2024

COMPUTER SCIENCE — HONOURS

Paper : CC-14

(Theory of Computation)

Full Marks : 50

The figures in the margin indicate full marks.

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

Answer ***question no.*** **1** and ***any four*** from the rest.

1. Answer ***any five*** questions : 2×5

(a) Why is it necessary to minimize the number of states in a finite state machine?

(b) Define a Non-deterministic Finite Automaton (NDFA).

(c) Define Instantaneous description (ID) of a Turing Machine.

(d) Given $\sum = \{a, b\}$. Write a regular expression where no two a's come together. Explain briefly.

(e) Give an example of an ambiguous grammar.

(f) State Arden's Theorem.

(g) Define Type-0 and Type-1 grammars as classified by Chomsky.

(h) What is the significance of Halting Problem in Turing Machine?

2. (a) Define a Moore machine M_1.

(b) How is it different from a Mealy Machine?

(c) Consider the Mealy machine described below. Construct a equivalent Moore machine.

Present State	**Next State**			
	Input $a = 0$		**Input $a = 1$**	
	State	**Output**	**State**	**Output**
q_1	q_3	0	q_2	0
q_2	q_1	1	q_4	0
q_3	q_2	1	q_1	1
q_4	q_4	1	q_3	0

2+2+6

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3. (a) Construct a DFA equivalent to an NDFA whose transition table is given below.

State	*a*	*b*
q_0	q_1, q_3	q_2, q_3
q_1	q_1	q_3
q_2	q_3	q_2
(q_3)	—	—

(b) Construct a Grammar which generates set of all palindromes over the alphabet $\{a, b\}$. 5+5

4. (a) Find a grammar G generating $L = \{a^i b^m c^m \mid m \geq 1, i \geq 0\}$.

(b) When is a grammar G said to be monotonic (or length – increasing)?

(c) Find the highest type number (in Chomsky classification) which can be applied to the following productions :

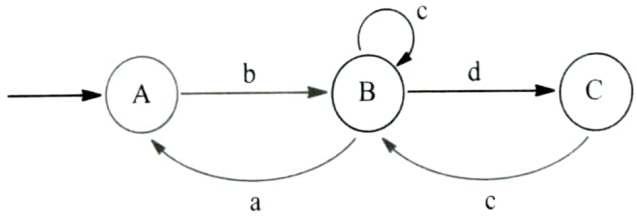
(i) $S \rightarrow aS \mid ab$, (ii) $S \rightarrow ASB \mid d$, $A \rightarrow aA$ 6+2+2

5. (a) Give a formal recursive definition of regular expressions over $\sum$.

(b) Prove that $(a^*ab + ba)^*a^* = (a + ab + ba)^*$

(use the relevant identities)

(c) Convert the following finite automata to a regular expression using Arden's theorem. Show all the steps. 2+3+5



6. Give the regular expression for the strings belonging to the following languages : 2×5

(i) $L_1 = \{x \in \{a, b\}^* \mid x$ has no two consecutive a's$\}$

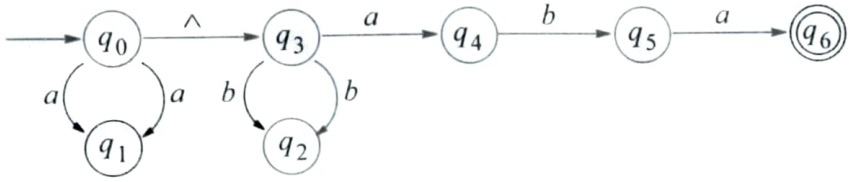
(ii) $L_2 = \{x \in \{a, b\}^* \mid x$ ends with $abb\}$

(iii) $L_3 = \{x \in \{a, b\}^* \mid x$ has a substring bab somewhere$\}$

(iv) $L_4 = \{x \in \{a, b\}^* \mid$ The length of x is 2 mod 3$\}$

(v) $L_5 = \{x \in \{a, b\}^* \mid$ Number of a's in x are even$\}$

7. (a) Convert the following transition system of a FA having a $\wedge$-move into an equivalent transition system having no $\wedge$-moves. Show all the steps.



(b) State the basic idea of a push-down automaton. Explain with the help of a suitable diagram, the working principle of a PDA. 5+5

8. (a) Design a TM that recognizes all strings having an odd number of a's.

(b) Design a Turing Machine to recognize the language $L = \{1^n 2^n 3^n \mid n \geq 1\}$. 5+5
