Z/K/TY

Reg. No: 24BB [redacted]

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Final Assessment Test – November 2025

Course: CBS2002 - Formal Languages and Automata Theory

Class NBR(s): 3280/4778 Slot: D2+TD2

Time: Three Hours Max. Marks: 100

- KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE
- DON'T WRITE ANYTHING ON THE QUESTION PAPER

General Instructions: The empty string is denoted by ε or λ.

COs	CO Statements
CO1	Demonstrate the knowledge of mathematical models of computation and describe how they relate to formal languages.
CO2	Derive an appropriate model of computation for a given language and vice versa.
CO3	Infer the equivalence of languages described using different automata or grammars.
CO4	Distinguish the computability power of automata and their limitations.

BL – Blooms Taxonomy Level (1 – Remember, 2 – Understand, 3 – Apply, 4 – Analyse, 5 – Evaluate, 6 – Create)

Answer ALL Questions

(10 X 10 = 100 Marks)

1. a) Construct a context-free grammar for the language $L_1 = \{w \in \{0,1\}^* : |w|_0 = |w|_1\}$ where $|x|_a$ refers to the occurrences of a in the string x. Derive at least two distinct words of the language from the grammar you established. **[4]** CO1 BL2

   b) Give some example languages ($L \subset \Sigma^*$) for which (i) $L = L^*$, (ii) $L = L^+$, (iii) $L = L^R$, where R is the reversal operation. Avoid trivial languages like Σ^* or ϕ – the empty set. **[6]**

2. a) Minimize the following DFA whose transition rules are represented by the following table. Here the states are {A,B,C,D,E} with A being the initial and the final states are {A,C,E}. The alphabet set $\Sigma = \{0,1,2,3\}$. Draw the final DFA obtained. **[4]** CO3 BL3

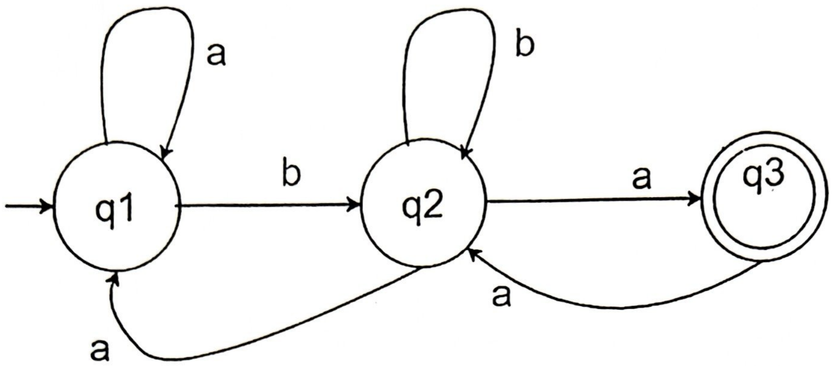
	0	1	2	3
A	A	B	C	D
B	C	D	A	B
C	A	B	A	B
D	C	A	C	D
E	A	B	C	D

   b) Consider the NFA with ε-transition whose transition function is given in the below table. Convert to equivalent NFA without epsilon transition. $\Sigma = \{a,b\}$ and q1 is the start and as well the final state. Draw the final NFA without epsilon transition. **[6]**

	a	b	ε
q_1	ϕ	q_2	q_3
q_2	$\{q_2, q_3\}$	q_3	ϕ
q_3	q_1	ϕ	ϕ

3. Consider the language $\{0^{2n} \mid n \geq 0\} \cup \{0^{3n} \mid n \geq 0\}$. For this language construct a NFA without ε-transition and from the NFA, exhibit an equivalent DFA by subset construction procedure. [Hint: Try fork like non-deterministic transition for the initial state q_0]. **CO2 BL3**

4. a) For the following DFA, derive the corresponding regular expression with proper steps. [7] **CO2 BL3**



   b) Give a regular expression that represents all strings over {0,1} that start and end with 1 and having at least two zeros in between. [3]

5. a) Simplify the context-free grammar whose rules are given by [4] **CO3 BL4**
   $S \rightarrow AB \mid AE \mid E$, $A \rightarrow aA \mid \varepsilon$, $B \rightarrow bB \mid \varepsilon$, $E \rightarrow eE \mid e$.

   b) Show that Union of two non-regular languages can be regular. Proof required for at least one language that you considered is not regular (use pumping lemma). [Hint: Consider similar languages of Q1a]. [6]

6. Construct a PDA that accepts the language $L_6 = \{a^n b^m c^{m+2n} \mid n, m \geq 1\}$. Write the logic behind your construction in four bullet points not more than 2 lines each. Given the input strings abcc and abccc describe how the PDA will process them. **CO2 BL2**

7. a) Consider the grammar rules (0, 1 are terminals) [4] **CO2 BL4**
   $S \rightarrow X \mid \varepsilon$, (S – start symbol of the grammar)
   $X \rightarrow 0XA \mid 1XB$,
   $XB \rightarrow CX$, $CX \rightarrow X0$, $0X \rightarrow 0$,
   $XA \rightarrow DX$, $DX \rightarrow X1$, $1X \rightarrow 1$.

   Derive any two different strings produced by the grammar. What is the grammar type and the language generated by the grammar?

   b) Construct a LBA (linear bounded automata) that accepts the language $L_6 = \{ww^R \mid w \in \{0,1\}^*\}$. [6]

8. a) Show that there exists recursively enumerable languages whose complement is not recursively enumerable. [4] **CO2 BL2**

   b) Prove that recursively enumerable languages are closed under union and intersection operations. [6]

9.a)	Construct a TM as transducer that takes a positive number in unary representation as input and produces the remainder in the tape when divided by 3 (i.e., mod 3).	CO4	BL5
	OR		
9.b)	Construct TM as transducer that takes the input w, w ∈ {a,b}* and produces the output ww in the tape. Given the input abb, describe how your constructed TM will process the input and produces what output.	CO4	BL5
10.a)	Discuss the following in short paragraphs. (i) Halting problem, (ii) Rice theorem, (iii) universal TM, (iv) Post Correspondence problem.	CO4	BL1
	OR		
10.b)	Describe the concept 'reducibility' and define the computational complexity classes P, NP-Complete and NP-Hard.	CO4	BL1

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