NTIN071 A&G: Tutorial 4 – More on closure properties, regular expressions

Solve 1, 2a-f, 3a-e (the rest is for practice).

Problem 1 (Delete)**.** Let L be a regular language over the alphabet $\Sigma = a, b$. Describe the following languages in set notation. Are these languages (necessarily) also regular? Prove or disprove.

Language consisting of all words obtained from words of the language L by...

(a) ... deleting all occurrences of the letter a.

(b) ... deleting the initial letter and writing this letter at the end of the word.

(c) ... deleting the longest contiguous sequence of a's from the beginning of the word.

Problem 2 (Constructing regular expressions)**.** Find regular expressions representing the following languages over $\Sigma = \{a, b\}$ consisting of words that:

(a) start with 'abba',

(b) end with 'abba',

(c) start with 'ab' and end with 'ba',

(d) contain 'abba' or 'bab' as a subword,

(e) do not contain 'aa' as a subword,

(f) contain an even number of a's,

(g) have at least 2 letters and the first letter is the same as the last letter,

(h) the first two letters are the same as the last two letters.

Problem 3 (Regex to automaton)**.** Construct finite automata accepting languages described by the following regular expressions:

(a) $ab + ba$

(b) $a^2 + b^2 + ab$

(c) $a + b^*$

(d) $(ab + c)^*$

(e) $((ab + c) + a(bc)^* + b)^*$

(f) $((ab + c)^* a(bc)^* + b)^*$

(g) $(01^* + 101)^* 0^* 1$

(h) $(01)^* 11 (01)^* (0 + 1)^* 00$