

TD3 - Formal grammars

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1. What are the languages generated by the following grammars? Are the grammars ambiguous?
 - (a) $\mathcal{G}_1 = (\{a\}, \{S\}, S, \{S \rightarrow Sa \mid a\})$
 - (b) $\mathcal{G}_2 = (\{a, b\}, \{S, T\}, S, \{S \rightarrow Tb, T \rightarrow Ta \mid \varepsilon\})$
 - (c) $\mathcal{G}_3 = (\{(\cdot, \cdot)\}, \{S\}, S, \{S \rightarrow SS \mid (S) \mid \varepsilon\})$
 - (d) $\mathcal{G}_4 = (\{a, b\}, \{S\}, S, \{S \rightarrow aSbS \mid bSaS \mid \varepsilon\})$
2. Propose grammars that generate the following languages:
 - (a) $L_1 = \{a^n b^n \mid n \geq 0\}$
 - (b) $L_2 = \{a^i b^j c^k \mid (i = j \text{ or } j = k) \text{ and } i, j, k \geq 1\}$
 - (c) $L_3 = \{w \in \{a, b\}^* \mid w = w^R\}$
 - (d) $L_4 = \{w \in \{a, b\}^* \mid |w|_a \neq |w|_b\}$
 - (e) The set of valid arithmetic expressions (in $\mathbb{N}$) over $\{0, 1, \dots, 9, \times, +, (\cdot, \cdot)\}$