

# Theoretical Computer Science - Bridging Course

## Summer Term 2019

### Exercise Sheet 3

for getting feedback submit electronically by 06:00 am, Friday, May 17th, 2019

#### Exercise 1: Regular Expressions (6 Points)

Give a regular expression for each of the following three languages.

- (a)  $L_1 = \{w_1w_2w_3 \mid w_1, w_2, w_3 \in \{a, b, c\}^*, w_1 \text{ contains no } a, w_2 \text{ contains no } b, w_3 \text{ contains no } c\}$
- (b)  $L_2 \subseteq \{a, b\}^*$  is the language of all words that do not have any of the words in  $\{aaa, aaaa, \dots\}$  as a consecutive substring.
- (c)  $L_3$  is the language, over alphabet  $\{a, b\}$ , of all strings not ending with  $aa$ .

#### Exercise 2: The Pumping Lemma: Sufficiency or Necessity? (4 Points)

Consider the language  $L = \{c^m a^n b^n \mid m, n \geq 0\} \cup \{a, b\}^*$  over the alphabet  $\Sigma = \{a, b, c\}$ .

- (a) Describe in words (not using the pumping lemma), why  $L$  cannot be a regular language.
- (b) Show that the property described in the Pumping Lemma is a necessary condition for regularity but not sufficient for regularity.

*Hint: Use  $L$  as counter example, i.e., show that it can be 'pumped' (in the sense of the pumping lemma), but is still not regular.*

#### Exercise 3: Application of The Pumping Lemma (6 Points)

Show that the following languages over the alphabet  $\Sigma = \{a, b\}$  are not regular:

- (a)  $L = \{a^m \mid m \text{ is a square number}\}$  ( $m$  being a square number means that  $m = n^2$  for some non negative integer  $n$ )

*Hint: Use the Pumping Lemma.*

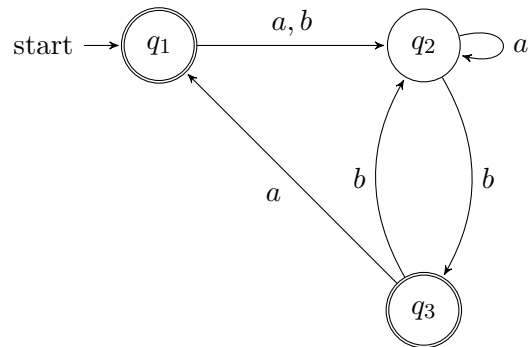
- (b)  $L = \{a^m b^n \mid m \neq n\}$

*Hint: Have a look at the languages  $\{a^n b^n \mid n \in \mathbb{N}\}$  and  $a^* b^*$  and use the fact that the class of regular languages is closed under intersection, complement, concatenation and the Kleene star.*

## Exercise 4: NFAs to Regular Expressions

(4 Points)

Consider the following NFA:



Give the regular expression defining the language recognized by this NFA by *stepwise* converting it into an equivalent GNFA with only two nodes.