Assignment (Fall-23)

United International University

(Solution)

Name (Optional)

ID No. Section

Invigilator's Signature with date

Course Code

Trimester / Semester : Spring / Summer / Fall, 20.....

Name of Exam : Class Test / Mid-term 1 / Mid-term 2 / Final Date: .....

1

L1 = { Strings with equal number of 'a's and b's (in any order) }

$S \rightarrow aSb \mid bSa \mid \epsilon$

L2 = { Strings not in the form $0^i 1^j$, where $i = j$; $i, j > 0$ }

$S \rightarrow A \mid \epsilon$

$A \rightarrow 0A1 \mid 1A0 \mid 10$

$L3 = \{ a^n b^{2m} \mid n \geq 1, m \geq n \}$

$S \rightarrow aSbb \mid aBbb$

$B \rightarrow bB \mid \epsilon$

$L4 = \{ a^n b^m \mid n \leq m \leq 2n \}$

$S \rightarrow aSbb \mid aSb \mid \epsilon$

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② :)

$S \to aX \mid bY \mid b \mid ZZc$

$X \to Yaa \mid abZ \mid \epsilon$

$Y \to bXXb \mid ab \mid cZ$

$Z \to a \mid b \mid XZ \mid \epsilon$

Step 1: As Starting Symbol is not on the right side of the production rule, skip this step.

Step 2: Removing $X \to \epsilon \Rightarrow$

$S \to aX \mid bY \mid b \mid ZZc \mid a$

$X \to Yaa \mid abZ$

$Y \to bXXb \mid ab \mid cZ \mid bXb \mid bb$

$Z \to a \mid b \mid XZ \mid Z \mid \epsilon$

Removing $Z \to \epsilon \Rightarrow$

$S \to aX \mid bY \mid b \mid ZZc \mid a \mid Zc \mid c$

$X \to Yaa \mid abZ \mid ab$

$Y \to bXXb \mid ab \mid cZ \mid bXb \mid bb \mid c$

$Z \to a \mid b \mid XZ \mid X$

Step 3: Removing $Z \to X \Rightarrow$

$S \to aX \mid bY \mid b \mid ZZc \mid a \mid Zc \mid c$

$X \to Yaa \mid abZ \mid ab$

$Y \to bXXb \mid ab \mid cZ \mid bXb \mid bb \mid c$

$Z \to a \mid b \mid XZ \mid Yaa \mid abZ \mid ab$

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Step 4: ~~Removing~~ Reducing Production rules that has length > 2 ⇒

$S \to aX \mid bY \mid b \mid ZA \mid a \mid Zc \mid c$

$X \to Ba \mid aC \mid ab$

$Y \to DE \mid ab \mid cZ \mid Db \mid bb \mid c$

$Z \to a \mid b \mid XZ \mid Ba \mid aC \mid ab$

$A \to Zc$

$B \to Ya$

$C \to bZ$

$D \to bX$

$E \to Xb$

Step 5: Bring the rules in the CNF format.

$S \to ZX \mid ZY \mid b \mid ZA \mid a \mid ZY \mid c$

$X \to BZ \mid ZC \mid ZZ$

$Y \to DE \mid ZZ \mid SZ \mid DZ \mid ZZ \mid c$

$Z \to a \mid b \mid XZ \mid BS \mid SC \mid ZZ$

$A \to ZY$

$B \to YZ$

$C \to ZZ$

$D \to ZX$

$E \to XZ$

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ii)

Step 1: Adding a new starting symbol

$S \rightarrow Q_0$

$Q_0 \rightarrow 0Q_0 \mid 1Q_2$

$Q_1 \rightarrow 0Q_3 \mid 1Q_0 \mid \epsilon$

$Q_2 \rightarrow 0Q_1 \mid 1Q_3 \mid \epsilon$

$Q_3 \rightarrow 0Q_4 \mid 1Q_1 \mid \epsilon$

$Q_4 \rightarrow 0Q_2 \mid 1Q_4 \mid \epsilon$

Step 2:

Removing $Q_1 \rightarrow \epsilon \Rightarrow$

$S \rightarrow Q_0$

$Q_0 \rightarrow 0Q_0 \mid 1Q_2$

$Q_1 \rightarrow 0Q_3 \mid 1Q_0$

$Q_2 \rightarrow 0Q_1 \mid 1Q_3 \mid 0 \mid \epsilon$

$Q_3 \rightarrow 0Q_4 \mid 1Q_1 \mid 1 \mid \epsilon$

$Q_4 \rightarrow 0Q_2 \mid 1Q_4 \mid \epsilon$

Removing $Q_2 \rightarrow \epsilon \Rightarrow$

$S \rightarrow Q_0$

$Q_0 \rightarrow 0Q_0 \mid 1Q_2 \mid 1$

$Q_1 \rightarrow 0Q_3 \mid 1Q_0$

$Q_2 \rightarrow 0Q_1 \mid 1Q_3 \mid 0$

$Q_3 \rightarrow 0Q_4 \mid 1Q_1 \mid 1 \mid \epsilon$

$Q_4 \rightarrow 0Q_2 \mid 1Q_4 \mid 0 \mid \epsilon$

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Removing $Q_3 \to \epsilon \Rightarrow$

$S \to Q_0$

$Q_0 \to 0Q_0 \mid 1Q_2 \mid 1$

$Q_1 \to 0Q_3 \mid 1Q_0 \mid 0$

$Q_2 \to 0Q_1 \mid 1Q_3 \mid 0 \mid 1$

$Q_3 \to 0Q_4 \mid 1Q_1 \mid 1$

$Q_4 \to 0Q_2 \mid 1Q_4 \mid 0 \mid \epsilon$

Removing $Q_4 \to \epsilon \Rightarrow$

$S \to Q_0$

$Q_0 \to 0Q_0 \mid 1Q_2 \mid 1$

$Q_1 \to 0Q_3 \mid 1Q_0 \mid 0$

$Q_2 \to 0Q_1 \mid 1Q_3 \mid 0 \mid 1$

$Q_3 \to 0Q_4 \mid 1Q_1 \mid 1 \mid 0$

$Q_4 \to 0Q_2 \mid 1Q_4 \mid 0 \mid 1$

Step 3: Removing $S \to Q_0 \Rightarrow$

$S \to 0Q_0 \mid 1Q_2 \mid 1$

$Q_0 \to 0Q_0 \mid 1Q_2 \mid 1$

$Q_1 \to 0Q_3 \mid 1Q_0 \mid 0$

$Q_2 \to 0Q_1 \mid 1Q_3 \mid 0 \mid 1$

$Q_3 \to 0Q_4 \mid 1Q_1 \mid 1 \mid 0$

$Q_4 \to 0Q_2 \mid 1Q_4 \mid 0 \mid 1$

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Step 4: Skip this step as there is no production rules that has length 2.

Step 5:

$S \rightarrow AQ_0 \mid BQ_2 \mid 1$

$Q_0 \rightarrow AQ_0 \mid BQ_2 \mid 1$

$Q_1 \rightarrow AQ_3 \mid BQ_0 \mid 0$

$Q_2 \rightarrow AQ_1 \mid BQ_3 \mid 0 \mid 1$

$Q_3 \rightarrow AQ_4 \mid BQ_1 \mid 0 \mid 1$

$Q_4 \rightarrow AQ_2 \mid BQ_4 \mid 0 \mid 1$

$A \rightarrow 0$

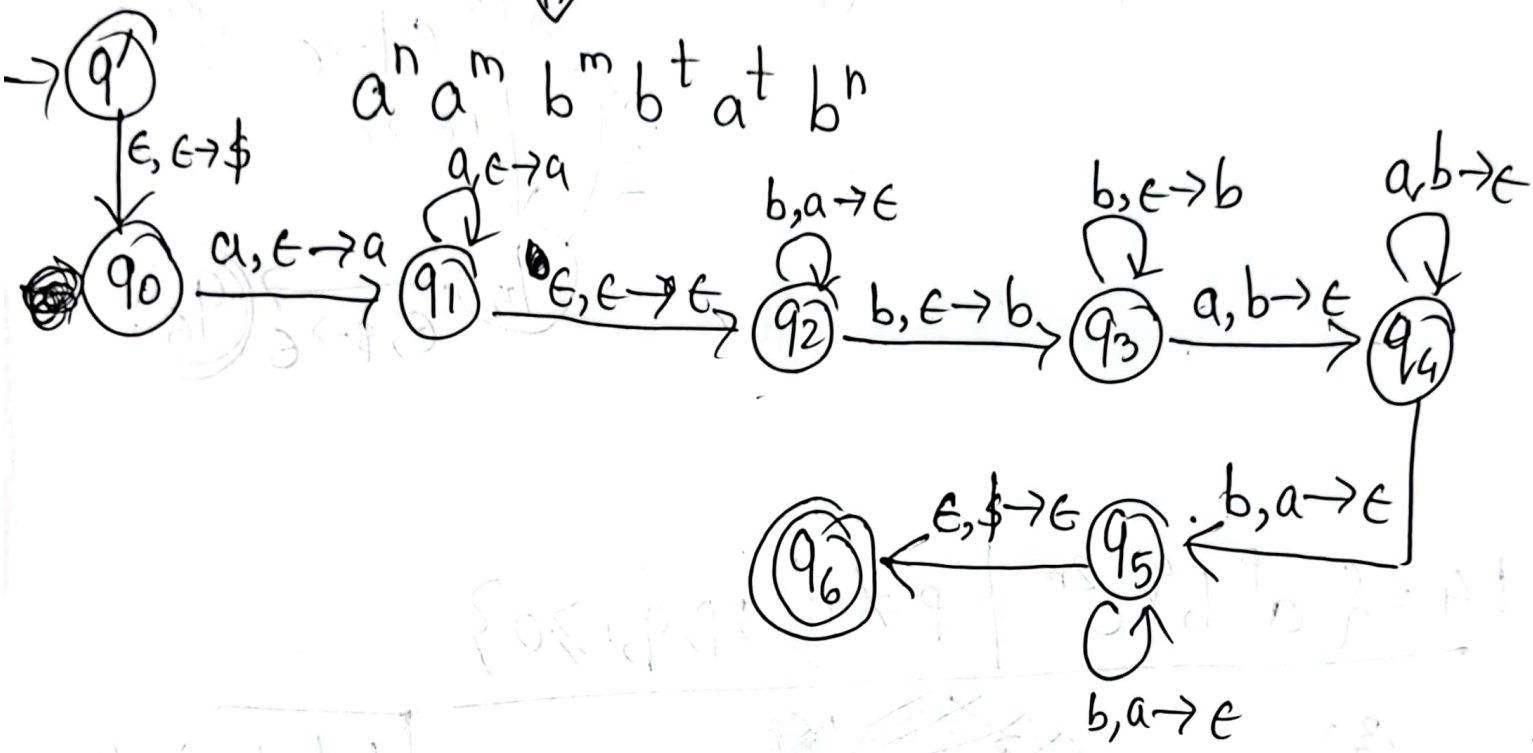
$B \rightarrow 1$

3

$$L1 = \{ a^{n+m} \; b^{m+t} \; a^t \; b^n \mid n, t > 0 \text{ and } m \geq 0 \}$$

$$\Downarrow$$

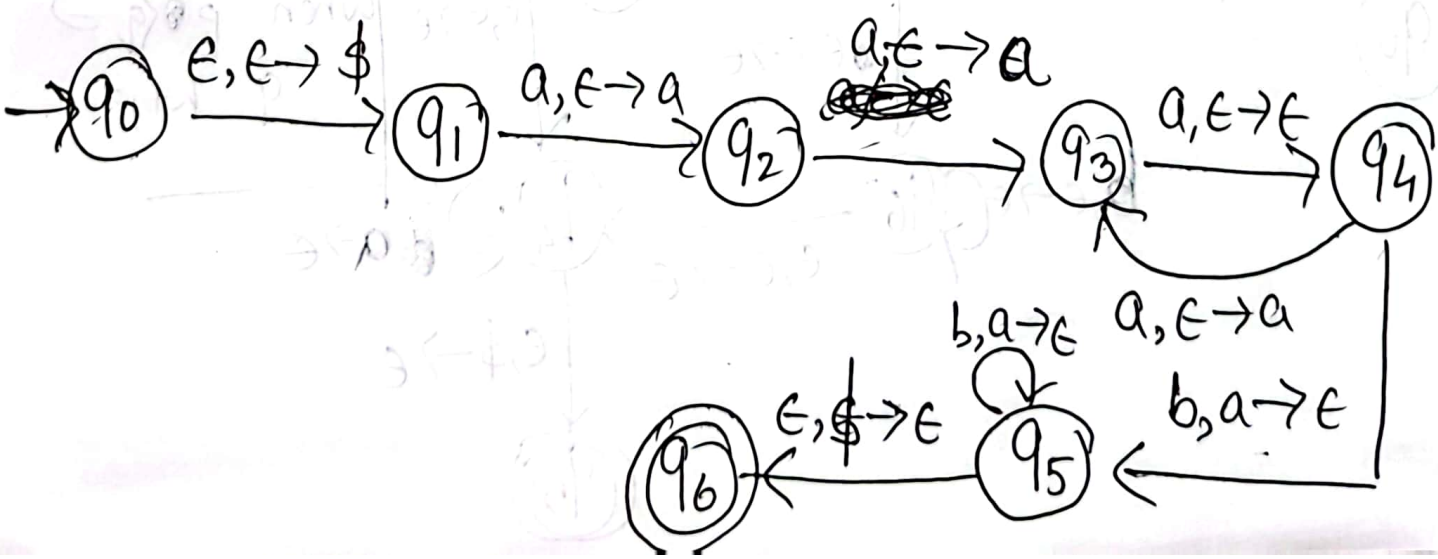
$$a^n a^m b^m b^t a^t b^n$$



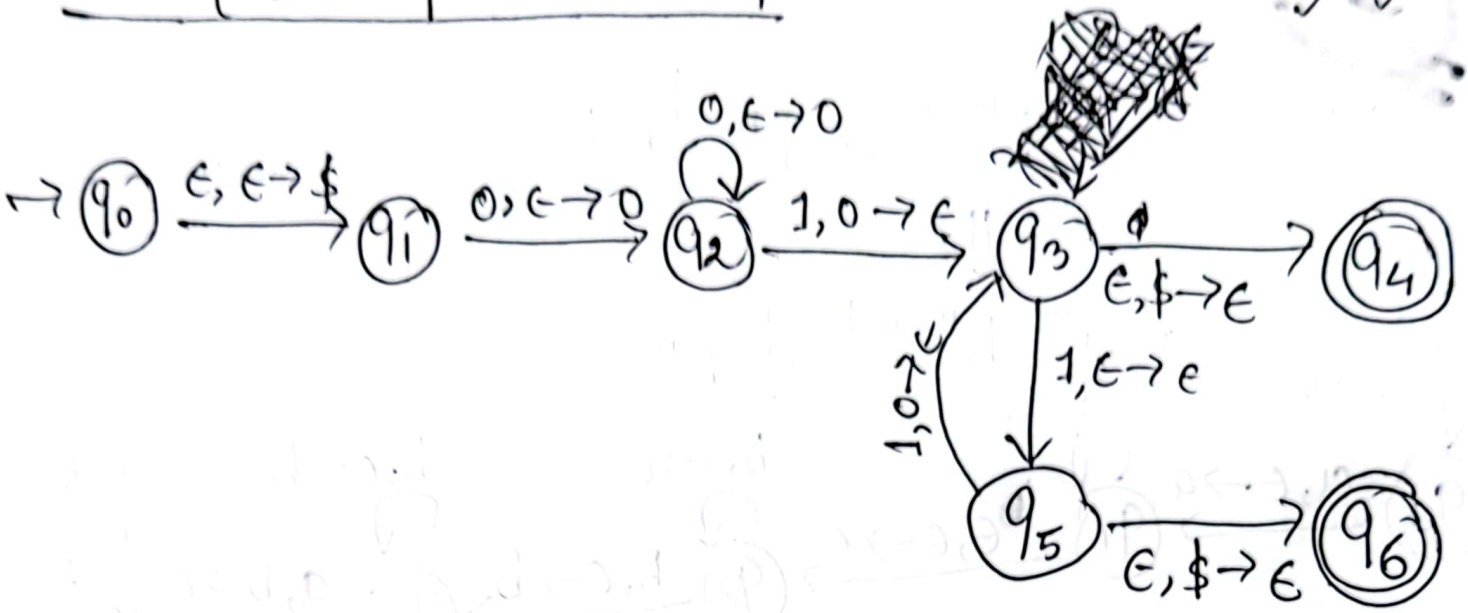
$$L2 = \{ a^{2n+1} \; b^n \mid n > 0 \}$$

$$\Downarrow$$

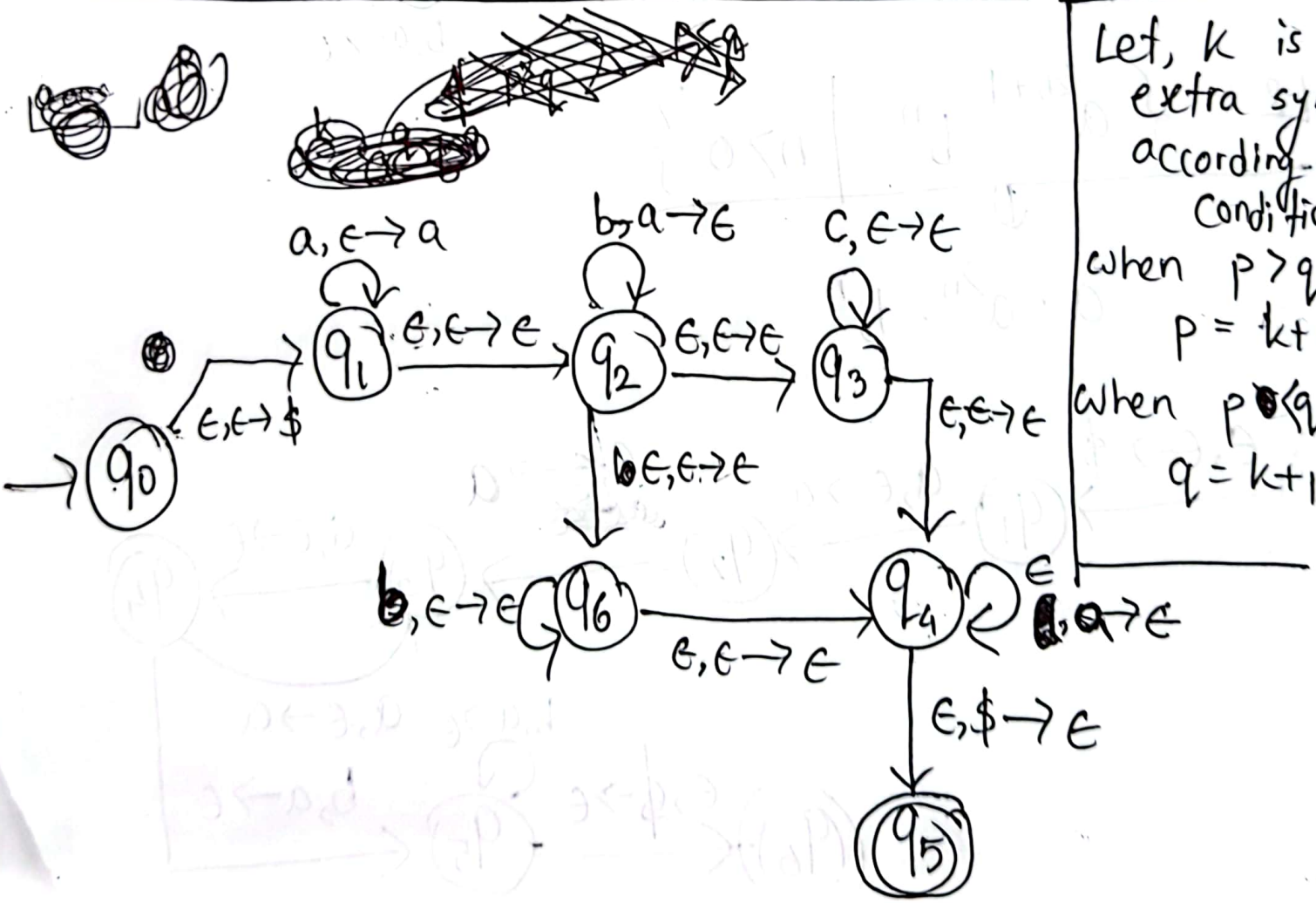
$$a \cdot a^{2n} \cdot b^n$$



$L3 = \{ 0^i 1^j \mid i \leq j \leq 2i \}$



$L4 = \{ a^p b^q c^{2r} \mid p \neq q \; ; p, q, r \geq 0 \}$



Let, k is the
extra symbo
according to
condition
when p > q =
p = k + q
when p < q =
q = k + p