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CSC 304

(25)

$S \rightarrow a^m | b^n | a^m b^n$

sol  
 $S \rightarrow aSa \rightarrow a\lambda a \rightarrow a^2$

$S \rightarrow aSa \rightarrow a^3$

$S \rightarrow aSa \rightarrow ab^2$

$S \rightarrow aSa \rightarrow b^2 \rightarrow b\lambda b \rightarrow b^3$

$S \rightarrow aSa \rightarrow b^3$

$S \rightarrow aSa \rightarrow ab^2ba \rightarrow ab\lambda b^2a \rightarrow abba$

$S \rightarrow aSa \rightarrow b^2 \rightarrow b^2b^2 \rightarrow b^4$

$S \rightarrow aSa \rightarrow b^3 \rightarrow bab$

$S \rightarrow aSa \rightarrow ab^2 \rightarrow ab\lambda b \rightarrow abb$

$S \rightarrow aSb \rightarrow a\lambda b \rightarrow ab$

$\{ a^n, b^n, ab^n, a^n b^n, a^n b^n a^n, a^n b^{2n}, a^n b^{3n}, \dots \}$

$\{ a^m b^n \mid m \geq 0, n \geq 0 \}$

(26)

$G = (V, T, S, P)$

i)  $S \rightarrow aS | bS | a | b$

sol  
 $S \rightarrow aS \rightarrow a^2$

$S \rightarrow aS \rightarrow ab$

$S \rightarrow aS \rightarrow abS \rightarrow ab^2$

$\{ a^n, b^n, ab^n, ab^{2n}, \dots \}$

ii)  $S \rightarrow aSa | bSb | aSb | \lambda$

sol  
 $S \rightarrow aSa \rightarrow a\lambda a \rightarrow a^2$

$S \rightarrow aSa \rightarrow abSb^2 \rightarrow ab\lambda b^2 \rightarrow abba$



$S \rightarrow aSa \rightarrow aaSba \rightarrow aqa\lambda ba \rightarrow aqa\lambda ba$   
 $S \rightarrow aSa \rightarrow abSba \rightarrow a\lambda a\lambda bba \rightarrow ab\lambda\lambda bba \rightarrow ab\lambda\lambda bba$   
 $\{ \lambda, aa, abba, aaba, ab\lambda\lambda bba, \dots \}$

iii)  $S \rightarrow aAb/aBb/aSb, A \rightarrow aA\lambda a, B \rightarrow bB/b$   
Sol

$S \rightarrow aAb \rightarrow aab$   
 $S \rightarrow aAb \rightarrow aqAb \rightarrow aqab$   
 $S \rightarrow aBb \rightarrow abb$   
 $S \rightarrow aBb \rightarrow abBb \rightarrow abbb$   
 $S \rightarrow aSb \rightarrow aaAbb \rightarrow aqaabb$   
 $\{ aab, aqab, abb, abbb, aqaabb, \dots \}$

(27)

i)  $S \rightarrow aAb, A \rightarrow aA/bA/\lambda$   
Sol

$S \rightarrow aAb \rightarrow a\lambda b \rightarrow ab$   
 $S \rightarrow aAb \rightarrow aqAb \rightarrow aqa\lambda b \rightarrow aqab$   
 $S \rightarrow aAb \rightarrow abAb \rightarrow ab\lambda b \rightarrow abb$   
 $S \rightarrow aAb \rightarrow aqAb \rightarrow aqabAb \rightarrow aqab\lambda b \rightarrow aqabb$   
 $\{ \lambda, ab, aqab, abb, aqabb, \dots \}$   
 $\{ a^m b^n / m \geq 0, n \geq 0 \}$

ii)  $S \rightarrow aSb/ab$

Sol

$S \rightarrow aSb \rightarrow aqbb$   
 $S \rightarrow aSb \rightarrow aqSbb \rightarrow aqa\lambda bbb$   
 $\{ a^m b^n / m \geq 0, n > 0 \}, \{ aqbb, aqa\lambda bbb \}$

iii)  $S \rightarrow aSc/aAc, A \rightarrow aAb/ab$

Sol

$S \rightarrow aSc \rightarrow aaAcc \rightarrow aqa\lambda bcc$   
 $S \rightarrow aSc \rightarrow aqAcc \rightarrow aqa\lambda Acc \rightarrow aqa\lambda bcc$



$S \rightarrow aSc \rightarrow aaaAcc \rightarrow aaaaAbcc \rightarrow aaaaaabbcc$   
 $\{a^{m+1}b^n c^2 \mid m > 0, n > 0\}$   
 $\{aaaaacc, aaaaabbcc, aaaaaabbcc, \dots\}$

iv)  $S \rightarrow AB, B \rightarrow bB/b, A \rightarrow A/a$   
Sol

$S \rightarrow AB \rightarrow aB \rightarrow ab$   
 $S \rightarrow AB \rightarrow aAB \rightarrow aab$   
 $S \rightarrow AB \rightarrow aB \rightarrow abB \rightarrow abb$   
 $S \rightarrow AB \rightarrow aAB \rightarrow aaAB \rightarrow aaab$   
 $S \rightarrow AB \rightarrow aAB \rightarrow aaAB \rightarrow aaAbB \rightarrow aaabbb$   
 $S \rightarrow AB \rightarrow AbB \rightarrow abbb \rightarrow abbbb$   
 $\{ab, aab, abb, aaab, aaabb, abbbb, \dots\}$   
 $\{a^{m+1}b^n \mid m > 0, n > 0\}$

(28)

$L(G) = \{a^n b^m \mid n \geq m\}$

$L(G)$  consist of words starting with one or more 'a's followed by one or more 'b's but a will be greater or equal to b.

(29)

$S \rightarrow aS/bS/a/b$

i) babbaa

Sol

$S \rightarrow bS \rightarrow baS \rightarrow babs \rightarrow babbs \rightarrow babbas \rightarrow$   
 $babbba$

ii) babababa

Sol

$S \rightarrow bS \rightarrow baS \rightarrow babs \rightarrow babas \rightarrow bababs \rightarrow$   
 $bababaS \rightarrow babababs \rightarrow babababa$



iii) ~~aa~~ aaabaa

Sol

$$S \xrightarrow{aS} aS \xrightarrow{aaS} aaS \xrightarrow{aaaS} aaaS \xrightarrow{aaabs} aaabs \xrightarrow{aaabaaS} aaabaaS$$

aaabaa

iv) baabaaa

Sol

$$S \xrightarrow{bS} bS \xrightarrow{baS} baS \xrightarrow{baaS} baaS \xrightarrow{baabs} baabs \xrightarrow{baabaaS} baabaaS$$

baabaaa

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v) Mod 2 = 0

$$(a+b)(a+b)^*$$

vi) Mod 2 = 1

$$(a+b)(a+b)^*(a+b)$$

vii) Mod 3 = 0

$$(a+b)(a+b)(a+b)^*$$

viii) Mod 3 = 2

$$(a+b)(a+b)(a+b)^*(a+b)(a+b)$$

ix) with the same power

$$(a+b)^*$$

x) Starting and ending with the same symbol  $\$(a+b)^*\$$