

CS314 Fall 2013  
Assignment 2  
Due Tuesday, February 11, **before** class

## 1 Problem — Context-Free Languages

Are the following languages context-free or not? If yes, specify a context-free grammar in BNF notation that generates the language. If not, give an informal argument.

1.  $\{ a^n b^m c^o \mid m > n \geq 0, o > 0 \}$ , with alphabet  $\Sigma = \{a, b, c\}$
2.  $\{ a^n b^{2n} \mid n \geq 0 \}$ , with alphabet  $\Sigma = \{a, b\}$
3.  $\{ ww^R \mid w \in \Sigma^* \text{ and } w^R \text{ is } w \text{ in reverse} \}$ , with alphabet  $\Sigma = \{a, b\}$
4.  $\{ a^n b^m c^m d^n \mid n \geq 0, m \geq 0 \}$ , with alphabet  $\Sigma = \{a, b, c, d\}$
5.  $\{ w \mid w \text{ has no more than 5 symbols} \}$ , with alphabet  $\Sigma = \{a, b\}$

## 2 Problem — Derivation, Parse Tree, Ambiguity, Precedence & Associativity

A language that is a subset of the language of propositional logic may be defined as follows:

$\langle \text{start} \rangle ::= \langle \text{expr} \rangle$   
 $\langle \text{expr} \rangle ::= \langle \text{expr} \rangle \vee \langle \text{expr} \rangle \mid$   
                   $\langle \text{expr} \rangle \wedge \langle \text{expr} \rangle \mid$   
                   $\langle \text{expr} \rangle \rightarrow \langle \text{expr} \rangle \mid$   
                   $\langle \text{const} \rangle \mid \langle \text{var} \rangle$   
 $\langle \text{const} \rangle ::= \text{true} \mid \text{false}$   
 $\langle \text{var} \rangle ::= a \mid b \mid c \mid \dots \mid z$

1. Give a leftmost and a rightmost derivation for the sentence  
           $a \vee \text{true} \wedge b \rightarrow \text{false} .$
2. Give the corresponding parse trees for the derivations.
3. Give the corresponding abstract syntax tree (AST).
4. Show that the above grammar is ambiguous.
5. Give an unambiguous grammar for the same language that enforces the following precedence and associativity:

- $\wedge$  has highest precedence (binds strongest), followed by  $\vee$ , and then  $\rightarrow$
  - $\wedge$  and  $\vee$  are left associative, and  $\rightarrow$  is right associative
6. Give the parse tree and AST for your new, unambiguous grammar for the sentence
- $a \vee \text{true} \wedge b \rightarrow \text{false} \vee \text{true} .$