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T-79.148 Introduction to Theoretical Computer Science (2 cr)
Exam Mon 18 Aug 2003, 12–3 p.m.

Write down on each answer sheet:
- Your name, department, and study book number
- The text: "T-79.148 Introduction to Theoretical Computer Science 18.8.2003"
- The total number of answer sheets you are submitting for grading

1. Describe the following languages **both** in terms of regular expressions **and** in terms of deterministic finite automata:

   (a) $\{w \in \{0,1\}^* \mid |w| \geq 2,\ w \text{ begins and ends with a } 1\}$ *7p.*

   (b) $\{w \in \{0,1\}^* \mid |w| \geq 2,\ w$ begins and ends with a 1, and each two consequent 1's are separated by one or two 0's$\}$. *8p.*

2. (a) Design a context-free grammar describing balanced sequences of parentheses that may also contain parallel subexpressions, e.g. "(()())()" or "()()()". Based on your grammar, give the parse trees for the above sequences. *8p.*

   (b) Prove (precisely!) that the language discussed in part (a) can not be recognised (accepted) by a finite automaton. *7p.*

3. Design a (nondeterministic) pushdown automaton that recognises (accepts) the language

   $$L = \{a^i b^j c^k \mid i = j \text{ or } j = k\}.$$

   (Present the automaton preferably as a state diagram rather than a transition table.) Show the accepting computation sequences ("runs") of your automaton on the inputs *ab* and *abbcc*. *15p.*

4. **One** of the following:

   (a) Design (in outline) algorithms for determining whether the language described by a regular expression r over the alphabet $\{0,1\}$ is (a) empty, i.e. $L(r) = \emptyset$, (b) contains all possible binary strings, i.e. $L(r) = \{0,1\}^*$. *15p.*

   (b) Assume that you are explaining the key contents of the course "Introduction to Theoretical Computer Science" to a friend who has not yet taken the course. Describe the Church-Turing thesis to her, and convince her of the fact that there are problems that cannot be solved by a computer. *15p.*

Total 60p.