does the string aaa belong to the language S^* ? Justify. (3)

P.T.O.

(b) Consider the following Context Free Grammar (CFG) :

$$S \rightarrow SAbAbAbA \mid \lambda$$

$$A \rightarrow aA \mid \lambda$$

Describe the language generated by given CFG.
List any two words of the language. (3)

(c) Construct a regular expression defining each of the following languages :

(i) $L_1 = \{\text{words in which a appears tripled (in clumps of 3) if at all}\}$

(ii) $L_2 = \{\text{ends with a and does not contain the substring bb}\}$ (4)

(d) Describe the language defined by each of the following regular expressions:

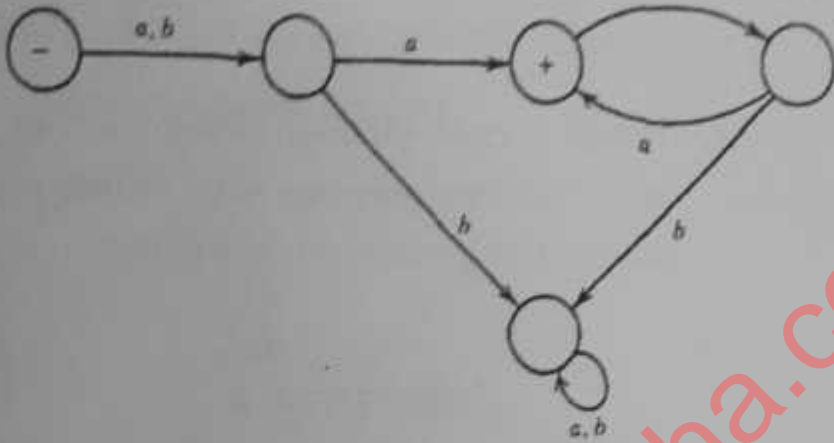
(i) bba^*b

(ii) $((a+b)a)^*$

Also, determine the shortest word in the language. (4)

(e) Build a finite automaton that accepts the language of words having exactly four letters. (4)

- (f) Describe the language accepted by following finite automaton : (2)



- (h) Using pumping lemma, show that the following language is a non-regular language : (4)

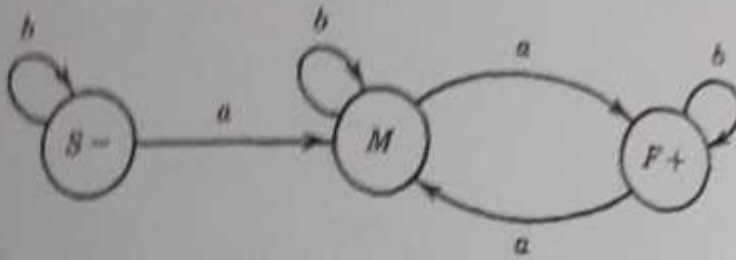
$$\{a^n b a^{2n} \text{ where } n \in \mathbb{N}\} = \{abaa, aabaaaa, aaabaaaaaa, \dots\}$$

- (i) Construct a deterministic PDA for the language $L_3 = \{a^n S \text{ where } S \text{ starts with } b \text{ and length } (S) = n\}$

(4)

- (j) Construct the context free grammar (CFG) for the language accepted by following finite automaton : (3)

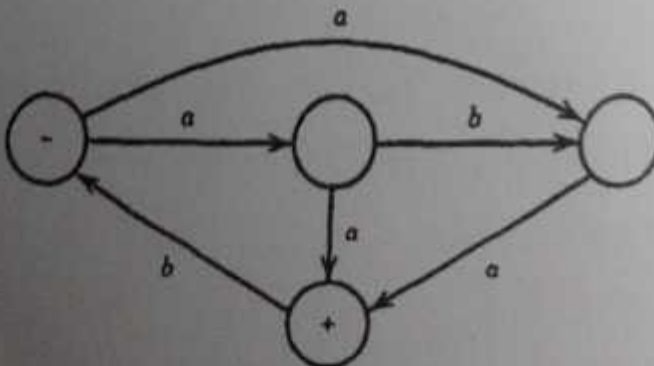
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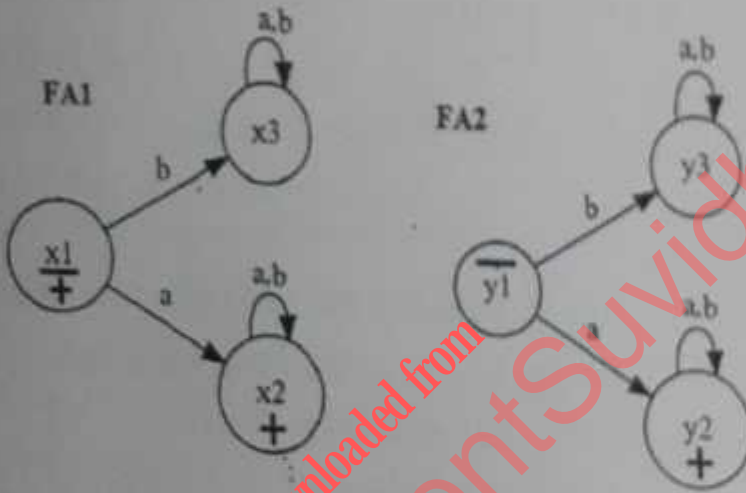
- (k) Design a right shifting Turing machine. Assume the initial configuration to be $\triangleright \sqcup w \sqcup$ and desired output configuration to be $\triangleright \sqcup \sqcup w \sqcup$. (4)

SECTION B

2. (a) Consider the following language of all the words defined over having $\Sigma = \{a, b\}$ comprising only b's including empty string λ . Build a finite automaton FA that accepts the given language and find its Kleene closure i.e. $(FA)^*$. (6)
- (b) Convert the following non-deterministic finite automaton to deterministic finite automaton: (4)

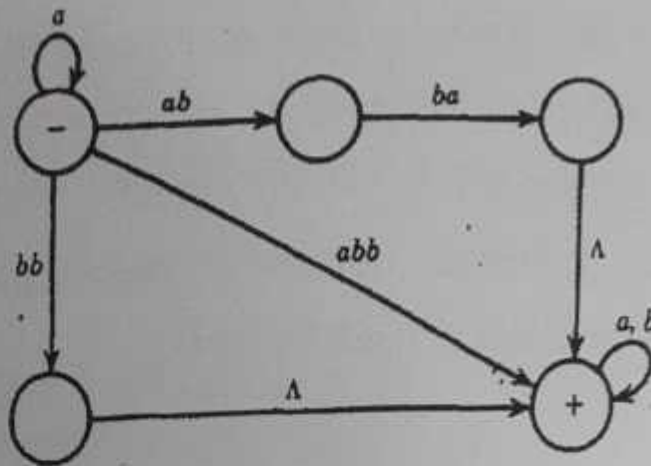


3. (a) For the following pairs of FAs, build a finite automaton that accepts the intersection of languages defined by FA1 and FA2. Also, build a finite automaton that accepts the complement of the language defined by FA1. (6)



- (b) Show that the set of regular languages are closed under union and Kleene closure using non-deterministic finite automata. (4)
4. (a) Using the bypass theorem, convert the following transition graph into a regular expression: (6)

P.T.O.

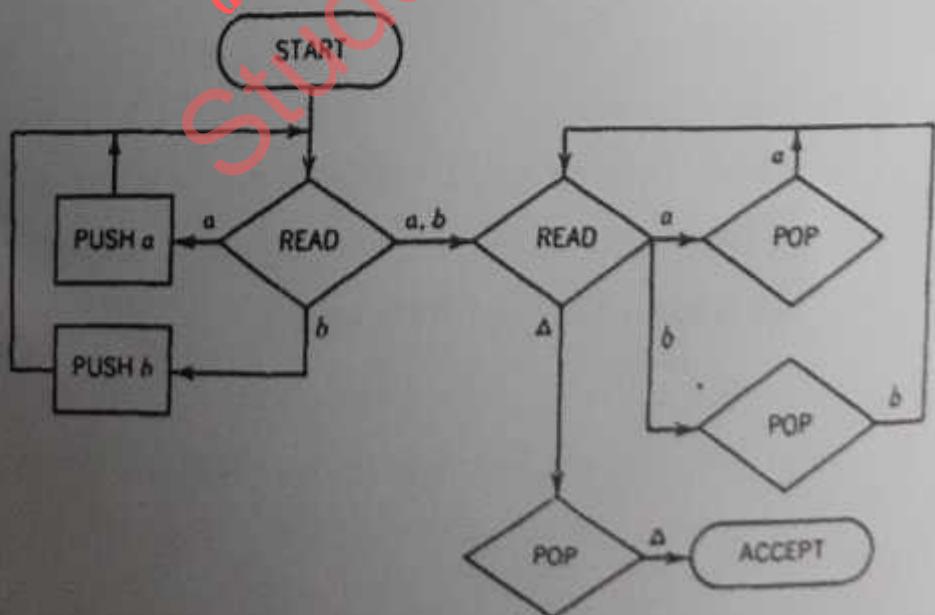


- (b) Use pumping lemma to prove that the language $\{a^n b^n c^n \text{ where } n=1, 2, 3, 4, 5, \dots\}$ is non-context free language. (4)

5. (a) For the Push Down Automata shown below :

(i) Describe the language accepted by it.

(ii) Is the given PDA deterministic or non-deterministic? (4)



- (b) Construct a PDA for the language $a^n b^q a^m$ where $m, n \geq 1$ and $q = m + n$. (6)

6. (a) Consider the following context free grammar :

$$S \rightarrow AbB$$

$$A \rightarrow aA \mid \lambda$$

$$B \rightarrow aB \mid bB \mid \lambda$$

Construct an equivalent CFG by eliminating all λ productions and convert the resultant grammar into chomsky normal form (CNF). (4)

- (b) Write the CFG for the language containing all words which are palindromes excluding the null string. Create a parse tree for the word abaaba. (4)

- (c) Show that the following CFG is ambiguous: (2)

$$S \rightarrow XaXaX$$

$$X \rightarrow aX \mid bX \mid \lambda$$

7. (a) Assume $\Sigma = \{0, 1\}$. Design a standard turing machine M that computes one's complement of the binary number on the input tape. Assume the

initial configuration to be $\triangleright \sqcup w$ (if the input is $\triangleright \sqcup w$, the output should be $\triangleright \sqcup w'$, where w' is the one's complement of w). Show the trace of above turing machine M on the string $\triangleright \sqcup 0110$. (5)

(b) Prove that if a language is recursive, it is also recursively enumerable. (2)

(c) Consider the Turing Machine $M = (K, \Sigma, \delta, s, \{h\})$, where $K = \{s, q, h\}$, $\Sigma = \{\sqcup, \triangleright, a\}$ and δ is given in the following table :

state, symbol		δ
s	a	(q, \sqcup)
s	\sqcup	(h, \sqcup)
s	\triangleright	(s, \rightarrow)
q	a	(s, a)
q	\sqcup	(s, \rightarrow)
q	\triangleright	(q, \rightarrow)

Give the representation of Universal Turing machine for M . (3)