

## Practice/

$$S \rightarrow X Y$$

$$Y \rightarrow a$$

$$Y \rightarrow Z$$

$$Y \rightarrow b$$

$$Z \rightarrow M$$

$$M \rightarrow N$$

$$N \rightarrow a$$

Removing unit productions,

$$M \rightarrow N$$

$$\therefore M \rightarrow a$$

$$Z \rightarrow M$$

$$\therefore Z \rightarrow a$$

$$Y \rightarrow Z$$

$$\therefore Y \rightarrow a$$

$\therefore$  Finally  $\rightarrow$

$$S \rightarrow X Y$$

$$M \rightarrow a$$

$$Y \rightarrow a$$

$$N \rightarrow a$$

$$Y \rightarrow b$$

$$Z \rightarrow a$$

## Practice

$S \rightarrow ABAC$

$A \rightarrow qA$

$A \rightarrow \epsilon$

$B \rightarrow bB$

$B \rightarrow \epsilon$

$C \rightarrow c$

Removing  $A \rightarrow \epsilon$

$S \rightarrow ABAC | BAC | ABC | BC$

$A \rightarrow qA | a$

$B \rightarrow bB$

$B \rightarrow \epsilon$

$C \rightarrow c$

Removing  $B \rightarrow \epsilon$

$S \rightarrow ABAC | BAC | ABC | BC | AAC | AC | C$

$A \rightarrow a$

$B \rightarrow bB | b$

$C \rightarrow c$

• CFG<sub>i</sub> to CNF :

$S \rightarrow ASA | aB$

$A \rightarrow B | S$

$B \rightarrow b | \epsilon$

Step 1

$S' \rightarrow S, S \rightarrow ASA | aB, A \rightarrow B | S, B \rightarrow b | \epsilon$

Step 2

for  $B \rightarrow \epsilon$ ,

$S' \rightarrow S, S \rightarrow ASA | aB | a, A \rightarrow B | S | \epsilon, B \rightarrow b$

for  $A \rightarrow \epsilon$

$S' \rightarrow S, S \rightarrow ASA | aB | a | AS | SA | S$

$A \rightarrow B | S, B \rightarrow b$

Step 3

$S' \rightarrow S, S \rightarrow S, A \rightarrow S, A \rightarrow B$

for  $S \rightarrow S, S' \rightarrow S, S \rightarrow ASA | aB | a | AS | SA,$

$A \rightarrow B | S, B \rightarrow b$

for  $S' \rightarrow S, S' \rightarrow ASA | aB | a | AS | SA,$

$S \rightarrow ASA | aB | a | AS | SA,$

$A \rightarrow B | S, B \rightarrow b$

for  $A \rightarrow B$ ,  $S' \rightarrow ASA|aB|a|AS|SA$

$S \rightarrow ASA|aB|a|AS|SA$

$A \rightarrow b|S$ ,  $B \rightarrow b$

for  $A \rightarrow S$ ,  $S' \rightarrow \underline{ASA}|aB|a|AS|SA$

$S \rightarrow \underline{ASA}|aB|a|AS|SA$

$A \rightarrow b| \underline{ASA}|aB|a|AS|SA$

$B \rightarrow b$

Step 4 & 5

$X \rightarrow AS$

$Y \rightarrow a$

$S' \rightarrow \underline{XA}|\underline{YB}|a|AS|SA$

$S \rightarrow \underline{XA}|\underline{YB}|a|AS|SA$

$A \rightarrow b| \underline{XA}|\underline{YB}|a|AS|SA$

$B \rightarrow b$

•  $S \rightarrow ABA$ ,  $A \rightarrow aA|\epsilon$ ,  $B \rightarrow bB|\epsilon$

for  $A \rightarrow \epsilon$ ,  $S \rightarrow ABA|AB|BA|B$

$A \rightarrow aA|a$

$B \rightarrow bB|\epsilon$

for  $B \rightarrow \epsilon$ ,  $S \rightarrow ABA|AB|BA|B|AA|A$

$A \rightarrow aA|a$

$B \rightarrow bB|b$

for  $S \rightarrow B$ , &  $S \rightarrow A$

$S \rightarrow ABA|AB|BA|bB|b|AA|aA|a$

$A \rightarrow aA|a$

$B \rightarrow bB|b$

$A_1 \rightarrow AB$     $B_1 \rightarrow b$     $A_2 \rightarrow a$

$S \rightarrow A_1 A_1 | AB | BA | B_1 B_1 | b | AA | A_2 A_1 | a$

$A \rightarrow A_2 A_1 | a$

$B \rightarrow B_1 B_1 | b$

•  $S \rightarrow abAB$ ,  $A \rightarrow bAB|\epsilon$ ,  $B \rightarrow BAa|A|\epsilon$

for  $A \rightarrow \epsilon$ ,  $S \rightarrow abAB|abB$

$A \rightarrow bAB|bB$ ,  $B \rightarrow BAa|A|Ba|\epsilon$

for  $B \rightarrow \epsilon$ ,  $S \rightarrow abAB|abB|abA|ab$

$A \rightarrow bAB|bB|bA|b$

$B \rightarrow BAa|A|Ba|Aa|a$

for  $B \rightarrow A$ ,  $S \rightarrow abAB|abB|abA|ab$

$A \rightarrow bAB|bB|bA|b$

$B \rightarrow BAa|bAB|bB|bA|b|Ba|Aa|a$

$A_1 \rightarrow a$      $B_1 \rightarrow b$

$C_1 \rightarrow A_1 B_1$

$C_2 \rightarrow AB$

$C_3 \rightarrow BA$

$S \rightarrow C_1 C_2 | C_1 B_1 | C_1 A_1 | A_1 B_1$

$A \rightarrow B_1 C_2 | B_1 B_1 | B_1 A_1 | b$

$B \rightarrow C_3 A_1 | B_1 C_2 | B_1 B_1 | B_1 A_1 | b | Ba_1 | AA_1 | a$