

**MAU22C00: TUTORIAL 8 PROBLEMS
FORMAL LANGUAGES AND GRAMMARS**

1) Let the formal language L over the alphabet $\{a, b, c\}$ be generated by the context-free grammar whose only non-terminal is $\langle S \rangle$, whose start symbol is $\langle S \rangle$, and whose production rules are the following:

- (1) $\langle S \rangle \rightarrow b$
- (2) $\langle S \rangle \rightarrow c$
- (3) $\langle S \rangle \rightarrow a\langle S \rangle$

- (a) Describe L . In other words, describe the structure of the strings generated by this grammar.
- (b) Which words does $aa\langle S \rangle$ directly yield?
- (c) Which words does $aa\langle S \rangle$ yield?

2) Consider the binary alphabet $\{0, 1\}$, start symbol $\langle S \rangle$, set of non-terminals consisting of $\{\langle S \rangle, \langle A \rangle, \langle B \rangle, \langle C \rangle, \langle D \rangle, \langle E \rangle\}$, and production rules given by

- (1) $\langle S \rangle \rightarrow \langle A \rangle \langle B \rangle \langle C \rangle$
- (2) $\langle A \rangle \langle B \rangle \rightarrow 0\langle A \rangle \langle D \rangle$
- (3) $\langle A \rangle \langle B \rangle \rightarrow 1\langle A \rangle \langle E \rangle$
- (4) $\langle D \rangle \langle C \rangle \rightarrow \langle B \rangle 0\langle C \rangle$
- (5) $\langle E \rangle \langle C \rangle \rightarrow \langle B \rangle 1\langle C \rangle$
- (6) $\langle D \rangle 0 \rightarrow 0\langle D \rangle$
- (7) $\langle D \rangle 1 \rightarrow 1\langle D \rangle$
- (8) $\langle E \rangle 0 \rightarrow 0\langle E \rangle$
- (9) $\langle E \rangle 1 \rightarrow 1\langle E \rangle$
- (10) $0\langle B \rangle \rightarrow \langle B \rangle 0$
- (11) $1\langle B \rangle \rightarrow \langle B \rangle 1$
- (12) $\langle A \rangle \langle B \rangle \rightarrow \epsilon$
- (13) $\langle C \rangle \rightarrow \epsilon$

- (a) What type of grammar is this (context-free or phrase structure)? Justify your answer.
- (b) What language does this grammar generate? (Hint: Rules (12) and (13) show you that the word before the last non-terminals are swapped out can contain only non-terminals $\langle A \rangle, \langle B \rangle, \langle C \rangle$. Figure out how the other rules combine to give you words consisting of the terminals and $\langle A \rangle, \langle B \rangle, \langle C \rangle$.)