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Revised Questions #3

25. $S \rightarrow aSa \mid bSb \mid a \mid b \mid \lambda$

generates palindrome language $PAL = \{w \in \{a, b\}^* \mid w = w^R\}$

Note: a palindrome is a word, number, phrase or other sequence of characters which reads the same backward as forward. (Wikipedia, 2020)

$S \rightarrow \lambda$

$S \rightarrow a$

$S \rightarrow b.$

$S \rightarrow aSa \rightarrow a\lambda a$

$S \rightarrow aSa \rightarrow aaa$

$S \rightarrow aSa \rightarrow aba$

$S \rightarrow bSb \rightarrow b\lambda b$

$S \rightarrow bSb \rightarrow bab$

$S \rightarrow bSb \rightarrow bbb$

$S \rightarrow aSa \rightarrow aaSaa \rightarrow aa\lambda aa$

$S \rightarrow aSa \rightarrow aaSaa \rightarrow aaaaa$

$S \rightarrow aSa \rightarrow aaSaa \rightarrow aabaa$

$S \rightarrow aSa \rightarrow abSba \rightarrow ab\lambda ba$

$S \rightarrow aSa \rightarrow abSba \rightarrow ababa$

$S \rightarrow aSa \rightarrow abSba \rightarrow abbba$

Palindrom strings: $\lambda, a, b, a\lambda a, aaa, aba, b\lambda b, bab, bbb, aa\lambda aa, aaaaa, aabaa, ab\lambda ba, ababa, abbba$

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

(i) $S \to aS \mid bS \mid a \mid B$

$S \to a$

$S \to B$

$S \to aS \to aa$

$S \to aS \to aB$

$S \to bS \to ba$

$S \to bS \to bB$

$S \to aS \to aaS \to aaa$

$S \to aS \to abS \to aba$

$S \to bS \to bbS \to bba$

$S \to bS \to baS \to bab$

$L = \{a, b, aa, aB, ba, bB, aaa, aba, bba, bab, ba\underline{B}\}$
$= \{a^n b^m B^p \mid n, m \geq 0,\ 0 \leq p \leq 1,\ n+m+p \geq 0\}$

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11) $S \to aSa \mid bSb \mid aSb \mid \lambda$

$S \to \lambda$

$S \to aSa \to a\lambda a \to aa$

$S \to aSa \to abSba \to ab\lambda ba \to abba$

$S \to aSa \to aaSba \to aa\lambda ba \to aaba$

$S \to aSa \to abSba \to abaSbba \to aba\lambda bba$

$S \to aSa \to abSba \to abaSaba \to aba\lambda aba$

$S \to aSa \to aaSaa \to aa\lambda aa \to aaaa$

$S \to bSb \to baSab \to ba\lambda ab \to baab$

$S \to bSb \to bbSbb \to bb\lambda bb \to bbbb$

$S \to bSb \to b\lambda b \to bb.$

$S \to bSb \to baSbb \to babb$

$L = \{\lambda, aa, bb, abba, aaba, ababba, abaaba, aaaa, baab, bbbb, babb, \ldots\}$

$L = \{a^n b^m \mid n, m \geq 0,\ n+m = 0 (\mathrm{mod}\ 2)\}$

iii) $S \to aAb \mid aBb \mid aSb$

$A \to aA \mid a$

$B \to bB \mid b$

$S \to aAb \to aab$

$S \to aAb \to aaAb \to aaab$

$S \to aAb \to aaAb \to aaaAb \to aaaab$

$S \to aBb \to abb$

$S \to aBb \to abBb \to abbb$

$S \to aBb \to abBb \to abbBb \to abbbb.$

$S \to aSb \to aaAbb \to aaabb$

$S \to aSb \to aaAbb \to aaaAbb \to aaaabb$

~~$S \to aSb \to aaBb \to aabb$~~

$S \to aSb \to aaBbb \to aabbb$

$S \to aSb \to aaBbb \to aabBbb \to aabbbb$

$L = \{aab, aaab, aaaab, abb, abbb, abbbb, aaabb,$
$aaaabb, aabbb, aabbbb, \ldots\}$

$L = \{a^n b^m \mid n, m > 0, \ n \neq m \ \$ m \neq n\}$

27 (i) $S \rightarrow aAb,$

$A \rightarrow aA \mid bA \mid \lambda$

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

$S \rightarrow aAb \rightarrow aaAb \rightarrow aa\lambda b \rightarrow aab$

$S \rightarrow aAb \rightarrow abAb \rightarrow ab\lambda b \rightarrow abb$

$S \rightarrow aAb \rightarrow aaAb \rightarrow aabAb \rightarrow aab\lambda b \rightarrow aabb$

$S \rightarrow aAb \rightarrow abAb \rightarrow abaAb \rightarrow aba\lambda b \rightarrow abab$

$S \rightarrow aAb \rightarrow aaAb \rightarrow aaaAb \rightarrow aaa\lambda b \rightarrow aaab$

$S \rightarrow aAb \rightarrow abAb \rightarrow abbAb \rightarrow abb\lambda b \rightarrow abbb.$

$= L = \{a^n b^m \mid n, m > 0\}$

or $\cancel{a b}$

(iii) ~~GA~~ $S \rightarrow aSc \mid aAc$

$A \rightarrow aAb \mid ab$

$S \rightarrow aSc \rightarrow aaAcc \rightarrow aaabcc$

$S \rightarrow aAc \rightarrow aabc$

$S \rightarrow aAc \rightarrow aaAbc \rightarrow aaabbc$

$S \rightarrow aAc \rightarrow aaAbc \rightarrow aaaAbbc$

$\rightarrow aaaabbbc.$

$S \rightarrow aSc \rightarrow aaScc \rightarrow aaaAccc \rightarrow aaaabccc$

$S \rightarrow aSc \rightarrow aaAcc \rightarrow aaaAbcc \rightarrow aaaabbcc$

$L = \{a^n b^m c^p \mid m, n, p > 0 \ \& \ m, p < n\}$

iii) $S \rightarrow aSb \mid ab$

$S \rightarrow ab$

$S \rightarrow aSb \rightarrow aabb$

$S \rightarrow aSb \rightarrow aaSbb \rightarrow aaabbb$

$S \rightarrow aSb \rightarrow aaSbb \rightarrow aaaSbbb \rightarrow aaaabbbb$

$S \rightarrow aSb \rightarrow aaSbb \rightarrow aaaSbbb \rightarrow aaaaSbbbb$

$\rightarrow aaaaabbbbb.$

$L = \{(ab)^n \mid n > 0\}$

iv) $S \rightarrow AB$

$B \rightarrow bB \mid b$

$A \rightarrow aA \mid a$

~~$S \rightarrow AB$~~

$S \rightarrow AB \rightarrow ab$

$S \rightarrow AB \rightarrow abB \rightarrow abb$

$S \rightarrow AB \rightarrow abB \rightarrow abbB \rightarrow abbb$

$S \rightarrow AB \rightarrow aAb \rightarrow aab$

$S \rightarrow AB \rightarrow aaAb \rightarrow aaAb \rightarrow aaab$

$S \rightarrow AB \rightarrow aAbB \rightarrow aabb$

$S \rightarrow AB \rightarrow aAbB \rightarrow aabbB \rightarrow aabbb$

$S \rightarrow AB \rightarrow aAbB \rightarrow aaAbB = aaabb$

$S \rightarrow AB \rightarrow aAbB \rightarrow aaAbbB \rightarrow aaabbb$

$L = \{ Ca^n b^m \mid n > 0, m > 0\}$

28.
$L(G) = \{a^n b^m \mid n \geq m\}$

$G = (\{S\}, \{a, b\}, S, P)$

with productions

$S \to \lambda \mid aS \mid aSb \mid ab$

$S \to \lambda$ (both $a^n b^m$ $n = m = 0$)

$S \to aS \to a\lambda = a$ ($a^n b^m$, $n > m$, $n = 1$)

$S \to aS \to aab$ ($n > m$, $n = 2$ & $m = 1$)

$S \to aSb \to a\lambda b$ ($n = m$)

$S \to aSb \to aaSb = aa\lambda b$ ($n > m$)

$S \to aSb = aabb$ ($n = m$)

29. $S \to aS \mid bS \mid a \mid b$

(i) babbaa:

$S \to bS \to baS \to babS \to babbS$
$\to babbaS \to babbaa$

(iii) aaabaa

$S \to aS \to aaS \to aaaS \to aaabS \to aaabaS$
$\to aaabaa$

(iii) babababa

$S \to bS \to baS \to babS \to babaS \to bababS$
$\to bababaS \to bababab S \to babababa$

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(iv) baabaaa

$S \to bS \to baS \to baaS \to baabS$
$\to baabaS \to baabaaS \to baabaaa$

30) (i) $(w \in \{a, b\} \mid |w| \bmod 2 = 0)$.

w is an even number

$V = \{S\}$ ← start variable

$\Sigma = \{a, b\}$ – set of terminals

$G = (V, \Sigma, S, P)$
$= (\{S\}, \{a, b\}, S, P)$

where the rules are :-

$S \to aSb \mid aSa \mid bSb \mid bSa \mid \lambda$

(ii) $w \in \{a, b\} \mid |w| \bmod 2 = 1$

w is an odd numbe

$G = \{V, T, S, P\}$

$V = \{S\}$, $T = \{a, b\}$, $S = S$

$G = \{\{S\}, \{a, b\}, S, P\}$

where P :

$S \to a \mid b$

$S \to aSa \mid bSb$

$S \to aSb \mid bSa$

$\therefore G = \{\{S\}, \{a, b\}, S, P\}$

where P: $S \to a \mid b \mid aSa \mid bSb \mid aSb \mid bSa$

iii) $w \in \{a, b\} \mid |w| \bmod 3 = 0$

$G = \{V, T, S, P\}$

$V = \{S\}$, $T = \{a, b\}$, $S = S$

$G = \{\{S\}, \{a, b\}, S, P\}$

where P:

$S \to \lambda$ (because $0 \bmod 3 = 0$)

$S \to aaSa \mid bbSb$

$S \to aaSb \mid bbSa$

$S \to abSb \mid abSa$

$S \to baSb \mid baSa$

$G = \{\{S\}, \{a, b\}, S, P\}$

where P: $S \to \lambda / aaSa \mid aaSb \mid abSb \mid baSb$

$S \to bbSb \mid bbSa \mid abSa \mid baSa$

iv) $(w \in \{a, b\} \mid |w| \bmod 3 = 2)$

$V = \{S\}$, $T = \{a, b\}$ $S = S$

P: $S \to aa \mid ab \mid bb \mid ba$

$S \to aaSa \mid aaSb \mid abSb \mid abSa$

$S \to baSb \mid baSa \mid bbSa \mid bbSb$.

$\therefore G = \{\{S\}, \{a, b\}, S, P\}$

where P: $S \to aa \mid ab \mid bb \mid ba$

$S \to aaSa \mid aaSb \mid abSb \mid abSa \mid baSb$

$\mid baSa \mid bbSa \mid bbSb$

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v) with the same power

$G = \{V, T, S, P\}$

$V = \{S\}$, $T = \{a, b\}$, $S = S$

P :. $S \longrightarrow ab \mid \lambda$

$S \rightarrow aSb \mid bSa$

$\therefore G = \{\{S\}, \{a, b\}, S, P\}$

where P: $S \rightarrow ab \mid \lambda \mid aSb \mid bSa$

vi) Starting and ending with the same syms

$G = \{V, T, S, P\}$

$V = \{S\}$, $T = \{a, b\}$, $S = S$

P: $S \longrightarrow \cancel{x}a \mid . b \mid aXa \mid bXb$

$X \rightarrow aX \mid bX \mid \lambda$

$\therefore G = \{\{S\}, \{a, b\}, S, P\}$

where P: $S \rightarrow a \mid b \mid aXa \mid bXb$

$X \rightarrow aX \mid bX \mid \lambda$