MCA 1st Semester Examination, 2024

MCA

(*Theory of Computing*)

PAPER—MCA-102

Full Marks : 100

Time : 3 hours

Answer **all** questions

The figures in the right hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

GROUP – A

Answer any **five** of the following questions : 2×5

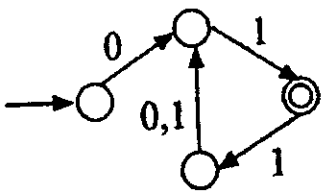
1. Is any grammar possible without a start symbol ? Give reason.

2. Compare NFA's ability with DFA in accepting languages.

3. Construct DFA for the language L = {w|w contains an equal number of occurrences of 01 and 10}

4. Why an FA with ε transition is called NFA ?

5. Write a regular expression equivalent to the following NFA :



6. Consider the unrestricted grammar over the singleton alphabet $\Sigma = \{a\}$, having the start symbol S, and with the following productions.

$S \rightarrow AS|aT$

$Aa \rightarrow aaaA$

$AT \rightarrow T$

$T \rightarrow \varepsilon$

Show a derivation of a^9 using this grammar.

(*Continued*)

7. Consider the context-free grammar G over $\{a, b\}$, with the start symbol S, and with the following productions. What is L(G) ?

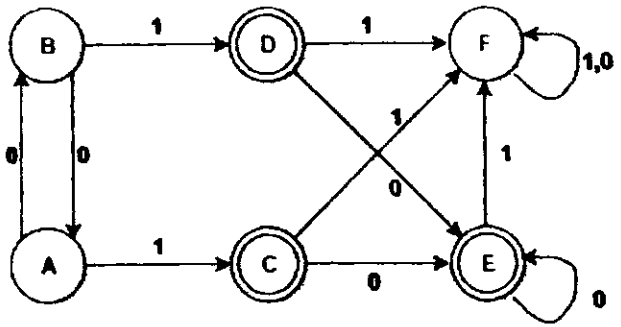
S→aaB|Abb
A→a|aA
B→b|bB

8. Define CNF and GNF.

GROUP – B

Answer any **four** of the following questions : 15×4

9. Explain the Chomsky hierarchy and corresponding type 0, type 1, type 2 and type 3 formalism with a table indicating the automata and grammar for the languages in the Chomsky Hierarchy. Minimize the following DFA using the table-filling method using the Myhill-Nerode theorem, and describe the steps in detail. 7 + 8



10. Construct NFAs for the following languages :

(*a*) $L = \{w|w$ is a string in which at least one a_i occurs even number of times (not necessarily consecutively), where $1 \leq i \leq 3$ over $\Sigma = \{a_1, a_2, a_3\}$.

(*b*) $L = \{w|w$ contains two 0s separated by a substring whose length is a multiple of 3$\}$, $\Sigma = \{0, 1\}$.

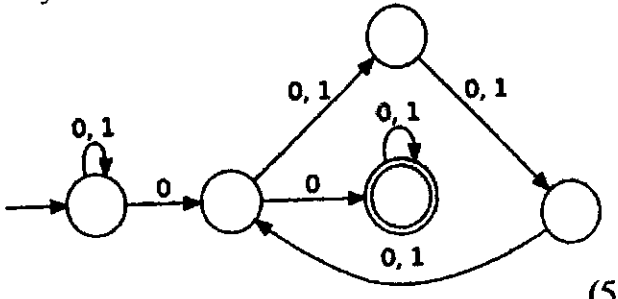
Design a DFA to accept the language $L = \{\alpha \in \{a, b, c\}^* | \alpha$ starts and ends with the same symbol$\}$. Only draw the transition diagram, and indicate the start and final states (s). (5+5)+5

11. Design FAs for the following regular expressions over $\Sigma = \{a, b\}$:

(a) $(aa^* + aba^*b^*)^*$

(b) $((aa+bb+\varepsilon)(ab+ba)^*+a)^*+b$

Consider the following NFA. Draw regular expressions corresponding to the NFA. Names of the states are Q_1, Q_2, Q_3, Q_4 and Q_5 accordingly.



(5+5)+5

12. (a) Construct a regular expression over the alphabet $\{a, b, c\}$ for $L = \{x \in \{a, b, c\}^* | x$ has $4i + 1$ b's for some integer $i \geq 0\}$.

(*b*) Consider the following grammar with the start symbol S :

$S \rightarrow abScB \mid \varepsilon$
$B \rightarrow bB \mid b$

What language does this grammar generate ? Is this grammar ambiguous ?

(*c*) Design a CFG for the set L of all non-palindromes over $\{a, b\}$. Assume that ε is not in the language. 5 + 5 + 5

13. (*a*) Consider the following context-free grammar to generate arithmetic expressions in one variable a, involving addition and multiplication operations only. Here, S is the start symbol.

$S \rightarrow a \mid S+S \mid S \times S$

Draw all the possible parse trees for the string a+a×a+a following this grammar.

(*b*) Let L be the language $L = \{w \in \{a, b\}^* | w$ contains an equal number of occurrences of ab and $ba\}$. For example $ababa \in L$ (two occurrences of ab, and two of ba), whereas $bbaba \notin L$ (one occurrence of ab, and two of ba). Give a regular expression whose language is L. 10 + 5

14. (*a*) Using the pumping lemma, prove that the language $L = \{a^i b^j \mid i, j \geq 0$, and $|i - j|$ is a prime$\}$ is not regular.

(*b*) Convert the following grammar into Chomsky Normal Form (CNF) 6 + 9

$S \rightarrow AACD$

$A \rightarrow aAb \mid \varepsilon$

$C \rightarrow aC \mid a$

$D \rightarrow aDa \mid bDb \mid \varepsilon$

15. Let $\Sigma = \{0, 1\}$. Give DFA's accepting the following strings (any *three*) : 5×3

(*a*) The set of all strings containing 1101 as substring

(*b*) $\{0^n \mid n \geq 0, n \neq 3\}$

(*c*) The set of all strings beginning with 101

(*d*) The set of all strings, which are divisible by 5.

(*e*) $\{01^4x1^3 \mid x \in \{0,1\}^*\}$

16. (*a*) Consider the following unrestricted (Type 0) grammar with the start symbol S, with non-terminal symbols S, A, B, C and with terminal symbols a, b, c.

$S \rightarrow ABCS \mid \varepsilon$, $AB \rightarrow BA$, $BA \rightarrow AB$, $AC \rightarrow CA$, $CA \rightarrow AC$, $BC \rightarrow CB$, $CB \rightarrow BC$, $A \rightarrow a$, $B \rightarrow b$, $C \rightarrow c$.

Show a derivation of the string *babacc* using this grammar. Show each step in the derivation, and mention the rule used in each step.

(*b*) Write an unrestricted grammar to accept the language $L = \{a^ib^jc^kd^l \mid i = k \text{ and } j = l\}$.

Mention the start symbol of your grammar. Use uppercase Roman letters for non-terminal symbols. Show a derivation of the string $a^2b^3c^2d^3$ according to your grammar. 5+(5+5)

[Internal Assessment — 30 Marks]