

<p style="text-align: center;">KING SAUD UNIVERSITY COLLEGE OF COMPUTER AND INFORMATION SCIENCES Computer Science Department</p>		
CSC 339 Theory of Computation	Tutorial # 4 Context Free Grammar (CFG)	2nd Semester 1443-2022

Exercise 1

Which language is generated by the grammar **G** given by each of the following productions:

1. $S \rightarrow aSa \mid aBa$
 $B \rightarrow bB \mid b$
2. $S \rightarrow abScB \mid \lambda$
 $B \rightarrow bB \mid b$

Exercise 2

Find a CFG that generates each of the following languages over $\Sigma = \{a, b, c, d\}$:

1. $L(G) = \{a^n b^m c^m d^{2n} \mid n \geq 0, m > 0\}$
2. $L(G) = \{a^n b^m \mid 0 \leq n \leq m \leq 2n\}$
3. $L(G) = \{a^n b^m c^k \mid k = n + m\}$

Exercise 3

Construct a CFG to generate the following languages over $\Sigma = \{0,1\}$:

1. $L(G) = \{w \mid w \text{ starts and ends with the same symbol}\}$
2. $L(G) = \{w \mid |w| \text{ is odd}\}$

Exercise 4

Explain why the grammar below is ambiguous:

$$\begin{aligned}
 S &\rightarrow 0A \mid 1B \\
 A &\rightarrow 0AA \mid 1S \mid 1 \\
 B &\rightarrow 1BB \mid 0S \mid 0
 \end{aligned}$$

Exercise 5

Given the following ambiguous CFG:

$$S \rightarrow Ab \mid aaB$$

$$A \rightarrow a \mid Aa$$

$$B \rightarrow b$$

1. Find the string s generated by the grammar that has two leftmost derivations and show them.
2. Show the two derivation trees for the string s .
3. Find an equivalent un-ambiguous CFG.
4. Give the unique leftmost derivation and derivation tree for the string s generated from the un-ambiguous grammar above.

Exercise 6

Convert the following ambiguous grammar into unambiguous grammar-

$$\text{bexp} \rightarrow \text{bexp or bexp} \mid \text{bexp and bexp} \mid \text{not bexp} \mid T \mid F$$

where bexp represents Boolean expression, T represents True and F represents False.