



1

$$L = \left\{ a^{n+1} b^n c^{n-1} : n \geq 1 \right\}$$

$$S \rightarrow aab \mid aaXbc$$

$$aaXbc$$

$$aX \rightarrow aabY \mid aab$$

$$aabYbc$$

$$Yb \rightarrow bY$$

$$aaabbYc$$

$$Yc \rightarrow Xcc$$

$$aaabbXcc$$

$$bX \rightarrow Xb$$

2

$$L = \left\{ a^n b^n a^{2n} : n \geq 1 \right\}$$

$$S \rightarrow abaa \mid abYca$$

$$aX \rightarrow aabY \mid aab$$

$$abYca$$

$$bX \rightarrow b$$

$$abXaaac$$

$$ya \rightarrow Xaaa$$

$$aXbcaaa$$

$$yb \rightarrow bY$$

$$aabYbcaaa$$

3

$$S \rightarrow aIX_aD \mid bIX_bD$$

$$IX \rightarrow bIB \mid aIA \mid N$$

$$Aa \rightarrow aA$$

$$Ab \rightarrow bA$$

$$B_a \rightarrow aB$$

$$abIB_aD$$

$$Bb \rightarrow bB$$

$aX \rightarrow X_a$  $bX \rightarrow X_b$  $N_a \rightarrow aN$  $N_b \rightarrow bN$  $AD \rightarrow X_a D$  $BD \rightarrow X_b D$  $ND \rightarrow \lambda$  $a b I_a b X D$  $c b b I X c b b D$  $N$ 

4

 $S \rightarrow A B C S \mid ABC$  $Z \rightarrow C S \mid C$  $AB \rightarrow BA$  $AC \rightarrow CA$  $BA \rightarrow AB$  $BC \rightarrow CB$  $cB \rightarrow BC$  $CA \rightarrow AC$  $A \rightarrow c$  $B \rightarrow b$  $C \rightarrow c C \mid c$