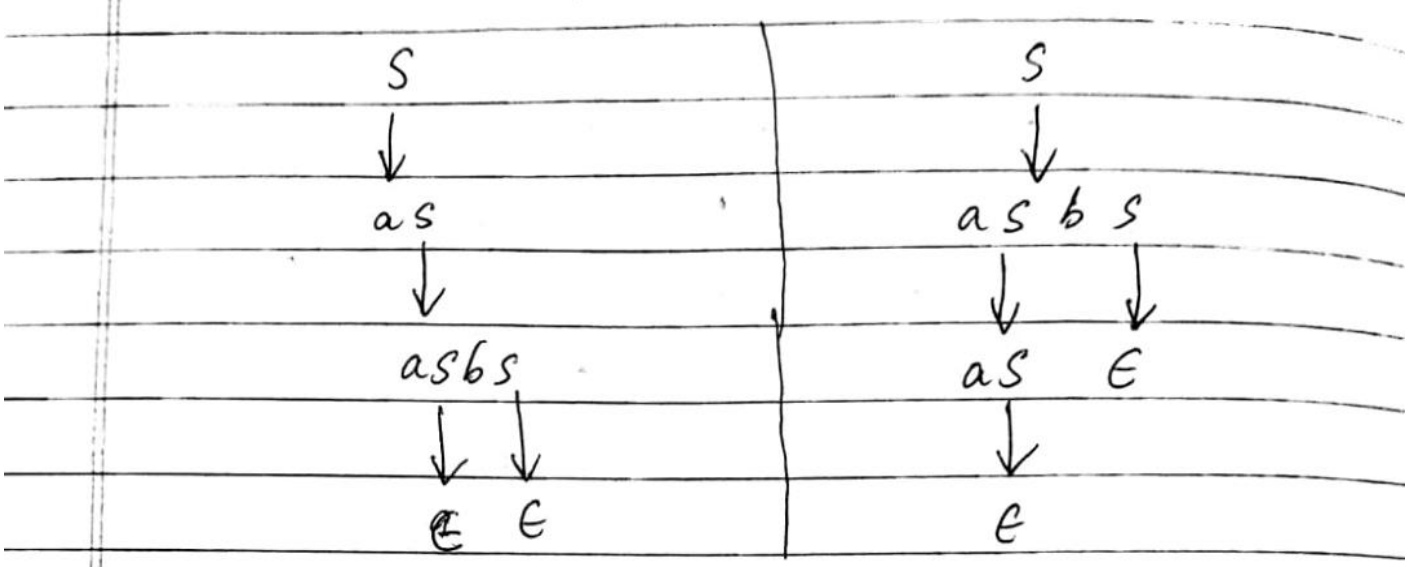
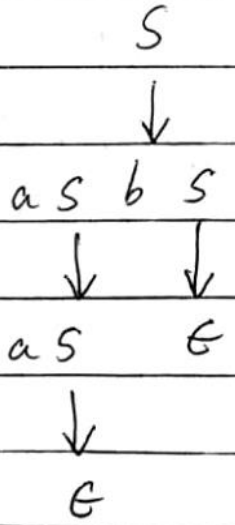
5.4.1

a) Parse trees:

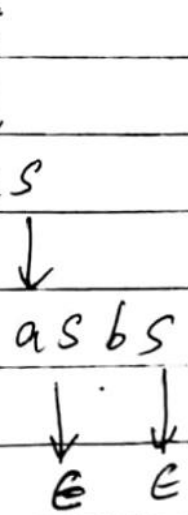
* $S \rightarrow aS \mid aSbS \mid \epsilon$ sequence $\rightarrow aab$



b) Left derivation



c) Right derivation



3) ~~(a)~~

$S \to 0A0 \mid 1B1 \mid BB$	$S \to 0A0$
$A \to C$	$S \to 1B1$
$B \to S \mid A$	$S \to BB$
$C \to S \mid \epsilon$	$A \to C$
	$B \to S \mid A$
	$C \to S \mid \epsilon$

* $A \to C$, $C \to S \mid \epsilon$, $\Rightarrow A \to S \mid \epsilon$
* $B \to A$, $A \to S \mid \epsilon \Rightarrow B \to S \mid \epsilon$
* $S \to 0A0 \mid 1B1 \mid \Rightarrow S \to 0S0 \mid 1S1$
* $S \to BB \Rightarrow S \to \epsilon$

$\therefore S \to 0S0 \mid 1S1 \mid \epsilon$

* Chomsky Normal form =>

Non terminal → Non terminal Non terminal

Non terminal → Terminal

$S \to 0P$	$S \to R_3 R_3$	$S \to 0A0 \mid 1B1 \mid BB$
$P \to AQ$	$R_3 \to B$	$A \to C$
$Q \to 0$	$A \to C$	$B \to S \mid A$
$S \to 1B1$	$B \to S$	$C \to S \mid \epsilon$
$S \to 1R_1$	$B \to A$	
$R_1 \to BR_2$	$C \to S$	
$R_2 \to 1$	$C \to \epsilon$	

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4) $S \to aAa \mid bBb \mid \epsilon$

$A \to \epsilon \mid a$

$B \to c \mid b$

$C \to CDE \mid \epsilon$

$D \to A \mid B \mid ab$

$S \to aAa$

$S \to bBb$

$S \to \epsilon$

$A \to c \mid a$

$B \to S \mid A$

$C \to CDE \mid \epsilon$

$D \to A \mid B \mid ab$

* $A \to c \mid a \quad C \to CDE \mid \epsilon \Rightarrow A \to cDE \mid \epsilon \mid a$
* $B \to S \mid A \; ; \; A \to c \mid a \Rightarrow B \to S \mid c \mid a$
* $C \to CDE \mid \epsilon, D \to A \mid B \mid ab \Rightarrow CAE \mid CBE \mid CabE \mid \epsilon$
* $D \to A \mid B \mid ab \quad A \to c \mid a, \; B \to c \mid b,$

$\Rightarrow D \to c \mid a \mid c \mid b \mid ab$

$D \to c \mid a \mid b \mid ab$

* $S \to aAa \mid bBb \mid \epsilon; \; A \to c \mid a, \; B \to c \mid b,$

$\Rightarrow S \to aaa \mid aca \mid bbb \mid bcb \mid \epsilon$

* Chomsky Normal Form $\Rightarrow$

Non terminal $\to$ Non terminal Non terminal

Non terminal $\to$ Terminal

$S \to aQ$	$S \to bM$	$A \to C$	$D \to A$	$Y \to b$	$S \to \epsilon$
$P \to AQ$	$M \to BN$	$A \to a$	$D \to B$	$C \to CT$	$C \to \epsilon$
$Q \to a$	$N \to b$	$B \to C$	$D \to XY$	$T \to DR$	
		$B \to b$	$X \to a$	$R \to E$	