

# Theory of Computer Science

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## Exercise Sheet 4

**Due: Wednesday, March 29, 2023**

### Exercise 4.1 (Regular Expressions, 0.5 + 0.5 + 0.5 + 0.5 Points)

Consider the following regular expressions over the alphabet  $\Sigma = \{0, 1\}$ . For each regular expression, specify two words that are in the language described by the expression and two words that are not.

(a)  $0^*(0|1)0^*1$

(c)  $00(11)^*(01|\varepsilon)$

(b)  $110|001$

(d)  $1\emptyset|0(\varepsilon|1)$

### Exercise 4.2 (Regular Expressions, 1.5 Points)

Describe the language  $L = \{w \mid w \text{ contains an even number of } a\}$  over  $\Sigma = \{a, b\}$  with a regular expression.

### Exercise 4.3 (NFAs for Regular Expressions, 2.5 Points)

Construct an NFA for the regular expression  $\gamma = (a|ab)^*b$  over the alphabet  $\Sigma = \{a, b\}$ . Use the construction rules from the lecture (chapter B5 slide 13/24, handout version). Specify all intermediate steps.

You can use JFLAP for this exercise but you should be able to find the solution without its support. Also note that JFLAP uses “+” instead of “|” for the alternative and “!” instead of “ $\varepsilon$ ” for the empty word. JFLAP also uses different construction rules compared to the ones used in the lecture. Strictly follow the set of rules *from the lecture* when writing down your solution.

### Exercise 4.4 (Regular Expressions and Pumping Lemma for Regular Languages; 4 Points)

Are the following languages over  $\Sigma = \{a, b, c\}$  regular? If so, prove it by specifying a regular expression which describes the language. If not, prove it with help of the Pumping-Lemma.

(a)  $L_1 = \{a^n b^m c^{n+m} \mid n, m \in \mathbb{N}_0\}$

(b)  $L_2 = \{a^2 b^n a^2 c^m \mid n, m \in \mathbb{N}_0\}$

*Note on marking:* One of the languages is regular, the other one is not. The subtask with the regular language is worth 1 point, the other subtask 3 points.