

## TD4 - Formal grammars

April 3, 2026

1. [*Homework 21/22*] A noun phrase is either a determiner followed by a noun or a noun phrase followed by a prepositional phrase. A prepositional phrase is a preposition followed by a noun phrase.
  - (a) Write the grammar  $G$  of noun phrases.
  - (b) Write the two derivation trees that  $G$  associates with the word sequence D N P D N P D N, where D is the symbol for the category ‘determiner’, N for ‘noun’ and P for ‘preposition’.
  - (c) Which of the two trees of question 1b would you choose to represent the structure of the NP ‘the cat on a mat by the door’?
  - (d) Propose a grammar  $G'$ , different from  $G$ , that associates to D N P D N P D N only the analysis that you have identified in the previous question.
  - (e) Assuming that D, N and P are terminal symbols, propose a regular grammar equivalent to  $G'$ .
2. [*Exam 22/23*] Let us consider the language  $L_1$  on the vocabulary  $V = \{the, man, bear, that, saw\}$  that include all finite sentences of the form  $(the\ man\ that\ saw)^+ the\ bear$ .
  - (a) Give a context-free grammar that generates  $L_1$ .

Let  $L_2$  be the language engendered by the grammar  $G_2$ :

S	→	NP Rel
NP	→	<i>the man</i>
		<i>the bear</i>
Rel	→	<i>that saw</i> NP Rel
		<i>that saw the bear</i>

  - (b) Propose a grammar  $G_3$  that engenders the language  $L_3$ , which is a superset of  $L_2$  in which the symbols *bear* and *man* are **interchangeable**.
  - (c) Describe informally the differences between  $L_1$  and  $L_2$ .
  - (d) Give a context-free grammar of the language  $L_2 \setminus L_1$ .
3. [*Homework 23/24*] Consider the following sentences.
  - (1)
    - a. Alice eats cakes.
    - b. The caterpillar gives Alice cakes.
    - c. The cat with a grin disappears.
    - d. Alice paints white roses red.

Define a context-free grammar that could generate these sentences.