Master of Science in Computer Science - University of Camerino
Compilers A. Y. 2019/2020
Written Test of 19th February 2020 (Session/Appello II)
Teacher: Luca Tesei

NOTE: Regular expressions should be written using the usual rules of precedence: the $*$ operator has precedence on concatenation, which has precedence on the $|$ operator. The notation $(r)^+$ can be used with the usual meaning.

EXERCISE 1 (10 points)

Consider the following regular expression:

$$a^*(bc^* \mid (bc)^+)$$

1. Give a minimal automaton accepting the language denoted by the regular expression. Show all the steps leading to your solution.

EXERCISE 2 (12 points)

Consider the following grammar:

$$\begin{array}{lcl} S & \rightarrow & B \mid Caa \\ B & \rightarrow & bC \\ C & \rightarrow & bbCa \mid \epsilon \end{array}$$

1. Write formally the language generated by the grammar as a set of strings.
2. Is the grammar LR(1)? If so, give the table of a bottom-up shift-reduce parser and show the parsing of the string $bbba$.

EXERCISE 3 (12 points)

Consider a language of expressions defined recursively as follows:

(i) x is an expression;

(ii) if $e_1, e_2, \ldots, e_n$ (with $n > 0$) are expressions then $f(e_1, \ldots, e_n)$ is an expression.

Your tasks are:

1. Define a Syntax Directed Translation Scheme suitable to be implemented by a top-down parser and such that it computes, for the starting symbol, an attribute $\mathbf{m}$ of type `int`. For a give expression, $\mathbf{m}$ must give the maximum number of arguments to which the function f is applied to. The maximum must be computed considering any possible subexpression, not only the top level f. Examples:
   - for the expression x it must result $\mathbf{m} = 0$,
   - for the expression $f(x)$ it must result $\mathbf{m} = 1$,
   - for the expression $f(f(x))$ it must result $\mathbf{m} = 1$,
   - for the expression $f(x, f(x, x))$ it must result $\mathbf{m} = 2$,
   - for the expression $f(f(x, x))$ it must result $\mathbf{m} = 2$,
   - for the expression $f(x, f(x, x), f(x, f(x)))$ it must result $\mathbf{m} = 3$,
   - for the expression $f(f(x, x), f(x, f(x), f(f(f(f(x))))))$ it must result $\mathbf{m} = 3$.