

## Exercise sheet 5

### Automaten und Formale Sprachen

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Submission<sup>1</sup>: Monday, May 20, 2019, 10:00 Uhr

**Exercise 15:** Regular expressions for regular languages (7 points)

Give regular expressions for the languages given below over the alphabet  $\Sigma = \{a, b, c\}$ .

- (a) The set of all words of even length. (1 p)
- (b) The set of all words where there are no more  $b$ 's after the first  $c$ . (1.5 p)
- (c) The set of all words which do *not* have length 1. (1.5 p)
- (d) The set of all words which do not contain any  $a$ , but contain at least one  $c$ . (1 p)
- (e) The set of all words which start with  $a$  and end with  $a$ . (2 p)

*Note:* When writing down your regular expressions, use *only* the notation used in the definition of regular expression from the lecture. (This means that e.g. there is *no*  $+$  operator.)

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<sup>1</sup>Options to submit your solutions: Letterbox next to LF 259 (Campus Duisburg) or via Moodle <https://moodle.uni-due.de/course/view.php?id=15777>

**Exercise 16:** Regular Expressions and their languages

(8 points)

Let the following regular expression over the alphabet  $\Sigma = \{a, b, c\}$  be given:

$$\alpha = (ac \mid bc \mid cc)^*$$

State for every regular expression  $\beta_i$  whether  $L(\alpha) \subseteq L(\beta_i)$  holds and whether  $L(\alpha) \supseteq L(\beta_i)$  holds, i.e. whether the language of one of the regular expressions is a sublanguage of the language of the other regular expression. Justify your answers!

(a)  $\beta_1 = (ca \mid cb \mid cc)^*$  (2p)

(b)  $\beta_2 = ((a \mid b \mid c)c)^*$  (2p)

(c)  $\beta_3 = (ac)^*(bc)^*(cc)^*$  (2p)

(d)  $\beta_4 = ((a \mid b)^*c)^*$  (2p)

*Note:* Two independent properties have to be shown for every pair  $\alpha, \beta_i$ .

**Exercise 17:** Statements about regular languages (5 points)

Let  $\Sigma \neq \emptyset$  and let  $\alpha$  be a regular expression over  $\Sigma$ . Decide for each of the following equations whether it holds for arbitrary  $\alpha$ . Briefly motivate your answer. For answers without motivation, *no* points are given.

(a)  $L(\emptyset)L(\alpha) = L(\alpha)$  (1p)

(b)  $L(\varepsilon | \alpha^*) = L(\alpha^*)$  (1p)

(c)  $L(\alpha\alpha^*) = L(\alpha^*) \setminus \{\varepsilon\}$  (2p)

Decide (with justification) whether the following statement is true or not.

(d) If a language is finite, then it is regular. (1p)

(In total, there are **20** points in this exercise sheet.)