

## Exercise for chapter 4 (Part 1) Automata

### 1 Introduction

In this exercise, we will be familiar with some basic concepts and definitions in automata: language, regular expression, finite automata and NFA (nondeterministic finite automata). Students should review the slide and related theoretical documents before doing the exercises below.

### 2 Example

#### Question 1.

Let  $\Sigma = \{a, b\}$  and  $L = \{ab, aa, baa\}$ .

Which of the following strings are in  $L^*$ : *abaabaaabaa*, *aaaabaaaa*, *baaaaabaaaab*, *baaaaabaa*?

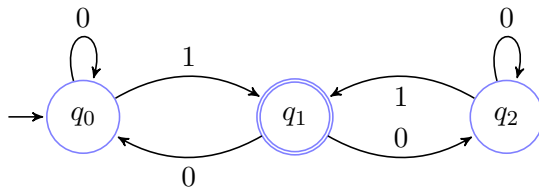
**Solution.**

*abaabaaabaa*, *aaaabaaaa*, *baaaaabaa*

□

#### Question 2.

Which of the strings 0001, 01001, 0000110 are accepted by the following automata:



**Solution.**

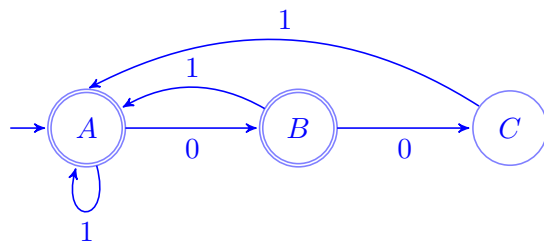
*0001*, *01001*

□

#### Question 3.

Consider the set of strings on  $\{0, 1\}$  in which every 00 is followed immediately by 1. For example 101, 0010, 0010011001 are in the language, but 0001 and 00100 are not. Construct an accepting automata.

**Solution.**



□

### 3 Homework

#### Question 4.

Let  $\Sigma = \{a, b\}$ .

Find all strings in  $L = ((a + b)^*b(a + ab)^*)$  of length less than four.

#### Question 5.

Let  $\Sigma = \{a, b\}$ .

For which language it is true that  $L = L^*$ ?

- a)  $L = a^n b^{n+1} : n \geq 0$
- b)  $L = w : n_a(w) = n_b(w)$

**Question 6.**

Give a finite automata for the language  $L = \{a, ba, aba, bab, bbba\}$ .

**Question 7.**

Let  $\Sigma = \{a\}$ . Give finite automata for the sets consisting of

- a) all strings with exactly one  $a$ .
- b) all strings with no more than three  $a$ 's.

**Question 8.**

Let  $\Sigma = \{a, b\}$ .

Give finite automata for the sets consisting of

- a) all strings with exactly one  $a$ .
- b) all strings with no more than three  $a$ 's.

**Question 9.**

Let  $\Sigma = \{a, b, c\}$ . Give finite automata for the sets consisting of

- a) all strings with exactly one  $a$ .
- b) all strings with no more than three  $a$ 's.
- c) all strings with no more than three  $a$ 's and at least one  $b$ .

**Question 10.**

Give an automata for the language  $L = \{ab^5wb^4 : w \in \{a, b\}^*\}$ .

**Question 11.**

Find automatas for the following languages on  $\Sigma = \{a, b\}$

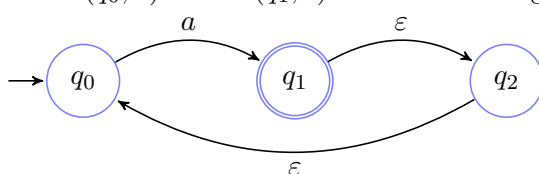
- a)  $L_1 = \{w : |w| \bmod 3 = 0\}$
- b)  $L_2 = \{w : |w| \bmod 5 \neq 0\}$
- c)  $L_3 = \{w : n_a(w) \bmod 3 > 1\}$

**Question 12.**

Show that the language  $L = a^n : n \geq 0, n \neq 4$  is regular.

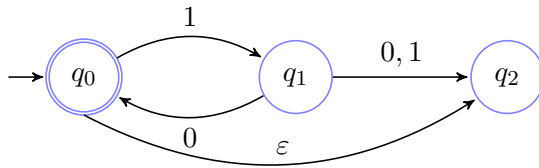
**Question 13.**

Find  $\delta^*(q_0, a)$  and  $\delta^*(q_1, \varepsilon)$  for the following automata



**Question 14.**

For the following automata, find  $\delta^*(q_0, 1010)$  and  $\delta^*(q_1, 00)$ .



**Question 15.**

Find an automata with three states that accepts the language  $\{ab, abc\}^*$

**Question 16.**

Let  $\Sigma = \{a, b, c\}$ .

Give complete automatas for the sets consisting of

- a) all strings with exactly one 'a'.
- b) all strings of even length.
- c) all strings which the number of appearances of 'b' is divisible by 3.
- d) all strings ending with 'a'.
- e) all strings not ending with 'a'.
- f) all non-empty strings not ending with 'a'.
- g) all strings with at least one 'a'.
- h) all strings with at most one 'a'.
- i) all strings without any 'a'.
- j) all strings including at least one  $a$  and whose the first appearance of 'a' is not followed by a 'c'.

**Complete automata:** a finite automata in which from each state, it is defined precisely when receiving any event.