

Theory of Computing

Regular Expressions

TD 4

2ND YEAR - ENSIA

PRE-TUTORIAL EXERCISES

For each of the following languages, give two strings that are members and two strings that **are not members**. Assume the alphabet $\Sigma = \{a,b\}$

- | | |
|-------------------|--|
| A. $a^* b^*$ | E. $\Sigma^* a \Sigma^* b \Sigma^* a \Sigma^*$ |
| B. $a(ba)^* b$ | F. $aba \cup bab$ |
| C. $a^* \cup b^*$ | G. $(\epsilon \cup a)b$ |
| D. $(aaa)^*$ | H. $(a \cup ba \cup bb)\Sigma^*$ |

\cup is the union operator (or) (in other textbooks, the + or | can be used)

EXERCISES

Exercise C1 (Formulating Regular Expressions) :

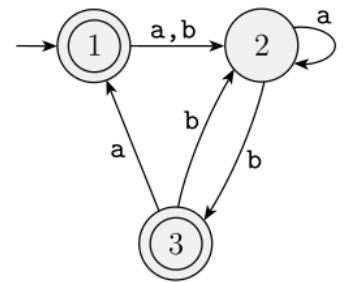
Find a regular expression corresponding to each of the following subsets of $\{a, b\}^*$.

1. The language of all strings containing exactly two a's.
2. The language of all strings containing at least two a's.
3. The language of all strings that do not end with ab.
4. The language of all strings that begin or end with aa or bb.
5. The language of all strings in which every a is followed immediately by bb.
6. The language of all strings containing both bb and aba as substrings.
7. The language of all strings in which the number of a's is even.
8. The language of all strings not containing the substring aa.
9. The language of all strings containing no more than one occurrence of the string aa.
(The string aaa should be viewed as containing two occurrences of aa.)

Exercise C2 (RegExp to NFA) :

Convert the following regular expressions to NFAs for $\Sigma = \{0, 1\}$.

1. $(0 \cup 1)^* 000(0 \cup 1)^*$
2. $((00)^* (11)) \cup 01)^*$
3. \emptyset^*
4. $(0 \cup 1^+)0^+ 1^+$



Exercise C3 (RegExp to NFA) :

Convert the following NFA to Regular Expressions:

Assignment 2 (Deadline 07 March 2024) :

Find the regular expressions for :

- The language of all strings in which the number of a's is even and the number of b's is odd.
- The language of all strings not containing the substring bba.
- A valid email address
- Valid URL (not domain name, but FULL URL)

Exercise P1 (Optional) :

In each case below, find a string of minimum length in $\{a, b\}^*$ not in the language corresponding to the given regular expression.

- A. $b^* (ab)^* a^*$
- B. $(a^* \cup b^*) (a^* \cup b^*) (a^* \cup b^*)$
- C. $a^* (baa^*)^* b^*$
- D. $b^* (a \cup ba)^* b^*$

Exercise P2 (Optional) :

Find a regular expression corresponding to each of the following subsets of $\{a, b\}^*$.

1. The language of all strings not containing the substring `aaa`.
2. The language of all strings containing both `bab` and `aba` as substrings.

Exercise P3 (Optional) :

Consider the two regular expressions

$$r = a^* \cup b^*$$

$$s = ab^* \cup ba^* \cup b^* a \cup (a^* b)^*$$

- A. Find a string corresponding to r but not to s .
- B. Find a string corresponding to s but not to r .
- C. Find a string corresponding to both r and s .
- D. Find a string in $\{a, b\}^*$ corresponding to neither r nor s .

Exercise P4 (Optional) :

For each of the following regular expressions, draw an NFA accepting the corresponding language, so that there is a recognizable correspondence between the regular expression and the transition diagram.

- A. $(b \cup bba)^* a$
- B. $(a \cup b)^* (abb + ababa)(a \cup b)^*$
- C. $(a \cup b)(ab)^* (abb)^*$
- D. $(a \cup b)^* (abba^* \cup (ab)^* ba)$
- E. $(a^* bb)^* \cup bb^* a^*$
- F. $a(abb)^* \cup b$
- G. $a^+ \cup (ab)^+$

Exercise P5 (Optional) :

Give a regular expression for the language L containing all strings in $a^* b^*$ whose length is a multiple of three. E.g. L contains `aaaabb` but does not contain `ababab` or `aaabb`.

Exercise P6 (Optional) :

Convert the following expressions to NFA:

1. $a(b \mid c) d$
2. $(abc)^*$
3. $((a b)^* c (d \mid e) (f \mid g)^* h$

Exercise P7 (Optional) :

Give a regular expression for :

- Arithmetic formulas in the simple form : $a+b$ or $a*b$ or $a-b$ (using real numbers..)
- Can you write a regular expression the compound arithmetic formulas considering the case of balanced parenthesis (Example $(1.2 * (1+3-(3-1)))$) ? Justify your answer.