a)

Case 1 :-

STMT → IF - THEN-ELSE

→ if condition then STMT else STMT

→ if condition then IF - ~~ELSE~~ THEN
else STMT

→ if condition then if condition then STMT
else STMT

→ if condition then if condition then ASSIGN
else STMT

→ if condition then if condition then a := 1
else STMT

→ if condition then if condition then a := 1
else ASSIGN

→ If condition then if condition then
a := 1 else a := 1.

Case 2

STMT → IF - THEN

→ if condition then STMT

→ if condition then IF - THEN - ELSE

→ if condition then if condition then STMT
else STMT

→ if condition then if condition then ASSIGN
else STMT

→ if condition then if condition then a := 1
else STMT

→ if condition then if condition then a := 1 else
ASSIGN

→ if condition then if condition then a := 1 else
a := 1

The grammar is ambiguous because the
string " if condition then if condition then a=1
else a:=1 " has 2 parse routines

b) $G' = (V', \Sigma, R', \langle STMT \rangle)$, where

$V' = \{ \langle STMT \rangle, \langle ASSIGN \rangle, \langle IF\ THEN \rangle, \langle IF -$
$THEN - ELSE \rangle, \langle MTCH \rangle, \langle M - IFTE \rangle \}$

$\Sigma = \{ if, condition, then, else, a:=1 \}$.

$R' \to \langle STMT \rangle \to \langle ASSIGN \mid \langle IF - THEN \rangle \mid \langle IF-THEN-$
$ELSE \rangle$.

$\langle IF - THEN \rangle \to if\ condition\ then\ \langle STMT \rangle$.

$\langle IF\ THEN\ ESLE \rangle \to if\ condition\ then\ \langle MTCH \rangle else$
$\langle STMT \rangle$.

$\langle MTCH \rangle \to \langle ASSIGN \rangle \mid \langle M - IFTE \rangle$.
$\langle M - IFTE \rangle \to if\ condition\ then\ \langle MTCH \rangle$
$else\ \langle MTCH \rangle$.

$\langle ASSIGN \rangle \to a:=1$.

2) Case 1:

$\{ a^i b^j c^k \mid$ when $i = j \}$

$S \rightarrow B$

$B \rightarrow D$

$D \rightarrow aDb \mid \varepsilon$

Case 2:

$\{ a^i b^j c^k \mid$ when $j = k \}$

$S \rightarrow A$

$A \rightarrow C$

$C \rightarrow bCc \mid \varepsilon$

when $i > k, \ k > i$

$A \rightarrow aA$

$B \rightarrow Bc$

$S \rightarrow A \mid B$

$A \rightarrow aA \mid C$

$B \rightarrow Bc \mid D$

$C \rightarrow bCc \mid \varepsilon$

$D \rightarrow aDb \mid \varepsilon$

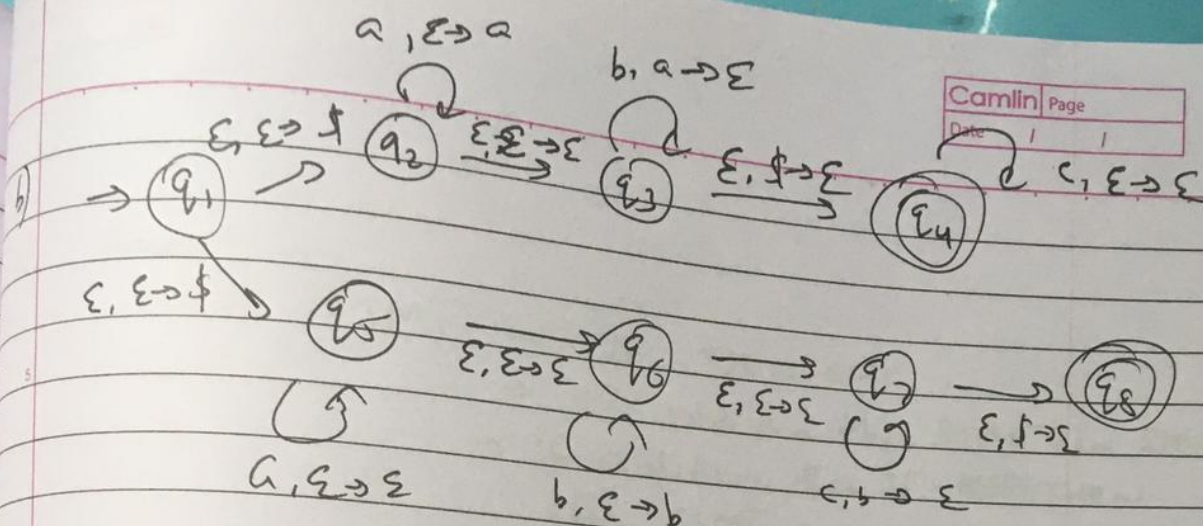Grammar $G = (V, \Sigma, P, S)$, where,

$V = \{ S, A, B, C, D \}$

$\Sigma = \{ a, b, c \}$

$S \rightarrow \{ S \}$

$P \rightarrow \{ S \rightarrow A \mid B, A \rightarrow aA \mid C, B \rightarrow Bc \mid D,$
$\qquad\quad C \rightarrow bCc \mid \varepsilon, D \rightarrow aDb \mid \varepsilon \}$

b)

$a, \varepsilon \to a$

$b, a \to \varepsilon$

$\varepsilon, \varepsilon \to \$$ (q₂) $\varepsilon, \varepsilon \to \varepsilon$ (q₃) $\varepsilon, \$ \to \varepsilon$ (q₄) $c, \varepsilon \to \varepsilon$

$\to$ (q₁)

$\varepsilon, \varepsilon \to \$$ (q₅) $\varepsilon, \varepsilon \to \varepsilon$ (q₆) (q₇) (q₈)

$\varepsilon, \varepsilon \to \varepsilon$ $\varepsilon, \$ \to \$$

$a, \varepsilon \to \varepsilon$ $b, \varepsilon \to b$ $c, b \to \varepsilon$

The PDA has a non-deterministic branch at q_1. If the string is $a^i b^j c^k$, with $i = j$, then the branch PDA takes the branch from q_1 to q_2. If the string is $a^i b^j c^k$ with $j = k$, then the PDA takes the branch from q_1 to q_5.

informally

PDA corresponding to given CFG.

$$PDA(A) = (\{q\}, \{a, b, c\}, \delta, \{a, b, c, S, A, B, C, D\}, \{q\}, \{S\}, \{F\}).$$

where

$q - \{q\}$

$\varepsilon - \{a, b, c\}$

$\Gamma -$ Stack symbol $\{a, b, c, S, A, B, C, D\}$

$q0 - \{q\}$

$z - \{S\}$

$F - \{q\}$.

3

a) L(G) in English ->

L(G) contains all strings such that each string begins with n number of a's and ends with n number of b's, where n can be 0, and then there it has either a or b followed by any number of a's and b's or any no- of a's and b's followed by a in the middle.

b) Complement

$$L(G) = a^n b (a \cup b) b$$

$$L(G) = a^n b (a \cup b)^* b^n \cup a^n (a \cup b)^* a b^n$$

4
a)

$S' \rightarrow S$

$S \rightarrow A | B | CS | DS | ES | FS$

$C \rightarrow AA$

$D \rightarrow AB$

$E \rightarrow BA$

$F \rightarrow BB$

$A \rightarrow 0$

$B \rightarrow 1$

b)

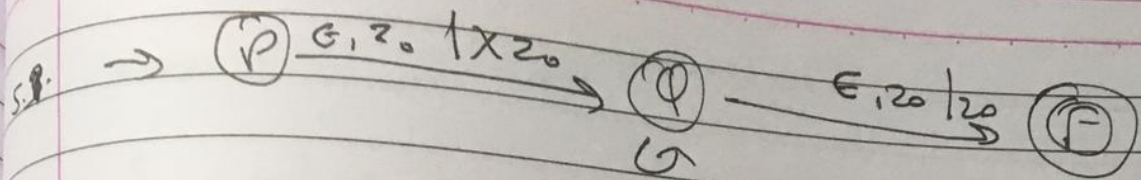$S' \rightarrow S$

$S \rightarrow A | B | AA | BB | CA | DB$

$C \rightarrow AS$

$D \rightarrow BS$

$A \rightarrow 0$

$B \rightarrow 1$

5.8.

→ (P) $\xrightarrow{G, z_0 \mid x z_0}$ (Q) — $\epsilon, z_0 \mid z_0$ (r)

G

$\epsilon, x \mid x - y$

$\epsilon, x \mid y$

$\epsilon, y \mid y \mid 2$

$\epsilon, y \mid 2$

$\epsilon, 2 \mid (x)$

$\epsilon, 2 \mid (q)$

Current State	Input	State Symbol	Transition
P	ϵ	z_0	$(q, x z_0)$
q	G	λ	$(q, x - x)$
q	ϵ	x	(q, Y)
q	G	Y	$(q, Y \mid 2)$
q	G	y	$(q, 2)$
q	q	.2	$(q, (x))$
q	ϵ	2	(q, q)
q	ϵ	-	(q, ϵ)
q	ϵ T	1	(q, ϵ)
q	ϵ (	(	(q, ϵ)
q	ϵ)	)	(q, G)
q	ϵ q	q	(q, ϵ)
q			

$q_x \epsilon \cdot x \ \sqcap \quad \rightarrow \ q \ x \ \sqcap^*$

6   S → UOVEVEY

E → UOVEVEYIN

N → 0|1|2|3|4|5|6|7|8|9|NN

O → add|subl|mul|div|mod

U → [

V → ·-

Y →)

§ Reducing the length → Chomsky -Normal form

S → UF
F → OG
G → VHY
H → EG
X → YIJ

E → UFIn

N → n

U → [

V → _

N → 0|1|2|3|4|5|6|7|8|9|NN

6   O → add|subl|mul|div|mod