Number of Printed Pages—5 **CS—404**

B. TECH.

FOURTH SEMESTER EXAMINATION, 2001-2002

THEORY OF AUTOMATA & FORMAL LANGUAGES

Time : Three Hours *Total Marks : 100*

Note : (1) Attempt ALL questions.
(2) All questions carry equal marks.
(3) Assume suitable data if required.

1. Attempt any FOUR of the following :— (5×4=20)

(*a*) Write regular expressions for each of the following languages over the alphabet {0, 1} :—

(*i*) The set of all strings in which every pair of adjacent zero's appears before any pair of adjacent one's.

(*ii*) The set of all strings not containing |0| as sub string.

(*b*) Draw DFA for the following language over {0, 1} :—

(*i*) All strings with even no. of 0's and even no. of 1's.

(*ii*) All strings of length at most five.

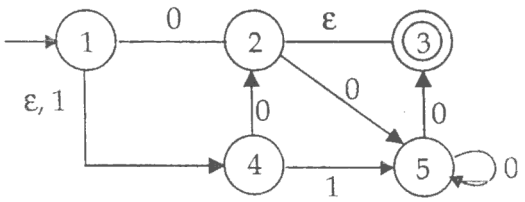
(*c*) Draw Non-deterministic finite automata with specified number of states to accept the following languages :—

(*i*) All strings that contain the substring 0|01 (5 states).

(*ii*) All strings such that the third symbol from the right end is a "0" (4 states).

(*d*) Prove that NDFA = DFA

(*e*) Consider the Finite Automation below and construct the smallest Deterministic Finite Automation which accepts the same language. Draw a regular expression and grammar that generates it.



(*f*) Prove or disprove whether following languages are regular or not :—

(*i*) The set of strings over the alphabet {0} of the form 0^n where n is not a prime.

(*ii*) The set of all binary strings that read backwards the same as forwards (pallindrome).

2. Attempt any FOUR of the following :— (5×4=20)

(*a*) Design context free grammar for the language $a^i \{a^i\, b^j\, c^k | 2 \neq j \text{ or } j \neq k\}$ that is set of strings of *a*'s followed by *b*'s followed by *c*'s such that there are either a different number of *a*'s and *b*'s or a different number of *a*'s and *b*'s or both.

(*b*) Define Chomsky Normal Form and Greibach Normal Form in reference to context free languages. Give suitable examples.

(c) Convert the grammar into Chomsky Normal Form :—

$S \rightarrow ABa$

$A \rightarrow aab$

$B \rightarrow AC$

(d) The following grammar generates the language of regular expression 0*1 (0+1)*

$S \rightarrow A1B$

$A \rightarrow 0A \mid \in$

$B \rightarrow 0B \mid 1B \mid \in$

Give leftmost and rightmost derivation of the strings 00101.

(e) Show that below grammar is ambiguous :—

$G = (V, T, E, P)$

$V = (E, I)$

$T = \{a, b, c, +, *, (..)\}$

and productions

$E \rightarrow I$

$E \rightarrow E + E$

$E \rightarrow E * E$

$E \rightarrow (E)$

$I \rightarrow a \mid b \mid c$

(f) Consider the following grammar, generating the language of balanced parenthesis

$S \rightarrow \in \mid (S) \mid SS$

Give a non-ambiguous grammar for the above.

3. Attempt any FOUR of the following :— (5×

(*a*) Prove PDA = CFG

(*b*) Give pumping lemma theorem in respect with CFG. Show it with some examples. Also give its utility.

(*c*) Design a PDA to accept the following language. You may accept either by final state or by empty stack whichever is most convenient.

$$\left\{0^n 1^n \mid n > 1\right\}$$

(*d*) Prove or disprove whether the following language is context free or not :—

(*i*) $\left\{a^n b^n a^n \mid n >= 0\right\}$

(*ii*) $\left\{a^n a^n b^n \mid n >= 0\right\}$

(*e*) Prove that the family of context free languages is not closed under intersection and complementation.

(*f*) Let L_1 be a CFL and L_2 be regular language, then prove $L_1 \cap L_2$ is context free.

4. Attempt any FOUR of the following :— 4

(*a*) Define a Turing machine mathematically.

(*b*) Design a TM that accepts the language of odd integers written in binary.

(*c*) For $\Sigma = (a, b)$, design a TM that accepts

$$L = \left\{a^n\ b^n;\ n \geq 01\right\}$$

(*d*) Explain Post Correspondence Problem. Find at least three solutions to PCP defined by the Dominoes

1
111

10
0

10111
10

(*e*) Design a TM (Turing Machine) that can compute proper subtraction i.e. $m \div n$, where m and n are positive integers, $m \div n$ is defined as $m - n$ if $m > n$ and 0 if $m \leq n$.

5. Attempt any TWO parts of the following :— (10×2=20)

(*a*) Define Chomsky hierarchy of languages.

(*b*) For each of the following languages indicate the smallest complexity class that contains it (i.e. Regular, Deterministic context free, Context free Turing machines (Recursive)). Assume an alphabet {0, 1}.

(*i*) $0^n1^m0^p1^q$ where $n+m=p+q$ and $n, m, p, q > 0$

(*ii*) The set of strings that have at least ten times as many 0's as 1's

(*iii*) The set of strings that are either odd length or contain 5 consecutive 1's.

(*iv*) The set of strings with 3 n 0's and 4 m 1's for m, n > 0.

(*c*) There exists a recursively enumerable language whose complement is not recursively enumerable. Prove it.