

*This homework is due in class on Friday, November 21.
Remember that there is a test on Monday, November 24.*

- Find a Context-Free Grammar that generates each of the following languages.
 - $L_1 = \{a^n b^m a^n \mid n, m \in \mathbb{N} \text{ and } n > 0\}$
 - $L_2 = \{a^n b a^m c a^k \mid n + m = k\}$
 - $L_3 = \{a^n b^m \mid n \neq m\}$
 - $L_4 = \{a^n b^m c^j d^k \mid n + m = j + k\}$
- Find the language generated by each of the following Context-Free Grammars. You should explain your answer, but you do not have to prove that your answer is correct.

a) $S \longrightarrow aSa$ $S \longrightarrow T$ $T \longrightarrow bTb$ $T \longrightarrow c$	b) $T \longrightarrow TT$ $T \longrightarrow ATb$ $T \longrightarrow bTA$ $T \longrightarrow \varepsilon$ $A \longrightarrow a$ $A \longrightarrow \varepsilon$	c) $S \longrightarrow TbT$ $T \longrightarrow TT$ $T \longrightarrow ATb$ $T \longrightarrow bTA$ $T \longrightarrow \varepsilon$ $A \longrightarrow a$ $A \longrightarrow \varepsilon$	d) $S \longrightarrow aT$ $S \longrightarrow bR$ $T \longrightarrow aTc$ $T \longrightarrow aT$ $T \longrightarrow R$ $R \longrightarrow bRc$ $R \longrightarrow bR$ $R \longrightarrow \varepsilon$
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- Using the grammar from part **d)** in the previous problem, draw *two different* derivations for the string *aabcc*.
- Using the grammar from part **d)** in the previous problem, draw *two different* parse trees for the string *aabcc*.
- Suppose that L is a context-free language. Suppose that L is generated by the CFG G , where $G = (V, \Sigma, P, S)$. Show how to construct from G a CFG that generates the language L^* . Explain why your construction works; you do not have to give a proof. (This shows that for any context-free language L , L^* is also context-free.)
- Given the following (very incomplete) BNF grammar for “names” in Java, write down **six** “names” generated by this grammar. Your examples should demonstrate all the possibilities represented in the rules.

$$\begin{aligned}
 \langle name \rangle &::= \langle object_ref \rangle [\text{“.”} \langle identifier \rangle] \\
 \langle object_ref \rangle &::= \langle identifier \rangle \mid \langle method_call \rangle \\
 \langle identifier \rangle &::= \text{“a”} \mid \text{“x”} \mid \text{“y”} \mid \text{“z”} \\
 \langle method_call \rangle &::= \langle identifier \rangle \text{“("} \langle name \rangle [\text{“,”} \langle name \rangle] \dots \text{“)”}
 \end{aligned}$$