

$$B \rightarrow SC_3 / a / C_b C_b / SC_b / \cancel{C_b S} / b / CaC_2 / CaA$$

$$C_3 \rightarrow C_b S$$

$$C_b \rightarrow b$$

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2. GNF : Greibach normal form

$$A \rightarrow a\alpha$$

$\alpha \in N^* \rightarrow$ set of non-terminals

Lemma 1:

$$\text{if } A \rightarrow B\alpha$$

$$B \rightarrow p$$

$$\text{then } A \rightarrow p\alpha$$

Lemma 2:

$$L \rightarrow \text{if } A \rightarrow A\alpha / p$$

doesn't have left recursion

change left recursion if we use lmd.

$$L' \rightarrow \begin{aligned} &3. \text{ reproduce the rht side:} \\ &A \rightarrow pA' / p \\ &A' \rightarrow \alpha A' / \alpha \end{aligned}$$

$$\text{eg: if } L: A \rightarrow A\alpha$$

$$\Rightarrow A\alpha\alpha$$

$$\Rightarrow A\alpha\alpha\alpha$$

$$\Rightarrow p\alpha\alpha\alpha$$

$$L': A \Rightarrow pA'$$

$$\Rightarrow p\alpha A'$$

$$\Rightarrow p\alpha\alpha A'$$

$$\Rightarrow p\alpha\alpha\alpha$$

$$Q. S \rightarrow AB$$

Let's

$$A \rightarrow BS / b$$

$$B \rightarrow SA / a$$

$$S = A_1$$

$$A = A_2$$

$$B = A_3$$

$$\therefore A_1 \rightarrow A_2 A_3$$

$$A_2 \rightarrow A_3 A_1 / b$$

$$A_3 \rightarrow A_1 A_2 / a$$

Take the 1st pdtⁿ,

$$A_1 \rightarrow A_2 A_3$$

repeat
till
 $i=j$
or
 $i>j$

\therefore it's of the form $A_i \rightarrow A_j \alpha$
where $i < j$

$$\Rightarrow A_1 \rightarrow A_3 A_1 A_3 / b A_3$$

$i < j$

If $i = j$ then apply Lemma 2 else if $i > j$ then the pdtⁿ is already in GNF.

$$\Rightarrow A_1 \rightarrow A_1 A_2 A_1 A_3 / b A_3 / a A_1 A_3$$

$A \quad i=j \quad \alpha \quad B_1 \quad B_2$

$$\Rightarrow \text{of the form } A \rightarrow A \alpha / B_1 / B_2$$

where $\alpha = A_2 A_1 A_3$

$$A_1 \rightarrow p_1 A_1' / p_2 / b A_3 / a A_1 A_3$$

$$Z_1 \rightarrow A_2 A_1 A_3 Z_1 / A_2 A_1 A_3$$

$$\cancel{Z_2} \rightarrow A$$

$$A_2 \rightarrow A_3 A_1 / b$$

$$A_2 \rightarrow A_1 A_2 A_1 / a A_1 / b$$

$$\cancel{A_2} \rightarrow \cancel{b A_1 A_2 Z_1 A_2 b A_1 A_2 Z_1}$$

$$A_2 \rightarrow b A_3 Z_1 A_2 A_1 / a A_1 A_3 Z_1 A_2 A_1 / b A_3 A_2 A_1 / a A_1 A_2 A_2 A_1 / a A_1 / b$$

$$A_3 \rightarrow \cancel{A_1 A_2} / a$$

$i > j$

$$A_3 \rightarrow b A_3 Z_1 A_2 / a A_1 A_3 Z_1 A_2 / b A_3 A_2 / a A_1 A_3 A_2 / a$$

$$\begin{aligned}
 Z_1 &\rightarrow bA_3Z_1A_2A_1A_1A_3Z_1 / aA_1A_3Z_1A_2A_1A_1A_3Z_1 \\
 &bA_3A_2A_1A_1A_3Z_1 / aA_1A_3A_2A_1A_1A_3Z_1 / aA_1A_1A_3Z_1 / bA_1A_3Z_1 \\
 &bA_3Z_1A_2A_1A_1A_3 / aA_1A_3Z_1A_2A_1A_1A_3 / bA_3A_2A_1A_1A_3 / \\
 &aA_1A_3A_2A_1A_1A_3 / aA_1A_1A_3 / bA_1A_3.
 \end{aligned}$$

Q. $S \rightarrow AB/a$

$A \rightarrow BBA/a$

$B \rightarrow b$

~~$A_1 \rightarrow AB/a$~~

~~$A_2 \rightarrow BBA/a$~~

$A_1 \rightarrow A_2A_3/a$

$A_2 \rightarrow A_3A_3A_2/a$

$A_3 \rightarrow b$

$A_1 \rightarrow \textcircled{A_2}A_3/a$

$A_1 \rightarrow \textcircled{A_3}A_3A_2A_3/aA_3/a$

$A_1 \rightarrow bA_3A_2A_3/aA_3/a$

$A_2 \rightarrow \textcircled{A_3}A_3A_2/a$

$\rightarrow bA_3A_2/a$

$A_3 \rightarrow b$

Q. $S \rightarrow ASB/AB$, $A \rightarrow SSB/a$, $B \rightarrow b$

$A_1 \rightarrow \textcircled{A_2}A_1A_2/\textcircled{A_2}A_3$

$$A_2 \rightarrow A_1 A_1 A_3 / a$$

$$A_3 \rightarrow b$$

(i) $A_1 \rightarrow \underbrace{A_1 A_1 A_3 A_1 A_3}_{\alpha_1} / \underbrace{a A_1 A_3}_{\beta_1} / \underbrace{A_1 A_1 A_3 A_3}_{\alpha_2} / \underbrace{a A_3}_{\beta_2}$
 apply lemma 2.

(ii) $A_1 \rightarrow a A_1 A_3 \tau_1 / a A_3 \tau_1 / a A_1 A_3 / a A_3 /$
 $a A_1 A_3 \tau_1 / a A_3 \tau_1$

$$\tau_1 \rightarrow A_1 A_3 A_1 A_3 \tau_1 / A_1 A_3 A_1 A_3 / A_1 A_3 A_3 \tau_1 / A_1 A_3 A_3$$

$$\tau_2 \rightarrow A_1 A_3 A_3 \tau_2 / A_1 A_3 A_3$$

(iii) $A_2 \rightarrow A_1 A_1 A_3 / a$
 \rightarrow

$$\tau_1 \rightarrow a A_1 A_3 \tau_1 A_3 A_1 A_3 \tau_1 / a A_3 \tau_1 A_3 A_1 A_3 \tau_1 / a A_1 A_3 A_3 A_1 A_3 \tau_1 /$$

$$a A_3 A_3 A_1 A_3 \tau_1 / a A_1 A_3 \tau_1 A_3 A_1 A_3 \tau_1 / a A_3 \tau_1 A_3 A_1 A_3 \tau_1 /$$

$$a A_1 A_3 \tau_1 A_3 A_1 A_3 / a A_3 \tau_1 A_3 A_1 A_3 / a A_1 A_3 A_3 A_1 A_3 /$$

$$a A_3 A_3 A_1 A_3 / a A_1 A_3 \tau_1 A_3 A_1 A_3 / a A_3 \tau_1 A_3 A_1 A_3 /$$

$$a A_1 A_3 \tau_1 A_3 A_3 \tau_1 / a A_3 \tau_1 A_3 A_3 \tau_1 / a A_1 A_3 A_3 A_3 \tau_1 /$$

$$a A_3 A_3 A_3 \tau_1 / a A_1 A_3 \tau_1 A_3 A_3 \tau_1 / a A_3 \tau_1 A_3 A_3 \tau_1 /$$

$$a A_1 A_3 \tau_1 A_3 A_3 / a A_3 \tau_1 A_3 A_3 / a A_1 A_3 A_3 A_3 /$$

$$a A_3 A_3 A_3 / a A_1 A_3 \tau_1 A_3 A_3 / a A_3 \tau_1 A_3 A_3$$

(iv) $A_2 \rightarrow A_1 A_1 A_3 / a$

$$\rightarrow a A_1 A_3 \tau_1 A_1 A_3 / a A_3 \tau_1 A_1 A_3 / a A_1 A_3 A_1 A_3 / a A_3 A_1 A_3 /$$

$$a A_1 A_3 \tau_1 A_1 A_3 / a A_3 \tau_1 A_1 A_3 / a$$

(v) $A_3 \rightarrow b$