Helsinki University of Technology
Laboratory for Theoretical Computer Science
Harri Haanpää (tel. 5243), Tommi Syrjänen (tel. 5082)

T-79.148 Introduction to Theoretical Computer Science (2 cr)
Exam Thu 13 May 2004, 1 p.m. – 4 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 13.05.2004"
- The total number of answer sheets you are submitting for grading

1. Finite state automata and regular expressions.
   (a) Design a deterministic finite state automaton that recognizes the language $L = \{w \in \{a, b\}^* \mid w \text{ has an odd number of both } a\text{s and } b\text{s}\}$ *5 p.*
   (b) Design a regular expression that describes the language $L = \{w \in \{a, b\}^* \mid w \text{ has an odd number of } a\text{s or } b\text{s (or both)}\}$ *5 p.*
   (c) Find the minimal deterministic finite state automaton that accepts the language $L = \{w \in \{a, b\}^* \mid w \text{ has an odd number of either } a\text{s or } b\text{s (but not both)}\}$ *5 p.*
2. Let $\Sigma = \{0, 1\}$. We examine the language
$$L = \{w \mid w = x0y, \text{ where } |x| = |y| \text{ and } x, y \in \Sigma^*\}.$$
   (a) Show that the language L is not regular. *7 p.*
   (b) Design a pushdown automaton that recognizes L. Present the pushdown automaton as a state chart. Additionally, give an accepting computation for the input strings 01001 and 11011. *8 p.*
3. Design a deterministic Turing machine that decides the language
$$L = \{a^i b^j c^k \mid i \geq j \geq k \geq 0, i - j = k\}.$$
If you wish, the machine you design may have multiple tapes and it may keep one or more tape heads stationary in a transition. Give a short description of your algorithm and present the machine as a state chart. *15 p.*
4. Let L be a formal language over the alphabet Σ.
   (a) Show that if $|L| = n$ for some $n \in \mathbb{N}$, then L is regular. *7 p.*
   (b) Show that if there exists an $n \in \mathbb{N}$ such that $|w| \leq n$ for all $w \in L$, then L is regular. *8 p.*

Total 60 p.

We ask you to fill in the feedback form of the department at `http://www.cs.hut.fi/Opinnot/Palaute/k2004/kurssipalaute-en.html` . Also, if you have participated in the monthly survey on the course, we ask you to fill in the fourth part of the survey.