Department of Information and Computing Sciences
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INFOB3TC – Final exam 2019

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Preliminaries

- The exam consists of 8 pages (including this page). Please verify that you got all the pages.
- Fill out the answers **on the exam itself**.
- Write your **name** and **student number** here:

- For open questions, the maximum score is stated at the top of each question. The total amount of points you can get is 90. You obtain your grade by dividing by that number and multiplying by 10, rounded to one digit after the comma.
- Try to give simple and concise answers. Write readable text. You may use Dutch or English.
- When writing grammar and language constructs, you may use any set, sequence, or language operations covered in the lecture notes.

Good luck!

1. Given is the following language $R = \{a^k b^\ell c^m \mid m = min(k, \ell)\}$. Prove with the Pumping Lemma for Regular Languages that R is not *regular*. •

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2. Given is the following regular expression:

$$(cb^* + a)(d(a + b)^*)^*$$

Give a finite state automaton that generates exactly the language of sentences described by this regular expression. You may choose to make a deterministic or non-deterministic one, but you are *not* allowed to use ϵ edges. •

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3. Assume you are given a deterministic finite state automaton (X, Q, d, S, F). Define precisely how to construct the regular grammar $G = (X', Q', R', S')$ that accepts the same language. •

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4. Assume that you have proven the construction given in the previous question correct. What does that tell you about the relationship between regular grammars and non-deterministic finite state automata? Explain your answer! •

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5. Given is the following grammar:

$$
\begin{aligned}
S &\rightarrow E\,\$ \\
E &\rightarrow Q\,Q \\
E &\rightarrow F\,Q \\
Q &\rightarrow p\,F\,Q \\
Q &\rightarrow m\,F\,Q \\
Q &\rightarrow \varepsilon \\
F &\rightarrow (E) \\
F &\rightarrow i \\
F &\rightarrow n
\end{aligned}
$$

where as usual capitals are non-terminals, and the terminals are $\{i, n, (,), p, m, \$\}$. Fill in the information on the next page and explain your reasoning. •

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The non-terminals that can derive the empty string are: . . . .

first $E =$

first $Q =$

first $F =$

follow $E =$

follow $Q =$

follow $F =$

6. Is the above grammar LL(1)? Explain (in general terms) how you can determine this using the lookahead sets of the productions. •

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7. Construct the $LR(0)$ automaton for the following grammar:

$$
\begin{aligned}
S &\rightarrow E\,\$ \\
E &\rightarrow E - V \\
E &\rightarrow V \\
V &\rightarrow i \\
V &\rightarrow i\,[E]
\end{aligned}
$$

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8. Your $LR(0)$ automaton should have exactly one conflict. Which node has the conflict and what kind of conflict is it? •

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9. Discuss whether the use of 1-lookahead in the SLR(1) parser is enough to resolve the conflict in the $LR(0)$ automaton. If it can, how is the conflict resolved based on the lookahead; if it cannot, why not? •

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10. In this question you should answer one of the two following questions. Which one is up to you to decide. They both give the same number of points. You are *not* allowed to answer both questions. You *must* choose.

- Construct a pushdown automaton for the language over the alphabet $\{a, b\}$

$$L = \{w \mid \text{nr of } a\text{'s in } w \text{ equals nr of } b\text{'s in } w\} \cup \{a\}$$

  It may, but need not be deterministic.

- Given is the following language $L = \{a^j b^k p^j q^k \mid j, k > 0\}$. Prove with the Pumping Lemma for Context-Free Languages that L is not *context-free*. Hint: use the word $z = uvwxy = a^n b^n p^n q^n$ where $n = max(c, d)$, and c and d are the constants from the Pumping Lemma.

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