

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.

$$S \rightarrow aSb \mid \epsilon$$

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

$$S \rightarrow aA$$

$$A \rightarrow aA \mid bA \mid \epsilon$$

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

$$S \rightarrow bB$$

$$B \rightarrow aB \mid bB \mid \epsilon$$

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

$$S \rightarrow aAb$$

$$A \rightarrow aA \mid bA \mid \epsilon$$

5. Create a CFG that contains ab substring.

$$S \rightarrow BAC$$

$$A \rightarrow ab$$

$$B \rightarrow aB \mid bB \mid \epsilon$$

$$C \rightarrow aC \mid bC \mid \epsilon$$

$$S \rightarrow MAN$$

$$A \rightarrow ab$$

$$M \rightarrow aM \mid bM \mid \epsilon$$

$$N \rightarrow bN \mid \epsilon$$

$$\textcircled{1} L = \{a^n b^n \mid n \geq 0\}$$

$$S \rightarrow a s b \mid \epsilon$$

$$\textcircled{2} L = \{a^n b^m \mid n, m \geq 0\}$$

$$S \rightarrow AB$$

$$A \rightarrow a A \mid \epsilon$$

$$B \rightarrow b B \mid \epsilon$$

$$\textcircled{3} L = \{a^n b^n c^n \mid n \geq 0\}$$

$$S \rightarrow a s \mid b s \mid c s \mid \epsilon$$

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

$$S \rightarrow a s a \mid b s b \mid a \mid b \mid \epsilon$$

$$\textcircled{5} L = \{a^n b^n c^m, n, m \geq 0\}$$

$$S \rightarrow AC$$

$$A \rightarrow a A b \mid \epsilon$$

$$C \rightarrow c C$$

$$\textcircled{6} L = \{a^n b^m c^m, n, m \geq 0\}$$

$$S \rightarrow AB$$

$$A \rightarrow a A$$

$$B \rightarrow b B c \mid \epsilon$$

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

$$S \rightarrow b s \mid a T \mid \epsilon$$

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

$$\textcircled{8} \text{ even no of } b\text{'s}$$

$$S \rightarrow a s \mid b T \mid \epsilon$$

$$T \rightarrow a T \mid a s$$

$$\textcircled{9} \text{ odd no of } a\text{'s}$$

$$S \rightarrow a E \mid b s$$

$$E \rightarrow a s \mid b E \mid \epsilon$$

$$\textcircled{10} \text{ odd no of } b\text{'s}$$

$$S \rightarrow b E \mid \phi s$$

$$E \rightarrow b s \mid a E \mid \epsilon$$

$$\textcircled{11} L = \{a^n b^n c^m d^m\}$$

$$S \rightarrow AC$$

$$A \rightarrow a s b \mid \epsilon$$

$$C \rightarrow c C d \mid \epsilon$$

⑬ starts and ends with same letter.

$$S \rightarrow aAa | bAb | a | b$$

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

⑭  $L =$  ends with substring  $ab$

$$S \rightarrow Aab$$

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

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

$$S \rightarrow aSb | bSa | SS | \epsilon$$