

# CMSC330: Discussion Material (10/1)

October 1, 2008

1) What language does the following grammar generate:

$$S \rightarrow aSbS \mid bSaS \mid \epsilon$$

**Answer:** The set of all strings with an equal number of  $a$ 's and  $b$ 's.

2)

a) Give the grammar that generates the language of the regular expression:  $0^*1(0 \mid 1)^*$

**Answer:**

$$\begin{aligned} S &\rightarrow A1B \\ A &\rightarrow 0A \mid \epsilon \\ B &\rightarrow 0B \mid 1B \mid \epsilon \end{aligned}$$

b) Give the leftmost and rightmost derivations of the following strings using the grammar from part a):

i) **1001**

**Answer:**

Leftmost:  $S \rightarrow A1B \rightarrow 1B \rightarrow 10B \rightarrow 100B \rightarrow 1001B \rightarrow 1001$

Rightmost:  $S \rightarrow A1B \rightarrow A10B \rightarrow A100B \rightarrow A1001B \rightarrow A1001 \rightarrow 1001$

ii) **00011**

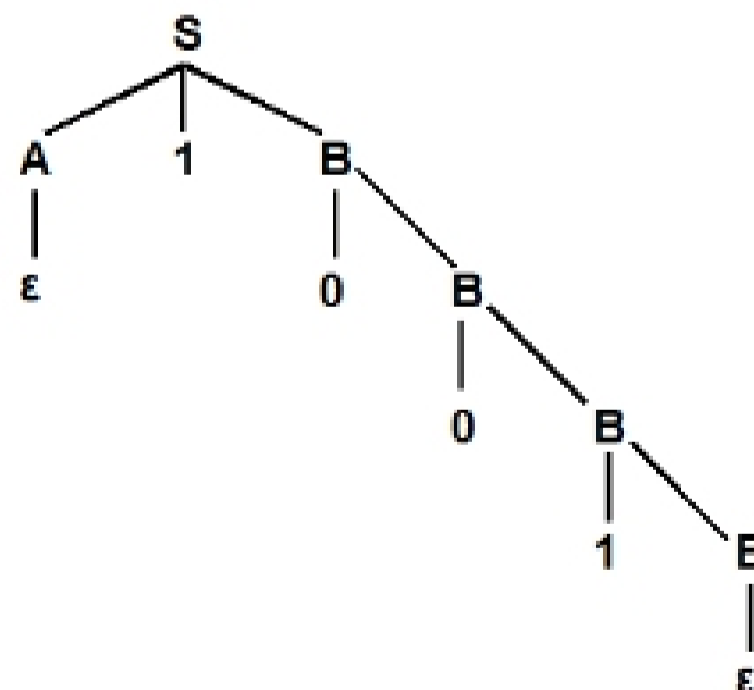
**Answer:**

Leftmost:  $S \rightarrow A1B \rightarrow 0A1B \rightarrow 00A1B \rightarrow 000A1B \rightarrow 0001B \rightarrow 00011B \rightarrow 00011$

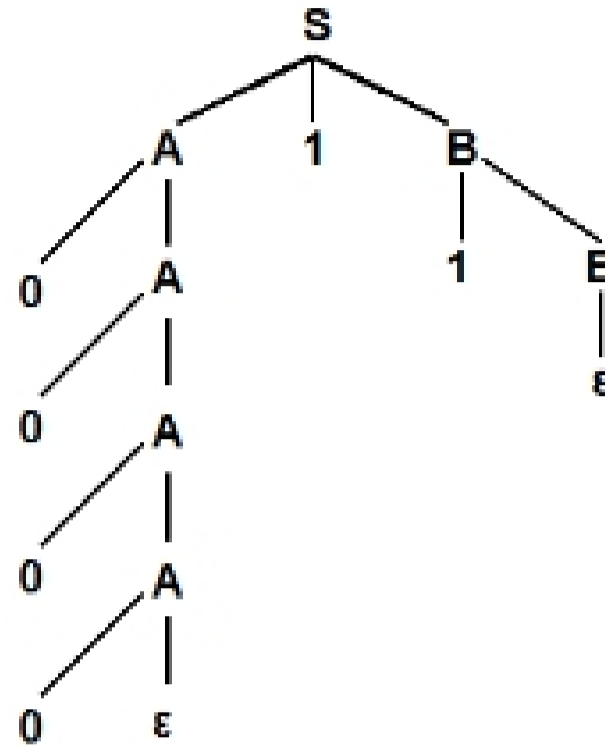
Rightmost:  $S \rightarrow A1B \rightarrow A11B \rightarrow A11 \rightarrow A011 \rightarrow A0011 \rightarrow A00011 \rightarrow 00011$

c) Give the parse trees for the strings in part b).

i) **Answer:**



ii) *Answer:*



3) Design a context free grammar for the following language:  $\{a^i b^j c^k \mid i \neq j \text{ or } j \neq k\}$

*Answer:*

$$\begin{aligned}
 S &\rightarrow RC \mid AT \\
 R &\rightarrow aRb \mid X \\
 X &\rightarrow aA \mid bB \\
 T &\rightarrow bTc \mid Y \\
 Y &\rightarrow bB \mid cC \\
 A &\rightarrow aA \mid \epsilon \\
 B &\rightarrow bB \mid \epsilon \\
 C &\rightarrow cC \mid \epsilon
 \end{aligned}$$

*Note:* The important productions rules here are for the symbols R and T. R enforces the constraint  $i \neq j$  and T enforces the constraint  $j \neq k$ . The start symbol just ensures that one or the other must be true for the string to be in the language of this grammar.

4) Given the following grammar:

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

a) Is this grammar ambiguous? Why?

*Answer:* Yes. The string  $aab$  has two parse trees, leftmost derivations, and rightmost derivations.

b) Redesign the grammar to be unambiguous.

*Answer:*

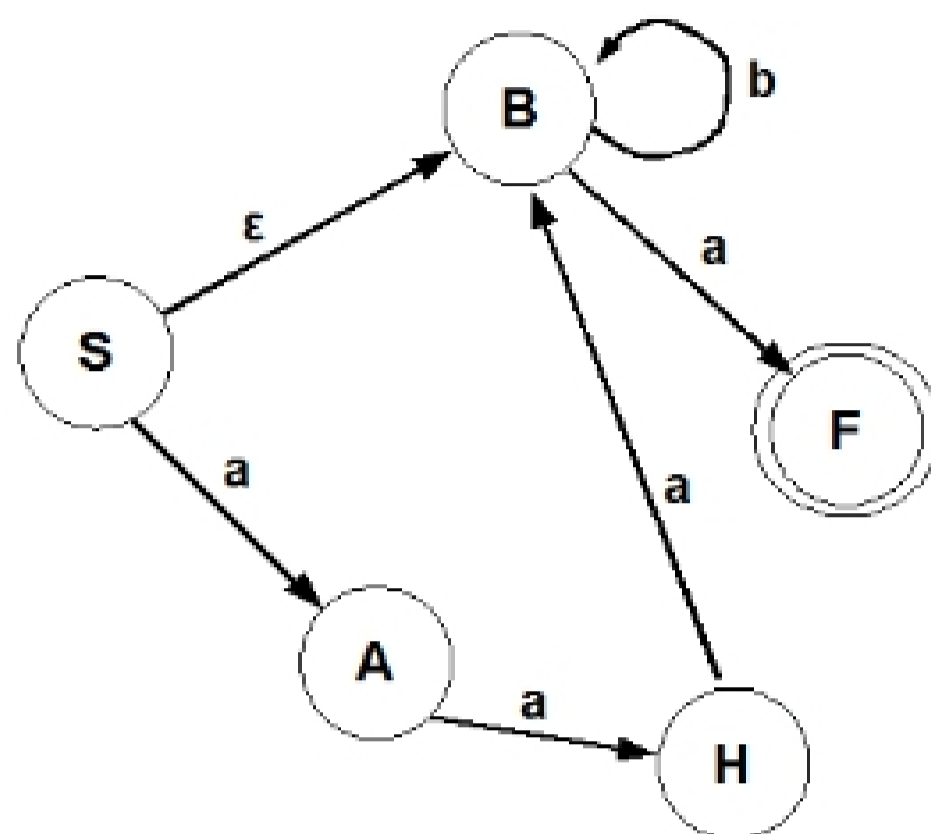
$$\begin{aligned}
 S &\rightarrow aSb \mid A \\
 A &\rightarrow Aa \mid \epsilon
 \end{aligned}$$

*Note:* This is the grammar for the language  $a^m b^n \mid m \geq n$

5) Construct a NFA for the following grammar:

$$\begin{aligned}
 S &\rightarrow aA \mid B \\
 A &\rightarrow aaB \\
 B &\rightarrow bB \mid a
 \end{aligned}$$

*Answer:*



*Note:* The grammar must be right or left-linear to perform this conversion. This grammar is right-linear.