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Laboratory for Theoretical Computer Science
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T-79.148 Introduction to Theoretical Computer Science (2 cr)
Exam Mon 14 Feb 2005, 4–7 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 14.2.2005”
- 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) $\{w \in \{0, 1\}^* \mid w \text{ contains } 101 \text{ as a substring}\}$, *7p.*

(b) $\{w \in \{0, 1\}^* \mid w \text{ does not contain } 101 \text{ as a substring}\}$. *8p.*

2. (a) Design a context-free grammar for the language

$$\{ [^i 1^j 0^k]^i \mid i, j, k \geq 0, j \geq k \}.$$

Draw the corresponding parse trees for the sentences $[[1]]$ and 110 . *8p.*

(b) Prove (precisely!) that the language discussed in part (a) is not regular. *7p.*

3. Design a deterministic single-tape Turing machine that checks that the binary string it receives as input contains more ones than zeros. Show the accepting computation sequence (“runs”) of your machine on input 011 , and the rejecting computation sequence on input 1010 . *15p.*

4. One of the following:

(a) Give a brief but precise justification, based on results presented on the course, for each of the following statements: (i) all regular languages are context-free, (ii) all context-free languages are recursive (“decidable”), (iii) all recursive languages are recursively enumerable (“recognisable”). *15p.*

(b) As you know, failure of numeric operations (division by zero, register over- or underflow) can result in the execution of a computer program terminating in a run-time error. Explain why this possibility cannot be eliminated in advance, e.g. by testing for the risk of division by zero before initiating the execution of a program. (Justify your answer carefully, based on results presented on the course.) *15p.*

Total 60p.