



SCHOOL OF COMPUTER SCIENCE AND ENGINEERING
CONTINUOUS ASSESSMENT TEST - II
WINTER SEMESTER 2025-2026

Programme Name & Branch : B.Tech Computer Science and Engineering
Course Code and Course Name : BCSE304L Theory of Computation
Faculty Name(s) : Common to All
Class Number(s) : Common to All
Date of Examination : 20.03.2026
Exam Duration : 90 minutes Maximum Marks: 50

General instruction(s):

- Answer All Questions
- M - Max mark; CO - Course Outcome; BL - Blooms Taxonomy Level (1 - Remember, 2 - Understand, 3 - Apply, 4 - Analyse, 5 - Evaluate, 6 - Create)
- Course Outcomes:
CO1: Compare and analyse different computational models
CO2: Apply rigorously formal mathematical methods to prove properties of languages, grammars and automata.
CO3: Identify limitations of some computational models and possible methods of proving them.

Q. No	Question	M
1.	<p>a. Construct the equivalent Finite Automaton (FA) for the following grammar by clearly specifying the set of states, input alphabets, start state, final states, and transition function. Finally, draw the state-transition diagram for the constructed automaton.</p> $S \rightarrow 0P 1P$ $P \rightarrow 0P 1P +Q -Q$ $Q \rightarrow 0Q 1Q 0 1$	5
	b. Prove that the language $L = \{a^n b a b^{n+1}\}$ is not regular.	5
2.	<p>a. Consider the following context-free grammar (Given in CNF).</p> $S \rightarrow AB BB$ $A \rightarrow CC AB a$ $B \rightarrow BB CA b$ $C \rightarrow BA AA b$ <p>Using the CYK algorithm, determine whether the following strings belong to the language generated by the grammar G. Show all the steps.</p> <p>i) aabb ii) ababa</p>	7
	<p>b) Prove that the following grammar is ambiguous by constructing at least two parse trees for the input string $abaabab$.</p> $S \rightarrow RS \epsilon, R \rightarrow Ra aRb ab$	3



VIT

Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

REG.NO.:

SLOT: E2+TE2

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3.	<p>a. Convert the following Context Free grammar (CNF) to Chomsky Normal Form (CNF). The grammar $G = \langle \{S, A, B\}, \{a,b\}, S, P \rangle$ with S as the start symbol.</p> <p>P: $\{ S \rightarrow AB$ $A \rightarrow aAA \mid \epsilon$ $B \rightarrow bBB \mid \epsilon \}$</p>	4
	<p>b. Consider the following grammar G. Eliminate the useless productions and null productions from the given grammar. $G = \{S, A, B, C, D\}, \{a,c,d\}, S, P \rangle$ P: $S \rightarrow a \mid aA \mid B \mid C$ $A \rightarrow aB \mid \epsilon$ $B \rightarrow Aa$ $C \rightarrow cCD$ $D \rightarrow ddd$</p>	6
4.	<p>a. Let $L_1 = \{a^n b^n c^m \mid n, m \geq 1\}$, $L_2 = a^* b^* c^*$, Find $L_1 \cap L_2$ and prove it is context free.</p>	6
	<p>b. Find a context-free grammar for $\Sigma = \{a, b\}$ for the language $L = \{a^n w w^R b^n : w \in \Sigma^*, n \geq 1\}$.</p>	4
5.	<p>Construct a PDA for the following language. $L = a^i b^j c^k \mid i, j, k > 0$ and $j = i+k$ Show the moves of the PDA for the string aabbbbcc using instantaneous description</p>	10

1a. Given Grammar

$$S \rightarrow 0P \mid 1P$$

$$P \rightarrow 0P \mid 1P \mid +Q \mid -Q$$

$$Q \rightarrow 0Q \mid 1Q \mid 0 \mid 1$$

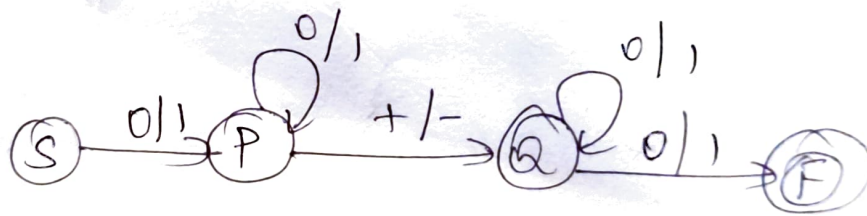
Each nonterminal considered as state plus one extra final state.

$$Q = \{S, P, Q, F\}$$

$$\Sigma = \{0, 1, +, -\}$$

start state $q_0 = S$

Final state $F = \{F\}$



1b. By Pumping Lemma, $L = \{a^n b a b^{n+1}\}$ can be proved that it is not regular

29. CYK Membership Algorithm

$S \rightarrow AB \mid BB$

$A \rightarrow CC \mid AB \mid a$

$B \rightarrow BB \mid CA \mid b$

$C \rightarrow BA \mid AA \mid b$

1) Given String aabb

C, B, A, S			
C, A	A, C, S		
C	S, A	S, B, A	
A	A	B, C	B, C
a	a	b	b

Since S is in the top most cell, aabb $\in L(G)$

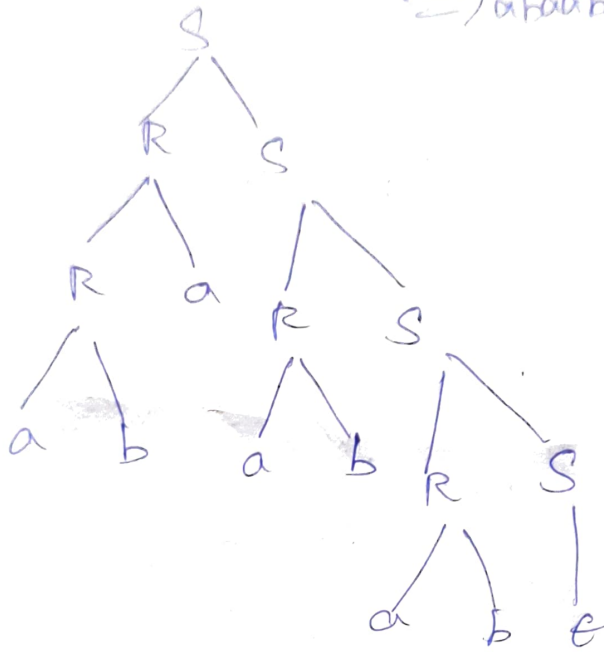
2) Given String ababa

S, A, B, C				
S, A, C	S, A, B, C			
S, A, C	S, A, B, C	S, A, C		
S, A	B, C	S, A	B, C	
A	B, C	A	B, C	A
a	b	a	b	a

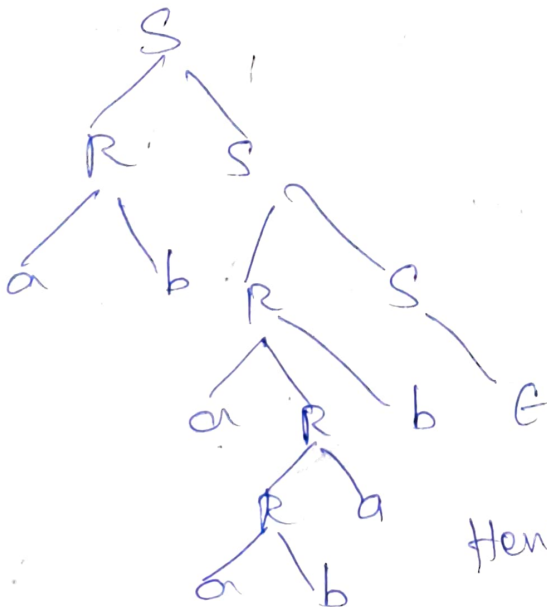
Since S is in the top most cell, ababa $\in L(G)$

2b)
1) Parse Tree

$S \Rightarrow RS \Rightarrow RaS \Rightarrow aboS \Rightarrow aboRS$
 $\Rightarrow abaaHS \Rightarrow abaaHRS$
 $\Rightarrow abaaHabe$
 $\Rightarrow abaaHah$



$2) S \Rightarrow RS \Rightarrow abS \Rightarrow abRS \Rightarrow abarBS$
 $\Rightarrow abarabS \Rightarrow abaaababS$
 $\Rightarrow abaaababe \Rightarrow abaaabab$



Hence the grammar is ambiguous.

39. CNF to Chomsky Normal Form

Given Grammar:

$$P = \{ S \rightarrow AB \\ A \rightarrow aAA | \epsilon \\ B \rightarrow bBB | \epsilon \}$$

i) Eliminate ϵ productions

$$A \rightarrow \epsilon, B \rightarrow \epsilon$$

In $S \rightarrow AB$

$$S \rightarrow A$$

$$S \rightarrow B$$

$$S \rightarrow \epsilon$$

$$\therefore S \rightarrow AB | A | B | \epsilon$$

For $A \rightarrow aAA$

$$A \rightarrow aA$$

$$A \rightarrow a$$

$$\therefore A \rightarrow aAA | aA | a$$

For $B \rightarrow bBB$

$$B \rightarrow bB$$

$$B \rightarrow b$$

$$\therefore B \rightarrow bBB | bB | b$$

After ϵ -removal,

$$S \rightarrow AB | A | B | \epsilon$$

$$A \rightarrow aAA | aA | a$$

$$B \rightarrow bBB | bB | b$$

Remove Unit Productions

Unit Productions

$$S \rightarrow A$$

$$S \rightarrow B$$

Replace ^{them} A & B Productions

$$S \rightarrow AB \mid aAA \mid aA \mid a \mid bBB \mid bB \mid b \mid \epsilon$$

Introduce new variables

$$X \rightarrow a$$

$$Y \rightarrow b$$

Let $C \rightarrow AA$

$$D \rightarrow BB$$

Final CNF Grammar

$$S \rightarrow AB \mid XC \mid XA \mid a \mid YD \mid YB \mid b \mid \epsilon$$

$$A \rightarrow XC \mid XA \mid a$$

$$B \rightarrow YD \mid YB \mid b$$

$$X \rightarrow a$$

$$Y \rightarrow b$$

$$C \rightarrow AA$$

$$D \rightarrow BB$$

3b.

Given Grammar:

$$P: S \rightarrow a|aA|B|C$$

$$A \rightarrow aB|E$$

$$B \rightarrow Aa$$

$$C \rightarrow cCD$$

$$D \rightarrow ddd$$

Step 1: Removing Useless Symbols

$$D \rightarrow ddd \quad (\text{Generating terminals})$$

$$C \rightarrow cCD \quad (\text{Depends on C itself, not generating})$$

$$A \rightarrow E$$

$$B \rightarrow Aa \quad (\text{Since A generates})$$

$$S \rightarrow a \quad (\text{Generates})$$

∴ Generating variables S, A, B, D
Remove C (useless symbol)

b) Reachable Symbols

D is never reachable from S

∴ Remove D

After removing useless symbols:

$$S \rightarrow a|aA|B$$

$$A \rightarrow aB|E$$

$$B \rightarrow Aa$$

Step 2: Eliminate Null Productions

$$A \rightarrow \epsilon$$

Removing $\Rightarrow S \rightarrow a | aA | B$

$$A \rightarrow aB$$

$$B \rightarrow \cancel{A}a | a$$

Final Grammar

Q4.

$$L_1 = \{ a^n b^n c^m \mid n, m \geq 1 \}$$

$$L_2 = \{ a^* b^* c^* \}$$

Find $L_1 \cap L_2$

Every string in L_1 already follows L_2 .

$$\therefore L_1 \subseteq L_2$$

$$\therefore L_1 \cap L_2 = \{ a^n b^n c^m \mid n, m \geq 1 \}$$

Prove as CFG by constructing Context free grammar

$$\begin{aligned} \text{Grammar: } & S \rightarrow AB \\ & A \rightarrow aAb \mid ab \\ & B \rightarrow cB \mid c \end{aligned}$$

$\therefore L_1 \cap L_2$ is Context free.

4b. Find CFG for $L = \{ a^n w w^R b^n \}$.

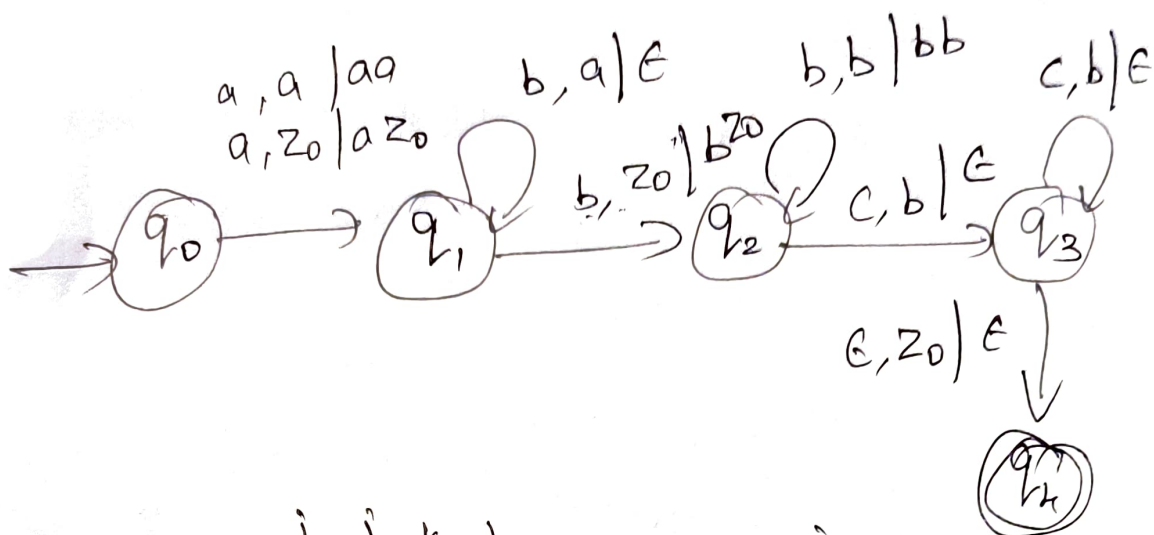
$w \in \Sigma^*$, $n \geq 1$

Ans.

$S \rightarrow aSb \mid aAb$

$A \rightarrow aAa \mid bAb \mid \epsilon$

B. PDA



$$L = a^i b^j c^k \mid i, j, k > 0, j = i+k$$

logic

$$L = a^i b^{i+k} c^k$$

$$= a^i b^i b^k c^k$$

~~///~~ Push a , pop b for i times, push b k times, pop c k times.

Instantaneous Description (ID)

For string $aabbbbcc$

- $(q_0, aabbbbcc, z_0) \vdash (q_1, abbbbcc, az_0)$
- $\vdash (q_1, bbbbcc, aaz_0) \vdash (q_2, bccc, abz_0)$
- $\vdash (q_2, bccc, z_0) \vdash (q_2, cc, bbz_0)$
- $\vdash (q_3, c, bz_0) \vdash (q_3, \epsilon, z_0)$
- $\vdash (q_4, \epsilon, \epsilon)$