answer

1. A) $S \to a$

$S \to aS \to aa$

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

$S \to aS \to aaS \to aaaS \to aaaa$

$S \to bS \to ba$

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

$S \to bS \to baS \to babS \to baba$

$= \{a, aa, aaa, aaaa, ba, bba, baba, \ldots\}$

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

(4) $S \to \lambda$

$S \to aS \to a\lambda \to a$

$S \to aS \to aaS \to aa\lambda \to aa$

$S \to aS \to aaS \to aaaS \to aaa\lambda$

$S \to bS \to b\lambda \to b$

$S \to bS \to bbS \to bb\lambda \to bb$

$S \rightarrow bS \longrightarrow baS \longrightarrow babS \longrightarrow babaS \rightarrow ba$

$\longrightarrow baba$

$\{\lambda, a, aa, aaa, b, bb, baba, \ldots \}$

$L = \{a^n b^m \mid n; m \geq 0\}$

11A) $S \rightarrow aAb \longrightarrow aab$

$S \rightarrow aAb \longrightarrow aaAb \longrightarrow aaab$

$S \longrightarrow aAb \longrightarrow aaAb \longrightarrow aaaAb \longrightarrow aaaab$

$S \longrightarrow aBb \longrightarrow abb$

$S \longrightarrow aBb \longrightarrow abBb \longrightarrow abbb$

$S \longrightarrow aBb \longrightarrow abBb \longrightarrow abBbb \longrightarrow abbbb$

$S \rightarrow aSb \longrightarrow aaAbb \rightarrow aaabb$

$S \rightarrow aSb \longrightarrow abBbb \rightarrow aabbb$

$\{aab, aaab, aaaab, abb, abbb, abbbb, aaabb, aabbb\}$

$L = \{a^n b^m\}$

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

n and m are greater than zero but they are not equal so when one has a value, the other has to be higher

2) $S \longrightarrow aSa \mid bSb \mid a \mid b \mid \lambda$

$S \rightarrow \lambda$

$S \rightarrow a$

$S \rightarrow b$

$S \rightarrow aSa \longrightarrow a\lambda a \Rightarrow aa$

$S \Rightarrow aSa \longrightarrow aaa \Rightarrow aaa$

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

7. $S \rightarrow aSa \rightarrow aaSaa \rightarrow aaaaa$

8. $S \rightarrow aSa \rightarrow aba$

9. $S \rightarrow aSa \rightarrow abSba \rightarrow ab\lambda ba \rightarrow abba$

10. $S \rightarrow aSa \rightarrow abSba \rightarrow abbba$

11. $S \longrightarrow aSa \rightarrow abSba \rightarrow ababa$

2. $S' \rightarrow bSb \rightarrow b\lambda b \longrightarrow bb$

3. $S \rightarrow bSb \rightarrow bab$

4. $S \rightarrow bSb \rightarrow bbb$

5. $S \longrightarrow bSb \rightarrow bbSbb \rightarrow bb\lambda bb \rightarrow bbbb$

6. $S \longrightarrow bSb \rightarrow baSab \rightarrow ba\lambda ab \rightarrow baab$

17. $S \longrightarrow bSb \rightarrow baSab \rightarrow babab$

18. $S \rightarrow bSb \rightarrow baSab \rightarrow baaab$

19. $S \rightarrow bSb \longrightarrow baSab \rightarrow babSbab$

$\longrightarrow bab\lambda bab \longrightarrow babbab$

20. $S \longrightarrow bSb \rightarrow baSab \longrightarrow babSbab$

$\longrightarrow bababab$

3. $w \in \{a, b\} \mid |w| \bmod 2 = 1$

$G = (V = \{S\}, \Sigma$

w is an odd number

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

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

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

where P:

$S \rightarrow a \mid b$ ———— One mod 2 = 1

$S \rightarrow a S a \mid b S b$ ———— multiples of 3 mod 2 = 1

$S \rightarrow a S b \mid b S a$ ———— variety,

∴ $G = (\{S\}, \{a, b\}, S, P)$

where the production rules are

$S \rightarrow a \mid b \mid a S a \mid b S b \mid a S b \mid b S a$

$F) ii) S \rightarrow a A b, A \rightarrow a A \mid b A \mid \lambda$

) $S \to aAb$,
$A \to aA | bA | \lambda$

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

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

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

$S \to aAb \to aaAb \to aaaAb \to aaabAb$
$\quad\quad\quad \to aaab\lambda b \to aaabb$

$S \to aAb \to abAb \to \cancel{a} ab\lambda b = abb$

$S \to aAb \to abAb \to abbAb \to abb\lambda b \to abbb$

$S \to aAb \to abAb \to abbAb \to abbbAb$
$\quad\quad\quad \to abbb\lambda b \to abbbb$

$S \to aAb \to abAb \to abbAb \to abbaAb$
$\quad\quad\quad \to abba\lambda b \to abbab$

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

iu) $S \to aSc \mid aAc$
$A \to aAb \mid ab$

$S \to aAc \to aabc$

$S \to aAc \to aaAbc \to aaabbc$

$S \to aAc \to aaAbc \to aaaAbbc \to aaaabbbc$

$S \to aSc \to aaAcc \to aaabcc$

$S \to aSc \to aaScc \to aaaAccc \to aaaabccc$

$S \to aSc \to aaScc \to aaaAccc \to aaaaAbccc$
$\quad\quad\quad \to aaaaabbccc$

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

(ii) $S \to aSb \mid ab$

$S \to ab$

$S \to aSb \to aabb$

$S \to aSb \to aaSbb \to aaabbb$

$S \to aSb \to aaSbb \to aaaSbbb \to aaaaSbbbb$

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

(iv) $S \to AB$

$B \to bB \mid b$

$A \to aA \mid a$

$S \to AB \to ab$

$S \to AB \to abB \to abb$

$S \to AB \to abB \to abbB \to abbb$

$S \to AB \to abB \to abbB \to abbbB \to abbbb$

$S \to AB \to aAb \to aab$

$S \to AB \to aaAb \to aaab$

$S \to AB \to aaAb \to aaaAb \to aaaab$

$S \to AB \to aAbB \to aabb$

$S \to AB \to aAbB \to aabbB \to aabbb$

$S \to AB \to aAbB \to aaAbbB \to aaabbb$

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

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