

Syntax and Semantics

Written Exam, June 4, 2014, 9:00 - 12:00

Navn:

Stud.nr.:

Read this before you start!

- This exam contains 8 exercises. Each exercise is compulsory and has an equal contribution to the final grade.
- Please use the white space at the bottom of each page and the back page for write your solution. You can ask for more pages if you need it.
- You can ask for paper drafts. However, you cannot hand in draft solutions along with the final solution.
- The solutions of the exercises must be written in English.
- During the exam you are allowed to consult the course materials that consists of: the two books used for the course (Hüttel's and Sipser's books) and a printed version of my slides. No other material is permitted.
- You are not allowed to use any electronic device.

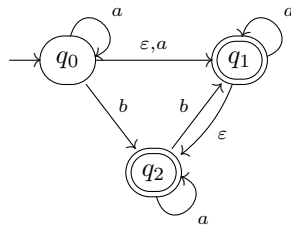
Exercises

Exercise 1. Consider the following context-free grammar with start variable S over the final alphabet $\Sigma = \{[,], a, +, *\}$:

$$\begin{aligned} S &\rightarrow T \mid S + T \\ T &\rightarrow F \mid T * F \\ F &\rightarrow a \mid [S] \end{aligned}$$

1. Which of the following strings are described by this grammar and which are not? For those that are described, provide a syntax tree.
 - (a) $a + a * a$
 - (b) $a * [a + a]$
 - (c) $[a + a] * a * [a + a]$
2. Use the construction presented in the course to construct a push-down automaton that recognizes the language generated by this grammar. The ad hoc solutions will not be considered.

Exercise 2. Let L be the language accepted by the following non-deterministic finite automaton.



1. Construct an equivalent deterministic automaton using the construction algorithm presented in the course. The ad hoc solutions will not be considered.
2. Use the construction presented in the course to give a regular expression r that characterizes L . The ad hoc solutions will not be considered.

Exercise 3. Consider the language $L = \{xy \in \{a,b\}^+ \mid y = x^R\}$, where x^R denotes the reverse string of x (for instance, the reverse string of $x = aab$ is the string $x^R = baa$).

1. Give a context-free grammar for L .
2. Use the construction presented in the course to give a push-down automaton that accepts L . The ad hoc solutions will not be considered.

Exercise 4. Consider the language **Bims** in which the Boolean expressions are given by the following grammar:

$$b ::= a_1 = a_2 \mid a_1 < a_2 \mid b_1 \rightarrow b_2 \mid \perp,$$

where a denote arithmetic expressions, \rightarrow denotes the classical logical implication and \perp denotes "false". Give a big-step semantics for these Boolean expressions, assuming that you already have the big-step semantics for arithmetic expressions. Describe the corresponding transition system.

Exercise 5. Is the language $\{a^n b^m \mid n = km, \text{ for some } k \in \mathbb{N}\}$ regular? Provide a proof for your answer.

Exercise 6. Consider the language **Bump** with call-by-name parameter passing. Hüttel's book presents transition rule for procedure calls assuming the case of mixed scope rules with dynamic scope rules for variables and static scope rules for procedures.

Provide the similar transition rule for procedure calls assuming static scope rules for variables and dynamic scope rules for procedures.

Exercise 7. Consider the language L over the alphabet $A = \{a, b, c\}$ consisting of all strings of form $w = ua$ for some $u \in A^*$ such that w contains at least one occurrence of each symbol in A .

1. Which of the following strings are in L : ε , $ccab$, cba , $abaca$?
2. Give a regular expression r that describes L .
3. Convert r into a nondeterministic finite state automaton using the algorithm of the course.
The ad hoc solutions will not be considered.

Exercise 8. Consider the following statement in **Bip**.

```
begin
  var x:=2;
  var y:=5;
  proc p is x:=x+1;
  proc q is call p;
  begin
    var x:=9;
    proc p is x:=x+1;
    call q;
    y:=x
  end
end.
```

1. What is the value of y after the statement is executed assuming fully dynamic scope rules for both variables and procedures? Motivate your answer.
2. What is the value of y after the statement is executed assuming dynamic scope rules for procedures and static scope rules for variables? Motivate your answer.
3. What is the value of y after the statement is executed assuming fully static scope rules for both procedures and variables? Motivate your answer.