

# CS 430 Grammar Lab

## Part 1: Grammars and Ambiguity

Consider the following context-free grammar, written using the variant of BNF we've used in class.

$$\begin{aligned}
 A &\rightarrow V = E \\
 E &\rightarrow E \wedge E \\
 &\quad | E \sim E \\
 &\quad | V \\
 V &\rightarrow a | b | c \dots y | z
 \end{aligned}$$

1. List all non-terminals.

**A, E, V**

2. How many productions are there total?

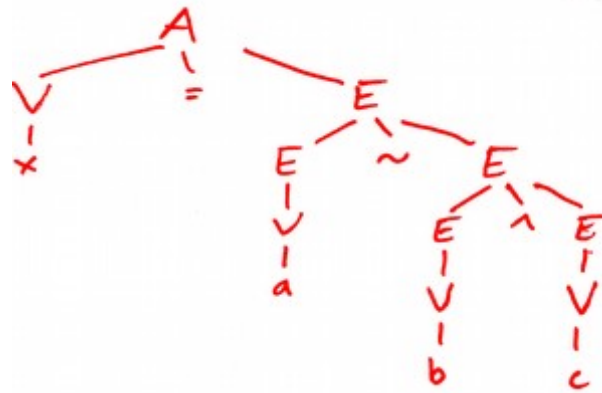
**1 (A) + 3 (E) + 26 (V) = 30**

3. List all terminals.

**=, ^, ~, a, b, c, ... y, z**

4. Write a leftmost derivation and draw the corresponding parse tree for the statement "x = a ~ b ^ c"

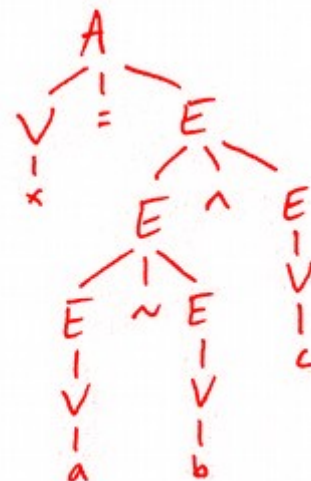
**A**  
**V = E**  
**x = E**  
**x = E ~ E**  
**x = V ~ E**  
**x = a ~ E**  
**x = a ~ E ^ E**  
**x = a ~ V ^ E**  
**x = a ~ b ^ E**  
**x = a ~ b ^ V**  
**x = a ~ b ^ c**



5. Is the grammar ambiguous? If it is, prove it by providing an example sentence with its leftmost derivations or parse trees.

**yes, here is an alternative leftmost derivation and parse tree of the same sentence:**

**A**  
**V = E**  
**x = E**  
**x = E ^ E**  
**x = E ~ E ^ E**  
**x = V ~ E ^ E**  
**x = a ~ E ^ E**  
**x = a ~ V ^ E**  
**x = a ~ b ^ E**  
**x = a ~ b ^ V**  
**x = a ~ b ^ c**



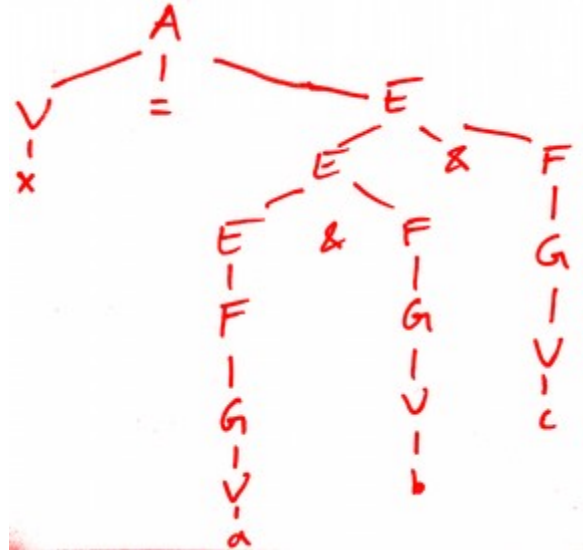
## Part 2: Associativity and Precedence

Consider the following grammar, written using the variant of BNF we've used in class.

$$\begin{aligned}
 A &\rightarrow V = E \\
 E &\rightarrow E \wedge F \\
 &\quad | E \& F \\
 &\quad | F \\
 F &\rightarrow F \sim G \\
 &\quad | G \\
 G &\rightarrow ! G \\
 &\quad | V \\
 V &\rightarrow a | b | c \dots y | z
 \end{aligned}$$

6. Is the & operator left or right associative? Give an example sentence and parse tree.

**left associative**  
**one possible example sentence:**  
 $x = a \& b \& c$



7. List all operators in order of precedence from higher to lower. If two operators have the same precedence, list them on the same line.

!  
 $\sim$   
 $\wedge, \&$   
 $=$

8. Modify the grammar to allow chained assignments (e.g., “ $x = y = a \sim b \wedge c$ ”). List only the productions for any non-terminals that you add or modify. Is the = operator left or right associative?

**one possible solution:**

$$\begin{aligned}
 A &\rightarrow V = A \\
 &\quad | V = E \quad \text{(right associative)}
 \end{aligned}$$