

Context-Free Grammar

1. Create a CFG for all strings over $\{a, b\}$ with any number of a's and b's in any order.

$$\boxed{S \rightarrow aSb|b}$$

2. Create a CFG that starts with the letter a.

$$S \rightarrow aA$$

$$A \rightarrow aA | bA | \epsilon$$

3. Create a CFG that ends with the letter b.

$$S \rightarrow bB$$

$$B \rightarrow aB | bB | \epsilon$$

4. Create a CFG that starts with a and ends with b.

$$S \rightarrow aAb$$

$$A \rightarrow aA | bA | \epsilon$$

5. Create a CFG that contains ab substring.

$$S \rightarrow BAC$$

$$A \rightarrow ab$$

$$B \rightarrow aB | bB | \epsilon$$

$$C \rightarrow aC | bC | \epsilon$$

$$S \rightarrow MAN$$

$$A \rightarrow ab$$

$$M \rightarrow aM | bM | \epsilon$$

$$N \rightarrow bN | aN | \epsilon$$

① $L = \{a^n b^n \mid n \geq 0\}$

$S \rightarrow aSbE$

⑦ $L = \{w \in \{a,b\}^* \mid w \text{ has even no of } a's\}$

② $L = \{a^n b^m \mid n, m \geq 0\}$

$S \rightarrow AB$

$A \rightarrow aA1E$

$B \rightarrow bB1E$

$S \rightarrow bS1aT1E$

$T \rightarrow bT1aS$

⑧ even no of b's

③ $L = \{a^n b^m c^n \mid n \geq 0\}$

$S \rightarrow aS1bS1cS1E$

$S \rightarrow aS1bT1E$

$T \rightarrow aT1aS$

⑨ odd no of a's

④ $L = \text{Palindrome over } \{a,b\}$

$S \rightarrow aSa1bSb1a1b1E$

$S \rightarrow aE1bS$

⑤ $L = \{a^n b^n c^m, n, m \geq 0\}$

$E \rightarrow aS1bE1E$

$S \rightarrow AC$

$A \rightarrow aAb1E$

$C \rightarrow cC$

⑩ odd no of b's.

$S \rightarrow bE1bS$

$E \rightarrow bS1aG1E$

⑥ $L = \{a^n b^m c^m, n, m \geq 0\}$

$S \rightarrow AB$

$B \rightarrow aA$

$B \rightarrow bBc1E$

⑫ $L = \{a^n b^n c^m d^m\}$

$S \rightarrow AC$

$A \rightarrow aSb1E$

$C \rightarrow cCd1E$

⑬ starts and ends with same letter.

$$S \rightarrow qAa1bAb1a1b$$

$$A \rightarrow qA1bA1\epsilon$$

⑭ L = ends with substring ab

$$S \rightarrow Aab$$

$$A \rightarrow qA1bA1\epsilon$$

⑮ $L = \{w \in \{a, b\}^* \mid \#_a(w) = \#_b(w)\}$

$$S \rightarrow asb1bss1s1e$$